

Advancing a Circular Economy for Food: Key Drivers and Recommendations to Reduce Food Loss and Waste in Singapore

Study by Singapore Environment Council (SEC)

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Foreword

Our esteemed partners and friends of the environment,

We are all aware that food loss and waste is one of the most pressing issues in Singapore and many parts of the world. It is, therefore, with pride and gratitude that Singapore Environment Council unveils its study on “Advancing the Circular Economy for Food: Key Drivers and Recommendations to Reduce Food Loss and Waste in Singapore.”

Your unwavering support, counsel and confidence over an intense six months of research work have enabled the successful completion of this food study. On behalf of Singapore Environment Council, my sincere thanks to you and all those who care enough for the environment to do something about it, for making our study on food loss and waste happen.

I would like to specially thank our knowledge partner Deloitte Singapore for their dedication and determination to uncover useful insights, especially key drivers behind food loss and waste. Special thanks also to our partners, stakeholders and respondents who participated in our study.

In Singapore, food waste is largely monitored at the consumer or downstream stage, with little awareness of the losses occurring at upstream and midstream. Our study plugs the gaps in research on food loss and waste. Taken together, it presents a fuller picture of the food loss and waste situation in Singapore.

The study has also thrown up opportunities for new technology and innovative solutions to close the loop on food loss and waste as we work towards creating a circular food economy. Cutting down on food loss and waste will contribute towards lowering greenhouse gases in Singapore and to mitigate climate change. According to the Food and Agriculture Organization, if food loss and waste was a country, it would be the third largest greenhouse gas emitting country. SEC’s food study is aligned and in full support of the national agenda of Year Towards Zero Waste, and “30 by 30” goal to help grow the local agriculture and food industries to produce 30% of our nutritional needs by 2030.

Our study found that an estimated 342,000 tonnes of food is lost from farm to market within Singapore, contributing to an estimated food loss of \$2.54 billion annually. Separately, key findings from the consumer survey revealed that an estimated \$6.57 million worth of food is thrown away from Singapore households weekly, or a loss of about \$342 million from households here each year.

No doubt, food security is critical to Singapore and food imports remain the biggest source of food in Singapore. Local food production is our second “food basket”. There is an urgent need to reform the current way our food is grown to reduce farming’s environmental footprint, boost resource efficiency, and cut food waste. Growing overseas is our third “food basket”, where companies can expand and grow overseas so that their produce can be exported back home.

If Singapore is able to cut down on food loss and convert it into food for consumers, it could create another “food basket”. Consumers can also do their part to cut down on food waste by emulating the example of the “smart consumer”, as uncovered by our survey. This would also reduce the importation of fresh produce.

I urge you to read our food report with an open mind and open heart, and ask yourself what you can do to cut down food loss and waste. We hope that our position paper will create value and trigger new and deeper conversations among multiple stakeholders to look at the issue with new and fresh eyes.

We welcome your feedback and look forward to exploring collaborative partnerships for the greater good of Singapore and our environment.

Jen Teo
Executive Director
Singapore Environment Council

Executive Summary

Food Loss and Waste is one of the most important issues on a global and local scale. Globally, approximately one-third of the food produced for human consumption is lost or wasted. This equals to 1.3 billion tonnes of edible food forgone yearly due to numerous reasons (FAO, 2011), resulting in economic losses of nearly USD \$1 trillion (Searchinger, Waite, Hanson, & Ranganathan, 2018). IPCC estimates that the global averaged per capita food loss and waste is 25–30% of global food produced (Kummu, Moel, Porkka, Varis, & Ward, 2012; Alexander, Holzhauser, & Rounsevell, 2017). Food waste has environmental repercussions contributing to 8% of the global Greenhouse Gas (GHG) emissions.¹ Reducing food waste even by 50% would lead to a net emission reduction of 20–30% of the total food-sourced GHG emissions (Bajželj, B., Richards, Allwood, & Smi, 2014).

According to the Food and Agriculture Organization of the United Nations (FAO), food loss refers to any food that is lost in the supply chain between the producer and the market. Whereas, food waste refers to the discarding or alternative (non-food) use of food that is safe and nutritious for human consumption (FAO, 2011). The food supply chain represents the flow of food from the farm to the consumer. This comprises three main components: upstream, midstream, and downstream. Upstream includes production of food and post-harvest handling and storage, while midstream includes processing, packaging and distribution. Downstream component includes food consumption (retail and consumers). Food losses occur at upstream and midstream stages of the food supply chain, whereas food waste occurs at the downstream stages. Amongst industrialised countries, food loss and waste primarily occurs downstream while the case is upstream for developing countries.

In Singapore, food waste is a significant environmental concern, forming one of the five largest waste streams. In 2018, Singapore generated a total of 763 thousand tonnes of food waste, a near 30% increase from the food waste

¹ EC, JRC/PBL, 2012 Emission Database for Global Atmospheric Research, version 4.2.

generated 10 years ago in Singapore (National Environment Agency, 2019). Along with challenge of mounting food waste, food security within the country is also a primary focus. Due to climate change and population growth, global food supplies are increasingly at-risk from extreme weather events and poor land management practices. By 2050, the world will face a 56% food nutrition gap, exacerbated by a shortage of nearly 600 million hectares of agricultural land for expansion (Tilman & Clark, 2014). These external factors will exert pressure on the global food system and pose a challenge to our 90% food import dependency. While Singapore pursues a 3-basket strategy of diversifying import sources, growing local and growing overseas, food imports still make up our largest "food basket". Our food imports are substantially sourced from countries that deploy traditional farming methods for weather-based agriculture (80% of crops are still rain-fed). Such forms of agriculture contribute towards greenhouse gases which stands at approximately 25% of global emissions and close to 70% of freshwater withdrawals (The World Bank, 2017).

Singapore's dependency on food imports, and the use of less than 1% of the land for agricultural food production (Mahmud, 2019), necessitates her to enhance its food security. Beyond the mass of available food, Singapore's vision is to locally produce 30% of the country's nutritional needs by 2030, supporting existing farms to raise productivity, and adopting a circular economy approach to overcome resource constraints (Ministry of the Environment and Water Resources (MEWR), 2019).

There are quite a number of food waste studies done at the consumer level in Singapore to study the drivers of food waste. However, there are limited studies conducted on the losses occurring at up and midstream stages of food production, handling and storage, processing and packaging, and distribution (from farm to market). Therefore, SEC conducted a study in Singapore to identify the volume of food loss and waste, the drivers contributing to these, and the possible solutions. While the study covered various fresh food categories, three key food groups, namely vegetables and fruits, fish and seafood, and eggs, were singled out for attention. The reasons for the focus is the fact that they form a large part of food imports and constitute a substantial

portion of Singapore’s recommended daily food intake (Health Promotion Board, 2019). Yet all three food groups are also grown locally in our farms. In our opinion, local farms have the opportunity to scale and thereby hold the key to meeting 30% of Singapore’s nutritional needs by 2030.

From this study, we found that an estimated 342 thousand tonnes of food is lost from farm to market within Singapore. As Singapore imports most of its food requirements, more than 144 thousand tonnes of food loss occurs when imported food lands in the country. For the locally-produced food within Singapore, more than five thousand tonnes of food is lost at production. This is followed by close to two thousand tonnes of food is lost during post-harvest handling and storage. During processing and packaging of imported and locally-produced food items, there is a food loss of close to 75 thousand tonnes. During distribution, there is a food loss of more than 116 thousand tonnes.

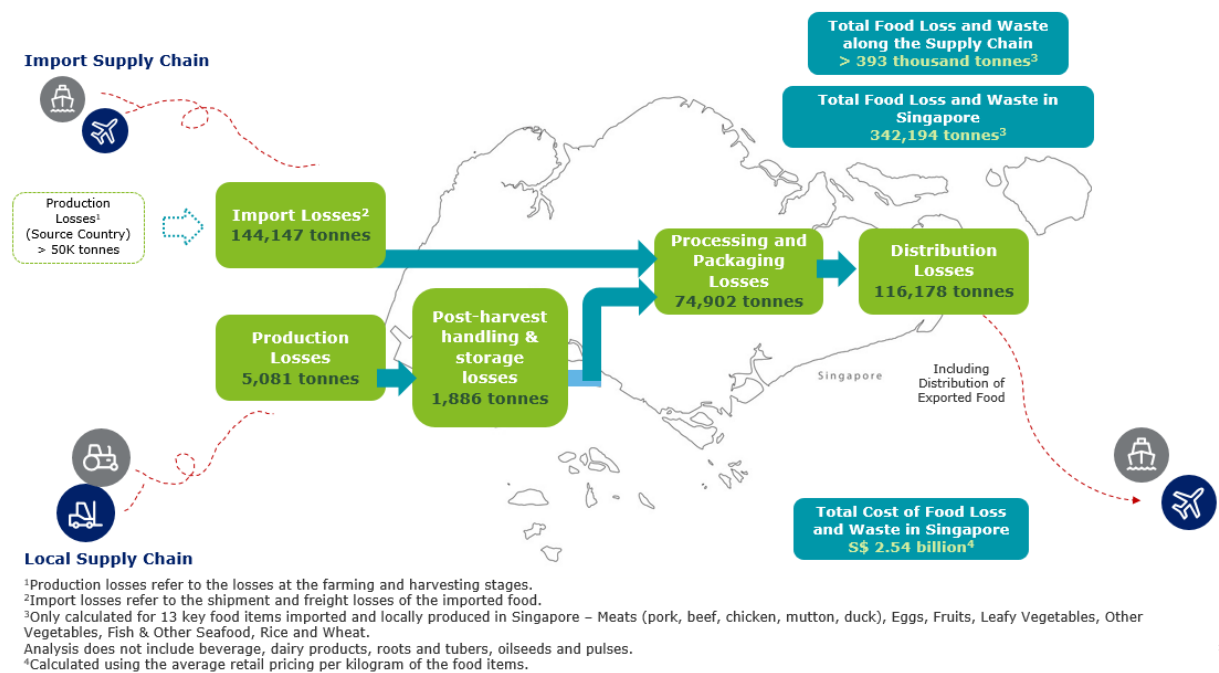


Figure 1: Food loss and waste in Singapore.

The food losses occurring contribute to an estimated \$2.54 billion² worth of food lost from farm to market in Singapore. This immense impact can be turned into

² Calculated using the average retail pricing per kilogram of the food items

economic, environmental and social opportunities. To achieve a circular economy for food, this study will explore a duality of approaches that aim to enhance the efficiency of our food production system today and while enabling the development of new agri-food industries and employment opportunities for tomorrow. To bridge the gap and transit towards a circular economy for food, we will need to harness a variety of levers that include financing support, standards-setting initiatives, policy measures and technological innovation. Already there are start-ups and new farming enterprises sprouting up across Singapore. Through the use of the latest technology and innovative thinking, we like to see them scale and make an indelible contribution to Singapore's food security. Equally, there is more that local traditional farms can do to apply new technologies, seek out creative solutions and adopt state-of-the-art practices to improve efficiency and increase yield. With the eggs supply chain as a case in point, the introduction of process automation and better feed quality over the last few decades has lowered food losses markedly. This two-prong approach promises to push local food production to new heights and will help to mitigate the environmental, economic, social and food security impact brought on by the heavy reliance on food imports.

The study is supported by qualitative and quantitative information gathered through comprehensive interviews with over 30 key stakeholders: including farmers, importers, distributors, retailers, waste management experts, academicians, and non-profit organisations (NPO). The study is also supported by concentrated research on past literature focusing on food loss and waste, and the drivers causing the food loss and waste. Data on consumer food storage behaviour, purchasing patterns and food handling habits, was collected from 1,002 respondents in Singapore through an online survey. Based on the results of the survey, an estimated 26 thousand tonnes of unconsumed food³ is thrown away from households annually.

³ Food thrown away prior to cooking. It refers to uncooked food that may be discarded as a result of expired food and/or spoilage from improper storage. Food items considered for calculations – vegetables, dairy products, bread, eggs, meats, seafood and fish, fruits, and beverages.

THE STORY BEHIND SINGAPORE'S FOOD LOSS & WASTE



2million*
tonnes of food
is imported



393,000
tonnes of food
IS LOST



UPSTREAM

Food loss that takes place during **production**



MIDSTREAM

Food loss that takes place during **processing and transportation**



Food and Agricultural Organisation (FAO) Definition

FOOD LOSS refers to any food that is **lost in the supply chain** between the producer and the market.

Example: post-harvest losses, handling, storages, packaging or transportation losses.

FOOD WASTE refers to the **discarding** or alternative (non-food) use of **food that is safe and nutritious** for human consumption.

Example: disposal of "Ugly Food", food close to 'Best-before' dates, edible unused or leftover foods discarded from kitchens.

167,000 tonnes of
Fruits & Vegetables lost

= **5,901** 20-foot Containers



25,000 tonnes of
Fish & Seafood lost

= **883** 20-foot Containers



5,500 tonnes of
Eggs lost

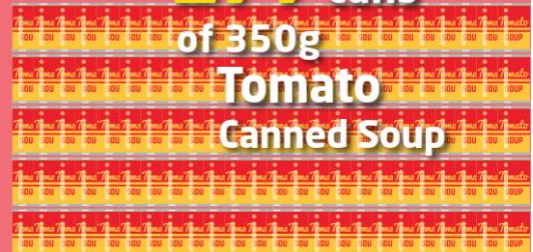
= **305** Double-Decker Buses



An average of
62 kg of food
is lost per person
each year
is equivalent to

177 cans

of 350g
Tomato Canned Soup



342,000
tonnes food loss is equivalent to

S\$2.54 billion

*Figures taken from SFA Import Data 2017.

Key findings from the consumer study revealed that an estimated \$6.57 million worth of food is thrown away from Singapore households weekly. This suggests a loss of about \$258 per household per year from unconsumed food or a loss of about \$342 million from Singapore households annually. The survey in this study highlighted that one in three respondents throw away more than 10% of the food they purchase weekly. Furthermore, over 80% of the consumers do not fully understand the difference between the three different labels ("use by", "best before" and "date of expiry") used on product packaging, which could be a contributing factor to food lost from unconsumed food.

With reference to the consumer survey, one in five respondents have been categorised as "smart consumers" since they do not throw away unconsumed food. "Smart consumers" seem to exhibit the following traits:

- They are effective and organised planners as most of the smart consumers always or often make a list of items.
- Most of them do not get swayed away by promotional offers and ensure that they consume all the items they purchase or do not purchase more than what is required.
- Most of them have a higher frequency of shopping, at least once a week.

The remaining 80% of the respondents do not fall under the category of "smart consumers" since they throw away a proportion of the unconsumed food items bought. Adopting the characteristics of "smart consumers" is important as this would help reduce household food waste in Singapore.

THE STORY BEHIND SINGAPORE'S FOOD LOSS & WASTE



How Much Food Are We Wasting?



DOWNSTREAM
Food waste made up of **unconsumed** and **uncooked** food

Value of food wasted amounts to **S\$342 million** each year

From **consumer survey**, **S\$258** worth of food is wasted per household annually

ONE-THIRD OF THE RESPONDENTS THROW AWAY MORE THAN **10%** OF FOOD WEEKLY.

80% OF THE RESPONDENTS DO NOT FULLY UNDERSTAND THE DIFFERENCE BETWEEN VARIOUS LABELS - 'USE-BY', 'BEST-BEFORE' AND 'DATE OF EXPIRY' USED ON THE PRODUCT PACKAGING.

68,400,000 plates of Nasi Lemak across all households in Singapore.

52 plates of Nasi Lemak per household each year!

1 in 5 ARE **SMART CONSUMERS** AS THEY DO NOT THROW AWAY FOOD.

EFFICIENT/SMART PLANNERS often make a list of items they would buy prior to a shopping trip

SMART SHOPPERS do not get swayed by promotional offers, and always end up consuming all the items purchased

ORGANISED PLANNERS shop frequently, while not throwing away any food

Households: Statistics on resident households are compiled by the Singapore Department of Statistics, Department of Statistics Singapore, 2018 Data.

Population and Population Structure: Statistics on Singapore's population are compiled by the Singapore Department of Statistics, 2018 Data.

Assumes retail price of nasi lemak @S\$5 per plate.

Based on the findings from the interviews with key stakeholders in the food supply chain in Singapore, and literature review of past studies on food loss and waste, the study provides the following key drivers and solutions for food loss and waste in Singapore.

Table 1: Key drivers of food loss and waste in Singapore.

	Key Drivers Upstream <i>(Production and Post-harvest Handling)</i>	Solutions
1.	<ul style="list-style-type: none"> Farmers have difficulty in obtaining financial support for adopting newer technologies 	<ul style="list-style-type: none"> Better communication between agencies to facilitate timely approvals of grants
2.	<ul style="list-style-type: none"> Disposal of imperfect produce due to strict industry standards 	<ul style="list-style-type: none"> Improve market access and increase awareness about imperfect produce Implement policies that ban the disposal of imperfect produce and provide incentives to companies seeking to purchase imperfect produce
3.	<ul style="list-style-type: none"> Low awareness and limited information on farming practices by Singapore citizens 	<ul style="list-style-type: none"> Development of "Community Supported Agriculture" by Singapore citizens partnering with local farming groups. Development of urban farming infrastructure Citizen groups can promote urban farming practices
4.	<p>During Harvesting:</p> <ul style="list-style-type: none"> Mechanical damage to vegetables Bycatch losses in fish and seafood Low calcium and/or salt in the feed decrease production and cause smaller/ soft-shelled/ shell-less/ cracked eggs 	<ul style="list-style-type: none"> Improve harvester and handling equipment (e.g. introduce proper harvester adjustments and technology improvement grants) Improvements and implementations in automation technology for efficient harvesting of fish

		<ul style="list-style-type: none"> Reselling/redistribution of unpopular food to other markets (e.g. milkfish) Consistent, automated feeding and probiotics feed for chickens
5.	<p>Farm Management:</p> <ul style="list-style-type: none"> Over-ripening due to unsuitable temperature Overcrowding of fish in small tanks No real-time information on the water conditions made available to farmers 	<ul style="list-style-type: none"> Implement indoor and climate-controlled farms Dredging of sea beds to clear fish waste Conduct proper disease monitoring via routine physical checks on fish and testing of water conditions
<p>Key Drivers Midstream (Processing, Packaging and Distribution)</p>		<p>Solutions</p>
6.	<ul style="list-style-type: none"> Limited use of processing waste side streams in Singapore (e.g. disposal of soybean residue, which otherwise can be used to create secondary productions) 	<ul style="list-style-type: none"> Explore new technologies to process side streams (e.g. use of soybean residue for creating yeast, and sustainable packaging material)
7.	<ul style="list-style-type: none"> Strict cosmetic standards for packaging industry (losses during trimming, and packaging for ease for distribution) 	<ul style="list-style-type: none"> Innovative packaging designs to enable cost-effective, efficient transport of irregular food items
8.	<ul style="list-style-type: none"> Fragile packaging materials or haphazard packaging 	<ul style="list-style-type: none"> Inspecting officer needs to record any damage to outer wrapping especially if the product has been exposed
9.	<ul style="list-style-type: none"> Over-importation of food into Singapore by suppliers (in an attempt to sell as much as possible) 	<ul style="list-style-type: none"> Policies to monitor the amount of food imported Demand forecasting by businesses to predict the amount of food that would be sold

10.	<ul style="list-style-type: none"> Food losses not monitored by weight, but instead monitored based on write-offs (If sales cover the cost of food loss, losses are unaccounted for) 	<ul style="list-style-type: none"> Redistribution of excess unsold food Import companies and distribution hubs to measure losses by weight of food items loss, to estimate the actual losses occurring
11.	<ul style="list-style-type: none"> Improper care of food during loading and unloading from vehicles leading to physical damages 	<ul style="list-style-type: none"> Introduce guidelines to be published on careful handling of different types of food items and training provided to food handlers
12.	<ul style="list-style-type: none"> No provision that protects entities from liabilities when they donate food to charity 	<ul style="list-style-type: none"> Introduce policies to safeguard entities from liabilities
Key Drivers Downstream <i>(Consumption)</i>		Solutions
13.	<ul style="list-style-type: none"> Confusion regarding "Expiry date", "Best before", and "Use by" dates 	<ul style="list-style-type: none"> Consider adopting different definitions for "Expiry date", "Best before", and "Use by" dates, to avoid confusion with the various labels and avoid any potential food waste occurring due to this confusion
14.	<ul style="list-style-type: none"> No penalty for disposal and incineration of food waste in Singapore 	<ul style="list-style-type: none"> Introduce policies to discourage food waste disposal and incineration in Singapore
15.	<ul style="list-style-type: none"> Limited policies to encourage redistribution 	<ul style="list-style-type: none"> Facilitate increased donation of unsold foods (e.g. from hotels, restaurants and cafeterias)
16.	<ul style="list-style-type: none"> Consumer knowledge of proper storage and management of food purchases 	<ul style="list-style-type: none"> Training for retailers, restaurant, cafeteria, and supermarket management to forecast

		<p>customer demand (avoid bulk purchases)</p> <ul style="list-style-type: none"> • Educate consumers on correct storage method and temperature (e.g. the shelf life of cod fillets at 0°C has been estimated 10–12 days)
17.	<ul style="list-style-type: none"> • Lack of conscious shopping and meal planning habits 	<ul style="list-style-type: none"> • Promote the habit of preparing shopping lists prior to shopping trips, among consumers
18.	<ul style="list-style-type: none"> • Consumer perception that inglorious foods are not nutritionally fit 	<ul style="list-style-type: none"> • Education of consumers on not being cosmetically selective during purchase

Developing a Circular Economy of Food within Singapore

Food loss in Singapore can be dealt with by building a circular economy to plug the leakages and gaps in the food supply chain. It is envisioned that once a circular economy is built up, whatever that is generally thrown away or wasted now, can be reintroduced into the food supply chain as useful by-products.

The supply chain for eggs in Singapore is identified as a good example, where the amount of food loss and waste generated is low. The egg farms in Singapore⁴ use automation to enable maximum output while ensuring minimal loss during production resulting in around 1% loss of eggs along the food supply chain. Moreover, good practices in these farms include the use of damaged eggs during production to create by-products such as liquid egg and powdered eggs. Chicken waste obtained from coop is used as fertiliser in vegetable farms in Singapore. These characteristics of valorising food from waste generated has the potential to be used as a model to exhibit circularity of food in Singapore.

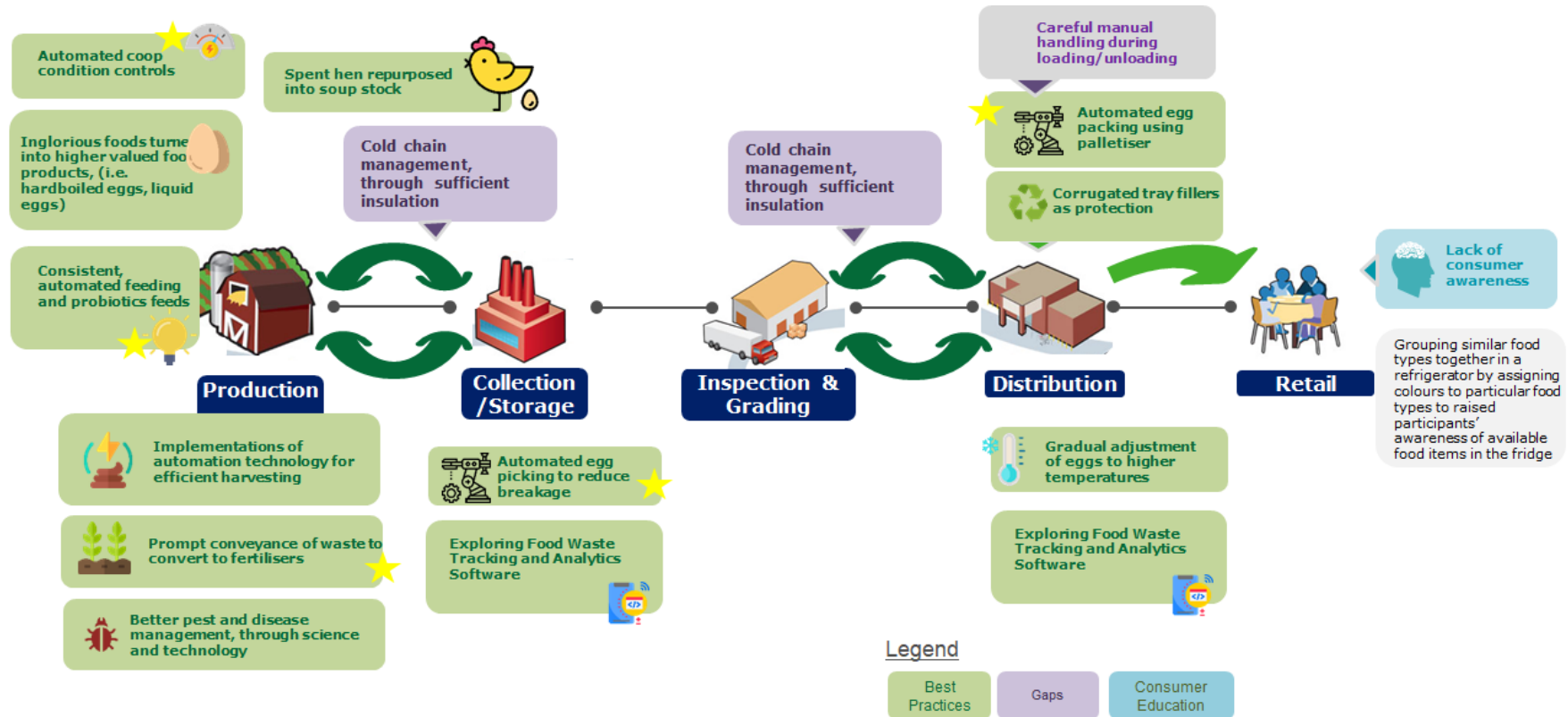
⁴ Three hen egg farms are currently operating in Singapore: Seng Choon Farm, N&N Agriculture, Chew's Agriculture

In fish farms, there are instances where fish and other seafood are left unsold and if there are no suitable buyers, these items would likely go to waste. To minimise the occurrence of such waste, there are fish farms who are looking to convert these unsold food items into other food products that would extend its shelf life. For instance, the production of a ready-to-eat seafood product (made from a combination of fish and prawn meat) is currently being developed in the local farms. This concept of transforming food has a great potential to be used as a model within the aquaculture industry and in Singapore.

Food security is critical for Singapore. It is evident that food imports remain the dominant source of food in Singapore. Local food production is important to supplement the food supply from imports, and is our second "food basket". Our third "food basket" would be coming from overseas-based Singaporean companies which have access to new and bigger markets, and be able to have economies of scale to reduce the price of food exports to Singapore.

It is suggested that Singapore moves towards greater circularity of food to reduce food loss and waste and create the fourth "food basket" to further enhance the food security of Singapore in the foreseeable future.

Suggested Circular Economy of Eggs in Singapore



Credits: Icon(s) from www.flaticon.com

Source of Food Production Chain: https://www.cdc.gov/foodsafety/outbreaks/investigating-outbreaks/figure_food_production.html

Figure 2: Circular economy of eggs in Singapore.

Suggested Circular Economy of Fish and Seafood in Singapore

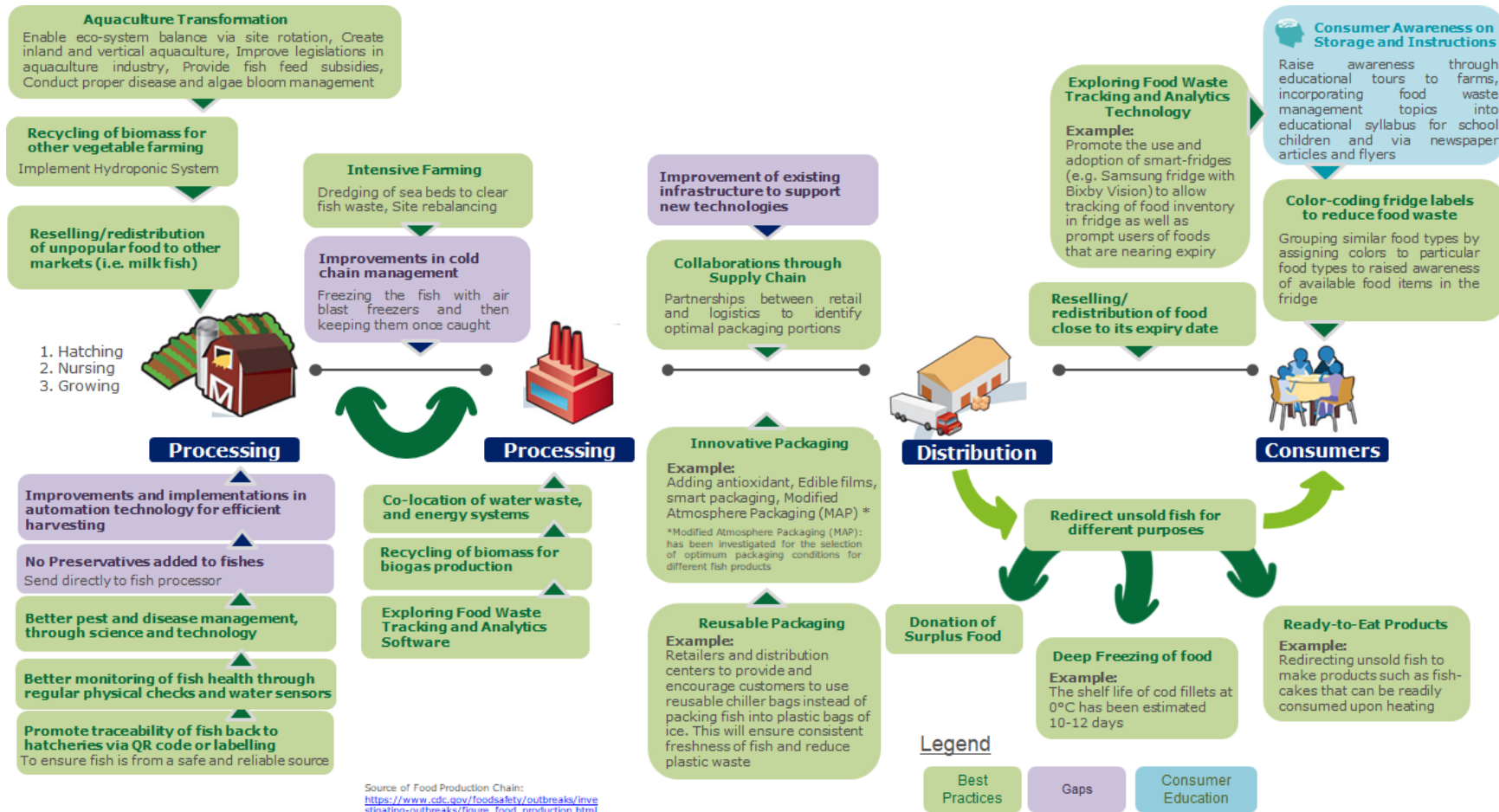


Figure 3: Circular economy of fish and seafood in Singapore.

Suggested Circular Economy of Vegetables in Singapore

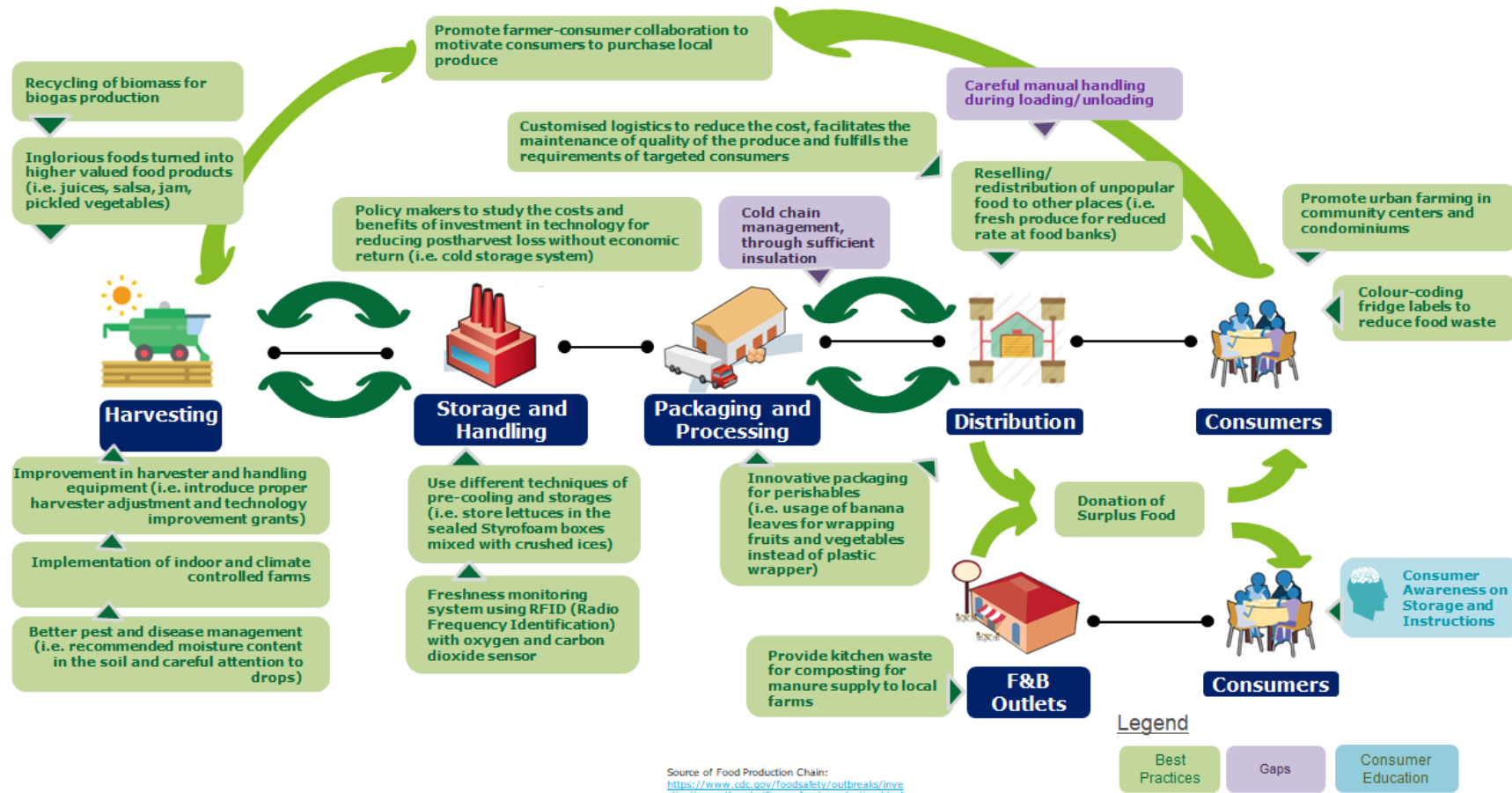


Figure 4: Circular economy of vegetables in Singapore.

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Introduction

1. Introduction

1.1. Background

The Food and Agriculture Organization (FAO) of the United Nations estimates that one-third of all food produced for human consumption globally (1.3 billion tonnes), is lost or wasted along the food supply chain (FAO, 2019). Global average per capita food waste and loss has increased by 44% between 1961 and 2011 (Porter, Reay, Higgins, & Bomberg, 2016) and are now around 25–30% of global food produced (Kummu, Moel, Porkka, Varis, & Ward, 2012; Alexander, Holzhauer, & Rounsevell, 2017). Meanwhile, more than 820 million people in the world are hungry today (FAO, IFAD, UNICEF, WFP and WHO, 2019).

Food waste is an urgent environmental concern due to its contribution to global GHG emissions. The global food system contributes to 19–29% of global GHG emissions (Vermeulen, Campbell, & Ingram, 2012). Meanwhile, food waste from this system contributes to 8% of these emissions.⁵ Reducing food waste even by 50% would lead to a net emission reduction of 20–30% of the total food-sourced GHG emissions (Bajželj, B., Richards, Allwood, & Smi, 2014). Food loss and waste squanders agricultural lands, and water resources. This highlights the issue of Food Loss and Waste as urgent and widespread, posing a multitude of challenges locally and globally.

Available scientific publications and researchers define food loss and waste differently. For the purpose of this paper, we use the definition outlined by FAO. FAO defines food loss as any food that is lost in the supply chain between the producer and the market that leads to a decrease in quantity or quality of the food. Whereas, food waste is defined as safe and nutritious food that is discarded or alternatively used (FAO, 2019).

In Singapore, food waste is one of the five largest waste streams generated in the city (Lim S. , 2019). In 2018, Singapore generated a total of 763 thousand tonnes of food waste, close to 30% increase from the food waste generated 10

⁵ EC, JRC/PBL, 2012 Emission Database for Global Atmospheric Research, version 4.2.

years ago in Singapore, with only 17% of the waste being recycled (NEA, 2019). While APEC economies have strived to reduce food loss and waste by 10% compared with the 2011–2012 levels by 2020 (APEC, 2014) in Singapore, food waste has increased by 20% from the 2011 levels.

While the increase in food waste is of critical concern, food security within the country is also a primary focus. Singapore imports more than 90% of the total food consumed in the country (Koh, 2018). The constraint of land in Singapore prompts the competing use of land, where less than 1% of the land is used for agricultural food production (Mahmud, 2019). Due to this, only a small percentage of food is produced locally with vegetables, seafood and hen eggs being the major food categories produced.

To strengthen the food security in Singapore, the country's vision is to locally produce 30% of the nutritional needs by supporting existing farms to raise productivity (Ministry of the Environment and Water Resources (MEWR), 2019). This includes developing capacities of the local agri-food industry by supporting farms to raise productivity and overcome resource constraints. Singapore also plans to adopt a circular economy approach towards zero waste target. Efforts on reducing food waste within the country can be tied back to achieving Singapore's vision of enhancing food security through a circular economy approach.

There are quite a number of food waste studies done at the consumer level in Singapore to study the drivers and explore solutions for food waste. However, there are limited studies conducted on the losses occurring at food production, handling and storage, processing and packaging, and distribution stages (from farm to market). Food losses occurring at these stages are also major contributors to the total food loss and waste, and in Singapore, losses from these streams are not yet monitored.

1.2. Objective of the Position Paper

The objective of the study is to:

- Determine the amount of food loss and waste along the entire food supply chain in Singapore
- Identify the drivers causing these food losses and waste
- Understand the household food storage behaviour, purchasing patterns and food handling habits, and their relationship to food waste
- Map drivers causing food loss and waste to possible implementable solutions based on food supply chain segments

1.3. Outline of Food Supply Chain Stages

The food supply chain represents the flow of food from the farm to the consumer. This comprises three main components: upstream, midstream, and downstream. Upstream includes production of food and post-harvest handling and storage, while midstream includes processing, packaging and distribution. Downstream component includes food consumption (retail and consumers). Food losses occur at upstream and midstream stages of the food supply chain, whereas food waste occurs at the downstream stages.

This study seeks to delve deeper into the food loss and waste that occurs throughout the food supply chain in Singapore; from losses during local production of food and losses from imported food landings in Singapore to food waste occurring at households (Figure 5). The study aims to shed light on the drivers and practices that cause such losses and the more representative environmental impact of Singapore's food landscape.



Figure 5: Three-stage food supply chain in Singapore.

In the fight toward zero-waste, the findings of this study aim to support stakeholders to make an informed decision on how to recognise drivers and practices causing food losses in their operations and tackle the issue of food loss and waste in the country.

1.4. Approach and Methodology

The food supply chain represents the flow of food from the farm to the consumer. This study looks into the entire food supply chain in Singapore to gather qualitative and quantitative inputs from all key stakeholders in the food supply chain, gather insights from reputable studies on food losses and food waste conducted in Singapore, and collect and analyse data on food storage behaviour, purchasing patterns and food handling habits through consumer surveys.

The study was conducted over a period of five months. The main steps of the study included:

1. Data gathering through interviews

Deep-dive interviews were conducted with over 30 prominent stakeholders in Singapore. These stakeholders represented an array of different segments of the food supply chain – from farmers, food importers, distributors, retailers, academicians, investors, non-profit organisations (NPO), and food-related and/or waste management related experts. Through these deep-dive interviews, information was gathered regarding the quantitative losses of food along the food supply chain in Singapore. The interviewees also provided key insights on the various drivers causing food loss and waste in Singapore.

2. Data gathering through surveys of 1,002 consumer

1,002 consumers in Singapore were interviewed through an online survey to understand their food storage behaviour, purchasing patterns and food handling habits. Survey results received were analysed for these traits in consumers to gain a deeper understanding of food waste issue downstream.

3. Desktop Review

More than 90 published and reputable studies on food loss and waste were used as a basis to categorise the primary causes of food waste, and possible solutions which suggest possibilities to reduce the amount of food loss and waste in Singapore.

4. Mapping Framework

Experts were consulted to develop a framework that maps the drivers causing food loss and waste to possible implementable solutions in the context of Singapore. Literature reviews were conducted to categorise the drivers and solutions based on food supply chain segments to streamline the solutions for target stakeholders.

Key Findings

2. Literature Review

Across the entire food supply chain, the flow of food goes in the direction of farm to the consumer. This supply chain can be represented by three main components; upstream, midstream, and downstream. Upstream includes production of food and post-harvest handling and storage, while midstream includes processing, packaging and distribution. Downstream component includes food consumption (retail and consumers). Food losses occur at the upstream and midstream stages of the food supply chain, whereas food waste occurs at the downstream stages.

Many research and studies have been conducted by governmental and international organisations looking to address food losses and food waste. A Resolution of the European Parliament suggested looking into measures that halve food waste by 2025 through a coordinated strategy back in 2012. This strategy combines European and national measures that enhance the efficiency of food supply chain on a sectoral basis (European Parliament, 2012). In 2014, 14 governments work with the African Union to translate the “Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods”. This declaration includes consideration on food loss reduction in developing proper national policy and strategies in Africa (African Union Commission, 2014).

The United Nations for Sustainable Development has also established the target of halving the amount of food waste per capita produced at the retail and consumer stages on a global scale by 2030 in 2015 (United Nations, 2015). A major research work conducted by Food Use for Social Innovation by Optimising Waste Prevention Strategies (FUSIONS), an EU FP7-funded project running from 2012 to 2016, aimed to reduce food waste all across the food supply chain via socially innovative approaches (Vittuari, et al., 2016). FAO works on the development of new metrics and methodologies to measure food loss and waste, through its SAVE FOOD initiative, collaborates with civil society to address the food loss and waste issue (FAO, 2015; FAO, 2018).

2.1. Drivers of Food Loss and Waste Globally

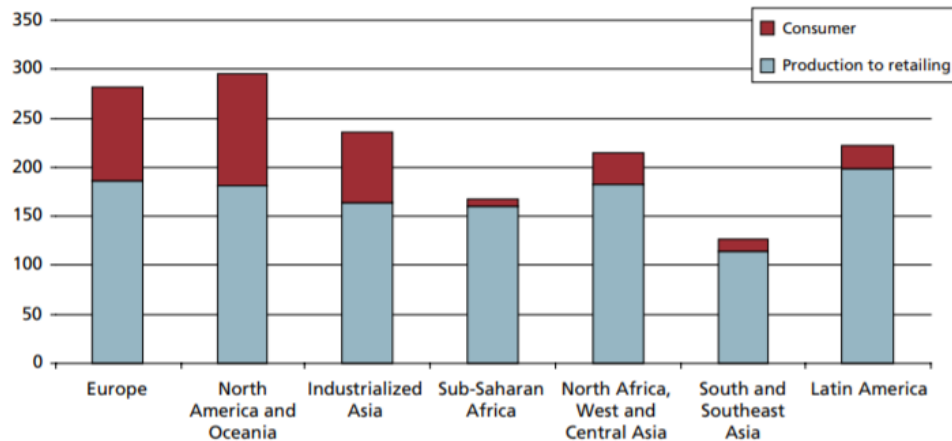


Figure 6: The capita food losses and waste (kg/year) across different regions. (FAO, 2011).

It has been estimated that one-third of the food produced in the world, approximately 1.3 billion tonnes, is lost or wasted every year (FAO, 2011). Most notably, the findings indicate that in developed countries, significantly high amounts of food is wasted at the final consumer level (Gustavsson, Cederberg, van Otterdijk, & Meybeck, 2011). This amount of food wasted at the consumer level accounts for approximately 40% of total food losses (Figure 6). On the contrary, developing countries such as South and Southeast Asia, Latin America and sub-Saharan Africa, food is more likely to be wasted or lost at the stages between primary production and retail.

It is to note that despite the contrasting differences identified by the study, the food loss and waste drivers discussed at the various stages in this section of the report will be applicable to both developing and developed countries so as to provide a holistic overview on what is occurring on a global level.

2.1.1. Upstream (Production and Post-harvest Handling and Storage)

Higher losses at pre- and post-harvest stages occur when the access to efficient and proper harvesting equipment, the extension of services, training courses for farmers, financial institutions and research is not easily available (Ishangulyyev, Kim, & Sang Hyeon, 2019). Frequently, inappropriate equipment and timing, as well as poor harvesting methods, can be crucial drivers of food loss for this stage. For example, overproduction happens due to

market uncertainties, weather conditions and farmers' actions of protecting crops against pest attacks, leading to more unharvested crops and lower market prices (Gustavsson, Cederberg, van Otterdijk, & Meybeck, 2011). Some products are low in quality of production due to lack of proper water management and insufficient nutrients during the grading process. With limited access to financial institutions and low returns from production, farmers tend to refuse in investing for new technologies, which could contribute to improved yields and increase inputs of production (Stangherlin & Barcellos, 2018).

Fresh vegetables and fruits rely heavily on agronomic practices and knowledge during the production stage. Poor methods of harvesting can result in harvested produce failing to meet quality standards (e.g. weight, colour, size or shape) required by target markets. As such, these poorly-harvested produce will be thrown out and result in a significant amount of food loss (Ishangulyyev, Kim, & Sang Hyeon, 2019). In fish production, anglers sometimes have no quota on fishing or no market for the caught species, leading to fish being discarded at an early stage of the supply chain. Some of the other drivers involved are non-selective fishing (trawl fishing) and non-selective gears, which indicate by-catches that are not utilised (Canali, et al., 2017).

2.1.2. Midstream (Processing, Packaging and Distribution)

Poor management and technical inefficiencies are among the major drivers of food loss occurrence in these stages. For animal products of fish, meat and milk, contamination that occurs in a processing line is caused by frequent changes in food produced and improper cleaning and sanitisation of processing units from the previous operations (Ishangulyyev, Kim, & Sang Hyeon, 2019). When there is an excess of raw materials, the lack of efficient facilities would also result in food loss (HLPE, 2014).

For vegetables, potatoes and tubers, the automated technology of European food production systems may lead to a significant amount of loss during processing stages such as mechanical peeling and handling. The significant losses incurred can be attributed to the soft nature of fresh vegetables and fruits that makes them susceptibility to damage during automated harvest and handling (Canali, et al., 2017).

The other key driver in creating food loss is suboptimal use of packaging and labelling, as proper utilisation will abate losses by maintaining quality of food product. For fish, losses occur during storage, icing, processing, and packaging (e.g. smoking and canning). Errors in packaging will normally result in defects on the food product, such as broken and damaged food items and incorrect shape, size and weight. These types of defects, do not severely influence the quality and safety of the final product but it will, unfortunately, be discarded as per established quality and safety standards (Canali, et al., 2017).

In distribution, the common drivers of losses include mishandling, damage due to inappropriate conditions of storage during transportation, and improper inventory stock management. These drivers resulted in the extension of product storage and subsequent rejection by the retailers (Wohner, Pauer, Heinrich, & Tacker, 2019). Lack of training and education also drive the creation of food loss in this stage (Canali, et al., 2017). Bad conditions of roads and insufficient protection of products due to poor packaging further increase the risk of food damage during transport.

Stackability is among one of the crucial packaging considerations while storing and distributing food. This is because the pressure from high loads may cause the stacked products to collapse and be damaged (Wohner, Pauer, Heinrich, & Tacker, 2019). In the United Kingdom (UK), poor stacking of strawberry trays is one of the main drivers of losses reported (Terry, Mena, Williams, & Whitehead, 2011).

Another example can be taken from the assessment of eggs packaging (i.e. plastic crates and corrugated cardboard), where 1.1% breakage rate was observed on average while the results differed between 0.56% and 2.38% for four different packaging scenarios. Reasons for damages reported were mismatched packaging, poor quality of the corrugated board used and poorly stacked crates (Wohner, Pauer, Heinrich, & Tacker, 2019). Perishability is another concern in this stage in which current technologies are not always able to manage such packaging scenarios. For example, fresh fruits are often bruised because of road conditions and rejected due to shortened expiry dates as a result of long distance in comparison to ripening duration (Ishangulyyev, Kim, & Sang Hyeon, 2019).

2.1.3. Downstream (Retail and Consumption)

After distribution, a similar situation occurs in the retail stage, a sector that is responsible for approximately 5% of food loss and waste in Europe. Based on reports by retail chains, delays at the distribution stage as mentioned above and premature spoilage attributable to mishandling and improper packaging may accelerate the expiration of shelf life and generation of food loss (Wohner, Pauer, Heinrich, & Tacker, 2019).

Similarly, retailers are responsible for managing various products in large quantities, which involves regular refill of shelves for customer satisfaction. This leads to the same products being mixed with different expiry dates, driving customers to purchase the later expiry dates as everyone prefers fresher products (Wohner, Pauer, Heinrich, & Tacker, 2019).

To meet consumer demand for nutritious, fresh and safe foods, retailers sell ready-made convenience foods as well as fresh-cut fruits and vegetables. Unfortunately, the majority of these types of foods have a one-day shelf life, where foods will be discarded when they cannot be sold. For instance, the amount of fresh-cut products that landed in the landfills of developed countries remain high despite having efficient temperature management conditions and good packaging systems (Papargyropoulou, Lozano, Steinberger, Wright, & Ujang, 2014).

The drivers of food waste in developed countries can be attributed to the improper amount of food products (huge portions of packaged foods), leftovers from cooking, preparing and serving, expiration date policy, as well as lack of purchase and consumption planning (Gustavsson, Cederberg, van Otterdijk, & Meybeck, 2011). In addition to the aforementioned drivers, individual attitude and structure of the households' demographics, culture, size, and composition, as well as income, have been broadly known to influence food waste (Parfitt, Barthel, & Macnaughton, 2010). The following explanations may help to illustrate how the quantities of household food waste generation vary. In the case of demographics, studies conducted in the UK and Australia highlight that older people, especially pensioners, have been identified to generate the least waste as compared to younger people. In addition, Hispanic households found

in the USA have demonstrated lower rates of food loss (around 25% less) as compared to non-Hispanics, indicating that culture is another factor that influences food waste. As for size and composition, studies in both the UK and the USA show that bigger households waste less per capita than smaller households while those houses with children tend to waste more compared to households without children (Parfitt, Barthel, & Macnaughton, 2010). In general, the complexity of food supply chain does not permit simple solutions that are applicable across all circumstances. Therefore, eradicating food loss and waste in the near future might be difficult. However, this situation can be improved if food loss and waste drivers across the entire food supply chain are clearly identified. The identification of drivers will allow the implementation of appropriate procedures and methods which will aid in reducing food loss and waste across the food supply chain.

To reduce food loss and waste across the entire food supply chain, a multi-stakeholder approach is required. This cooperation between the stakeholders will be pivotal in enabling suitable food loss and waste reduction policies, frameworks, measures and programmes to be adopted and practiced and overall reduce the impact of food loss and waste across the food supply chain (Parfitt, Barthel, & Macnaughton, 2010).

2.1.4. Food Loss and Waste Interventions

In general, the complexity of food supply chain does not permit simple solutions that are applicable across all circumstances. Therefore, eradicating food loss and waste in the near future might be difficult. However, this situation can be improved if food loss and waste drivers across the entire food supply chain are clearly identified. The identification of drivers will allow the implementation of appropriate procedures and methods that will aid in reducing losses and waste across the food supply chain. Research within various disciplines provides us with extensive knowledge of food loss and waste drivers. To reduce food loss and waste across the entire supply chain, a multi-stakeholder approach is required. This cooperation between the stakeholders will be pivotal in enabling suitable food loss and waste reduction policies, frameworks, measures and programmes to be adopted and practiced, overall reducing the impact of food loss and waste across the supply chain (Parfitt, Barthel, & Macnaughton, 2010).

Table 2 below showcases identified food loss and waste drivers that have been found in several literature reviews and their relation with the suggested solutions aimed at influencing them.

Table 2: Summary of food loss and waste drivers identified along the food supply chain and its potential solutions on a global context.

Supply Chain Stage	Key Food Groups	Driver(s) of Food Loss and Waste	Possible Solutions
Upstream (Production, Storage and Handling)	Fresh fruits and vegetables	<ul style="list-style-type: none"> • Poor harvesting methods • Inappropriate equipment and timing • Deterioration of perishable crops in the warm and humid climate 	<ul style="list-style-type: none"> • Improve agronomic practices • Development of farm facilities (e.g. new equipment) • Better storage (e.g. ethylene control)
	Fish and seafood	<ul style="list-style-type: none"> • No quota on fishing/ non-selective fishing • Fishery policies • Inefficient cold-chain management 	<ul style="list-style-type: none"> • Improved fishing gear and expand the range products in fish (e.g. allow more species caught in one net to be saleable and thus reduce the fish by-catch) • Revise government policy for better quotas • New certification system (e.g. cold chain management practices)
	Eggs	<ul style="list-style-type: none"> • Lack of knowledge/ training • Breakage due to improper picking and handling 	<ul style="list-style-type: none"> • Automated poultry care, feeding • Automated egg-picking to reduce breakage
Midstream (Processing, packaging and distribution)	Fresh fruits and vegetables	<ul style="list-style-type: none"> • Mechanical peeling and handling due to soft nature of certain fruits and vegetables • Food products loss during shipment to retail distribution centres • Supply chain/ cold chain inefficiencies 	<ul style="list-style-type: none"> • Introduction of technology improvement grants • Use direct shipments and cold-chain certified carriers from suppliers to stores to increase shelf life • Integrated cold chain from production, transportation to display
	Fish and seafood	<ul style="list-style-type: none"> • Improper cleaning and sanitisation of processing units from previous operations • Storage, icing, processing, and packaging (e.g. smoking and canning) • Deterioration of food • Spread of diseases • Lack of training and education 	<ul style="list-style-type: none"> • Proper use of the cold chain • Staff education/ training • Better disease and pest management • Improvement of infrastructure at distribution source

Supply Chain Stage	Key Food Groups	Driver(s) of Food Loss and Waste	Possible Solutions
	Eggs	<ul style="list-style-type: none"> • Corrugated cardboard and plastic crates causing breakage 	<ul style="list-style-type: none"> • Corrugated tray fillers as protection
Downstream (Retail and consumption)	Fresh fruits and vegetables	<ul style="list-style-type: none"> • Strict cosmetic standards • Improper storage • Leftovers and plate size 	<ul style="list-style-type: none"> • Sell imperfect fruits and vegetables at a discount • Cook expired food and damaged fruits and vegetables into jams and jellies • Use "best kept" stickers on fresh products to show customers the best way of preserving fresh products at home • Food sharing sites and apps to support behaviour change • Campaign to raise food awareness
	Fish and seafood	<ul style="list-style-type: none"> • Smelly leftovers of fish in the fridge are not favoured • Over importation 	<ul style="list-style-type: none"> • Deep freeze method • Intelligent fridge to update consumer with knowledge of stock • Redirection of unsold fish and seafood for different purposes • Campaigns that provide detailed online advice to how different food products should be stored
	• Eggs	<ul style="list-style-type: none"> • Best before dates on eggs • Limited power of information 	<ul style="list-style-type: none"> • Change "best before" legislation in countries where products which passed their best before date have to be destroyed • Consumer education campaigns

Through introduction of new initiatives and extension of existing efforts, Table 2 displays significant opportunities or possibility of interventions to contribute to food loss and waste reduction and prevention across the food supply chain. It demonstrates that inadequate infrastructures and poor harvesting techniques in handling fresh products are among the main drivers of food loss in the upstream of food supply chain. This calls for successful introduction of technological investments alongside innovations across the food supply chain to reduce and prevent losses in the upstream. On another hand, date labelling,

packaging sizes, and lack of education and training were found to be among the main causes of food loss related to the midstream of food supply chain. Standardised date labelling, packaging adjustments and spoilage prevention packaging can be considered as food loss prevention solutions at this stage.

The consumers' demand of cosmetically perfect produce is also inherent to food waste due to "out-grades" and incorrect use of fridge/ freezers, which may require interventions that involve awareness raising and communication with consumers on the importance of reducing and preventing food waste in the downstream of food supply chain. In conclusion, key insights from the reviewed literature highlight that practices that drive food loss and waste are deeply intertwined in day-to-day routines of business, work and life. This section also underlines the importance of a synergy of different approaches in order to reduce food loss and waste as well as the need to collaborate between relevant stakeholders to address the causes of food loss and waste simultaneously.

2.2. Drivers of Food Loss and Waste in Singapore

Food waste is a pressing issue because it creates multiple societal problems. Food waste causes vector breeding, odour problems and contaminates between 30% and 50% of recyclables collected – which affects the recycling efforts in Singapore. According to a Public Waste Collector, around 40% of the 16 thousand tonnes of recyclables collected are contaminated each year (Boh, 2016).

With the current rate of waste disposal, drastic measures would need to be taken if the amount of food waste continues to increase. By then, Singapore would require a new waste-to-energy plant to be built every 7 to 10 years and a new landfill to be built every 35 years (Lim M. , 2017; NEA, 2019). Furthermore, this problem is compounded by the fact that Singapore's only offshore landfill Semaku Landfill is expected to run out of space by 2035 (MEWR, 2019).

2.2.1. Upstream (Production and Post-harvest Handling and Storage)

In local food farms that are located outdoors, the drivers for food loss can be

attributed to natural climatic conditions. During periods of excessive rainfall and overcast skies, vegetable farms can experience severe crops damage and losses that can reach up to 40% of their total crop and this leads to substantial loss of edible crops (Charles & Lee, 2018; APSA, 2018).

Fish farmers are also at risk of losing their entire stock of fish during a harmful algal bloom (HAB) which can be attributed to climate conditions such as warm waters and sunny weather. The onset of a HAB due to ideal bloom conditions has killed an estimated 500 to 600 tonnes of fish in 2015 (Khew, 2017). Ultimately, the impact of food loss brought about by natural climatic conditions reduces the availability of food for consumption.

2.2.2. Midstream (Processing, Packaging and Distribution)

In Singapore, food importers and some supermarkets have facilities that process and package the food. The drivers of food loss at this stage is due to aesthetical requirements and business contractual agreements. For instance, fruits and vegetables have to meet specific aesthetical requirements where they are not to have physical defects (i.e. bruises and odd shapes) else they are thrown away.

Furthermore, business contractual agreements dictate that certain produce are to be processed into specific shapes and sizes (e.g. carrot to be rectangular in shape and 5cm in length). This practice creates food scraps that would be discarded. In terms of quantity of food loss, close to half the amount of imported fruits and vegetables are discarded due to these two drivers (CNA, 2019).

2.2.3. Downstream (Retail and Consumption)

One driver of food loss and waste at the retail stage would be the lack of stipulated rules or regulations to enforce proper management of food products (i.e. what can be disposed of and what can be kept). This can result in significant amounts of food waste which has been the case in Mustafa Centre. Employees in Mustafa Centre were found to be disposing around one tonne of fruit and vegetables daily (Ng, 2018).

Another driver of food loss and waste at this stage can be attributed to consumers' demand for "perfect-looking" produce. In a survey conducted by

Electrolux in 2016, it has been estimated that approximately 83% of respondents would only purchase fruits and vegetables that look fresh and good with another quarter of respondents indicating that they would never consume “ugly foods” (Othman, 2016). This results in significant amounts of food waste as retailers would dispose of produce that is not “perfect-looking”. In Pasir Panjang Fruits and Vegetables Wholesale Centre, up to 300 tonnes of food is discarded daily (Low & Aw, 2010).

At the consumer level, food loss and waste can be attributed to rising affluence, organisational aspects of food-related habits and practices at home. The increase in affluence has led to consumers purchasing more food in terms of quantity and variety but results in food waste as food is not fully consumed (Lim M. , 2017).

In a study conducted by the National Environmental Agency (NEA), food waste accounts for half of the waste disposed of daily by households and 27% of the households had leftovers at least half the time. Furthermore, around one in four had mentioned that they threw away spoilt and expired food when they buy too much or not take proper inventory stock of their fridge.

This is consistent with the findings from a 2010 research by Nanyang Technological University (Low & Aw, 2010). The findings indicated that 6 in 10 respondents would purchase more than what they needed while shopping for groceries and this led to an overstocking of food which was likely to expire or spoil before consumption.

Table 3 below summarises the food loss and waste drivers along with the potential solutions that can be implemented in Singapore to address these drivers of food waste.

Table 3: Summary of food loss and waste drivers identified along the food supply chain and its potential solutions in Singapore.

Supply Chain Stage	Key Food Groups	Driver(s) of Food Loss and Waste	Possible Solutions
Upstream (Production, Storage and Handling)	Vegetables and Fish	<ul style="list-style-type: none"> Natural Climatic Conditions 	<ul style="list-style-type: none"> Provision of technical support and advice by experts and relevant authorities on selecting the most

Supply Chain Stage	Key Food Groups	Driver(s) of Food Loss and Waste	Possible Solutions
			climate resistant varieties and implementing best practices relating to farm management
Midstream (Processing, Packaging)	Fruits and Vegetables	<ul style="list-style-type: none"> • Aesthetical requirements • Business contractual agreements 	<ul style="list-style-type: none"> • Economy-wide legislation on food loss reduction to address produce specifications
Downstream (Retail)	Fruits and Vegetables	<ul style="list-style-type: none"> • Lack of stipulated rules or regulations • Demand for “perfect-looking” produce 	<ul style="list-style-type: none"> • Development of a comprehensive Food Waste Framework that can be tracked via a Food Waste Index • Food donation support • Retailing “ugly foods” at lower prices
Downstream (Consumption)	All food groups	<ul style="list-style-type: none"> • Rising affluence • Organisational aspects of food-related habits and practices at home 	<ul style="list-style-type: none"> • Economy-wide legislation to enable effective monitoring and quantification of food waste reduction programmes • Implement a food waste tax • Promote ethical consumption • Value-added processing to convert food waste into other edible products

2.2.4. Research Recommendations

Research in Singapore has been mostly focused on the downstream (retail and consumption) component of the food supply chain. The need for further research is highlighted by findings from a survey report by the Asia-Pacific Economic Cooperation (APEC) which indicates that Singapore still has gaps in implementing solutions to target food loss and waste (e.g. standardized date labelling, pre- and post-harvesting technical aid and support, adjustments and spoilage prevention packaging and, improved handling and transportation) (Hsu, Chang, & Trang, 2018).

In terms of identification of food loss and waste drivers across the entire supply chain, greater analysis and further identification is required within the upstream and, midstream components of the food supply chain. For instance, the identified food loss driver (i.e. natural climatic conditions) in the production stage can be analysed in greater detail. This will enable greater pre- and post-harvesting technical support to be provided to producers should research findings indicate that such solutions are necessary to reduce food loss.

Further identification of other food loss drivers in the midstream component (i.e. the distribution stage) of the food supply chain is also recommended. This is because, in this midstream component, a potential food loss driver could be due to improper shipment and distribution methods. Given that both local production and imports are passing through this stage, the impact of food loss could potentially be significant. Thus, more research is necessary to recommend the most appropriate solutions (e.g. improved handling and transportation) and reduce food loss at this component.

Overall, it is recommended that greater research focus should be placed on identifying the drivers of food loss in the first two components of the food supply chain. This is because it is only through research and identification of the food loss drivers that appropriate solutions to reducing food loss can be developed and implemented.

3. Interview Findings

More than 30 stakeholders were interviewed from May 2019 to August 2019. The interviews included the following: 6 farmers, 2 food importers, 3 distributors, 4 retailers, 1 academician, 1 investor, 2 NPOs, and 12 food-related and/or waste management related experts.

The main objective of interviewing these key stakeholders was to understand the drivers of food loss and waste in Singapore, the amount of losses that occur in different segments of the food supply chain, and good practices that could be implemented locally.

3.1. Food Losses during Local Production (Upstream)

*Findings from interview with experts reveal that an estimated **5,000 tonnes** of food is lost during local production of food in Singapore.*

In Singapore, the three major locally-produced food categories include vegetables (leafy vegetables and other vegetables), seafood (fish and other seafood), and hen eggs. Farmers from all three food categories were interviewed. Interviews revealed that approximately more than five thousand tonnes of locally-produced food is lost during production. This includes losses from vegetable farms, fish farms, seafood farms and eggs farms. The losses from egg farms were the lowest among the farms interviewed.

Vegetables

Weather conditions

Vegetable farmers in Singapore were interviewed to validate the amount of vegetable loss during harvesting, storage and handling, and to identify the drivers causing vegetable losses in their operations. According to the interviewees, leafy vegetables are easily lost to sudden weather changes and pests. For example, cloudy days gives rise to yellowish vegetables which need to be discarded. Similarly, hot weather promotes the growth of pests. Plants might have difficulties to transpire during hot weather, which will lead to

spoilage. At such, cold chain management for vegetables is critical to extending the shelf life of vegetables – around a week instead of 2–3 days shelf life for certain vegetables.

Fish and Seafood

Natural selection and cannibalism

Fish farmers in Singapore were interviewed to validate the amount of food lost at fish production stages, and to identify the drivers causing fish and seafood losses during production, storage and handling. Based on the interviews, there is an 80–90% loss of eggs from parent stock during production, which occurs during fertilisation testing and inheritance disease testing (eggs are channelled through a saline solution to gauge buoyancy and the more buoyant eggs were sifted out as healthy). During the nursery stage, 70% of the stock is naturally lost due to natural selection (poor genetics) or cannibalism. During the growing stage, the environment is a critical factor for survivability. Fish reared in open sea cages have a survival rate of 70%. However, if environmental conditions are poor, the survival rate will drastically decrease to around 20%.

Fish disease and site management

Conditions during the growth stage of fish and seafood determine the amount of food lost during this stage. One of the interviewees stated that disease is the primary cause of loss of fish; antibiotics will not protect the fish against all types of diseases. Genetic enhancement is the way forward to enhance fish resilience. Site management during fish growth is also critical to avoid overcrowding of fish in the tanks and allow optimal growth. However, the fish farms located in the Johor Straits have been utilising the same site for over 30 years. This has led to the accumulation of debris and fish faecal matter which has reduced the available space and deteriorated the overall water conditions making fish production difficult. The interviewee recommends that relevant authorities initiate proper site management plans that facilitate the relocation of fish farms and also carry out dredging of the sea beds.

Water quality and other environmental factors

Environmental conditions need to be well maintained to avoid losses during growth stage. The water quality is getting poor due to the recent developments

around the eastern part of Singapore. Due to the land reclamation activities in Tekong island and the sealing up of Punggol and Seletar waterways, water exchange is becoming poor, leading to an accumulation of nutrients. Moreover, mangrove swamps in Johor (Pasir Gudang) are disappearing reducing the water quality as natural filtering processes are removed. In addition, petrochemical plants on the Malaysian side are increasing in numbers in and around Singapore. With such developments, there will be a greater accumulation of nutrients, which potentially result in the spawning of harmful algal blooms that could decimate entire fish crops.

Eggs

Economies of scale achieved

Interviewees from the layer hen farms in Singapore revealed that around 1.45 million eggs per day are produced in Singapore. Less than 10% of the eggs produced are larger than 60 g. The egg farms in Singapore are mature and have advanced technology, due to which there is less than 1% of egg loss during production. Losses along the value chain are negligible for those eggs locally produced. Even the eggs imported into the country, might not comply with the regulations set by the government as compared to those eggs produced locally.

Lack of financial support

Most of the newer, advanced technologies have the ability to increase production while minimising losses. However, one of the interviewees mentioned the challenges in adapting to newer technologies and the difficulty in obtaining financial support for the same. One of the reasons stated by the interviewee is the lack of communication between different agencies, due to which there is a bottleneck in obtaining the necessary grants and approvals.

Awareness to the public

This also highlights the issue of lack of awareness of people on the local farming practices in Singapore. One of the interviewees from an NPO in Singapore stated that people in Singapore have very little relationship with the farmers, unlike countries such as China and Japan. In Japan, consumers have established co-partnerships with local organic farmer groups, also known as *teikei*, which gives the opportunity for several social interactions between

farmers and consumers and negotiated pricing of the produce. Also known generally as “Community Supporting Agriculture”, this practice needs to be given more importance in Singapore.

“Community Supporting Agriculture” can be achieved with the development of satellite farms that would allow a more experiential and hands-on educational experience for consumers.

“Food waste, food security, farming itself, it is all related in the way people think and Singaporeans need to be exposed to the farming industry. This can be done through the development of satellite farms by using the abandoned schools, those schools which have merged and now left unoccupied... schools are generally placed in the heartlands and will be a convenient place where people can come to visit to understand the importance of combating food waste, why it is important to support local producers and the importance of food security to Singapore.” [sic]

3.2. Food Losses from Imports (Upstream)

*Findings from interview with experts reveal that an estimated **144,000 tonnes** of food is lost when imported food lands in Singapore.*

Lack of Import Regulations

Singapore imports more than 90% of its food. There are 13 key food categories majorly imported into Singapore. These include – vegetables (leafy vegetables, and other vegetables), seafood (fish and other seafood), hen eggs, meats (pork, mutton, beef, chicken, duck), cereals (rice and wheat), and fruits.

From an interview with a local NPO, the limited restrictions on the amount of food imported into Singapore is a factor that encourages food loss. To encourage a free port and free trading, Singapore decided not to levy any restrictions on the quantity of food being imported into the country. Although this protects the country's food sources, suppliers have the tendency to over import food items in an attempt to sell as much as possible. In the process, unsold food is lost. The interviewee mentioned,

"If I wanted to start a business, I wouldn't choose Malaysia, I wouldn't choose Philippines, I wouldn't choose Indonesia, because everyone has an import tax. I will choose Singapore as a re-distribution hub as the cost of doing business in Singapore (...), is EXCEPTIONALLY low. Because imported food is cheap, (...), they don't think twice of throwing it away." [sic]

Economic Value vs Weight for Food Discarded

Based on findings from interviews with food import companies, food losses occurring during import are measured by companies only based on its dollar value, which is generally only about 2–3%. Even though half or more of the food imported into Singapore are thrown away due to quality reasons, if sales exceed the cost of the food lost, companies would not account for it as a write-off.

"For example, if we were to bring in 10 tonnes of corn at the price of \$5,000. But if we were to trim and throw away quite a fair bit, but only to sell the heart of corn and we can get back more, then those edible parts that are being thrown away are not considered write-off because we still gain a net profit out of the whole sell.

If it is something to do with the shipment process – delay in shipment, the tomatoes are not fresh enough – the supplier would absorb the write-off, and the company would have no record of the amount of write-offs." [sic]

The reason that import companies measure food loss only through dollar value could also stem from the practice of not weighing the losses from trimmings or quality issues. One interviewee stated that the largest loss occurs at the post-harvest stage, depending on whether the produce grown is suitable for sale in the market.

"... the Australian farms that we are importing from would sometimes have a whole batch of carrots that didn't meet the standard. They would have to write this off completely on-site and re-use it as compost (...) It would have cost more to send it to processing or to send it for shipment to the supermarkets, just for it to then be rejected." [sic]

Furthermore, on the practice of what happens to the post-harvest food losses, only some farms compost these written-off vegetables. Other conventional farms do not have this practice and just throw away the produce.

Environmental Conditions Affecting Quality of Produce

Other reasons for loss of food at the harvest and post-harvest stage could also include environmental conditions that impact the quality of the food grown. An example stated by the interviewee included the growth of okra – if temperatures were to suddenly change and become hot a few days prior to the harvest of okra, the vegetables would have grown beyond the best to consume tenderness and freshness, rendering it long and fibrous. This would be thrown away at farms as these cannot be sold at the markets. To profit despite losses due to environmental factors and quality of the produce, there is an overproduction of majority of the produce grown around the world.

Stringent Cosmetic Standards

High cosmetic standards are also a source of food loss during imports. High cosmetic standards are not only seen at the retail segment but can also be prevalent during sorting and packaging, prior to import and distribution. Based on the insights gathered through the interviews, there are multiple reasons why cosmetic standards are applied.

Food size and its perceived value have a lot to do with why the industry has high cosmetic standards. If the food item sold is irregular, customers may compare the item to its “regular” or perceived quality of their “regular” purchase, and the nutritional value would be questioned.

“For example, salmon is bred to be red. This orangish colour is not the original salmon colour. The original salmon colour is white-greyish. Similarly, the red snapper doesn’t look red, it is actually yellowish in colour. You need to feed them with krill and then they will and then they will start taking on the colour which makes it more appealing.” [sic]

During imports, cosmetic standards are essential to ensure efficient packaging of the products. For example, bananas all have a comparable size because of ease of display and packaging during shipment. Similarly, straight carrots are easy for packaging and require less trimming prior to shipment. Extensive food losses also occur due to high industry demand for particular food sizes. Disposal of irregular looking food items occur because they do not suit the food item to be sold. For example, flat potatoes do not suit the company producing potato wedges.

Lack of Public Education

Food importers also face a challenge to educate the masses on food loss. Education generally only focusses on the healthy living rather than managing food loss, as companies do not see any monetary value in educating the masses on food losses. Their justification is based on the presumption that post-education, consumers might avoid purchasing food items from the company if they do not buy into the whole concept. Or even if they do buy into the concept of avoiding food losses, they might make a purchase elsewhere.

Packaging of food and food handling during transport also determines the amount of food loss during freight and shipment.

**"In terms of transportation, unlike Japan, where they really take extra care (...) to make sure that the vegetables are cushioned and better managed. Again, it's down to education and the respect that they give to fresh products that they produce."
*[sic]***

Further to the results obtained through interviews, data was gathered through an extensive review of the literature to understand drivers causing losses during transport of imported goods to Singapore. Improper care of food during loading and unloading, quality losses and physical damages to frozen foods during cargo shipment, improper packaging, damages due to incorrect temperature and humidity in shipment, are some of the drivers of food losses during transport of food during shipment and air freight. Table 4 explains further on the various possible drivers causing food losses during shipment into Singapore for vegetables and seafood.

Table 4: Drivers causing vegetable, fruit, and fish losses during shipment.

Drivers Causing Losses during Shipment of Fruits and Vegetables	
Damage through Freezing and Chilling	
<ul style="list-style-type: none"> ➤ Fruit stems have lesser sugar content than the actual fruit which causes it to freeze faster during cold chain transport. This results in the death of the stalk with likely impact to the fruits' market value when it is brought back to ambient temperatures. ➤ Tropical fruits and vegetables face chill damages in low temperatures due to injury to tissues (symptoms such as pitting of surface tissues, discolouration of flesh, and an increased susceptibility to decay). 	
Damage through Humidity	
<ul style="list-style-type: none"> ➤ The moisture released by the fruits and vegetables due to respiration gets carried onto the surface of the evaporator coils and settles as condensate. If the refrigerant conditions are less than 0°C, the condensate may freeze on the surface of the evaporator tubes in the form of frost and may block the airflow through the tubes and/or prevent heat transfer across evaporator coils, disrupting the refrigeration. 	
Damage through Air Circulation	
<ul style="list-style-type: none"> ➤ Circulation of air within the transport compartment is of paramount importance. Any miscalculation in the air pressure of the container during shipment and airfreight can facilitate the rate of deterioration of the produce. 	
Damage through Air Exchange	
<ul style="list-style-type: none"> ➤ Climacteric⁶ fruits and vegetables, ripen faster with the accumulation of carbon dioxide and other gases. The rates of respiration for fruits such as peaches, apricots, bananas, mangos, papaya, avocados, plums, tomatoes and guavas, increase during transport, with improper air exchanges. ➤ Whereas for non-climacteric⁷ fruits and vegetables such as cucumbers, grapes, lemons, limes, oranges, temple fruit (satsumas, tangerines, mandarins) and strawberries, the rate of respiration decreases. 	

(continue on next page)

⁶ Climacteric fruits and vegetables continue to ripen post-harvest.

⁷ Non-climacteric fruits and vegetables do not ripen further post-harvest.

Drivers Causing Losses during Shipment of Fish and Seafood

Loss of Quality During Frozen Storage

Incorrect Freezing Process

- The refrigerated holds of reefer ships⁸ are designed as cold stores to maintain the temperature of already frozen products and they do not have the refrigeration capacity to freeze products at the required rate.
- Another defect arising during frozen storage is excessive loss of moisture from the product, which leads to general or localised dehydration known as a freezer burn.

Rate of deterioration is also affected by exposure to air. Damage or loss of plastic wrapping around frozen products causes deterioration.

Physical Damage to Frozen Products

- If the cargo in the hold of a reefer is stacked to a height of 4 or 5 m, as is often the case, there is sufficient pressure to distort fish to some extent at minus 7°C (-7°C), and to distort and compress fish considerably at minus 5°C (-5°C) or higher.
- Frozen products at low temperatures are often brittle and prone to damage by rough handling. For example, tails are easily broken off whole fish and blocks can be shattered or chipped.
- Products can also be damaged by contamination. If oil or chemicals are spilled, they may penetrate the wrappings and affect the contents. When cartons and wrappings are torn, the contents are more vulnerable to both contamination and dehydration.

Packaging

- Fragile packaging material or haphazard packaging of fish.
- Contamination of fish from seawater, bilge water⁹, fuel oil if the packaging is damaged.

During Unloading

- During unloading the product loses quality due to the sudden rise in temperature and also due to the time is taken to bring the product back down to the required temperature after storage.

⁸ Refrigerated cargo ships

⁹ Dirty water that collects inside the bilge (lower compartment of a ship)

3.3. Food Losses during Processing and Packaging (Midstream)

*Findings from interview with experts reveal that an estimated **74,000 tonnes** of food is lost during processing and packaging of food items in Singapore.*

Many of the raw food items brought into Singapore are processed and packed into secondary food items, which are consumed within the country or exported. Food losses from the processing of vegetable commodities include losses due to spillage and degradation during industrial or domestic processing, e.g. juice production, canning and bread baking. Food losses during processing also include losses that occur when unsuitable-to-process food items are discarded or losses that occur during washing, peeling, slicing and boiling. Processing of food items may also cause food loss when there are process interruptions and/or accidental spillages of processed food.

Processing of meat also leads to food losses in Singapore. For bovine, pork and poultry meat, losses refer to trimming spillage during slaughtering and additional industrial processing, e.g. sausage production with the country. Losses in fish during processing occurs during canning or smoking. Similarly, for milk, losses refer to spillage during industrial milk treatment (e.g. pasteurisation) and milk processing to, e.g., cheese and yoghurt.

The interviews with the academician revealed insightful findings on how food processing waste could be avoided. The academician said that there is a high potential for utilisation of the side streams of food processing in Singapore. Known as food waste valorisation, the utilisation of waste from side-streams to supplement another industry with raw materials has the potential to create a circular economy model for food.

An example of food waste valorisation can be implemented in the case of processing of soy residues in Singapore. Unutilised soybean residues – also known as “Okara”, can be used to cultivate yeast – an ingredient used in baking, beer making and vaccine production. The utilisation of soybean residue in Singapore would help save 30 thousand kilograms of soybean residue from going to waste in Singapore (Nanyang Technological University, 2018). Similarly, “Okara” can also be turned to create sustainable packaging materials. By removing lipids and proteins in “Okara”, researchers have developed a

biodegradable cling wrap, which has the potential of reducing the use of conventional plastic made cling wrap that is not biodegradable. (Nanyang Technological University, 2018).

3.4. Food Losses during Distribution (Midstream)

*Findings from interview with experts reveal that an estimated **116,000 tonnes** of food is lost during distribution of food items in Singapore.*

Oversupply Due to Business Decisions

Losses occurring at the wholesale markets, supermarkets, retailers and wet markets make up a significant volume of the total food losses occurring in Singapore.

According to the interview with a local NPO, the oversupply of food is a major driver of food loss at retail. To achieve sales targets, bigger brands generally carry more stock that ultimately leads to food waste, if the produce is not sold. For example, if a company's sellout is at \$1.5 million, they would make distributors carry \$2 million worth of stocks each month. This would lead to an excess of \$500 thousand worth of extra stock that might not get sold.

Inability to Predict Consumer Demand

Over-availability of foods at retail can also be a result of the product not having enough demand for sale at that time that leads to food losses. The interviewee stated that high-quality products such as Angus beef, abalone and many gourmet kinds of cheese are often thrown out of supermarket shelves if the demand for the product is low. Consumer preference for selecting food items with longer shelf life also results in food with shorter shelf lives being rejected.

Strict Cosmetic Standards to Satisfy Consumers' Perception

Retailers will sell things that sell well. Therefore, cosmetic standards are very much taken into consideration at retail and F&B outlets. Products with small irregularities in packaging such as dents in canned food and discolouration of the cans are often left behind in the shelves.

Labour Shortage Resulting in Longer Lead Time

Labour shortages at wholesale markets in Singapore also prompt cartons of fresh produce to be thrown away if the top layer of the carton is not cosmetically appealing.

The expiry dates and best before dates on the packaging is also a major factor of food left-overs during distribution. Due to the high-quality standards of consumers and businesses alike, items with a longer shelf life are generally preferred.

The following was said by the interviewee from the NPO in Singapore,

"Entity X (unnamed) orders the food from us. If the batch I sent yesterday expires on 31st December 2020, and the batch I send today expires on 30th December 2020 – this batch will be rejected. But the irony is that they order 10 cartons from us daily which means they use 10 cartons every single day. Even though, they have 18 months to use the product." [sic]

3.5. Food Waste during Consumption (Downstream)

Food waste occurs at the consumer stage, either when uncooked, expired or when cooked food is thrown away.

Based on interviews with importers, retailers and NPOs, there are many drivers causing food waste in Singapore at the consumer stage.

Strict food safety standards for catered food is a source of food waste in Singapore, based on the interview with the NPO. According to guidelines issued by the NEA, food should not be kept in room temperature for more than four hours from the time it is cooked at the caterer's kitchen to the time it is consumed. The rationale behind this is that food pathogens multiply rapidly between 5°C and 60°C, and can cause food poisoning when the food is consumed.

However, this four-hour food ruling results in a lot of "good food" being thrown away, says an interviewee. The interviewee said that the food ruling can be selectively applied to only those food items that are more prone to microbial

growth. It is also critical to check on how much food waste is occurring from this ruling compared to how many people are affected by food poisoning.

Cosmetic Filtering to Match Customers' Expectation of Quality

Cosmetic filtering of produce is also a driver of food waste at the consumer stage. Consumers are choosy in what they buy and leave "odd-looking" produce behind. Food waste due to trimmings for presentation purposes at food & beverage (F&B) outlets and hotels is another driver of food waste.

"I hear it from the caterer (*for airlines*). So because now, they have a problem with their veggie tender because their trade (*servicing*) for economy class is a specific size. So if their vegetable (...) is too long or too short, the aunty that is working in the kitchen has to cut it. (...) For aesthetics, the tray has to look a certain way, which causes food losses." [sic]

Convenience of Incinerating Food Waste

In addition, the driver for food waste downstream is incineration of food waste because it is convenient and carries no penalty. Rather than donating the food, the traders, distributors and wholesalers find it easier to throw away the food, which would later be incinerated. Singapore does not have laws that protect entities from liabilities when they donate food to NPO, which also makes entities prefer throwing away food than donating food to charity organisations.

19% of the 236 participants surveyed in Singapore have reported severe food insecurity (Glendinning, Shee, Nagpaul, & Chen, 2018). As explained by this report, food insecurity is the lack of physical and/or economic access to sufficient, safe and nutritious food. The findings in this report indicate that access to food in Singapore is also an issue for specific groups of people. This includes the elderly, persons with disabilities and health conditions which are identified as being the most vulnerable to food insecurity. It is possible that with food prices on the rise in Singapore, any financial difficulties could potentially compromise the availability of food for these groups of people. This issue of food insecurity was confirmed by comments from an interviewee who works in an NPO.

Therefore, this highlights the existence of a major discrepancy in the accessibility to food resources for people in Singapore. On one hand, substantial food is lost along the supply chain. On the other hand, there are Singaporeans experiencing the issue of food insecurity.

4. Findings from Consumer Surveys

4.1. Design and Methodology

The empirical research was conducted using online surveys which comprised open and closed questionnaire questions. The online survey was conducted to understand the respondent's food storage behaviour, purchasing patterns and food handling habits, and how all these have been linked to food waste at households.

The survey was piloted on a test population prior to roll out, to guide further survey enhancements. The final survey comprised 18 survey question, with an estimated completion time of 15 minutes.

Based on Singapore's population of 5.6 million in 2018¹⁰, a 95% confidence level with a 3% margin of error would require a sample size of about 1,000. The survey targeted more than 1,000 respondents using an online survey tool. The online survey was selected as the survey approach for practical reasons – Singapore being digitally included, and there is no theory relating digital inclusion to food storage, purchasing or handling behaviour. The online survey was conducted from July to early August 2019.

¹⁰ <https://www.singstat.gov.sg/find-data/search-by-theme/population/population-and-population-structure/latest-data>

4.2. Demographic Profile of Survey Participants

Table 5: Demographic profile of survey respondents.

Category	Count
Total survey respondents	1,002
Number of people in households	
1	27
2	117
3	180
4	303
5	185
>5	190
Type of housing	
Condominium	232
HDB	674
Landed property	96
Frequency of grocery shopping	
I don't go shopping	46
Once a month	48
Once in 2 weeks	118
Once a week	374
Twice a week	247
More than twice a week	169
Average spend on groceries per shopping trip	
<20 SGD	126
20-40 SGD	240
40-60 SGD	231
60-80 SGD	121
80-100 SGD	94
100-120 SGD	91
>120 SGD	99
Monthly household income bracket	
<1,000 SGD	60
1,000-3,000 SGD	113
3,000-5,000 SGD	163
5,000-7,000 SGD	146
7,000-9,000 SGD	146
9,000-11,000 SGD	130
>11,000 SGD	244

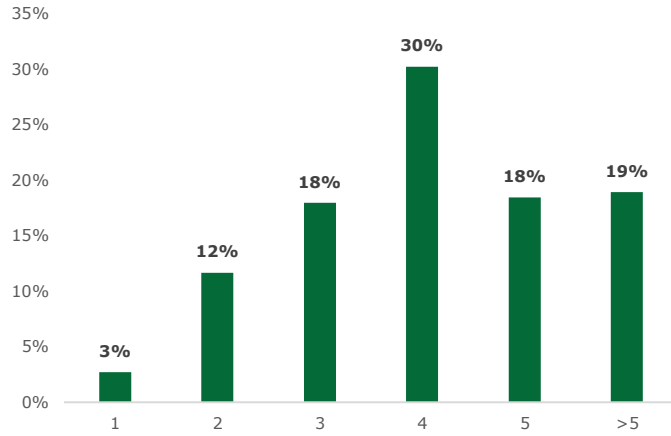


Figure 7: Number of people in the household of the survey respondents.

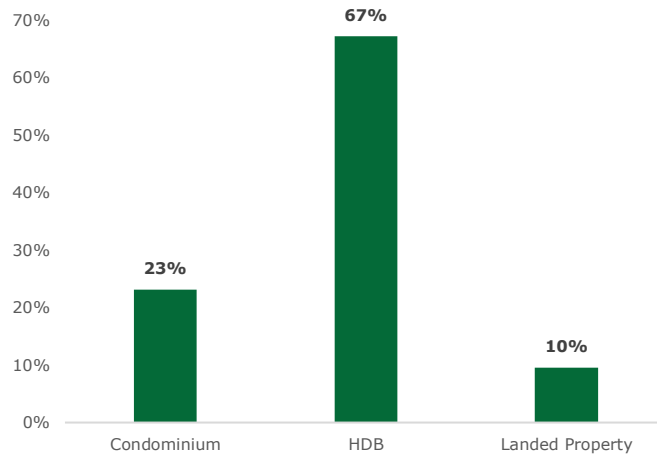


Figure 8: Type of housing of the survey respondents.

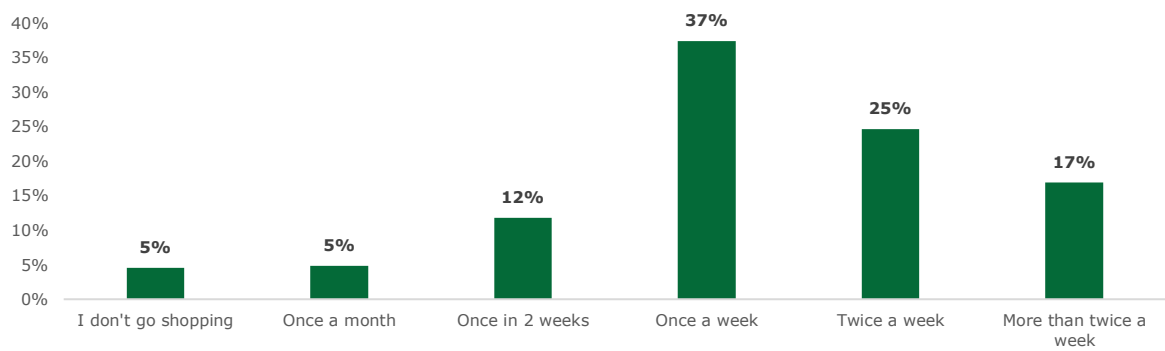


Figure 9: Frequency of grocery shopping of the survey respondents.

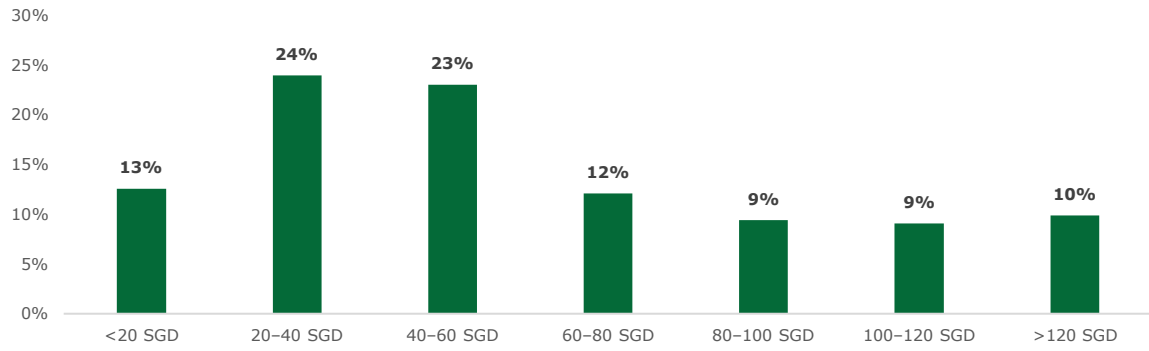


Figure 10: Average spend on groceries per shopping trip of the survey respondents.

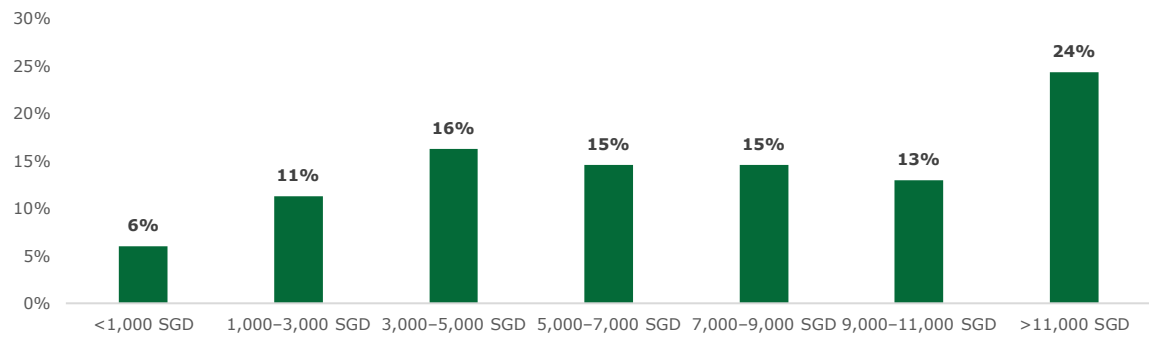


Figure 11: Monthly household income bracket of the survey respondents.

4.3. Key Results of Consumer Surveys

Key Result 1:

More than 26,000 tonnes of unconsumed foods are thrown away from households annually due to improper storage, purchasing patterns and food handling habits, amounting to estimated losses of \$342 million.

Survey analysis found that an estimated 26 thousand tonnes of selected food items to be thrown by households annually. These food items included beverages, bread, dairy products, eggs, fruits, vegetables, meat, fish and seafood. Through cost analysis of the food (taking the per average retail price of food items), it was found that these losses amounted to \$342 million.

Key Result 2:

One in three respondents throw away more than 10% of the food weekly. On average, 324 respondents out of 1,002 respondents throw away more than 10% of the food they do not fully consume on a weekly basis. When extrapolated in the context of Singapore, this suggests that close to one-third of the population throws away more than 10% of the food weekly.

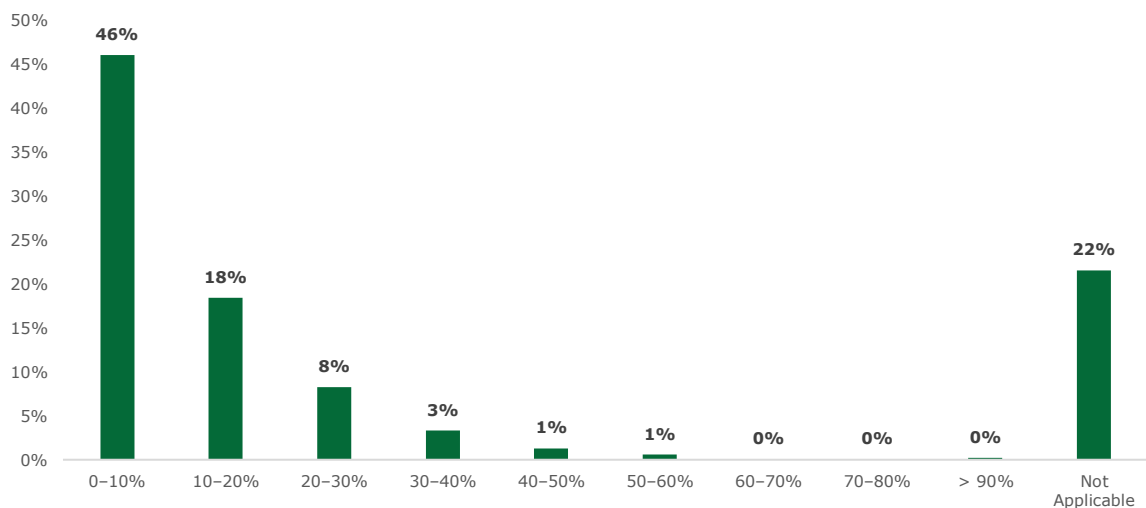


Figure 12: Percentage of food thrown away from households weekly.

Key Result 3:

Over 80% of the respondents do not fully understand the difference between various labels – “use by”, “best before” and “expiry date” used on the product packaging.

Regulation 10 of Singapore Food Regulations states that certain prepacked food should bear the expiry date marking which can be shown in the following ways:

- (a) “USE BY (here insert the day, month and year)”;
- (b) “SELL BY (here insert the day, month and year)”;
- (c) “EXPIRY DATE (here insert the day, month and year)”;
- (d) “BEST BEFORE (here insert the day, month and year)”.

Clause 10 of Regulation 10 also states that “best before” has the same meaning as “use by”. Also, according to the Singapore Food Agency (SFA), expiry date marking on the food indicates the date before which the food should be ideally consumed.

Since products in Singapore use different terms to indicate the “expiry date” in packaging, respondents were asked a few questions to test their level of awareness on these terms. The first question was on whether the “use by”, “best before” and “date of expiry” all convey the same meaning. Respondents were consequently asked to indicate what each of these terms conveys, and were given the options below:

- Date is just an indication of freshness
- Food items to be used before the date printed
- Food items used around the date printed

Results reveal that only 25% of the respondents agree that “use by”, “best before” and “date of expiry” all convey the same meaning. The results also reveal that only close to 20% of the respondents believe that expiry date marking on the food indicates the date before which the food should ideally be consumed.

In other countries, when the food almost reaches its “use by” or “best before” date, it does not always mean that the food is expired. The “use by” and “best before” labels mean that if the food reaches these dates, the quality and flavour

of the food is lowered, but it could still be edible. Singapore can consider adopting this to avoid confusion with the various labels and avoid any potential food waste occurring due to this confusion.

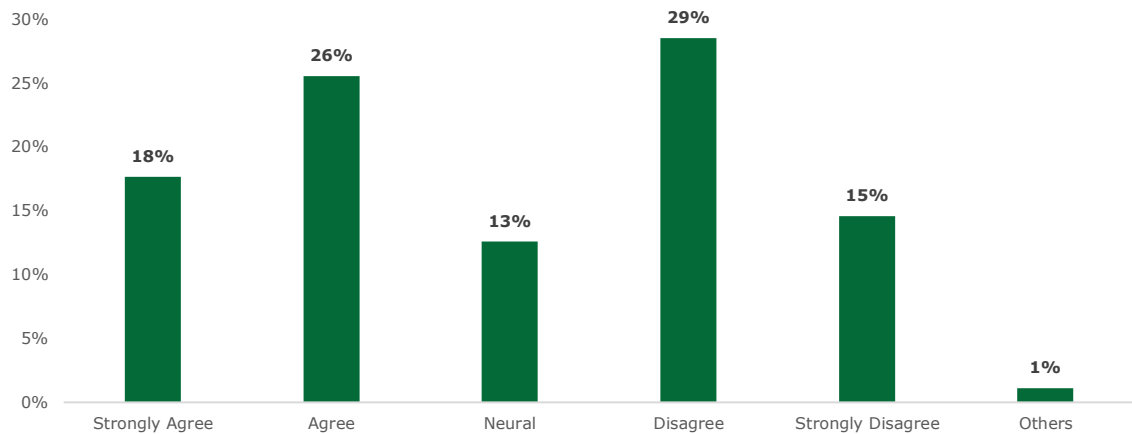


Figure 13: Consumer survey response on whether the "Use by", "Best before" and "Date of Expiry" all convey the same meaning.

Key Result 4:

One in five respondents claims that they do not throw away any food, and can be classified as "Smart Consumers". They are consumers who exhibit characteristics that generally include the following:

- They do not throw away unconsumed food.
- They are effective and organised planners who always or often make a shopping list of food items to buy.
- They are not swayed by promotional offers to buy excess food items that are potentially wasted.
- Make sure they consume all food items bought and do not buy more than they need.
- Shop at least once a week without contributing to an increase in food waste.

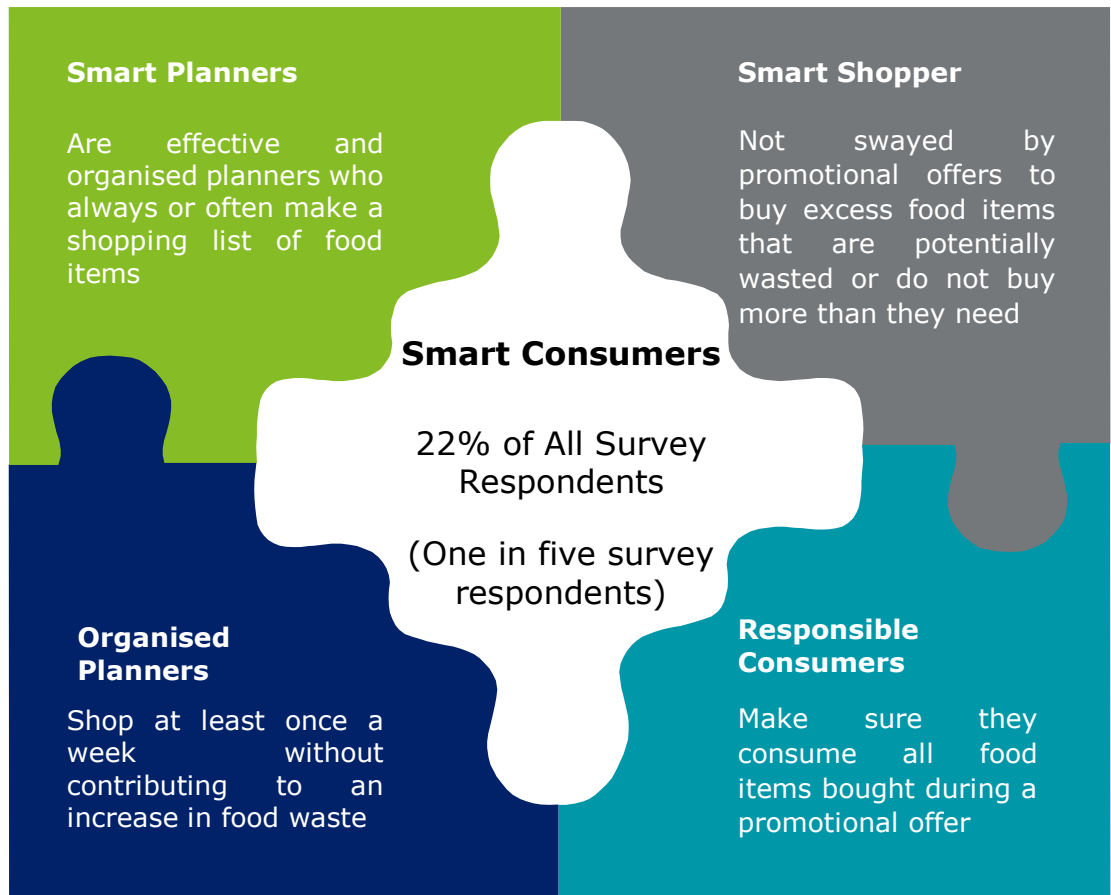


Figure 14: Characteristics of smart consumers.

Framework

*Mapping Food Loss and Waste Drivers to Possible Solutions
based on Target Drivers*

5. Mapping of Potential Solutions to Drivers of Food Loss and Waste

This study reveals food loss and waste as a multifaceted and an intricate issue that cannot be assigned to single variables, which demands a robust integration of distinct disciplinary approaches. As many drivers of food loss and waste have been mentioned in the context of this study, each of these drivers must be addressed in order to develop a comprehensive strategy for food loss and waste reduction and prevention. Mapping the various food loss and waste drivers to possible solutions deepen the understanding of the type of solutions provided by different stakeholders identified for future research and design interventions.

The analytical approach in this study was developed through investigating the food supply chain segments (primary production; processing and packaging; distribution; retail and consumption). The context of food loss and waste drivers in this mapping exercise are classified into three categories as suggested in intensive studies by FUSIONS on identification of the main causes of food waste generation along the food supply chain: technology-oriented; business management/economic and legislation/policy related; and consumers' behaviours and attitudes oriented (Canali, et al., 2014).

To help design reduction and prevention strategies, the following tables summarise the examples of possible solutions related to respective contexts to prevent food loss and waste at different stages of the food supply chain within each group of the stakeholders.

Table 6: Possible solutions to prevent food loss and waste throughout the food supply chain in Singapore (TECHNOLOGICAL CONTEXT).

TECHNOLOGICAL			
Food supply chain segments	Target Drivers	Possible Solutions	Identified Stakeholders
<i>Primary production</i>	<ul style="list-style-type: none"> Farmers in Singapore find it difficult to obtain financial support for adopting newer technologies necessary to improve production and reduce losses 	<ul style="list-style-type: none"> Better communication between agencies to facilitate timely approvals of grants 	Farmers, relevant agencies
	<p>Fruits and Vegetables</p> <ul style="list-style-type: none"> Mechanical damage; harvesting when the fresh vegetables are too immature Over ripening, disease due to unsuitable temperature Sudden changes in environmental conditions that render the fruit or vegetable unsaleable (e.g. when okra become fibrous due to heat) 	<ul style="list-style-type: none"> Improve harvester and handling equipment (e.g. introduce proper harvester adjustments and technology improvement grants) Implement indoor and climate-controlled farms Research into more climate resilient fruits and vegetable varieties 	
	<p>Fish and Seafood</p> <ul style="list-style-type: none"> Limited use of tools to gauge different diseases in fish Inefficient harvesting of aquaculture produce (outdated resources used) Losses from unpopular fish and bycatch (marine species that is caught unintentionally while catching certain target species and target sizes of seafood) Accumulation of fish faeces in sea beds leading to overcrowding of fish 	<ul style="list-style-type: none"> Implement automation technology for efficient harvesting of fishes Genetic enhancement to enhance fish resilience towards diseases Better monitoring of fish health through regular physical checks and water sensors Improvements and implementations in automation technology for efficient harvesting Reselling/redistribution of unpopular food to other markets (e.g. milkfish) Dredging of sea beds to clear fish waste Conduct proper disease monitoring 	

TECHNOLOGICAL			
Food supply chain segments	Target Drivers	Possible Solutions	Identified Stakeholders
		via routine physical checks on fish and testing of water conditions	
	Eggs <ul style="list-style-type: none"> Low calcium and/or salt in the feed decrease production and cause smaller/ soft-shelled/ shell-less/ cracked eggs 	<ul style="list-style-type: none"> Consistent, automated feeding and probiotics feed for chickens 	
<i>Processing and packaging</i>	<ul style="list-style-type: none"> Limited use of processing waste side streams 	<ul style="list-style-type: none"> Explore new technologies to process side streams (example: use of soybean residue for creating yeast, and sustainable packaging material) 	Retailers, consumer-facing businesses
	Fruits and Vegetables <ul style="list-style-type: none"> The field heat of the fresh fruits and vegetables after harvesting causes quality degradation 	<ul style="list-style-type: none"> Use different techniques of pre-cooling and storages (e.g. store lettuces in the sealed Styrofoam boxes mixed with crushed ices) 	
	Fish <ul style="list-style-type: none"> Fragile packaging material or haphazard packaging of fish 	<ul style="list-style-type: none"> Inspecting officer needs to record any damage to outer wrapping especially if the product has been exposed 	

TECHNOLOGICAL			
Food supply chain segments	Target Drivers	Possible Solutions	Identified Stakeholders
<i>Distribution</i>	Fruits and Vegetables <ul style="list-style-type: none"> • Damage through freezing and chilling during transport • The moisture released by the fruits and vegetables due to respiration gets carried onto the surface of the evaporator coils disrupting refrigeration • Unpleasant odours in the cargo or freight will lead to deterioration of the product 	<ul style="list-style-type: none"> • The optimum and required transport temperature provided to the shipper • Relative humidity of the air of 85% to 95% is recommended for the carriage of most perishable produce to impede wilting or shrivelling caused by moisture loss • Fruits and vegetables, being respiring cargoes, need frequent defrosting (every 4 to 8 hours) • Ensuring air circulation within the cargo or freight • Improve transportation (e.g. trucks used may be of a certain standard, where they are able to take the shocks of rough road conditions) 	Producers, manufacturers, retailers

TECHNOLOGICAL			
Food supply chain segments	Target Drivers	Possible Solutions	Identified Stakeholders
	Fish <ul style="list-style-type: none"> • Incorrect freezing process • Physical damages to frozen products (example stacking of cargo to a height adds sufficient pressure to distort fish) • Contamination of fish from seawater, bilge water, fuel oil if the packaging is damaged • Cold chain inefficiencies leading to loss of quality during frozen storage 	<ul style="list-style-type: none"> • Temperatures between -1 and -3°C are known as thermal arrest period, where the temperature of the produce drops very slowly; To preserve the quality of the product, it is important that the thermal arrest period is as short as possible, preferably less than two hours; This rate of cooling can only be achieved in equipment designed for the purpose • Pre-shipment/freight inspection of the product to determine the quality of the produce • The temperature of frozen fish to be presented for loading. Temperature records could provide evidence on how the product was stored during shipment • Improve packaging to keep food fresher for longer (proper conservation) and cold room facilities 	
	Eggs <ul style="list-style-type: none"> • Fresh product loss during shipment (e.g. road conditions cause damages to egg conditions) 	<ul style="list-style-type: none"> • Improve packaging and safe handling of eggs to avoid breakage during transport 	
<i>Consumption</i>	<ul style="list-style-type: none"> • Consumer knowledge on proper storage and management of food purchases 	<ul style="list-style-type: none"> • Use of thermal shopping bags • Introduce and advocate the adoption of new refrigeration 	Consumers, retailers

TECHNOLOGICAL			
Food supply chain segments	Target Drivers	Possible Solutions	Identified Stakeholders
		<p>technologies for consumers (e.g. Samsung Smart Fridge is able to provide an inventory log of foods available in the fridge and also warn users of foods nearing their expiry date)</p> <ul style="list-style-type: none"> • Provide detailed guidance on storage and preparation of food for consumers • Retailers to utilise smart shelves that can be connected to a mobile application via IoT to enable consumers to shop via the app and through the application, useful information such as proper storage instructions for the consumer along with a record of expiry dates of items purchased will be to enable better food management 	

Table 7: Possible solutions to prevent food loss and waste throughout food supply chain in Singapore (BUSINESS MANAGEMENT CONTEXT).

BUSINESS MANAGEMENT			
Food supply chain segments	Target Drivers	Possible Solutions	Identified Stakeholders
<i>Primary production</i>	<ul style="list-style-type: none"> • Strict consumer standards (cosmetically perfect products) • Overproduction due to poor forecasting of demand 	<ul style="list-style-type: none"> • Increased use of imperfect fruits and vegetables, and fish • Inglorious foods turned into higher valued food products (e.g. juices, salsa, jam, pickled products) 	Farmers, consumer-facing businesses, food recovery organisations
	Fish <ul style="list-style-type: none"> • Small tanks leading to overcrowding of fish 	<ul style="list-style-type: none"> • Site management during fish growth to avoid overcrowding of fish 	
<i>Processing and packaging</i>	<ul style="list-style-type: none"> • Cosmetic standards (irregular sizes of food items) applied by packaging industries and importers for ease of distribution) • Location of cold chain stores • Packaging management to avoid • Contamination in processing lines 	<ul style="list-style-type: none"> • Innovative packaging designs to enable cost-effective, efficient transport of irregular food items • Deploy cold chain stores within close proximity of the processing and packaging facility to optimise cold-chain management • Improve the knowledge and ability of workers • Improve the capacity of processing line 	Manufacturers, Retailers
<i>Distribution</i>	<ul style="list-style-type: none"> • Over-importation of food into Singapore by suppliers (food is ordered in bulk in an attempt to try selling as much as possible. Unsold food leads to food losses) • Food losses not monitored by weight, but instead monitored based on write-offs • (If sales cover the cost of food loss, losses are unaccounted for) • Transportation and market facilities • Commercial conditions 	<ul style="list-style-type: none"> • Policies to monitor the amount of food imported • Demand forecasting by businesses to predict amount of food that would be sold • Redistribution of excess unsold food • Import companies and distribution hubs to measure losses by weight of food items loss, to estimate the actual losses occurring 	Manufacturers, retailers, consumer-facing businesses

BUSINESS MANAGEMENT			
Food supply chain segments	Target Drivers	Possible Solutions	Identified Stakeholders
	<ul style="list-style-type: none"> • Improper care of food during unloading and loading leading to quality losses and physical damages of produce • Losses from unsold fish in retail and distribution 	<ul style="list-style-type: none"> • Improve transportation vehicles • Introduce online marketplaces to facilitate the sale of perishable products • Guidelines to be published on careful handling of different types of food items, and training provided to food handlers • Redirecting unsold fish to make products such as fish-cakes that can be readily consumed upon heating 	
<i>Consumption</i>	<ul style="list-style-type: none"> • Management inefficiencies (forecasting/ ordering of stocks) • Confusing application of date marks/ labels 	<ul style="list-style-type: none"> • Practise order-to-shelf inventory management • Incorporate forecasted spoilage through the use of simulations • Standardise food date labelling practices • Cut back on in-store promotions 	Manufacturers, retailers, consumers

Table 8: Possible solutions to prevent food loss and waste throughout the food supply chain in Singapore (INSTITUTIONAL CONTEXT – LEGISLATION AND POLICY).

INSTITUTIONAL – LEGISLATION AND POLICY			
Food supply chain segments	Target Drivers	Possible Solutions	Identified Stakeholders
<i>Primary production</i>	<ul style="list-style-type: none"> Overproduction of food due to poor demand foresight Disposal of imperfect produce Authorities are not aware and do not possess the necessary knowledge on the local farming industry 	<ul style="list-style-type: none"> Improve market access and increase awareness about imperfect produce Implement policies that ban the disposal of imperfect produce and provide incentives to companies seeking to purchase imperfect produce Implement multi-agency farm visits for relevant authorities to educate them about the farming industry 	Farmers, relevant authorities
	<p>Fish</p> <ul style="list-style-type: none"> Poor water quality due to recent developments around the East coast of Singapore preventing natural filtering processes of water Development of petrochemical plants leading to greater accumulation of nutrients The high cost of fish feed in Singapore Accumulation of fish faeces in sea beds decreases the space available for the fish stock to grow No real-time information on the water conditions made available to farmers 	<ul style="list-style-type: none"> Better developmental planning around Singapore to safeguard water quality, especially around aquaculture farms. Provide grants for farmers to purchase high-quality fish feeds Provide grants to further research and develop fish feed that will lower the Feed Conversion Ratio Support to initiate the dredging of sea beds along the Johor Straits to clear fish waste and other debris Intervention and assistance to carry out proper site management and planning to revitalize the existing farming sites Increase the transparency in sharing relevant data with fish farmers to keep them updated on 	

INSTITUTIONAL – LEGISLATION AND POLICY			
Food supply chain segments	Target Drivers	Possible Solutions	Identified Stakeholders
		the current water conditions and allow them to take the necessary action (i.e. raising of nets and transference of fish stock during the event of a harmful algal bloom)	
<i>Processing and packaging</i>	<ul style="list-style-type: none"> Legislation restrictions (e.g. regulatory standards) 	<ul style="list-style-type: none"> Eliminate standards that are not related to safety 	Policymakers
<i>Distribution</i>	<ul style="list-style-type: none"> Outdated vehicles Particular marketing standards No provision that protects entities from liabilities when they donate food to charities 	<ul style="list-style-type: none"> Provide transportation infrastructure for food recovery Introduce policies to safeguard entities from liabilities 	Food recovery organisations
<i>Consumption</i>	<ul style="list-style-type: none"> Confusion regarding “Expiry date”, “Best before”, and “Use by” dates Limited policies to encourage redistribution No penalty for disposal and incineration of food waste in Singapore 	<ul style="list-style-type: none"> Consider adopting different definitions for “Expiry date”, “Best before”, and “Use by” dates, to avoid confusion with the various labels and avoid any potential food waste occurring due to this confusion Facilitate increased donation of unsold foods (e.g. from hotels, restaurants and cafeterias) Introduce new business models for imperfect produce Policies to discourage food waste disposal and incineration in Singapore 	Retailers, food recovery organisations consumers

Table 9: Possible solutions to prevent food loss and waste throughout the food supply chain in Singapore (SOCIAL CONTEXT – BEHAVIOURS AND ATTITUDES).

SOCIAL – BEHAVIOURS AND ATTITUDES			
Food supply chain segments	Target Drivers	Possible Solutions	Identified Stakeholders
<i>Primary production</i>	<ul style="list-style-type: none"> • The volatility of food demand • Urbanisation and changes in dietary habits • Poor relationship of Singapore citizens and the local farmers and farming practices 	<ul style="list-style-type: none"> • Development of “Community Supported Agriculture” by Singapore citizens partnering with local farming groups. • Development of urban farming infrastructure • Citizen groups can promote urban farming practices 	Farmers, research institutions, relevant agencies
<i>Processing and packaging</i>	<ul style="list-style-type: none"> • Misinterpretation of date labels 	<ul style="list-style-type: none"> • Awareness to correctly interpret date labels 	Manufacturers
<i>Distribution</i>	<ul style="list-style-type: none"> • Inglorious foods (aesthetically unappealing foods) not bred or packaged due to consumer’s perceived value • Minor irregularities in food packaging lead to longer shelf life items (such as dents and discolouration of cans) • Consumers’ selective behaviour of consumers (e.g. aesthetical appearance of food and food packaging) 	<ul style="list-style-type: none"> • Awareness to place more emphasis on nutritional quality rather than the appearance of the food item • Sell items with irregularities in packaging at a discounted rate • Adopt good storage practices • 	Manufacturers, retailers, consumer-facing businesses
<i>Consumption</i>	<ul style="list-style-type: none"> • Food waste due to unconsumed food is thrown away (due to various reasons) • Promotional sales and habit of bulk shopping • Poor food skills and information • Lack of correct shopping and meal plans • Incorrect storage of certain types of food (e.g. not storing fish and seafood at the right temperature) • Consumer perception that inglorious foods are not nutritionally fit 	<ul style="list-style-type: none"> • Colour-coding of the refrigerator: Grouping similar food types by colours to particular to raise awareness of available food items in the fridge • Training for retailers, restaurant, cafeteria, and supermarket management to forecast customer demand (avoid bulk purchases) • Provide consumer education and 	Retailers, food recovery organisations, consumers

SOCIAL – BEHAVIOURS AND ATTITUDES			
Food supply chain segments	Target Drivers	Possible Solutions	Identified Stakeholders
		<p>campaigns</p> <ul style="list-style-type: none"> • Distribute excess food to charitable groups • Promote the habit of preparing shopping lists prior to shopping trips, among consumers • Educate consumers on correct storage method and temperature (e.g. the shelf life of cod fillets at 0°C has been estimated 10–12 days) • Leverage on the local education system to educate the youth about proper food management practices • Education of consumers on not being cosmetically selective during purchase 	

Managing Food Loss and Waste in Singapore

6. Circular Economy for Food in Singapore

For a very long time, the global economy has been always been “linear” (Government of the Netherlands, 2019). The linear model of “take, make, waste” means that natural resources are taken out of the Earth to make a product, and after usage of the product, it will end up as waste.

However, the world population is increasing at an exponential rate but the number of natural resources is somewhat finite. This population growth has put tremendous strain on the environment. To ensure the sustainability of materials for future generations, the economy should move from a “linear model to a “circular model” of the economy – or commonly referred to as “circular economy”.

The circular economy looks beyond the current take-make-waste extractive industrial model to redefine growth and focus on positive society-wide benefits (Ellen MacArthur Foundation, 2019). With regard to the food supply chain, this would mean decoupling the linearity of the food supply chain, via a holistic set of strategies to prevent food loss at source, facilitate redistribution of foods, encourage recycling and composting and exploit food waste-to-energy recovery processes that will deliver business and economic opportunities, and social and environmental benefits.

While there are many success stories of implementing a circular economy model in the food supply chain in other countries, a similar approach might need to be contextualised for Singapore. As a small city-state, Singapore has always been aware of the need to balance economic development and environmental sustainability.

To overcome these challenges and continue to grow sustainably in the land-constrained country, Singapore will roll out its Zero-Waste Masterplan (Cheng, 2019). The masterplan will set out steps that Singapore must take to minimise its packaging, electrical and electronic waste, and most importantly – food waste. To look into the circular economy model to minimise food waste locally, there are three approaches to be considered.

The first approach to bring circularity of food in Singapore is to source and

consume locally grown food regeneratively (in a way that replenishes and improves the overall health of the ecosystem). Local food production is important to supplement the food supply from imports in Singapore. Building a strong partnership between consumers and local farmer organisations can provide the opportunity for a community-supported agricultural practice ensuring better security to the local farming practices. Connecting city dwellers with farmers and farming practices, can benefit the local environment, improve the health of citizens, and also form resilient local food supply. This can also be achieved by promoting urban farming systems.

The second approach is to create Singapore as a centre where food by-products can be transformed, through emerging technologies and innovations, into an array of valuable materials. Food waste valorisation is a method of doing this. Food waste valorisation is the process of transforming food waste streams into useful by-products, which could provide economic opportunities in the city whilst preventing waste. Research organisations in Singapore can be supported to explore opportunities for food waste valorisation and their large scale applications. Similarly, the use of technology to extend the shelf life of food items can be explored by stakeholders in the food supply chain in Singapore, to prevent food losses.

The third approach is to build multilateral collaborations between different players in the supply chain in Singapore to identify opportunities for food loss reduction. Food loss and waste occur at every stage of the food supply chain. Collaborative efforts between different stakeholders in the supply chain can provide a catalytic action of reducing food loss along the supply chain. Collaborations can not only prevent losses but also provide an economic advantage to the stakeholders collaborating. The circular economy model of food is designed to cycle within the system. Singapore can make most of the food by redistributing surplus edible food to industries, and food charities.

The supply chain for eggs in Singapore is identified as a good example in the food supply chain, where the amount of food loss and waste generated is low. The egg farms in Singapore use automation to enable maximum output while ensuring minimal loss during production resulting in around 1% loss of eggs along the food supply chain. Moreover, good practices in these farms include

the use the damaged eggs during production to create by-products such as liquid egg and powdered eggs. Chicken waste that is obtained from coop is used as fertiliser in vegetable farms in Singapore. These characteristics of valorising food from waste generated has the potential to be used as a model to exhibit circularity of food in Singapore.

In fish farms, there are instances where fish and other seafood are left unsold and if there are no suitable buyers, these items would likely go to waste. To minimise the occurrence of such waste, there are fish farms who looking to convert these unsold food items into other food products that would extend its shelf life. For instance, the production of a ready-to-eat seafood product (made from a combination of fish and prawn meat) is currently being developed in of the local farms. This concept of transforming food has a great potential to be used as a model to exhibit circularity of within the aquaculture industry and in Singapore.

Food security is critical to Singapore and food imports remain the biggest source of food in Singapore. Local food production is our second "food basket". There is urgent need to reform the current way our food is grown to reduce farming's environmental footprint, boost resource efficiency, and cut food waste. Growing overseas is our third "food basket", where companies can expand and grow overseas so that their produce can be exported back home.

It is suggested that Singapore moves into the circularity of food which will help to reduce food loss and waste, and to create the fourth "food basket" and further enhance the food security of Singapore for the foreseeable future.

Suggested Circular Economy of Food in Singapore

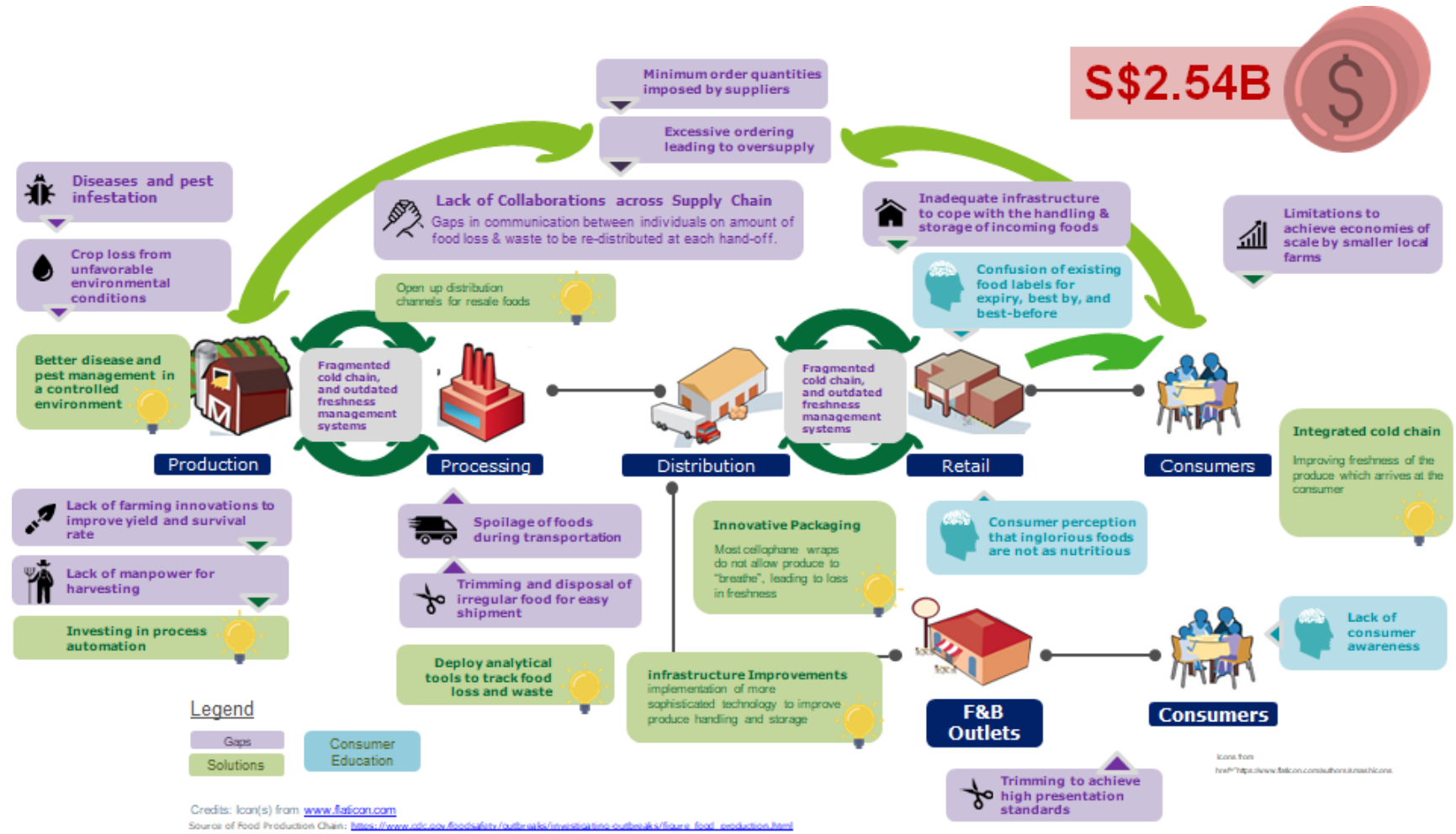
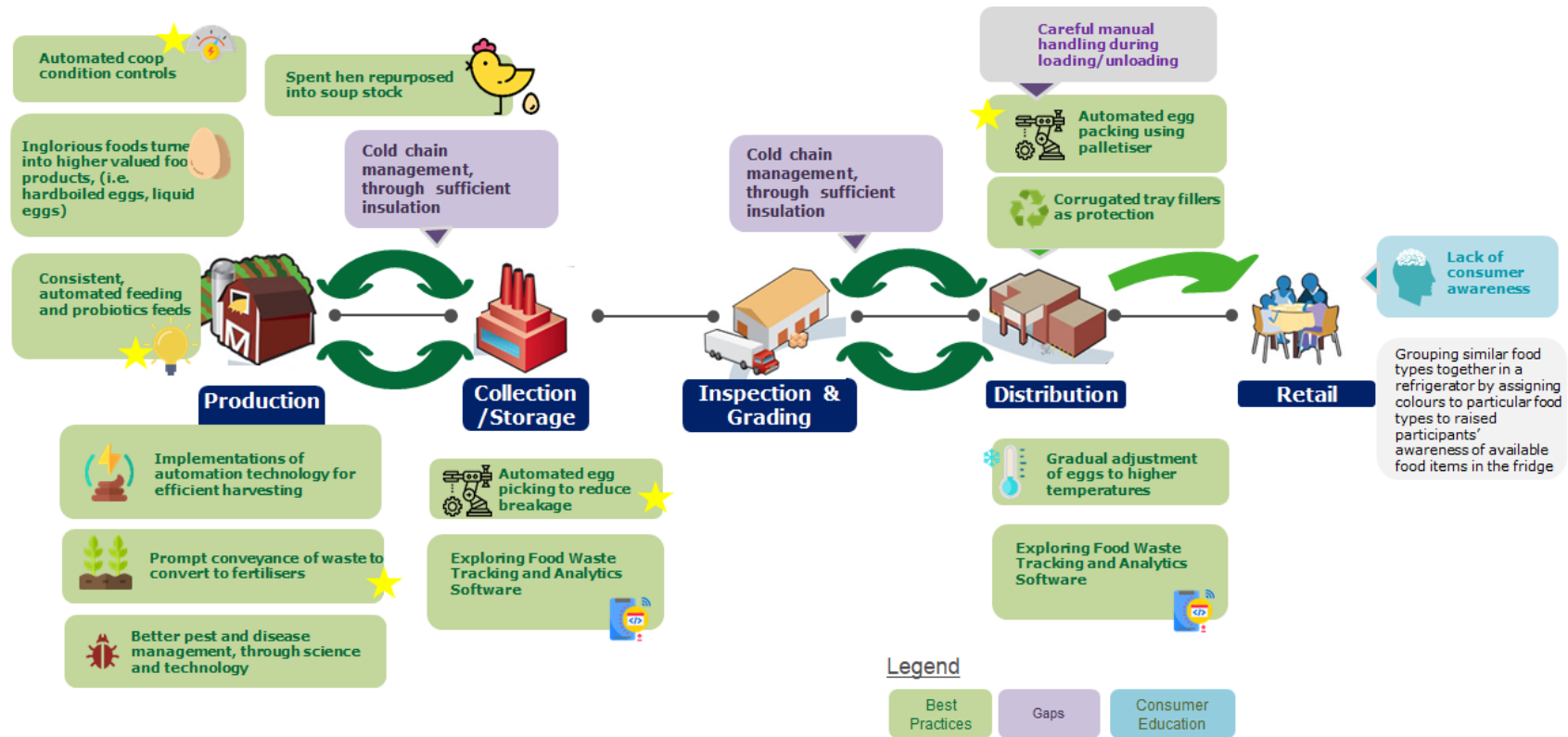


Figure 15: Circular economy of food in Singapore.

Suggested Circular Economy of Eggs in Singapore



Credits: Icon(s) from www.flaticon.com
 Source of Food Production Chain: https://www.cdc.gov/foodsafety/outbreaks/investigating-outbreaks/figure_food_production.html

Figure 16: Circular economy of eggs in Singapore.

Suggested Circular Economy of Fish and Seafood in Singapore

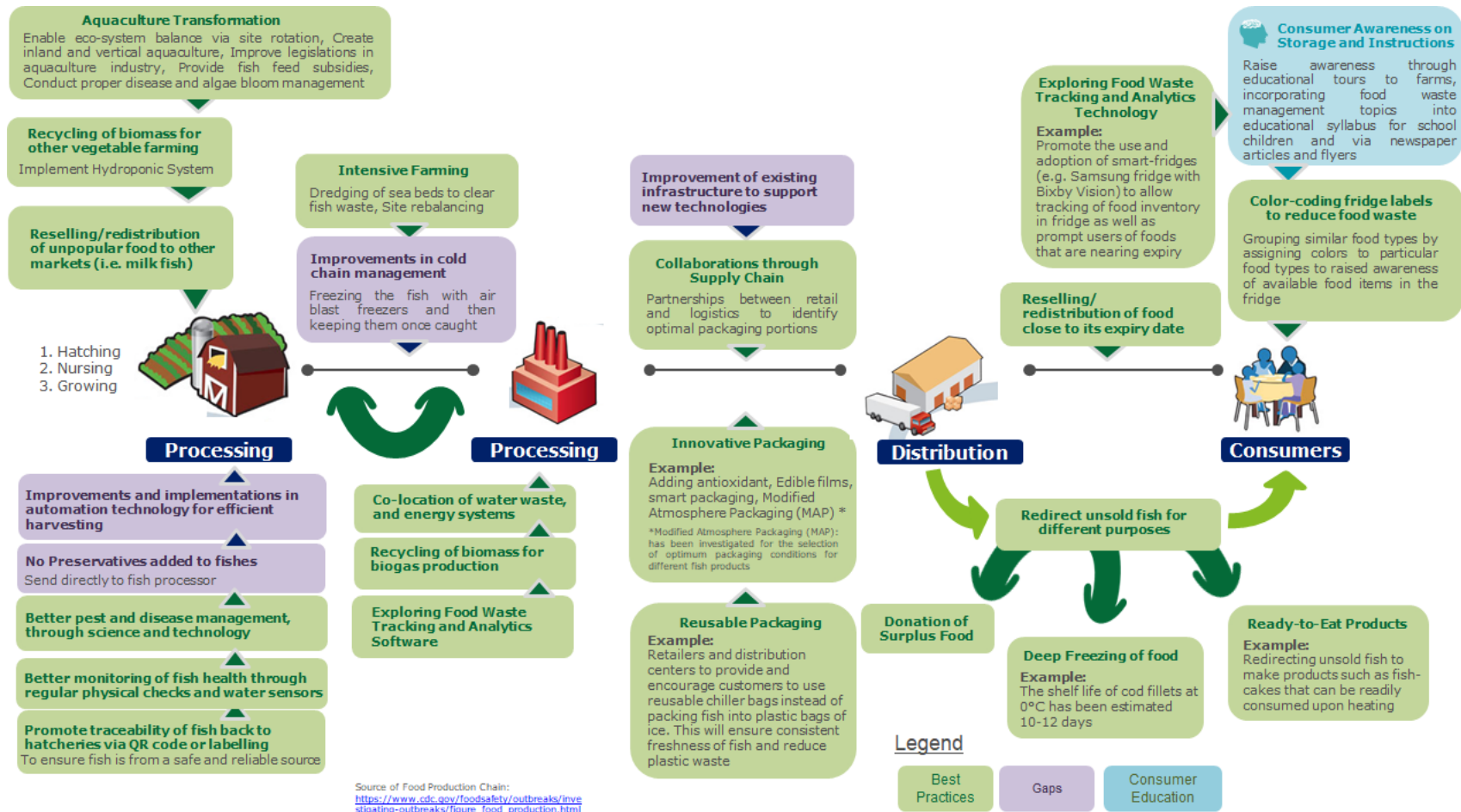


Figure 17: Circular economy of fish and seafood in Singapore.

Suggested Circular Economy of Vegetables in Singapore

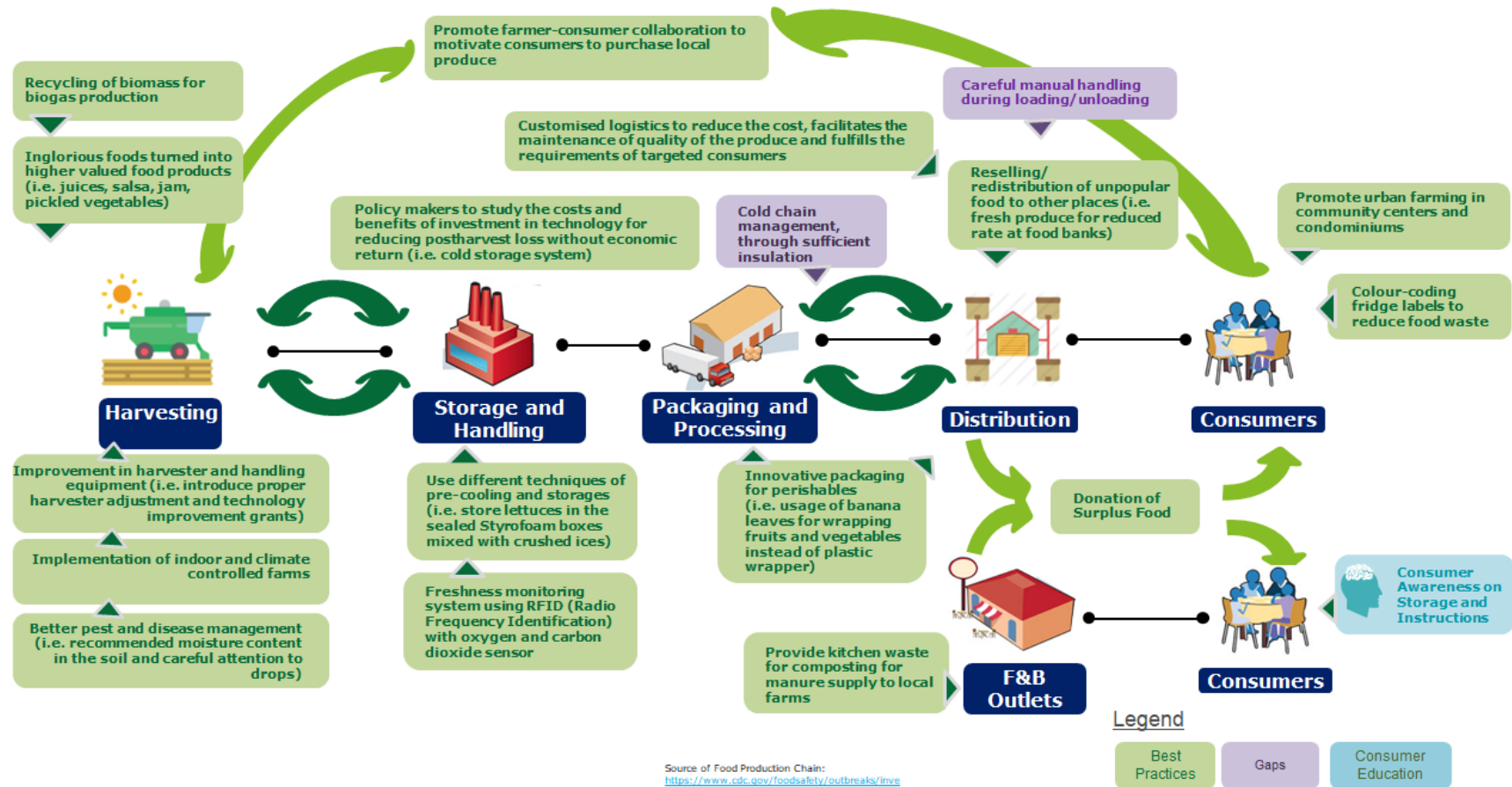


Figure 18: Circular economy of vegetables in Singapore.

Conclusion

7. Conclusion

There is an urgent need to reform the current food supply chain in Singapore. The issue of food loss and waste within the country would need to be addressed in the supply chain of production, processing and packaging, distribution, as well as consumption stage. From the stages, the study has explored and identified the drivers of food loss from a global perspective and a local perspective along this food supply chain. As there is limited information available, the food loss is supplemented based on interviews and survey conducted.

Based on the value drivers identified in the study, Singapore should envision an economy for the food supply chain to be both sustainable and circular. There will be three approaches to be considered if Singapore is to achieve this vision.

With the announcement of the “30 by 30” goal set by Singapore Food Agency (SFA) recently, raising local food production to 30% by 2030 would strengthen the ‘grow local’ basket and augment our source of locally-grown food for local consumption. This would not only mitigate potential food loss prior to reaching the consumer as local produce would travel fewer food miles¹¹ but also reduce our reliance on food imports – which might be critical if we wish to enhance our food security in the future. Efforts on reducing food waste within the country can concurrently help Singapore to achieve food security through circular economy approach.

The rapid development in agri-food innovations could perhaps be one of the most important approaches to reduce food loss and waste in various stages in the food supply chain. This could be recent developments in cold chain technology to reduce food losses prior to reaching consumer stage or using predictive capability to optimise the amount to be transported or put on supermarket shelves. Similarly, these innovations have been improved so that

¹¹ Food miles refers to the distance food travels from where it is grown to where it is ultimately purchased or consumed by the end user

it could be adopted in an urban farming setting.

Perhaps the most significant approach would be potential collaboration between different stakeholders in the local food supply chain to identify opportunities in reducing food loss. Apart from organisations – commercial and non-profit alike – and governmental push, the public sector also would need a significant change in attitudes and behaviours to ensure all stakeholders play a part towards achieving circular economy in Singapore.

Undeniably, Singapore will face considerable challenges in achieving circular economy for food supply chain locally. These challenges might be due to rise in population and rising consumption of the middle class, the need to balance food security, as well as economic considerations of Singapore being a transshipment hub (including food items). As part of evolving food supply chain in Singapore towards the future economy, there need to be coordinated approach to achieve synergy to ensure progress towards circular economy.

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9. Appendix

Survey Questionnaire for Consumer Study

The Singapore Environment Council ("SEC") is an independently managed, not-for-profit non-governmental organisation that influences thinking on environmental and sustainability efforts in Singapore. This year, SEC is embarking on a study to understand the food losses and food waste occurring throughout the entire food supply chain in Singapore.

As part of this study, we are reaching out to consumers to understand their food storage patterns, purchasing planning behaviour, and food handling habits.

This survey would take about 10 minutes to complete. Thank you for your time!

* Required

1. 1. How many people are there in your household? *

Mark only one oval.

- 1
- 2
- 3
- 4
- 5
- >5

2. 2. How often do you shop for groceries and fresh food items? *

Mark only one oval.

- More than twice a week
- Twice a week
- Once a week
- Once in 2 weeks
- Once a month
- I don't go shopping

3. 3. On average, how much do you spend each time you shop for groceries and fresh food items? *

Mark only one oval.

- <20 SGD
- 20 - 40 SGD
- 40 - 60 SGD
- 60 - 80 SGD
- 80 - 100 SGD
- 100 - 120 SGD
- > 120 SGD

4. 4. What is your monthly household income bracket? *

Mark only one oval.

- < 1000 SGD
- 1000 - 3000 SGD
- 3000 - 5000 SGD
- 5000 - 7000 SGD
- 7000 - 9000 SGD
- 9000 - 11000 SGD
- > 11000 SGD

5. 5. What type of housing do you stay in? *

Mark only one oval.

- Condominium
- HDB
- Landed Property

Storage Method

6. 6. Where do you store the following items once you get home? Kindly select one option per food item. *

Mark only one oval per row.

	I do not purchase this item	Refrigerator	Freezer	Stored at room temperature
Dairy Products (e.g. milk, cheese etc)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Beverages (e.g. juices)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green Leafy Vegetables	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other Vegetables (tomatoes, potatoes, chillies, cucumbers)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Seafood and Fish	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Meat	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bread	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bananas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Apples	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Carrots	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eggs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. 7. Do you refrigerate those items labelled 'Keep Refrigerated'? *

Mark only one oval.

- All the time
- Sometimes
- Never

8. 8. Would you prefer the packaging label on the food item to also indicate storage advice to help prolong self life, including whether to refrigerate or not? *

Mark only one oval.

- Yes Skip to question 9.
 No Skip to question 11.
 No Preference Skip to question 11.

Storage Method.

9. 8) i) Would you like to know the ideal temperature of storage of food, to be stated on the packaging? *

Mark only one oval.

- Yes
 No

10. 8) ii) Does your fridge come with temperature control features that allow you to set the ideal temperature recommended? *

Mark only one oval.

- Yes
 No

Purchase Planning

11. 9. Do you make a list of what to buy before you shop for groceries and fresh food items? *

Mark only one oval.

- Always
 Often
 Occasionally
 Rarely
 Never

12. 10. How often do you check what is in your fridge to know what needs to be thrown away or quickly eaten? *

Mark only one oval.

- Daily
 Weekly
 Monthly
 Never
 Only before a shopping trip
 Other: _____

Perception and Habits

13. 11. From the groceries and fresh food items that you purchased, which of these food items do you throw away without fully consuming them? Please select all that apply. *

Check all that apply.

- Dairy Products (milk, cheese, etc.)
- Beverages (e.g. juices)
- Green Leafy Vegetables
- Other Vegetables (e.g. tomatoes, potatoes, chillies, cucumbers)
- Seafood and fish
- Bread
- Meat
- Fruits
- Eggs
- Not Applicable

14. 12. To the food items selected in question 11, on average, what is the percentage of food that you throw away weekly? *

Mark only one oval.

- 0% - 10%
- 10% - 20%
- 20% - 30%
- 30% - 40%
- 40% - 50%
- 50% - 60%
- 60% - 70%
- 70% - 80%
- 80% - 90%
- > 90%
- Not Applicable

15. 13. The 'use by', 'best before' and 'date of expiry' all convey the same meaning. *

Mark only one oval.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree
- Other: _____

16. 14. What do the following descriptions mean to you? Please select the most appropriate description for each label/term. *

Mark only one oval per row.

	Food items to be used before the date printed	Food items used around the date printed	Date is just an indication of freshness
'Use By'	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
'Best Before'	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
'Date of Expiry'	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

17. 15. Would you purchase a food item that is on a promotional offer (e.g. "buy 1 get 1 free"), even if you had not planned on purchasing it prior to your shopping trip? *

Mark only one oval.

- Yes
 No
 Not Applicable

18. 16. What is the biggest advantage of seeing food items under a promotional offer (e.g. "buy 1 get 1 free) for you? *

Mark only one oval.

- It makes me feel the price is low
 I feel like it is more convenient since I am able to purchase a greater quantity at once
 I feel like getting value for my money
 I do not see any advantage
 Not Applicable
 Other: _____

19. 17. What is the biggest disadvantage of seeing food items under a promotional offer (e.g. "buy 1 get 1 free) for you? *

Mark only one oval.

- This is a company's way of attracting customers
 Only lower quality items are kept on promotional offers
 It promotes food waste
 Only close to expiry date products are kept on promotional offers
 I do not see any disadvantage
 Not Applicable
 Other: _____

20. 18. Do you consume all the additional food items that you purchase from a promotion offer (e.g. "buy 1 get 1 free")? *

Mark only one oval.

- Always consume all the food I purchase from a promotion offer
 Occasionally consume all the food I purchase from a promotion offer
 Rarely consume all the food I purchase from a promotion offer
 Never fully consume all the food I purchase from a promotion offer
 I never purchase any food item from a sale offer
 I do not buy more than what I require

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