

# Towards Sustainable Food Waste Management: A Reflection on Food Waste Evolutions in Singapore

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## Abstract

Undeniably food waste is daily generated in large quantities globally, suggesting the diminishing of natural resources and the initiation of ecological pollution concerns if repudiated without valorization or consumption. Incidentally, food waste management presents a significant threat in the circular society, and it destabilizes the sustainable development in global food production, worsening ecosystem destruction. The international community must work towards reducing the extent of food that gets wasted. Notwithstanding, there are possible tensions between reducing food waste and the resilience of food production. On the one hand, over-production of food is a factor contributing to waste. On the other hand, they also offer stability in the form of redundancy. In this study, we explore specific intercessions intended to reduce food waste by assessing its influence on the various facets of resilience. It also recognizes established, appropriate, governmental, and social considerations that hinder food waste and alleviation. Applying global expertise and best practices in dealing with food waste, recommendations are made on how these issues must be addressed. The results from this study widen suggestions to the waste management authorities in Singapore in determining strategies for future growth and application of food waste source activities in community programs and the information drive that encourage the use of these programs.

**Keywords:** Food loss and waste (FLW), sustainability, supply chain, circular economy

## I. INTRODUCTION

Food waste embodies an untenable approach to food manufacturing and consumption. Moreover, food waste is a societal concern, a failure of both economic and ecological tragedy. It further accentuates an ethical question. For example, wastage produces dangerous greenhouse gas. According to Poore&Nemecek (2018), the food sector accounts for 26% of greenhouse-gas emissions, 6% of which is a consequence of food that is never consumed and ends up as food waste. An unwavering commitment to sustainable development through implementing sustainability-oriented innovations (SOI) can have the capacity to be advantageous to a variety of

firms in the food sector. Adams et al. (2016) characterize SOI as a form of innovation that necessitates creating deliberate or purposeful modifications to a firm's philosophy and values, including its products, processes, or practices to fulfill the particular goal of generating and attaining societal and ecological value in addition to financial performance.

Research indicates that third-party technology suppliers can encourage the pioneering capability of firms in SOI (Klewitz& Hansen, 2014). Sustainable development evolutions refer to the radical changes in societal structures. The challenge of food waste in Singapore is significant; however, it remains understudied (Corsini et al., 2019), notwithstanding growing literature in food waste methodology and its policy effects (Schanes et al., 2018).

Today, owing to acute ecological challenges, for instance, water and soil contamination, it is imperative for governments to identify cost-efficient and ecologically nice ways for reusing, taking into account sustainable development and the circular economy involving food and plastic waste. Conceivably, redefining a paradigm shift in generating less waste is much more efficient than recycling it. Besides, less waste production appears to involve less power than the recycling processes (UN 2015). Existing literature reveals the underlying triggers of this problem and finds an appropriate and long-term answer to cut food waste. Indeed, scholars have carried out investigations on (i) the design concepts (Hebrok&Boks 2017), (ii) user conduct (Block et al., 2016), (iii) habit theory (Schanes et al., 2018), and discovery (Baron et al. 2018).

The capacity to decrease food waste and food losses is vital in lowering food systems' ecological footprint. Furthermore, this is shown as critical towards reducing greenhouse gas emissions, thereby decelerating global warming and de-escalating the usage of natural resources. According to FAO (2018), food loss and wastage insinuate profound wasting resources such as water, land, energy, labor, and capital. Consequentially lead to impacts on the environment, both directly and indirectly.



Indeed, food loss and waste (FLW) is a critical issue that must be addressed urgently because of the soaring economic and social costs and its parallel to waste management and global warming issues. It is a small wonder Beretta et al. (2013) argue that FLW can usher in hefty financial losses, invaluable resources, and triggering ecological destruction. Besides, FLW is an ethical concern since 12 percent of the world's inhabitants are experiencing starvation and malnutrition (Lohnes & Wilson, 2018). Despite this perception and the attempts taken to curtail FLW, the situation continues to be excessive.

#### **A. Ecological impacts**

There are two significant direct ecological impacts: First is the excess of the resources used to make the food lost and wasted. Second, it is a principal source of adverse effects involving greenhouse gas production (GHG) at disposal. Implied ecological externalities encompass unwarranted contaminated water resulting from the extensive utilization of stimulants in food production. In a similar vein, adverse externalities contain mono-cropping and agriculture expansion into the woodlands, thus creating severe biodiversity loss (FAO, 2013).

Moreover, food wastage entails a substantial financial loss for both manufacturers and customers alike (HLPE, 2014). To be specific, food waste, including food losses, exemplify an investment failure that diminishes agriculturalists' revenues and raises consumers' expenditures (FAO, 2018; Cattaneo et al., 2021). The unwanted waste frequently includes discarded food and crumbs, leafy vegetables, fruit skin, and expired dairy. Because of the organic components, FLW is related to people's health concerns, especially when thrown away improperly at unauthorized waste disposal locations. This, in turn, is an attractive breeding ground for midges and gnats. The FLW is usually handled by suitable landfill sites, incineration, composting, and animal feed ingredients. But these alternatives may well result in cross-contamination and added energy use. Hence increasingly, the circularity of the FLW bio-economy is becoming more sustainable in recent years. (Maina et al., 2017; Dahiya et al., 2018).

Both Ong et al. (2018) and Cecchi et al. (2019) asserts that the reusing of FLW as an essential resource for the manufacturing of chemicals, materials, and fuels has been pointed out in most countries relative to developing economies like Malaysia and Thailand based on the consumption rates (Ministry of Environment Korea 2015; Lim et al., 2016). The FLW valorization in developed economies like Taiwan, South Korea, Australia, including Sweden is an exciting model that can be patterned as these economies are more likely to embrace zero waste or resource recycling policy.

#### **B. Technological developments**

In another vein, technological developments are especially relevant to angst expressed by academics stemming from

their work for quantifying within food supply chains (Eriksson et al., 2018; Malefors et al., 2019; Martín-Rios & Ciobanu, 2019). Additionally, technology supports enterprises with gizmos to expand food waste valorization alternatives (Vandermeersch et al., 2014). It evaluates the actual value of waste (Wen et al., 2016), enhances the reduction and improvement strategies (Wen et al., 2018), and generates awareness between experts (Martín-Rios et al., 2018).

Notwithstanding the large quantity of waste, the growth of contemporary and innovative recycling waste techniques with characteristics, e.g., cheap, biodegradable, viable, and profitable reusing, has been getting considerable attention. To accomplish this goal, the notion of a circular economy should be considered as a required method in managing waste. Jose et al. (2020) assert that a circular economy is progressively vital due to the dramatic rise of waste, notably every five years, and a viable resolution for utilizing these wastes as valuable materials (Dahiya et al. 2020).

#### **C. Food waste and responses**

Turning to Singapore, FLW continues to be a fundamental challenge in Singapore. Without a doubt, this transitory stage of FLW sustainability is vital for Singapore's food security and survival. Given that the FLW reduction constitutes many intricate and interconnected facets of societal, governmental, commercial realms, it can depend heavily on native cultures and specific accounts of locales. By squandering edible food, infers that the entire supply food chain (e.g., planting, harvesting, handling, and distributing) that food is likewise misspent, causing adverse environmental impact (Gustavsson et al. 2011). Reduced FLW together with appropriate waste management can facilitate other financial resources and ensure food security.

According to MSE (2021), FLW is one of Singapore's most significant waste streams; unsurprising, the quantity of food waste created has increased by around 20 to 30 percent over the previous decades. In 2019, Singapore produced about 744 million kg of food waste. That is equal to two bowls of rice per person per day, or around 51,000 double-decker buses.

The measures taken by the Singapore government are primarily restricted to championing altruistic food supplies; there is a developing panorama of resident-managed food redistribution projects. These projects underscore the crucial link between the residents and the locales, emphasizing Infocom tools as enablers for people engagement. This study explores the challenges that engage residents in reducing FLW and promote social transformation in FLW within Singapore.

In this study, the authors employ the word 'food waste' generically and used it interchangeably with food loss and food waste or both with human consumption in mind but at the end of the day, escaped the food supply chain. The

authors refer to food loss as losses in the supply chain or transportation inadequacy and market accessibility. Conversely, food waste reference is made to losses later on in the supply chain or related to individual actors' conduct.

The world view of FLW of 30% and beyond is considered disproportionate in the high but not the low-income economies. The remaining is the effect of over-production required for food security, particularly short-term resilience. In part, a considerable reduction of FLW is thought of as an essential step forward in helping ecosystem services, plus a significant reduction of GHG emissions from the food system, which is crucial for continuing resilience.

**II. MATERIALS AND METHODS**

Notwithstanding the difficulties of sampling bias, prejudice, and absence of applicability, a qualitative and descriptive case study methodology was chosen (Ridder, 2017; Yin, 2014) as it is apt for the assessment of a recent experience and the ambiguous confines between the context and the phenomenon of interest." (Yin, 2014, p. 16). The authors appreciate the need to develop trusted relationships with individuals as research respondents. Trust can alleviate the adverse consequences of societal acceptability preferences that may affect the quality of the primary data gathering on FLW. (Principato et al., 2018). The qualitative research and the descriptive case study methods, in part, prevail over the sensitivity and distrust

issues. In conducting this research, the authors borrowed Arksey&O'Malley's (2005) framework, which primarily comprises (a) determine the research questions, (b) find relevant articles, (c) choose relevant articles, (d) examine the data from the articles, and (e) gather, synthesize, and record the results.

This study was undertaken from 16 Dec 2020 to 7 Mar 2021. The research strategy starts with a comprehensive assessment of publicly available government documents, aside from consideration of existing literature that facilitated detecting agents of interest and understanding the food supply chain and, in particular, the FLW and fostering sustainability of food security. Consequently, individual interviews were organized by our research team. We know that food waste has high carbon, water, and ecological footprint; hence, an additional discussion was held with a local MNC (multinational company) with a history championing the quest for global food security, which presented a corresponding viewpoint stakeholder.

We adopted snowball sampling to gain access to respondents of interest in our assessment. All interviews were recorded with respondents' permission, facilitated by two research assistants, and scrutinized by the authors. The 18 respondents' summaries were presented but not in greater detail to honor individuals' confidentiality and safeguard anonymity (see Table 1).

**Table(1).Socio-demographic data (n=18)**

Demographic Variables	Categories	Frequencies	Percentage
Gender	Male	10	55.6
	Female	8	44.4
Higher Education	Postgraduate	6	33.3
	Undergraduate	10	55.6
	College/Diploma	2	11.1
Working Status	Permanent	7	38.9
	Contract	11	61.1
Working Experience	1 – 5 years	9	50.0
	6 – 10 years	6	33.3
	More than 10 years	3	16.7

All in all, 16 interviews of an hour each were completed. The interviews captured different and emergent views of sustainability:

1. The objections and disagreements that these proposals encountered were also tackled.
2. Eco-environment, as well as their effect and sustainability option.
3. Social networking sites were analyzed to establish the role of ICT (Infocom technology) as a means of community involvement concerning environmental and social responsibility.
4. Including reasons for participation and the nature of activities developed.

5. The degree of understanding of individuals concerning long-term food waste management and their mindset for it?
6. The extent correlation with the understanding of practical food waste management and views for it?

This research delves into two key factors that influence individual behavior vis knowledge and attitude (Westaby, 2005). It is thought that what people know about FLW will sway their opinions and force them to take appropriate measures.

From the self-directed survey, having no predetermined limit or boundary; A five-point Likert scale was applied to assess the depth of respondents' experience plus their

attitudes towards FLW management, which ranges from 1 for ‘strongly disagree’ to 5 for ‘strongly agree.’ Correspondingly, 15 elements on awareness about FLW were classified into four categories, for example, experience with reference to:

1. Cutting wastage of food.
2. FLW from meal planning.
3. Discarded food.
4. Restaurant/eatery plate waste.

As a supplement to the categories (15 elements) about mindsets towards FLW, an evaluation of the waste pyramid ranking with a particular emphasis on anticipation, recycle/repurpose, composting, energy-saving, and throwing away. Table 2 below describes these categories in detail regarding experience and mindset for managing FLW.

**Table (2). The detailed information regarding experience and mindset towards FLW**

Attributes/Traits	Construct Items	Description
Experience	Cutting wastage of food	Understanding about storing and procuring food items in connection with food waste reduction.
	FLW from meal planning	Basic food preparation; knowledge of food processing.
	Discarded food	Understanding of food-serving and preparing food safely.
	Restaurant/Eatery plate waste	Understanding of reducing plate waste.
Mindset	Anticipation	Involvement in vocational training on waste segregation
	Recycle/Repurpose	Inclination to donate or allowing workers to bring home fit-for-consumption leftover food.
	Composting	Desire to engage in compostable actions.
	Energy-saving	Ready for future development in the circular economy.
	Throwing away	Mentality on the concept of waste not; want not.

Additional to the interviews, a participatory observation that contained the field notes compilation, interactions, and pictures were undertaken. The triangulating of data from the three (3) sources is the triangulation of secondary literature reviews, observations, and inputs/comments of the interviewees. [Triangulation implies utilizing data and the information obtained through secondary research, getting a data series that complement each other by applying various categories of sources. Hence boosting the integrity of the study (Honorene, (2018).]

### III. RESULTS AND DISCUSSION

The numerous adverse environmental impacts on food consumption should be reduced to safeguard adequate food supply to sustain the growing world population. Knowledge of consumption patterns, in particular, sustainable-food consumption, is crucial for the survival of organizations. Hence, gravitating towards a more sustainable food consumption is required and imperative for our survival. Consequently, urgent measures are needed in the food value chain to manage demand, supply extra food, better control, and minimize FLW (Gorgitano&Sodano, 2014).

#### A. Awareness, knowledge, and attitude towards food waste management

A critical awareness of the significance of exploring FLW offers a basis for expanding sustainable strategies and programs to tackle the problem. Through education on FLW, the societal community can change their lifestyle (e.g., perceptions and attitudes) in this direction, conceivably generating behavioral modifications to lessen food waste consumption. Without a doubt, FLW continues to be a significant challenge in the city-state. It is an essential policy for the government to address and resolve

as currently in the flux of sustainability transition. FLW prevention generates a variety of complicated and entwined challenges with societal and political implications. There are also financial, ecological, and practical considerations. The findings suggest that developed and developing nations also encounter these challenges in Singapore. In contrast, several of these challenges are similarly experienced in countless nations associated with the sustainable food system. However, others may be very much reliant on native cultures.

The maxim of “waste not, want not!” is very much alive. Go green involves adopting a way of life or lifestyle that assists preserve the environment by reducing, reusing, and recycling items. Here, the focus is on reducing the waste of food. FLW in Singapore expanded by 40% over the last decade (NEA, 2019). This prompted the government to launch an ambitious policy objective to develop into a Zero Waste Nation before 2030, where FLW prevention is required to play an important role. According to Ong (2019), Singapore amazingly produced 800,000 tons of food waste in 2018, which can feed each person struggling with food security.

Interestingly, Singapore has few avenues for excess food redistribution from the FLW. Furthermore, it does not have a law to champion food donation to charitable foundations, lessening benefactors’ liability. Worst still, there is no data on food security supplied by the government (Glendinning et al., 2018). Even though measures taken by the government have been inadequate to helping charitable food provision, on the other hand, there is a budding number of citizen-led food redistribution leadership sprouting up. These initiatives underscore the value of the connection between individuals and locales, with a

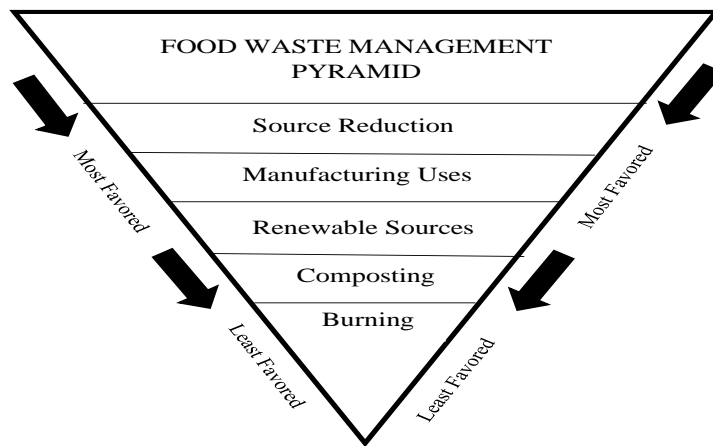
particular emphasis on ICT (Information Communication Technologies) as a critical technology facilitating community involvement.

It is worthy to note here that attempts to sign up broader publics in these surplus food redistribution initiatives to reduce FLW and encourage social transformation concerning food in Singapore. Keep in mind that when food is consumed, more food has to be sourced to satisfy the food demand and eventually impinge on food security because Singapore imports over 90 percent of its food supply (Foodwaste, 2021).

From the result of the interviews, several respondents raised major concerns centered around the extent of biodegradability (R7, R10, R15). Community food waste is

a global problem in waste disposal, particularly in Singapore. The physical characteristics of community food waste are unsuited to waste disposal sites and combustion due to subsequent impact on the environment and decreasing processing efficiency (R2, R5, R11-13). Since bio-energy is a valuable end product from Singapore’s standpoint, technology in co-digestion with other carrier materials is proposed. Nevertheless, there are four critical issues of FLW management, involving (i) low final product demand, (ii) ineffective waste management strategy, (iii) low-cost disposal handling, and (iv) poor community awareness (R1-4, R8, R13, R17-18). As a result, a food waste management pyramid is recommended (see Figure 1). For example, the most favored choices are source reduction, manufacturing uses, renewable sources, and composting then burning.

**Figure (1). Food Waste Management Pyramid (Authors’ adaptation)**



The National Environment Agency (NEA) also underlined the urgency of growing awareness and action on food waste reduction. It is heartening to know that more than 90% of people (consumers) are motivated not to waste food if it saves money and protects the environment (Elangovan, 2019). Of significance, being green is clearly about finding ways to reduce waste—likewise, water and whatever natural resources are not to be wasted (Lefko, 2017). Water is a part of food; it should be discerned that water must be conserved in the land or space-scarce Singapore. Since 2011, the water catchment area has pragmatically improved from half to two-thirds of Singapore’s land surface with the achievement of the Marina, Punggol, and Serangoon Reservoirs, making Singapore one of the rare nations in the world to harvest municipal stormwater on a massive scale for potable consumption (PUB, 2021).

**B. Environmental influences of food services – LovingYour Food @ Schools**

The Love, Your Food @ Schools Project aims to build a culture of not being wasteful among the youth and promote proper food waste management in Singapore (NEA, 2017; Foodwaste, 2021). The concept here is having students have fun, know more about the food management cycle

through an experiential trial. “Education,” “awareness,” and “mind change” are necessary as cited by respondents (R2-5, R8, R10, R12, R14-15), and it is good to start Singaporeans young. Being green is akin to educating (Lefko, 2017) and promoting the mind-growth of the people (Low &Teo, 2021). It is “an attitude of loving or valuing nature and one’s environment”; and “the acceptance (belief) that our survival is dependent on this welcoming, valuing or caring for nature and environment (as well as input or food for humankind)” (R3-6, R9, R18). All in all, the essence of “when one grows one’s vegetables, crops... food, one appreciates and values food as a whole. A farmer appreciates farming and its output. Children too have gardening plots and corners within their school compounds, and that makes them appreciate farming and food” is etched in the inputs from the respondents (R2, R4-5, R7-8, R12-14). It is said that such participation, education, involvement, and action-based ways are some, if not the keyways (Low, 2020) that undoubtedly influence the school children to love (and/or not to waste) their food.

Preventing FLW is an essential but challenging strategy that necessitates the engagement of various actors (not just students), and minimizing food waste in schools is feasible and crucial. Consumers see food waste as an unavoidable

aspect of consumption. The marketing by producers and sellers entice consumers to make impulse buying through attractive discounting or bundling and even up-selling, thus manipulating their buying choices, which will gravitate towards other waste. Respondents (R5, R7-9) suggested that one approach is to promote awareness (e.g., social norms) and the implications of food waste. Social norms could be engineered to cut food waste in schools. Other respondents (R10-12, R17) noticed that social pressure, incredibly guilty feelings, could be prompted by indications of insufficient efforts in curtailing FLW.

### **C. Significance of FW – using landfills**

Waste management in Singapore can be split into two classifications vis common waste and manufacturing waste. Common waste is akin to the often-used phrase “municipal solid waste” (MSW). This can also be categorized as bulk waste, such as unwanted equipment, biodegradable waste, scrap paper, garbage, household rubbish, toxic (or harmful) waste, food waste, and environmental waste. In part, FLW can be deemed as a particular biodegradable waste because of its biological components for valorization. But in the case of industrial waste, it is often implying as waste that is produced by industrial activities. In connection with this, the food waste may be generated from residential places (or non-industrial), for instance, homes, organizations, and other lodgings and commercial establishments (e.g., eateries, motels, resorts).

Unsurprisingly, several respondents (R2-3, R7, R11) noted that “restaurants often prepare or ready more food than they sell. “and groceries pull food off the shelf when it starts going to expire or going stale. “A lot of people prepare more food than what is necessary.” In Singapore, in 2015 alone, the amount of food waste produced reached 785,000 tons – about two rice bowls of food per person every day – only 13 percent of which was recycled. The remaining 87 percent was disposed of in landfills (Ecozonics, 2021; Foodwaste, 2021).

In island-Republic, the Semakau Landfill opened on 1 April 1999, is presently the country's only landfill facility. Covering an area of 350 hectares, it is anticipated to fulfill the island nation's solid waste disposal needs up to 2035 and beyond. In 2016, the landfill collected an average of 2,189 tonnes of Waste-to-Energy plant ash and non-incinerable waste daily. Steps are taken throughout the landfill's construction to safeguard the marine environment, such as the coral reefs along Pulau Semakau's western shore, which stay primarily undamaged. The two parcels of transplanted mangroves are also flourishing and can be viewed from the bund (NEA SW, 2021).

### **D. Approaches to FW management – Building up local R&D capabilities**

All the 18 respondents assert that “This is a big area with big potential... we can also grow our research and development (R&D) competencies and know-how.” The Singapore government has been rightly looking into R&D

possibilities and contemplating expanding pilot plants to experiment with ingenious approaches in reusing food waste. A case in point is that of the National Environment Agency (NEA). In collaboration with the Agri-Food & Veterinary Authority (AVA), to promote or motivate food manufacturers to undertake R&D projects in pioneering solutions like transforming soya bean waste into valuable products in the food chain. NEA plans to develop local R & D capabilities and create new solutions in administering food waste (Foodwaste, 2021).

Acknowledging Singapore's land and resource constraints, the Singapore Food Agency (SFA) has provided full support to local farmers, transforming the contemporary to technology and innovative ways to enhance production. For example, some farms utilize indoor multi-story LED lighting and recirculating aquaculture systems to generate 10 to 15 times higher than conventional farms. To facilitate the farms' growth and expansion, the SFA has launched co-funding schemes to offer financing support to farms developing and enlarging their manufacturing facilities and capacities. Furthermore, these farms are also backed by specialized administrators from SFA providing expertise and advisory on technology implementation and commercial development. From the SFA master plan perspective, the Lim Chu Kang precinct will be converted into a high-tech agri-food zone that can boost food output more sustainable and resource-efficient.

From banging on technology to R&D, the Singapore government collaborates with industry partners to boost output. It is imperative to optimize the agricultural land such as the Lim Chu Kang precinct to grow more with less sustainably. The introduction of circular economy principles (i.e., by-products of farms) may be used for different parts of the agri-food ecosystem. Conversely, it becomes increasingly essential for agri-food production. In retrospect, the government is contemplating how best to integrate and engage the public in educational farm tours.

One respondent (R4) was quoted as saying that this “added to the of attempts to make use of unconventional farming spaces, such as the rooftops of multi-story car parks, to overcome our land constraints.” Another beaming respondent (R7) recapitulated that “We are also exploring the extension of viable fish farming in the deeper Southern Waters of Singapore and transforming the coastal fish farms in the Straits of Johor to improve local fish production further.

### **E. Drivers of FW – Developing novel solutions to treat food waste**

The Singapore government established a pilot scheme to examine the feasibility of using on-site methods to handle food waste at hawker centers if there is an adequate and active involvement of the stallholders to separate the food waste. On-site food waste management methods have been adopted at seven hawker centers. The knowledge gained from the pilot cases will be used to identify more hawker centers and markets in effecting the food waste treatment

options, such as at Kampung Admiralty and Yishun Park hawker centers (Foodwaste, 2021). A zero-food waste system (ZFWS) handles food waste, turns it into composts (or biofuels), and lowers greenhouse gas emissions. The ZFWS not only reduces food waste but also reuses leftover food into compost. Based on a fermented-extinction method using bio wood chips (Oh & Lee 2018), the ZFWS can be used in a field experiment introduced in key hawker centers. The on-site ZFWS consists of three main sections: (i) a food waste slot into which food waste is injected; (ii) a fermented-extinction apparatus where food waste is blended with bio wood chips comprised of complex enzyme and aseptic wood chips; and (iii) sanitizing equipment in which an ultraviolet and ozone photolysis process is used.

According to FAO (Food and Agriculture Organization), hunger and nutrition social expenditures are incredibly high, considering that those are pillars for human health, security, and physical and mental development. Inefficient food waste management can have several adverse effects on people's health. Mainly, when waste is disposed of in open landfills, a considerable amount of food waste goes, they cause the spread of diseases.

Half of the respondents interviewed (R3-5, R8-9, R13, R15-17) argued that "it is also important to acknowledge and consider the reasons, as to why the wasting of food should be deemed as an unethical behavior."

Interestingly, one of Singapore's major banks, the Development Bank of Singapore (DBS), in 2020, supports social enterprises to launch a particular category of grants for innovative businesses working towards the Zero Food Waste annual Social Enterprise Grant Program. (e.g., technology, applications, novelties, products that cut down on food loss in the supply chain, and individuals handling excess food or change food waste to value-added products (DBS, 2021).

#### ***F. Tapping green opportunities***

Businesses that incorporate environmental goals in their corporate strategy or organizational culture are said to have a sustainable business model (Lüdeke-Freund & Dembek, 2017). Sustainable business models appeared as organic augmentations of earlier business model frameworks, e.g., the Triple-Bottom Line Business Canvas, combining societal and ecological importance to the Business Model Canvas (Joyce & Paquin, 2016).

Similarly, the Singapore government encourages and stirring companies to consider green opportunities and invest in green things. A subcategory of sustainable business models aims at applying the circular economy. The circular economy is a critical streamlining of the supply chain, where supplies do not flow in a linear manner (from use to discarding) but are continually reused.

These circular business models aim to remove waste streams and plug resource loopholes. As an illustration, it

involves lifetime products and technological resources, such as waste management and sustainable chemistry. One such case is Singapore's successful waste management company, 800 Super, set up in 2019. 800 Super (on Dec 2, 2019) officially opened its new integrated energy and resource recovery facility in Tuas South, which costs over \$130 million. Goh (2021) reported that no clean and green country or city could do without proper waste management. And today, it is said that (with the presence of such companies like 800 Super) Singapore can (help to) establish the benchmark for waste management and capture the growing circular economy market in the region. More so, Singapore's Minister for Trade and Industry, Chan Chun Sing (cited in Goh, 2021), also underscored the fact that this would help attract a new generation of engineers to join an "exciting" green industry, sometimes overlooked for its opportunities.

#### ***G. Extracting gold from food waste***

Vast amounts of food waste can be traced to global production. It is estimated that 30 percent of all food for human consumption is lost, causing enormous expenses for the worldwide economy besides considerable environmental concerns (Kumar & Longhurst, 2018). However, food waste can be a potential reservoir for highly functional molecules vis-à-vis carbohydrates, proteins, and lipids which can be retrieved and converted into high-value products. Recycling food waste into valuable chemicals enhances the switch from present fossil fuel-based economies to a bioeconomy, thus reducing waste. The second-generation valorization approach is where the bioproduction of chemical building blocks uses food waste as a "feedstock" (Kumar & Longhurst, 2018).

One Singapore insect farm harvests lucrative biomaterials from maggots. The Black soldier flies' maggots are renowned for their ability to consume food waste. And they can quickly increase their body mass. Up to 400 kilograms of food waste is broken down by hundreds of millions of these Black soldier larvae (YouTube, 2021). And using environmental-friendly methods, this Singapore insect company, Insecta, specializes in extracting chitosan (which has anti-inflammatory properties), melanin, and probiotics from these insects. The pigment melanin can also be processed to conduct electricity for use in electronics. And interestingly, the company is also using these insects to make probiotics for animal food (Insecta, 2020; YouTube, 2021). Insecta also produces fertilizers, other insect-derived products, and high-value biomaterials (Insecta, 2020).

As one of the respondents (R17) puts it this way, "An easy way to recycle food waste is to create nutrient-rich fertilizer. Household composting recycles food waste in an environment where there is an abundance of oxygen available. Fungi and bacteria break down the proteins, fats, and carbohydrates in the waste into compost and CO<sub>2</sub>." This is indeed positive, as it turns something unwanted and harmful into something positive and of high value.

### **H. Legislating**

It is undoubtedly critical for the government to be conscious of the need for a multilateral policy and go beyond a statutory agreement to accelerate implementation. Nevertheless, a statutory obligation for the community food supply chain can act as a significant responsibility for expanding and enhancing food supply to the community. Therefore, government contracts need to be combined with community distribution. A law that safeguards public access to food and allocates accountability and liability to force the government to take up the entire food supply chain issues, for instance, the actual food distribution to the manufacturing and consumption trends, ultimately guaranteeing food security. The most crucial point here is that such a law should ensure common access.

A landmark Resource Sustainability Act (RSA) enacted in October 2019 gives legislative effect to new measures to address Singapore's priority waste streams. The prerequisites relating to food waste are:

1. From 2021: Developers of significant business and manufacturing properties to allocate and set aside space for on-site food waste treatment systems in their design plans.
2. From 2024: Huge business and manufacturing food waste originators will have to separate their food waste for treatment (NEA 3R, 2021).

### **I. Redistributing**

Singaporeans love good food, but they also enjoy food that is not harmful to the environment. One respondent (R8) observed that "there was an increasing number of organic and sustainability-driven restaurants like Summerhouse or City Hall's Salted & Hung, which use locally-sourced, and responsibly fished ingredients." "Not to mention of the mushrooming organic foodstuff in the NTUC supermarket chain," echoed another respondent (R6).

Yet, the way that the food sector wastes ugly food produce has just been in the limelight of the public's awareness or realization. For example, in Singapore, fruits and vegetables are particularly infamous for going through a rigorous practice of "aesthetic or visual filtering" to be put on sale in supermarkets due to their perishability.

Fortunately, this triggers the citizen-led business enterprises, and that behind the ugly food is the core business of another chance to the "misunderstood" produce. Hitherto, these citizen-led enterprises have salvaged almost 90,000 units of production and created a variety of food products, e.g., teas, juices, ice creams, and popsicles. With additional F&B partnerships soon, it has been increasingly becoming a plausible business venture. In Singapore, the DBS's (Development Bank of Singapore) People of Purpose frequently volunteer with a charitable foundation like Food Bank Singapore to salvage ugly food and redistribute them to communities in dire need. The bank collaborates with Food Bank Singapore

and Food from the Heart to sort and pack bequeathed food items for redistribution to beneficiaries (DBS, 2021).

### **J. Sharing (Giving/Donating) food to others via Food Bank Singapore**

According to Low (2012, p.1), there is much truth in the Chinese hypothesis that "if you continuously give, you will continuously have." Accomplishment in leadership and, generally, in life about giving. It has been said that only as people learn to give do people learn to live. Additionally, it is precisely in giving happiness that people are likely to discover or obtain it. (Low, 2012). From the respondent's interview, many of them (R2-5, R7-10, R12-15, R17-18) accentuated that "sharing is caring," gives away or donates food, and exemplifies care for others. Extra or excess food is given away or shared with others, and "everyone wins."

Anyone can drop off their food donation in the food bank boxes at designated places. One of the enormous benefits of this is that it supports society by offering donated intact food that might otherwise have been wasted to people who may not have a constant food provision (the United States Environmental Protection Agency, 2021). In addition, it is evident that while giving food to others conserves energy and resources. Another advantage is that it lowers methane emissions from landfills and decreases the total carbon footprint. [Note that Food Bank is part of the Global Food-banking Network – an international food distribution non-profit that assists tackle hunger. Here, the organization collects and redistributes donated food items to (130) beneficiaries, handing the food to the needy (Zheng and Lee, 2017). Singapore has separate food bins for beverages, sauces, noodles, rice, spreads, and sugar/oil; snacks and dried food such as dried fruits, vegetables, and seafood.]

Interestingly, opportunities in social media platforms, such as apps and Facebook groups in which users donate free food products, are becoming increasingly popular in Singapore (Lock, 2019). And this is good; after all, the app is available for free, and users do not have to pay for posting or collecting food items. There is also treasure. That is, treat food as treasure! For example, Singapore's first mobile reservation platform connects businesses and hotels with surplus food to everyday consumers (Treasure 2021), thus minimizing food wastage.

### **K. Having a role for all of us**

Ecoconics (2021) asserts that every small part supports the preservation of our ecosystem. There is no better way to help than teach Singapore's future about environmental sustainability and eco-friendliness. Through educational programs intended to encourage green practices and behaviors in schools and demonstrate to students that everyone can play their role in preserving the environment. Food companies have to play their part; even Nespresso uses ground coffee, and the latter becomes or is turned into fertilizer. In cultivation, compost produced from the used coffee fields is remarkably resourceful, offering abundant benefits such as improved soil drainage, water retention,



and aeration. Besides, they acidify the soil, acting as a natural repellent that prevents pests from destroying crops (Sustainability Nespresso, 2021).

Technological innovation is especially relevant to worries voiced by respondents (R1, R4) as a consequence of their analysis and appraisal of the food chain. Furthermore, technology supports businesses with tools to improve food waste valorization opportunities. Another respondent (R6) contended that composting is the best way to reduce food waste. Composting is an aerophilic process vis it requires air, decomposing organic solid wastes. It can consequently be used to recycle organic material. The process includes decomposing organic material into a humus-like material, commonly referred to as compost, a good fertilizer for plants.

Lim (2021) revealed that Singapore has been planning for long-term food security through the strategy of "three food baskets," which include (a) diversifying food sources, (b) growing locally, and (c) growing overseas. Firstly, the concept here is diversified sourcing. Singapore's food traders took advantage of the city-state's connectedness and the worldwide free market ecosystem in importing from different sources around the world. To prevent interruption to any one source, importers can exploit other food sources and guarantee supply stability, secondly, as a local production which can be an essential buffer. To enable and help the hi-tech and productive farms in Singapore, SFA (Singapore Food Agency) tenders out land depending on the qualitative benchmarks, for example, production capability, production track record, relevant experience and qualifications, innovation, and sustainability.

Furthermore, these efforts can develop Singapore's agri-tech sector, transforming the local agri-tech companies into champions and expanding overseas. Thirdly, by exploring alternative and underutilized spaces. By revitalizing and reconfiguring rooftops and underutilized areas in the cityscape, farming is becoming a reality. In metropolitan

Singapore, other areas such as rooftops of car parks are being modified for urban agriculture. Ultimately, in managing environmental variables for augmented increase. Swift advances in agri-tech catapulted sustainable municipal food production. One illustration is Eco-Ark, a custom-built, moving, closed-containment aquaculture system. Eco-Ark maintains fish in containers separated from the external environment, so the changes in temperature and oxygen can be monitored and regulated. This provides a safeguard against plankton blooms, oil spills, waste discharge, and warming waters, all factors that can destroy fish stockpiles (Lim, 2021). With technology, ocean water and used water are treated and recycled efficiently. Several respondents (R1-3, R9-11, R17) resonated, "with sophisticated automated and digitalized techniques gradually being employed in farming, Singapore's commercial farming has also become pioneering "agri-engineers" and experts in its own right."

Finally, in shaping a sustainable food waste management plan is to appraise the form and extent of wastage. When waste amounts and the corresponding stage in the food supply chain are identified, it is now feasible to launch a successful waste management strategy. However, a number of significant factors should be considered before successful waste management can be achieved, as seen in Figure 2, for example:

1. Government administration, legislature, economic sustainability
2. Civic involvement, education, attitude, user-friendliness
3. Application of waste products, municipal recognition, A&P (advertising & promotion) drive
4. Cost versus value assessment
5. Local facilities, operating costs, supply chain, logistics
6. Review of waste sources, supply (pre-and post-harvest), wholesalers, retailers, food service providers, households

**Figure (2). Key factors for the efficient use of a food waste-based product**



#### IV. INADEQUACIES AND OPPORTUNITY FOR FUTURE RESEARCH

In this paper, the authors applied a theoretical approach to construct and describe the complex relationships between various actors and adjustments to the food supply and its system, centering on collaborations between involvements aimed at FLW and food security. This approach was based primarily on the encounters and understanding of the experts involved. As far as possible, the authors sought to establish the decisions on the possible causes and impacts on observed records; nonetheless, this has not been possible for each identified connection.

Furthermore, while the authors endeavored to be inclusive by adopting a systemic approach, specific significant linkages may be entirely overlooked, which could be enhanced in the future by requiring a broader spectrum of stakeholders in the system-mapping development. Nevertheless, the authors are convinced that this approach and their findings have value and will provide a foundation for future research on these conundrum fundamentals to the circular economy. Future research themes identified are summarized in Table 3.

**Table (3). Future research themes on Food Waste Management**

SN	Suggested Themes	Research Issues
1	Food wastage in the low, medium, and high-income countries	Is food wastage more significant amongst the less privileged? Are there unique reasons that facilitated them to waste food?
2	Emotions and food waste	Can positive feelings (e.g., joy and love) impair food waste? How do negative sentiments (e.g., regret and distress) link to waste?
3	Social relationship and food waste	Are communally bonded family circles consuming more or less food? What triggers and alleviates food waste in such situations?
4	Communications ideas for alleviating food wastage	Do users react well to convincing methods or indirect messages? How likely are users to accept new technologies (e.g., app) and be manipulated through them?
5	The role of religion (or culture) in food wastage	Are users that are more devout less wasteful? Do more devout people feel more responsible when food is wasted? Are there important distinctions between various religious customs?
6	Food abundance and food wastage	Is an abundance of food promoting food waste? How do the various aspects of food abundance influence food waste?

#### V. Concluding remarks

The Singapore Green Plan 2030, released by five ministries on Wednesday (10 Feb 2021), would help chart and advance the island republic's way towards a more sustainable future over the next ten years (Tan, 2021). As a result, Singapore will be greener and more sustainable, cutting daily waste sent to the landfill by 20 percent per capita by 2026 and 30 percent per capita by 2030 (Big Story, 2021). The Plan also aims to reduce the daily household water consumption to 130 liters by 2030, down from 141 liters in 2019 (Big Story, 2021).

The green or sustainability industry can indeed be stimulating. And in being and handling greenness as a way forward, lessons learned here are that all of us should be adaptable, embracing mind-growth; these are indeed

needed. We should be open-minded, participative and proactive, flexible, making full use of our gifts and strengths, and capitalizing on new opportunities for our sake and the sake of our future generations and that of our Mother Earth.

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The authors declare no conflict of interest.

#### REFERENCES

- [1] Ackrill, R., Abdo, H., On-farm anaerobic digestion uptake barriers and required incentives: a case study of the UK East Midlands region. *Journal of Cleaner Production*, 264 (2020) 121727.
- [2] Adams, R., Jeanrenaud, S., Bessant, J., Denyer, D., Overy, P., Sustainability-oriented innovation: A systematic review. *International Journal Review*, 18 (2016) 180–205.
- [3] Arksey, H., & O'Malley, L., Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology*, 8(1) (2005) 19–32.
- [4] Baron, S., Patterson, A., Maull, R., & Warnaby, G., Feed people first: a service ecosystem perspective on innovative food waste reduction. *Journal of Service Research*, 21 (2018) 135–150.
- [5] Beretta, C., Stoessel, F., Baier, U., & Hellweg, S., Quantifying food losses and the potential for reduction in Switzerland. *Waste Management*, 33(3) (2013) 764–773.
- [6] Big Story. The Big Story (2021, March 12). Parliament Singapore's sustainability plans: Greener Tomorrow. *The Straits Times*, (2021) A10.
- [7] Block, L., Keller, P., Vallen, B., Williamson, S., Birau, M., Grinstein, A., Haws, K., La Barge, M., Lamberton, C., Moore, E.,

- Moscato, E., Reczek, R., Tangari, A., The squander sequence: Understanding food waste at each stage of the consumer decision-making process. *Journal of Public Policy and Marketing*, 35(2) (2016) 292–304.
- [8] Cattaneo, A., Federighi, G., & Vaz, S., The environmental impact of reducing food loss and waste: A critical assessment. *Food Policy*, 98 (2021).
- [9] Cecchi, F., & Cavinato, C., Smart approach to food waste final disposal. *International Journal of Environmental Research and Public Health*, 16 (2019) 2860.
- [10] Corsini, F., Certomà, C., Dyer, M., & Frey, M., Participatory energy: Research, imaginaries, and practices on people' contribute to energy systems in the smart city. *Technological Forecasting and Social Change*, 142 (2019) 322–332.
- [11] Dahiya, S., Katakajwala, R., Ramakrishna, S., & Mohan, S.V., Biobased products, and life cycle assessment in the context of circular economy and sustainability. *Materials Circular Economy*, 2(1) (2020).
- [12] Dahiya, S., Kumar, A.N., Sravan, J.S., Chatterjee, S., Sarkar, O., & Mohan, S.V., Food waste biorefinery: Sustainable strategy for circular bioeconomy. *Bioresour Technol*, 248 (2018) 2–12.
- [13] DBS. Towards zero food waste. [dbs.com. https://www.dbs.com/sustainability/zero-food-waste](https://www.dbs.com/sustainability/zero-food-waste)
- [14] Ecomonics, Food waste management in Singapore. *Ecomonics*, (2021). <https://www.ecomonics.com.sg/food-waste-management/>
- [15] Elangovan, N., Singaporeans are learning to reduce food waste: NEA survey. [Today. https://www.todayonline.com/singapore/singaporeans-are-learning-reduce-food-waste-nea-survey](https://www.todayonline.com/singapore/singaporeans-are-learning-reduce-food-waste-nea-survey), (2019).
- [16] Eriksson, M., Osowski, C. P., Björkman, J., Hansson, E., Malefors, C., Eriksson, E., & Ghosh, R., The tree structure—A general framework for food waste quantification in food services. *Resources, Conservation & Recycling*, 130 (2018) 140–151.
- [17] FAO. Key facts on food loss and waste you should know (2018). <http://www.fao.org/savefood/resources/keyfindings/en>
- [18] FAO. Food waste footprint. Impacts on natural resources. Summary report. Rome, (2013).
- [19] Food waste. [Food waste. https://www.towardszerowaste.gov.sg/foodwaste/#:~:text=Food%20waste%20is%20one%20of,around%2051%2C000%20double%20decker%20buses,](https://www.towardszerowaste.gov.sg/foodwaste/#:~:text=Food%20waste%20is%20one%20of,around%2051%2C000%20double%20decker%20buses,) (2021).
- [20] Glendinning, E., Shee, S. Y., Nagpaul, T., & Chen, J., Hunger in a food lover's paradise: Understanding food insecurity in Singapore. [https://ink.library.smu.edu.sg/cgi/viewcontent.cgi?article=1011&context=lien\\_reports](https://ink.library.smu.edu.sg/cgi/viewcontent.cgi?article=1011&context=lien_reports), (2018).
- [21] Goh, G. Singapore can set the region's standards for waste management: Chan Chun Sing', *The Business Times*. <https://www.businesstimes.com.sg/government-economy/singapore-can-set-the-regions-standards-for-waste-management-chan-chun-sing>, (2021).
- [22] Gorgitano, M.T., & Sodano, V., Sustainable food consumption: Concept and policies. *Calitatea*, 15 (2014) 207–212.
- [23] Gustavsson, J., C. Cederberg, U. Sonesson, R., Otterdijk, & Meybeck, A., *Global Food Losses and Food Waste*. Food and Agriculture Organization, Rome, Italy, (2011).
- [24] Hebrok, M., & Boks, C., Household food waste: Drivers and potential intervention points for design—an extensive review. *Journal of Cleaner Production*, 151 (2017) 380–392.
- [25] HLPE. Food losses and waste in the context of sustainable food systems. Rome, (2014). <http://www.fao.org/3/a-i3901e.pdf>.
- [26] Honoree, J., Understanding the role of triangulation in research. *Scholarly Research Journals*, 4(6) (2018).
- [27] Insecta. Little creatures; big change. <https://www.insecta.com>, (2020).
- [28] Jose, R., Panigrahi, S.K., Patil, R.A., Fernando, Y., & Ramakrishna, S. Artificial intelligence-driven circular economy as a key enabler for sustainable energy management. *Materials Circular Economy*, 2(1) (2020).
- [29] Joyce, A., & Paquin, R.L., The triple layered business model canvas: a tool to design more sustainable business models. *Journal of Cleaner Production*, 135 (2016) 1474–1486.
- [30] Klewitz, J., & Hansen, E.G., Sustainability-oriented innovation of SMEs: A systematic review. *Journal of Cleaner Production*, 65 (2014) 57–75.
- [31] Kumar, V., & Longhurst, P., Recycling of food waste into chemical building blocks. *Current Opinion in Green and Sustainable Chemistry*, 13 (2018).
- [32] Lefko, M., *Global sustainability*, Morgan James Publishing, (2017).
- [33] Lim, K. T., Singapore: Food security despite the odds. *Food for Thought – a digital publication by Singapore Food Agency*, (2021).
- [34] Lim, W.J.; Chin, N.L.; Yusof, A.Y.; Yahya, A.; Tee, T.P., Food waste handling in Malaysia and comparison with other Asian countries. *International Food Research Journal*, 23 (2016) S1–S6.
- [35] Lock, C., Don't throw it away, share it: Sharing platforms gaining popularity in Singapore. *The Straits Times*, (2019). <https://www.straitstimes.com/lifestyle/dont-throw-it-away-share-it>
- [36] Lohnes, J., & Wilson, B., Bailing out the food banks? Hunger relief, food waste, and crisis in Central Appalachia. *Environment and Planning A: Economy and Space*, 50 (2018) 350–369.
- [37] Low, K. C. P., (2nd ed.). *Successfully Negotiating in Asia – 36 Success Pathways to Arguing Well and Dealing with Various Negotiator Types*, Springer, (2020).
- [38] Low, K. C. P., Cleanliness is next to Godliness – The Bhutan Perspective. *International Journal of Business and Social Science*, 10(4) (2019) 155 – 166.
- [39] Low, K. C. P., Success in Leadership is in Giving [Are Leaders Giving Enough?]. *Global Education Journal*, 2012(1) (2012) 1 – 10.
- [40] Low, K.C.P. and Teo, T.C., The 7Ps in corporate social responsibility – Insights from explorative case studies in Singapore. *SSRG International Journal of Humanities and Social Science*, 8(3) (2021) 35–41.
- [41] Lüdeke-Freund, F., & Dembek, K., Sustainable business model research and practice: emerging field or passing fancy? *Journal of Cleaner Production*, 168 (2017) 1668–1678.
- [42] Maina, S., Kachrimanidou, V., Koutinas, A., A roadmap towards a circular and sustainable bioeconomy through waste valorization. *Current Opinion in Green and Sustainable Chemistry*, 8 (2017) 18–23.
- [43] Malefors, C., Callewaert, P., Hansson, P. A., Hartikainen, H., Pietiläinen, O., Strid, I., Strotmann, C., & Eriksson, M., Towards a baseline for food waste quantification in the hospitality sector—Quantities and data processing criteria. *Sustainability*, 11 (2019) 3541.
- [44] Martín-Rios, C., & Ciobanu, T., Hospitality innovation strategies: An analysis of success factors and challenges. *Tourism Management*, 70 (2019) 218–229.
- [45] Martín-Rios, C., Demen-Meier, C., Gössling, S., & Cornuz, C., Food waste management innovations in the foodservice industry. *Waste Management*, 79 (2018) 196–206.
- [46] Ministry of Environment (MOE, Korea). Ministry of Environment; MOE: Seoul, Korea, (2015), 20 April (2020). <http://eng.me.go.kr/eng/file/readDownloadFile.do?fileId=115224&fileSeq=1&openYn=Y>
- [47] MSE Ministry of Sustainability and the Environment. Food waste. <https://www.towardszerowaste.gov.sg/foodwaste/> (2021).
- [48] NEA., Food waste management. <https://www.nea.gov.sg/our-services/waste-management/3r-programmes-and-resources/food-waste-management> ., (2019).
- [49] NEA 3R., 3R Programmes, and Resources. <https://www.nea.gov.sg/our-services/waste-management/3r-programmes-and-resources/food-waste-management> ., (2021).
- [50] NEA SW., Solid Waste Infrastructure', National Environmental Agency (NEA). <https://www.nea.gov.sg/our-services/waste-management/3r-programmes-and-resources/waste-management-infrastructure/solid-waste-management-infrastructure> (2021).
- [51] NEA., NEA Launches 'Love Your Food @ Schools' Project To Encourage Youth To Cherish And Not Waste Food'. <https://www.nea.gov.sg/media/news/news/index/nea-launches-love-your-food-@-schools-project-to-encourage-youth-to-cherish-and-not-waste-food> ., (2017).
- [52] Oh, J., & Lee, H., Exploring a zero-food waste system for sustainable residential buildings in urban areas. *Environmental Engineering Research*, 23(1)(2018).

- [53] Ong, A. I., Legislating food waste. We can do more. <https://medium.com/@antheaindiraong/legislating-foodwaste-we-can-do-more-2b711ec9be6c> ., (2019).
- [54] Ong, K.L., Kaur, G., Pensupa, N., Uisan, K., & Lin, C.S.K., Trends in food waste valorization for the production of chemicals, materials and fuels: Case study South and Southeast Asia. *Bioresource Technology*, 248 (2018) 100–112.
- [55] Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, 360, 987–992.
- [56] Principato, L., Pratesi, C., & Secondi, L., Towards zero waste: An exploratory study on restaurant managers. *International Journal of Hospitality Management*, 74 (2018) 130–137.
- [57] PUB., Water from the local catchment. <https://www.pub.gov.sg/watersupply/fournationaltaps/localcatchmentwater> ., (2021).
- [58] Richie, J. and Lewis, J., *Qualitative Research Practice: A Guide for Social Science Students and Researchers*. Sage Publications., (2003).
- [59] Ridder, H.-G., The theory contribution of case study research designs. *Business Research*, 10(2) (2017) 281–305.
- [60] Schanes, K., Dobernik, K., & Gözet, B., Food waste matters-A systematic review of household food waste practices and their policy implications. *Journal of Cleaner Production*, 182 (2018) 978–991.
- [61] Sustainability Nespresso., Used coffee grounds make rich fertilizer. The Positive Cup. <https://www.sustainability.nespresso.com/value-in-used-coffee-grounds> ., (2021).
- [62] Tan, A., Singapore Green Plan 2030 to change the way people live, work, study and play. *The Straits Times*. <http://www.straitstimes.com/singapore/environment/singapore-green-plan-2030-to-change-the-way-people-live-work-study-and-play> (2021).
- [63] Tan, J. and Liu, V., Scaling towards zero food waste in fish-farming. *Sunday Times*. <https://www.dbs.com/livemore/serious-talk/scaling-towards-zero-food-waste-in-fish-farming.html> (2020).
- [64] Trashhero., Food Waste is Not Garbage! [https://trashhero.org/food-waste-is-not-garbage/?gclid=EAIaIQobChMIypbBwYrI7wIVkzUrCh0RQqjIEAAYAiAAEgJ8FfD\\_BwE](https://trashhero.org/food-waste-is-not-garbage/?gclid=EAIaIQobChMIypbBwYrI7wIVkzUrCh0RQqjIEAAYAiAAEgJ8FfD_BwE) (2019).
- [65] Treatsure., Sharing food in the circular economy. <https://www.treatsure.co> (2021).
- [66] (UN) UN., Transforming our world: the 2030 agenda for sustainable development. United Nations, New York, NY, <https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf>. (2015).
- [67] USDA Natural Resources Conservation Service. Mulching. [https://www.nrcs.usda.gov/wps/portal/nrcs/detail/?cid=nrcs143\\_023585#:~:text=Mulch%20is%20simply%20a%20protective,inorganic%20mulches%20have%20numerous%20benefits](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/?cid=nrcs143_023585#:~:text=Mulch%20is%20simply%20a%20protective,inorganic%20mulches%20have%20numerous%20benefits). Accessed (2021).
- [68] Vandermeersch, T., Alvarenga, R., Ragaert, P., Dewulf, J., Environmental sustainability assessment of food waste valorization options. *Resources, Conservation & Recycling*. 87 (2014) 57–64.
- [69] Wen, Z., Wang, Y., & De Clercq, D., What is the true value of food waste? A case study of technology integration in urban food waste treatment in Suzhou City, China. *Journal of Cleaner Production*, 118 (2016) 88–96.
- [70] Wen, Z., Hu, S., De Clercq, D., Beck, M. B., Zhang, H., Zhang, H., Fei, & F., Liu, J., Design, implementation, and evaluation of an Internet of Things (IoT) network system for restaurant food waste management. *Waste Management*, 73 (2018) 26–38.
- [71] Westaby, J. D., Behavioral reasoning theory: Identifying new linkages underlying intentions and behavior. *Organizational behavior and human decision processes*, 98(2) (2005) 97-120.
- [72] Yin, R. K., *Case study research: Design and methods* (5th edition). Sage., (2014).
- [73] YouTube., Maggots convert food waste to gold at Singapore insect farm. YouTube. <https://www.youtube.com/watch?v=wLQdVL4VZs> (2021).
- [74] Zheng, Z. and Lee, J. (2017, March 5). 5 Ways you can share excess food with the needy and Reduce food waste in Singapore. Mothership. <https://mothership.sg/2017/03/5-ways-you-can-share-excess-food-with-the-needy-and-reduce-food-waste-in-singapore/>