A Circular Capability Framework to address food waste and losses in the agri-food supply chain: The antecedents, principles and outcomes of Circular Economy

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Abstract

Food loss and food waste (FLW) within agri-food supply chains in the developing world remains a perennial problem. This is partly due to the lack of knowledge on how business operations within supply chains contribute towards the FLW issue, particularly in the case of small and medium-sized enterprises (SMEs). Circular Economy (CE) has been heralded as an appropriate pathway for businesses towards reduction of FLW, however, the practical realities of how the CE can be best employed remains unclear. This paper fills this knowledge gap by studying growers, distributors and retailers in the agri-food supply chain, in order to develop a Circular Capability Framework. The findings generate unique insights into FLW understandings, causes and mitigation strategies to provide a detailed, developing world relevant food waste hierarchy. The novel framework we propose can aid participation in the CE by conceptualising CE antecedents as business capability pathways, set out as eight propositions.

Keywords: Circular Economy; Food Loss; Food Waste; Natural Resource Based View; SMEs

1. Introduction

With the global population expected to grow by 3 billion in the next 30 years (World Bank, 2020), actors across food supply chains are facing increasing pressure to keep pace with fruit and vegetable demand (Chen, Chaudhary, & Mathys, 2020). However, food loss and food waste (FLW) is a significant and increasing challenge as the world's population continues to increase and there is an expanding requirement for sufficient, healthy food. Whilst total food production exceeds demand (Messner, Johnson, & Richards, 2020), distribution is unequal and many people lack access to sufficient sustenance and face hunger while others' habits are wasteful (Food and Agriculture Organization [FAO], 2019; Movilla-Pateiro, Mahou-Lago, Doval, & Simal-Gandara, 2020).

FLW occurs at various nodes within food supply chains with 30% of the world's total food production being wasted or lost for a wide range of reasons (World Bank, 2020). FLW results in a loss of the resources, energy and time invested in food production (Krishnan, Agarwal, Bajada, & Arshinder, 2020). FLW can cause an increase in food prices (due to reduced supply), which in turn prevents access to affordable food (Shafiee-Jood & Cai, 2016). FLW is also a leading cause of greenhouse gas (GHG) emissions (Schanes, Dobernig, & Gözet, 2018) originating from the decomposition of food in landfill and the needless emissions generated in growing, transporting and retailing food that is eventually wasted (Segrè, Falasconi, Politani, & Vittuari, 2014).

It is noteworthy that in the developing world, a significant proportion of companies operating in the agri-food supply chain (and a substantial part of the FLW problem) are small and medium-sized enterprises (SMEs) (Jose & Shanmugam, 2020). There is, however, limited research exploring how SMEs' operations generate food waste. This under-representation of SMEs is problematic as it results in a partial understanding of the global picture with respect to food waste. For example, the food waste hierarchy is a widely used concept in academic and practitioner work, but it can be critiqued as it fails to consider the nuances and challenges present in developing countries (Papargyropoulou, Padfield, Rupani, & Zakaria, 2014b). Furthermore, there is a lack of appreciation of informal waste infrastructures and an absence of awareness of the FLW issue within wider society (Soma, 2017).

The Circular Economy (CE) has been heralded as a strategy to tackle our unsustainable use of resources and enable businesses to better understand the natural inputs that sustain them.

Employing CE principles, such as waste valorisation, cost reduction, and greater efficiency in resource use, offers significant opportunities for reducing FLW (Ellen MacArthur Foundation [EMF], 2013; Garcia-Garcia, Stone, & Rahimifard, 2019; Prieto-Sandoval, Jaca, Santos, Baumgartner, & Ormazabal, 2019; Rizos et al., 2016). Whilst agri-food businesses are increasingly becoming more aware of the benefits of increasing their efficiency of resource use, there is a wider failure to connect such actions with a sustained engagement in CE (Rizos et al., 2016). Therefore, there is a compelling need to understand how the environmental management capabilities of businesses can better align short-term reactive economic decision making with longer-term views of better resource management in line with CE engagement.

Given that FLW can be viewed as a waste of natural resources (Kummu et al., 2012), there is potential for businesses to apply practices of eliminating food waste for greater competitiveness (Rodrigues, Demir, Wang, & Sarkis, 2021) by considering the adoption of CE principles. In this way, tackling FLW across the supply chain means a boost to efficiency for SMEs (Buzby & Hyman, 2012; Wunderlich, & Martinez, 2018), in the pursuit of achieving sustainable production and consumption (Govindan, 2018). SMEs can gain competitive advantage by considering their resource requirements and capabilities to better manage their environmental inputs (Barney, 1991; Hart, 1995).

This research fills a CE knowledge gap with regards to the link between levels of understanding of CE principles and effective CE implementation. As indicated by relevant research (Dora, Biswas, Choudhary, Nayak, & Irani, 2021) the prevention of FLW through the lens of the CE is a reasonably new concept, therefore new theories are required to comprehend the bridge between CE principles and CE implementation. Dora et al. (2021) argues that a theoretical research gap is exemplified by the fact that, to date, CE research has been largely confined to journals devoted to the environment sciences. It is surprising that no article on the subject has been published in any mainstream economics or management journal focusing on the food supply chain. This indicates that no critical assessment of the CE paradigm and its economic and managerial implications for SMEs in the context of FLW has been conducted to date.

Our central research question in this paper is double-pronged: "*How can SMEs within the agri-food supply chains in the developing world incorporate CE to tackle FLW problems, and what capabilities and resources do they need to possess?*" Addressing these questions is fundamentally important on theory and practice-development grounds and, for that reason, we propose a framework which conceptualises how such businesses can better understand and

mitigate FLW through the adoption of CE strategies. The framework links together the antecedents of CE principles to the outcomes of CE, which are postulated as the key performance indicators of FLW reduction in the agri-food supply chain, whose actors are predominantly SMEs.

This paper contributes to the body of knowledge by extending the organisational theory of strategic management Natural Resource Based View (NRBV) to study the CE phenomenon in tackling FLW. NRBV has been employed to examine environmental practices and holds common features with CE, such as considering the underlying motives driving the extensive use of natural resources and the associated environmental impacts. Specifically, this paper explores how the NRBV capabilities provide a necessary focus upon the antecedents required to ensure effective implementation of CE principles in relation to FLW; this has not been extensively discussed in academic literature and therefore represents an important contribution from our research.

This research is contextualised by the increasing challenges being faced by the agri-food sector in developing countries, with respect to the imperative to feed an increasing population and simultaneously reduce FLW within supply chains (Joshi & Visvanathan, 2019; Kumar, Mangla, Kumar, & Karamperidis, 2020). Our research focuses on Indonesia, a developing country with increasing urbanisation and the fourth most populous globally (Statista, 2020), and estimated to be responsible for the second highest levels of global FLW per capita (Economist Intelligence Unit, 2016).

The remainder of this paper comprises six sections. The next section reviews the academic literature that analyses FLW in the developing world, waste mitigation strategies and the employment of CE strategies in this context, noting their key outcomes. The theoretical lens underlying this research is then introduced and based on this lens, an initial framework that guides the execution of the empirical work is presented. We then discuss the methodology, explaining the research design and data collection, before the presentation of the findings detailing the understanding, causes, and mitigation practices of growers, distributors and retailers. This then leads to a formulation of several propositions that position SMEs' capabilities as antecedents of the CE. The paper concludes by affirming the contributions being made to knowledge, the implications of the framework for practice and suggestions for future research.

2. Literature review

2.1. Food loss and food waste in the developing world

FLW can be defined and measured in different ways and units, which vary according to country and research focus (see Buzby & Hyman, 2012; Liu, 2014; Papargyropoulou, Lozano, Steinberger, Wright, & Ujang, 2014a). As Jurgilevich et al. (2016: p. 6) note "the estimates of food waste differ throughout literature depending on the definition and what is counted", this paper therefore sought a definition that encompasses both food loss and food waste. The FAO (2019) defines food loss as the edible food that is lost during production and distribution, while food waste refers to food discarded at the retailer and consumer levels. In this article, we adapt this definition such that food loss and food waste (FLW) encapsulates food loss at sites of primary production and distribution, and food waste from distribution to the retailer.

Strategies to tackle food waste vary in terms of where in the agri-food supply chain they focus but concur that preventing food from becoming waste is the most preferable action over reducing the food waste material (Papargyropoulou et al., 2014a; Teigiserova, Hamelin, & Thomsen, 2020). Research has explored the valorisation of agri-food waste, such as the production of value-added products which mainly focus on bioactive compounds (Ben-Othman, Jöudu, & Bhat, 2020; Garcia-Garcia et al., 2019). Waste management technologies include anaerobic digestion, incineration, and animal feed production (Girotto, Alibardi & Cossu, 2015; Padolecchia et al., 2018). The scope of these interventions is represented in the food waste hierarchy (Papargyropoulou et al., 2014a), a much-used concept which signifies preference for preventative actions over reduction actions and prioritises avoidance of the least efficient outcome, i.e. sending food waste to landfill.

In developing countries, mitigating FLW has largely been focused on production (Hodges, Buzby, & Bennet, 2011). This aligns with the agricultural base of the countries' economies and the lack of technological and logistical input into food supply chains in such regions (World Bank, 2020). Furthermore, the rapid rate of urbanisation in Southeast Asia is transforming consumption markets and increasing the demand for quality, retail accessible products, thus increasing the generation of waste (United Nations [UN], 2017). Notwithstanding the extant waste management strategies, such as animal feeding, anaerobic digestion and composting (Thi, Kumar, & Lin, 2015), research seems to overlook the consequential links between businesses operating within the supply chain and the potential for tackling FLW with

interventions further up in the food waste hierarchy (Li, Peng, Wang, & Wu, 2018; Maina, Kachrimanidou, & Koutinas, 2017).

In Indonesia, there are more than 55 million SMEs employing around 97% of the entire country's workforce and dominating the agricultural sector (Martdianty, Coetzer, & Susomrith, 2020). These SMEs contribute around 57 percent of Indonesian GDP (BPS, 2017). Having understood the important role of SMEs in the agri-food sector, businesses have been found to be undertaking a range of actions to move towards more sustainable pathways. This includes an examination of material flows and energy use, in terms of how value adding and cost reduction within production processes affect the supply chains at all levels, resulting in increased competition through revised business structures, strategy conditions and product development, among other factors (Esty & Porter, 1998). With a greater understanding linked to a specific efficiency gaining strategy, notably better resource use in reducing and preventing food waste, further knowledge must be gathered on how SMEs can best operate in a competitive manner and, moreover, progress sustainable supply chain arrangements (Martdianty et al., 2020; Kivimaa & Kern, 2016).

There has been a lack of comprehensive research examining how food waste arises within agri-food supply chains in Indonesia, particularly with regard to how businesses understand and operationalise the concept of FLW. For example, whilst recovery of FLW material to generate bio-fertilisers has been promoted (Thi et al., 2015), what has been overlooked is how more modern systems of food retailing, over traditional forms of localised agriculture, are impacting upon FLW. Soma (2017: p. 432), for example, states in her study of the waste infrastructure in Bogor, Indonesia, that "urbanization causes a distancing process that results in a more complex, long distance food supply chain and presents significant challenges to the sustainable management of food waste". It is this transitioning point within the agri-food supply chain that requires further study, to capture how food waste is understood, caused and managed and the need to provide a working, and relevant, developing world framework for more sustainable production and consumption.

2.2. Application of the Circular Economy to the problem of FLW

The CE is a concept that illustrates the sustainability potential of moving to a more circular model of material use to replace the existing linear 'make, use and dispose' approach. There is an imperative to ease the burden currently being placed on ecosystems through resource use,

avoid further increases in emissions and achieve greater efficiency in business operations (Patwa et al., 2021; Rizos et al., 2016). Achieving these goals requires a major paradigm shift incorporating actions of prevention, reduction and recovery of waste, the re-circulation of resources, energy and extraction of value, as a pathway to sustainable development (Ghisellini, Cialani, & Ulgiati, 2016; Kristensen & Mosgaard, 2020).

Research on how the CE has been adopted to solve food supply chain and waste issues has highlighted a process of social and technical transition. Jurgilevich et al. (2016) explain how CE approaches can revise nutrients' flows, from the recovery of nutrients from farmers' wastewater, to modifying consumer purchasing patterns towards less nutrient-embedded food sources, such as a move to a plant-based diet. Papers have shown there is huge potential in utilising food waste across the supply chain for anaerobic digestion (Ingrao, Faccilongo, Di Gioia, & Messineo, 2018); however, SMEs have a poor record in correctly recycling their biowaste (Woodard, 2021)

Different aspects of CE thinking can be applied to create FLW solutions at each point in the waste hierarchy. Vilariño, Franco, & Quarrington (2017) summarise these into three categories, emphasising technological, cultural and behavioural factors which collectively contribute to policy solutions. Collectively, this shows the need for holistic thinking to tie together actors in the agri-food chain to mitigate FLW through collaborative recirculation, reduction and resource recovery (Vilariño et al., 2017).

In addition to the seemingly obvious *FLW reduction*, previous research has also claimed that the adoption of a CE in agri-food supply chains could lead to successful *outcomes*, which, amongst others, may include: *increased food security*, *price stability*, *economic resilience*, *preservation of natural resources* and *reduction of greenhouse gases*. Food waste is ethically unacceptable (Kowalska, Czajkowska, Cichowska, & Lenart, 2017; Moggi, Bonomi, & Ricciardi, 2018) so the CE should have a social element that can be integrated as part of the corporate responsibility of firms to ensure food is available and can be fairly accessed by those who need it. The CE also brings benefits to the conservation of natural resources (Menguc & Ozanne, 2005), which is part of corporate social responsibility. Another outcome of a CE is price stability. The price of a commodity depends on supply and demand. Ideally, food that has been produced can be supplied to and absorbed by the markets; however, often an oversupply not only causes food loss, but also affects the commodity price (De Angelis, Howard, & Miemczyk, 2018). Given the perishable nature of agri-food products (Petit, Lunardo, &

Rickard, 2020), the adoption of a CE will enhance firms' capability with respect to achieving economic resilience (Fatimah, Govindan, Murniningsih, & Setiawan, 2020). Further outcomes include reducing GHG emissions, and regenerating resources. The CE promotes the efficient use of renewable energy resources to transform inputs into outputs and regenerate nutrients by re-using food waste.

Whilst the outcomes may be clear, there are few studies that have evaluated how CE approaches have been incorporated in developing world agri-food supply chains. Much attention has been paid to municipal waste management, given the public health and pollution issues resulting from landfilling being the dominant or only form of waste processing (Tisserant et al., 2017). Kurniawan et al.'s (2020) study of resource recovery in Indonesia shows how the application of CE principles has enabled waste reduction at a community level. Fatimah et al.'s (2020) work proposes a CE waste management system for Indonesia, showing how technological developments can supplement sustainable waste treatment. Such studies show the lack of research that engages more directly with businesses in developing countries in terms of a focus on how their actions lead to FLW generation.

In the case of FLW, it is important to consider how businesses are currently managing the environmental resources that are contingent on their operations (Mazzucchelli, Gurioli, Graziano, Quacquarelli, & Aouina-Mejri, 2021), and furthermore what the barriers to engagement in waste mitigation strategies are. This is particularly important in the case of how SMEs can better engage in more sustainable, circular and resource-based thinking and how this can be better reflected in their operations. This paper addresses this gap through a focus on actors across the Indonesian agri-food supply chain to understand the causes of FLW at grower, distributor and retail levels. We further develop our contribution by better aligning the capabilities of businesses to manage their environmental resources with the principles and outcomes of the CE. This is based upon a theoretical lens which is introduced in the next section.

3. Theoretical lens

Whilst the CE has been the subject of much theorisation in understanding its circular components (see for example the work of Suárez-Eiroa, Fernández, Méndez-Martinez, & Soto-Oñate (2019) or Kalmykova, Sadagopan & Rosado (2018)), what is lacking is a

conceptualisation of how the capability of businesses to manage their resources maps onto such a framework.

One avenue of advancement to better conceptualise the application of CE principles and outcomes to business activities is using the organisational theory of NRBV (Hart, 1995; Hart & Dowell, 2011). This theory provides a lens to recognise the environmental resources that businesses depend upon and how capabilities linked to their management can be linked to sustaining competitive advantage (Aboelmaged, 2018; McDougall, Wagner, & MacBryde, 2019). NRBV has been interpreted as a means for progressing a proactive environmental strategy, whereby businesses apply a number of dynamic capabilities (Aragón-Correa & Rubio-López, 2007; Hart & Dowell, 2011).

The work of Hart (1995) makes an important contribution by incorporating sustainability into the strategic advantages gained from organisational capabilities, explaining how "the most important drivers of new resource and capability development for firms will be the constraints and challenges posed by the natural (biophysical) environment" (1995: p. 989). NRBV consists of three core elements: *pollution prevention* (preventing waste and emissions), *product stewardship* (involving different stakeholders in the firm's activities), and *sustainable development* (providing products that can be sustainable to a broader extent) (Hart & Dowell, 2011). These feature as 'strategic capabilities' underpinned by environmental driving force factors that better sustain key resources and therefore enable competitive advantage.

Pollution prevention focuses on the elimination of waste and emission from its source. According to Graham (2018), there are two places of implementation of pollution prevention: one is tactical, which operates at an operational level, such as modifying the operational process to eliminate waste; the other operates at a strategic level, which can be investment in a management system. This suggests that pollution prevention is proactive and needs pre-planned coordination. The competitive advantage of pollution prevention is in terms of cost reduction and increased efficiency of natural resources (Mishra, Chiwenga, & Ali, 2019).

Product stewardship allows operating at the supply chain level (Miemczyk, Howard, & Johnsen, 2016). Firms collaborate to design the products and are responsible for the disposal of those products. The key resource of product stewardship is stakeholder engagement. Some of the advantages are to secure green raw materials, minimise cost of life cycle products, and prevent hazardous substances from being released into the environment (Hart & Dowell, 2011).

Sustainable development determines the firm's future position, i.e. the ability of firms to produce in a sustainable way in order to achieve environmental, economic and social benefits. The competitive advantages are future position and long-term growth. Firms strive to advance their technology while at the same time adhering to their commitment to alleviate social ill.

Research using a theoretical lens based on NRBV is still limited (McDougall et al., 2019; Mena, Terry, Williams, & Ellram, 2014), in particular with regard to CE (Mishra et al., 2019; Kusumowardani & Tjahjono, 2020). This study fills this gap by proposing a conceptual framework, as an adaptive approach following our research context, and utilising NRBV as a theoretical lens in tackling FLW in agri-food supply chains. The application of NRBV as a concept to capture and act upon the environmental capability of businesses is utilised to better understand FLW in a developing agri-food context. This can be used to understand how the food waste hierarchy has proved to be a valuable tool in justifying the importance of preventative over reductive FLW solutions, but lacks the nuance required for developing in a world context.

4. Methodology

4.1. Research design

Encouraged by our understanding of the NRBV theory, we developed our initial framework that we used as a lens through which we qualitatively studied the SMEs within the Indonesian agri-food supply chain. The initial framework (Figure 1) emphasised the CE thinking and NRBV capabilities on the SMEs under investigation and was employed to guide us in the development of the research protocols. The initial framework guides the research questions and sets the boundaries of the research in order to extract relevant data to illustrate the related constructs. The initial framework also served as a basis in analysing and interpreting the data, understanding the concepts according to the participant's points of view. This initial framework featured three main building blocks (see Figure 1). The first one is related to CE (labelled E in Figure 1), the second is NRBV (labelled F in Figure 1), and the third is related to SMEs (labelled A, B, C and D in Figure 1). These labels (A to F) correspond to the questions in the interview guideline in the Appendix.

[Insert Figure 1 here]

We adopted a qualitative approach, allowing an in-depth examination of complex issues pertinent to the research problems to be conducted, within the auspices of a multiple-case study design (Eisenhardt, 1989; Yin, 2013). The purpose was to understand the perception of FLW across the agri-food supply chain (de Hooge, van Dulm, & van Trijp, 2018), the underlying reasons, and the extent to which the CE principles have been adopted. The sampling strategy was purposeful sampling, a form of non-probability sampling (Creswell & Poth, 2018). The SMEs were selected as demonstration cases (Yin, 2013) to address the research questions and support new understandings (Flyvbjerg, 2006; Starman, 2013). The units of observation were small and medium-sized growers, distributors and retailers of fruits and vegetables.

The study took place in the island of Java, which is the largest vegetable production area in Indonesia (Wulandari, Meuwissen, Karmana, & Oude Lansink, 2017). The retailers operate in Jakarta, a densely populated capital city with over 10 million people demanding large amounts of fruit and vegetable products from surrounding areas such as West, Central and East Java. The growing middle-class population in Indonesia has changed its lifestyle by moving away from purchasing groceries from traditional markets to shopping at modern retailers (supermarkets).

4.2. Data collection

Data collection for this study involved several sources and multiple rounds, conducted between 2019 and 2020. The repertoire included 38 semi-structured interviews with key informants representing eight growers, three distributors and four modern retailers (two interviews per informant). These interviews lasted approximately between 1 and 1.5 hours. Interview data were supplemented by observations and walk-throughs during visits to the premises of the key informants, which were recorded as field notes.

The growers and distributors are based in West, Central and East Java, while the modern retailers are mostly located in Jakarta, although they do have branches in other provinces in Indonesia. Growers and distributors were all SMEs, but modern retailers are predominantly large enterprises. According to the Indonesian Central Bureau of Statistics (BPS, 2017), a company with 5-19 employees is considered to be a small enterprise and 20 to 99 employees is considered to be a medium enterprise. Key informants are typically the business owner or a manager, chosen for their know-how about FLW and their willingness to participate in the study. Table 1 shows the details of the informants. The guiding questions covered enquiries

about the companies, the roles of the informants and the commodities they grow/distribute/sell, the current state of FLW in their businesses (volumes, categories, patterns), their efforts in tackling FLW and the extent to which the CE principles have been adopted to prevent FLW.

[Insert Table 1 here]

4.3. Data analysis

The interviews were conducted in the Indonesian language, audio recorded and then transcribed before being translated into English, with the anonymity of the informants assured. The interview transcripts were coded using NVivo 12, a qualitative data analysis tool. *A priori* codes were created prior to commencing data analysis and *post hoc* codes were added during the analysis of the interview transcripts. The coding was carried out by three researchers to minimise bias (Denzin, 2017). Upon the agreement and consensus of the three researchers, the codes were then collated into several themes. The main emerging themes are: terms used by informants to describe FLW, causes of FLW in various stages of the supply chain, recovery initiatives in tackling FLW, and capabilities needed in preventing FLW. We then compared our findings across cases before the thematic analysis (King, 2012; Tranfield, Denyer, & Smart, 2003) was carried out. Table 2 shows the theme structure and some examples of codes used.

[Insert Table 2 here]

5. Findings

This section presents the findings of our in-depth interviews with growers, distributors and retailers within the agri-food supply chain. From the coding and thematic analysis conducted, we structure the content of this cross-case analysis based on the four emerging themes.

5.1. Understanding the term 'food loss and food waste'

We approached our cases with an awareness that due to the context of Indonesia, with its multitude of culture, ways of thinking and wide range of social strata, the term FLW may have various meanings and understandings. Our interviews have indeed identified five ways in which our informants describe the term food loss and food waste.

The first concerns food products that do not meet specifications relating to the physical appearance of products, such as texture, shape, weight, and colour. Wastage caused by lack of

adherence to specification is described as loss. Informant 1 explained, *"some tomatoes or cherries are too small so this cannot enter the minimum grade for sales, that is loss"*. Informant 3 equated loss in the same way noting *"if the product includes mature leaves, we get rid of…vegetables that are late in production we discard"*.

The second way in which informants defined wastage was as products that are not suitable for human consumption. The growers (Informants 2, 6, 7, 8, and 12) indicated that products rejected by modern retailers are not considered waste as they can be diverted to traditional retailers or markets where almost all grades are accepted; as Informant 12 explained *"if we send to traditional markets, there will be no loss"*. Only the products *"that are not suitable for human consumption are considered as loss"* – Informant 6.

The third way in which waste was defined was where food could not be marketed because of surplus production. Informant 5 outlined how this unfavourable circumstance occurred, *"when surplus…the price drops… when price drops it is unlikely to rise again".*

The fourth way in which informants categorised wastage refers to the edible remnants left after damaged products have been removed or excess parts removed to meet the required weight, as Informant 9 explained, *"products come from growers where the outside is damaged, … for example, like cabbage or mustard greens, we peel them. The remains we call loss".*

Whilst food products may appear fresh, if their shelf-life has passed, then products are taken down from shelves. Informant 16 explained, *"we are quite stringent in receiving goods and determining the length of fresh produce in the displays"*. Any food products that do not have a sufficient shelf-life are considered as *"products that are not worth selling and consuming"* (Informant 16). Furthermore, cosmetic appearance is key to the competitiveness of modern retailers as consumers not only want food to be safe but also to look appealing.

The final understanding of food waste is associated with the business risk, which refers to the company's exposure to economic losses. This was the response given by Informant 13, stating that waste is inevitable due to many causes, for instance because of a slow rate of selling. This statement was reiterated by Informants 4, 5 and 9 who admitted that FLW was an integral and unavoidable part of the business with any efforts they make being limited in curtailing the problem.

Finding 1: *There are differing understandings of FLW in the agri-food supply chain that leads to five main categories of food waste.*

5.2. Causes of food losses and waste

Having understood how our informants interpreted FLW in their businesses, we then went on to investigate how FLW has occurred in different levels of the supply chains and its possible root causes. Understanding the root causes of FLW will allow the actors to take precautionary actions and develop capabilities to prevent or reduce FLW.

5.2.1. Grower level

The interviews highlighted some key issues that growers confronted and how these were contingent to why food losses occur. Manual harvesting is prone to human error which can be compounded by environmental conditions causing losses. Informant 5 gave an example that during harvest, employees often made mistakes due to challenging working conditions, such as, the extreme heat. This view was echoed by Informant 1 who gave an example of an employee accidentally pricking tomatoes causing losses.

The grower businesses have faced major constraints in accessing funding to acquire new equipment and modern technologies that could have prevented FLW. Such growers were greatly exposed to losses from natural disasters, pests and the impact of the rainy season. Informant 3 noted that the *"rainy season causes losses, and we do not have the technology to overcome the problem"*. Informant 2 also recounts *"sometimes our crops are attacked by pests but we cannot save them"*.

Another cause of FLW was the production surplus. Growers reported circumstances where there was no choice other than to waste the crops because the cost of harvesting was higher than the market price of the products. This situation is exacerbated by the perishable nature of the fruit and vegetables grown. Informant 2 made it clear that this was not an issue of ability, but rather the knowledge of market and the nature of growers' agreements with retailers, *"we do not have contract farming with retailers…, now the price of tomatoes is falling… we do not have any option than to waste the crops".*

5.2.2. Distributor level

Food loss at the distributor level can be broken down into two stages. The first is the sorting and packing stage. Products are discarded in order to meet retailer specifications and due to human error when receiving products from growers, e.g. from dropping the products and poor sorting. These processes are performed manually without the electronically connected systems that commonly exist in developed countries. False estimation of how retailer demand is met is also a limitation. The second stage happens at the distribution level, where the products' damage is due to the high temperatures during transportation.

A further reason for food waste is product rejection. Distributors in this study experienced food waste because retailers refused to take products as their available stock was sufficient. Informant 11 explained, *"sometimes we experience rejection from modern retailers, they say that they still have stock. Whether we like it or not we have to accept that".*

5.2.3. Modern retailer level

In the case of the modern retailers in the study, food waste occurred during four discrete stages: ordering, receiving, storage and display. In the stages of ordering and receiving, food waste was mostly caused by human error such as incorrect purchase orders and poor demand forecasting. Retailers did not have 'take back' agreements with growers or distributors, so the onus was upon them to ensure that the products sell.

Waste can be caused in the storage display stage due to damage resulting from poor handling practices. Damage can also occur from customer's interaction with the product, as Informant 14 explained, *"... sometimes our customers cause physical damage such as scraping and pressure using nails".* Informant 18 went on to state that whilst customers were critical of a retailer's success, there was a contradiction in treating customers with a high standard of customer service even if they damage food products or return perishable items incorrectly, causing spoilage, as a product could no longer be displayed or had a compromised lifespan. Even in the cases where these actions were noticed by employees, the retailer could not ask the customer for compensation.

Finding 2: *The different challenges faced by the actors and the perishable nature of food products generate FLW across the supply chain. Stringent specifications from modern retailers resulted in FLW both for growers and distributors.*

5.3. Disposal and recovery of food waste material

This section presents the extent to which practices of CE have been demonstrated by the actors within the agri-food supply chain. In general, it is rather disappointing to find that the majority of informants in this study chose to landfill FLW. However, the informants were keen to discuss various ways of tackling food loss through changes in their growing and post-harvest processes rather than minimising or addressing the waste material, with Informant 1 being one example. This is because businesses involved in the study did not have access to a dedicated waste management facility.

Most growers believed that organic food waste will decompose naturally and be safely returned to the biosphere, thus organic landfilling does not harm the environment. However, these growers' beliefs are misplaced as landfilling organic produce can lead to excess methane emissions. Our research identified some growers who did demonstrate CE practices in an effort to avoid landfill. Informants 2, 6, 7 and 9 mentioned that they recirculate food waste into compost and other nutrients (organic fertiliser). In some cases, growers utilised food waste as animal feed. However, as Informant 6 highlighted, not all vegetables are suitable. Other growers preferred a different disposal method with Informant 6 admitting that food waste was burnt with other waste that included plastics mulch. Distributors also exhibited similar responses in terms of food landfilling.

Informant 17 commented that there used to be a charity programme aimed at distributing food waste to the nearby community, demonstrating the social principles within the CE. Nevertheless, the brand protection within modern retailers often posed a barrier to any food recovery for redistribution. Informant 18 described how products that are no longer suitable for display are removed, chopped and binned for disposal, often with a chemical additive (colourant) to deter scavengers or anyone who wanted to recover the food.

Other retailers in the study claimed that food waste recovery and a redistribution programme had not been successful. Having attempted several times, food waste abuse by irresponsible collectors discouraged retailers from continuing with the programme. This was also driven by food safety compliance that was upheld by many modern retailers, meaning they often had no option but to dispose of food surpluses, as Informant 14 commented, *"So, we have no choice but to chop up the products that do not have a good appearance and we dispose of them"*.

***Finding 3**: There is a belief that disposing of food that cannot be sold formally into landfill is a valid option. At the upstream supply chain (modern retailers), recovery of food waste is a sensitive issue, pertinent to brand reputational risks.*

5.4. Classifying food waste mitigation strategies

From the FLW management actions identified from the informants, we have classified six categories of waste mitigation strategies within the agri-food supply chains. These capabilities, to a large extent, resemble the natural resource-based capabilities (Hart, 1995). The first is best practice cultivation at the growers' level. This strategy emphasises the capability to ensure maximum agriculture produce and minimum waste by taking care of the whole life cycle of the produce, from selection of superior quality seeds to good cultivation practices, including post-harvest processes (product stewardship), as stated by Informant 7, *"the use of superior seeds reduces the risk of crop failure"*. However, some growers were rather sceptical about enhancing horticultural practices, given the uncertainty of market price. Informant 2 commented*, "if there is a commitment to the agreed price and quantity of produce, the growers will definitely take care of it [plants]"*.

The second category is pertinent to the capabilities for businesses to upskill and gain greater knowledge across all stages of the supply chain. For example, growers called for greater technical skills in cultivation, such as proper soil preparation. At the distribution and retailer levels, responses included training in manual handling and how to safely move, load and arrange the products to prevent damage to food products.

The third category is the capability to invest in improved infrastructure and better technology to mitigate wastage. For example, using a refrigerated truck for transportation, or an automatic sprayer to prolong the life of products displayed. Informant 1 discussed the importance of the availability of an infrastructure to support employees, *"not just demanding good work"*. Improved infrastructure can support workers across all stages of the supply chain to prevent food waste.

The fourth strategy is to repurpose and redistribute food that is destined to be wasted due to seasonal demand and slow rate of purchases. This strategy focuses on the capabilities required to minimise waste and hence retain the value of products – two of the important principles in the CE. This may involve creating derivative products for juice or salad, offering a discount to customers that purchase such food, or diversion of these food products for an alternative use

via other channels. However, one factor that often impinges on this strategy is the quality and grading of food produce. Modern retailers described how recirculation of agri-food into other types of food products is not always straightforward, as Informant 19 outlined, *"there are types of vegetables that we can still recover, such as in making salad. But this must also be sold within a day"*.

The fifth category of capabilities includes better planning, scheduling and overall organisation of the business. This involves scheduling more convenient delivery times and more accurate demand forecasts for distributors and retailers, as explained by Informant 15 *"we ask our suppliers to send the leafy vegetables every day in the morning before the store opens"*. Accuracy of demand forecast is essential to prevent food waste as Informant 16 stated, *"excessive orders without regard for historical average sales will cause large food waste or significant spoilage"*.

The sixth category is the proper management of operations, ensuring that strategies such as those mentioned here are implemented correctly. This strategy appeared at all levels of the supply chain and includes actions of supervision, checking storage, arranging displays, and conducting audits both internally and externally, as indicated by Informant 10, *"we have someone who supervises the daily operation to make sure that nothing goes wrong"*.

Finding 4: *Mitigating FLW requires the actors in the agri-food supply chain to have a set of capabilities, which can be classified into six strategies.*

6. Discussion

We now set out a contribution towards the understanding of FLW in the context of a developing nation's Southeast Asian agri-food supply chain. In this section we first illustrate an alternative food waste hierarchy that further considers the commercial realities expounded in the findings. Secondly, we link this hierarchy to the application of the CE principles. Thirdly, we construct and explain the Circular Capability Framework.

6.1. A food waste hierarchy to better represent the agri-food supply chain in a developing country

Having identified the definitions and causes of, and solutions to FLW in the agri-food supply chain, we now turn our attention to exploring the implications for the food waste hierarchy to revise its applicability to businesses operating in a developing country.

Our findings indicated that the awareness amongst the actors in the agri-food supply chain was relatively low. The main reason for this is their focus on improving the output quality in order to meet consumers' demands, e.g. achieving perfect shapes of fruit and vegetable produce. Another reason is the apparent misconception about food waste and the relatively low food price that caused the food waste to be undervalued. Retailers have concerns about their business reputation, so they have preferred to throw away unsold fruits or vegetables, rather than selling them for a lower price or giving them away as a donation. They have also incorrectly assumed that organic waste from fruits and vegetables will decompose in landfill without generating negative impacts.

In line with previous studies, our findings also demonstrated that whilst there was a genuine intention to maintain the economic value of food products, further dynamics of the commercial realities mean supply chain actors undertake extended actions to gain economic valorisation at the expense of addressing or tackling the generation of FLW (Fatimah et al., 2020). In the context of the agri-food supply chain, involving many small and medium-sized farmers and distributors, there is a genuine intention to maintain the economic value of the products, and this was demonstrated especially in the upstream nodes of the agri-food supply chain.

We therefore propose a modified version of the waste hierarchy (Eriksson, Ghosh, Mattsson, & Ismatov, 2017; Papargyropoulou et al., 2014a) to better represent the actions within the context of agri-food supply chains in a developing country (Figure 2).

[Insert Figure 2 here]

In this modified hierarchy, avoiding unnecessary product surpluses is the first option to prevent food waste. Waste prevention at source requires cogent production planning from the primary production stage (Teigiserova et al., 2020). However, at this stage, over-production is often inevitable (though preventable by, for instance the so-called selected-harvesting method). The excess produce, including products that fall below specifications and are thus unacceptable to modern retailers, can be diverted to traditional markets and local food services (second level). Some products can also be sold as the raw materials of animal feed.

The third level of the hierarchy suggests that the excess produce should be processed further, as long as it is safe for human consumption, into other derivative products. These derivative products intrinsically extend the life of products, hence their values, by converting them to another form of food, e.g. banana cakes, canned food, potato chips or dried chilli powder. In many cases, excess produce can also be processed into herbal medicine products; this is common practice in Indonesia.

In the case of the agri-food supply chain, donation is mostly done at the upstream level as a gesture of social responsibility, rather than to maximise the value retained by the excess produce. Consequently, the donation of agri-food produce must adhere to food health and safety standards for human consumption (Kowalska et al., 2017; Moggi et al., 2018). Again, excess produce that is not suitable for human consumption can be used for animal feed (Thi et al., 2015), although care must be taken as not all vegetables and fruits are suitable for animals.

Our finding aligns with studies indicating that the bottom layer of the hierarchy before landfill is concerned with converting food waste into biogas (e.g. using anaerobic digestion) (Ingrao et al., 2018), bio-fertiliser and compost (Girotto et al., 2015; Padolecchia et al., 2018; Thi et al., 2015). Such activities are examples of how the implementation of CE can provide financial benefits (Fatimah et al., 2020). However, in order to draw the most benefit from composting, the recovery of waste should become part of the business process.

6.2. Mapping the agri-food waste hierarchy to the Circular Economy

Our adoption of CE principles has been inspired by the work of Ripanti & Tjahjono (2019) who reformulated the CE values into *principles*, *attributes* and *enablers*. Principles are defined as essential actions or guiding rules to be followed to implement a CE; attributes are the natural characteristics of a certain product enabling the CE principles to be implemented; and enablers are external entities that will support the practicality and continuity of the CE implementation. Ideally, the full set of CE values should be considered, but in this study, we focus only on the CE principles emphasising the guiding rules to be followed. The six guiding rules include: *cascading orientation*, *waste elimination*, *economic optimisation*, *environmental consciousness, maximisation of product's retained value* and *leakage minimisation.*

In this section, we aim to investigate how the principles of CE can be used alongside our food agri-food waste hierarchy (Figure 3). Naturally, the hierarchy resembles the *cascading orientation* in CE that aims to keep the materials, be they products, components or materials or

biological nutrients, longer in circulation, before being transformed into different types of products (Jurgilevich et al., 2016). Cascading orientation in CE can therefore be used to reduce FLW by recirculating food surplus.

[Insert Figure 3 here]

At the top of the hierarchy lies the prevention of unnecessary surplus of products which could become waste. This is directly mapped to the *waste minimisation* principle of the CE (Ripanti & Tjahjono, 2019). The principle of *economic optimisation* intends to sustain the economic growth of a firm. As this principle does not feature in the traditional waste hierarchy, arguably it is a crucial route to be preserved. This can be achieved by optimising the products at all times so that they retain their economic values. Before they turn into waste, the producers can divert the excess or unsold products to other, lower value, channels, such as traditional markets.

Firms innovate and transform the products that bring monetary value. In the case of agri-food products, innovation can occur by converting the commodity into other forms of derivatives, e.g. canned food and dried assortments, with longer shelf lives, so the value of products (excess produce) will increase (Ben-Othman et al., 2020; Garcia-Garcia et al., 2019). This transformation illustrates both the principles of *economic optimisation* and *maximisation of product's retained value*. Longer shelf-life also implies that the products are being kept longer in circulation (De Angelis et al., 2018).

Energy recovery in the waste hierarchy maps to the CE principle of *environmental consciousnes*s. With this principle, the actors in the agri-food supply chain should shift their orientation towards environmental conservation. It is widely understood that companies are driven by bottom-line profits; however, resource scarcity, environmental pressure, and the explosion of the world's population, pose new challenges for them (Chen et al., 2020). Environmental sustainability has now become a vital determinant for competitiveness, and firms endeavour to incorporate CE principles to reduce agri-food waste.

Leakage minimisation is the principle that ensures there are no wasted materials along the biological cycle. In the food waste hierarchy, this principle appears in the form of composting. The food waste is designed to be put back into the system through the process of composting or anaerobic digestion. Another form of leakage minimisation is by converting food waste into bio-fertiliser for plants (Thi et al., 2015), ensuring no contaminated substances are released into the biosphere (Hart & Dowell, 2011).

Our food waste hierarchy allows a wide range of cascading alternatives to be implemented. Nonetheless, social responsibility does not feature in the current array of CE principles proposed by Ripanti & Tjahjono (2019), yet it is deep-rooted in the agri-food waste hierarchy in the form of donation. We therefore suggest adding *social responsibility* into the CE principles.

6.3. The antecedents of the Circular Economy principles

Our findings have highlighted six categories of capability as prerequisites for the mitigation of FLW in the agri-food supply chain. If the adoption of CE principles can prevent and reduce waste, then we can posit that the capabilities (possessed and exhibited by the firms in our study) may well act as the antecedents of the CE principles. This section will unravel these observed capabilities and map them to the theoretical lens of NRBV's *pollution prevention, product stewardship* and *sustainable development* (Hart & Dowell, 2011), and build a linkage between those capabilities and the associated CE principles.

As part of the pollution prevention strategy, the *continuous improvement* capability aims to actively seek a better process to prevent waste (Ghisellini et al., 2016; Kristensen & Mosgaard, 2020), right from the upstream processes of cultivation, harvesting and post-harvesting management, to the downstream product delivery. Evidently, from the majority of the firms we interviewed, the continuous improvement capability was found to have been embedded within their lean management practices. These include eliminating waste from the farms and warehouses, as well as the adoption of modern logistics systems, including proper storage and cold chain management. Therefore, we put forward our first proposition stating that

Proposition 1: *In the context of agri-food supply chains, firms that have a continuous improvement capability will be able to effectively adopt the waste elimination endeavour.*

The *environmental commitment* capability can be described as the ability of firms to uphold their responsibilities regarding environmental sustainability (Aragón -Correa & Rubio-López, 2007; Hart & Dowell, 2011). In our study, firms that demonstrated a strong commitment to the environment were capable of reducing negative environmental impacts (Aboelmaged, 2018; McDougall et al., 2019). These firms were also capable of demonstrating success in preventing the loss of products, by cascading the food surpluses. In this respect, we suggest the following

proposition that links this capability to the relevant CE principles, i.e. environmental consciousness and leakage minimisation.

Proposition 2a: *In the context of agri-food supply chains, firms that have an environmental commitment capability will uphold their environmental responsibilities.*

Proposition 2b: *In the context of agri-food supply chains, firms that have an environmental commitment capability will be able to prevent loss of products.*

The second group of antecedents is the *product stewardship* strategy, within which the *stakeholder engagement*, *market monitoring* and *information sharing* capabilities oversee the agri-food products throughout their life cycle, thus reducing food losses.

The *stakeholder engagement* capability was exhibited across all the firms we studied. This capability allows them to collaborate within their supply chain (Miemczyk et al., 2016; Vilariño et al., 2017), resulting in increased agri-food product stewardship along the supply chain, thereby leading to the reduction of FLW. For instance, growers collaborate with their supplier to secure superior seeds that ensure high quality produce; distributors actively engage with both growers and retailers to support take-back agreements on unsold products (thus eliminating waste and reducing leakage); and retailers work together with growers to develop new agri-food products (increased economic growth and value-adding offerings) (Hart & Dowell, 2011). We therefore suggest that

Proposition 3: *In the context of agri-food supply chains, implementing the CE principles requires stakeholder engagement.*

The *market monitoring* capability is crucial for firms to be able to jointly observe market dynamics (Mena et al., 2014). Fruits and vegetables are commodity products that are exposed to market price volatility (Garcia-Garcia et al., 2019). Excessive supply in the market results in unmarketable products and leads to food waste. Nonetheless, growers, distributors, and retailers in our study have all exhibited a range of market monitoring capability, employing this capability to retain (and extend) the value of their products, thus gaining financial advantages and economic growth. Their awareness of the market conditions helps all the actors in the supply chain to make decisive actions, so that the excess products can be diverted to other channels before they turned to waste. In this regard, we posit that

Proposition 4a: *In the context of agri-food supply chains, firms that have an effective market monitoring capability will gain economic growth and be financially resilient.*

Proposition 4b: *In the context of agri-food supply chains, firms that have an effective market monitoring capability will be able to prolong and retain the value of their products.*

In line with previous research, the *information sharing* capability contributes to reducing FLW by enabling the visibility of product flows in the supply chain (Rodrigues et al., 2021). Information sharing entails the processes of monitoring of product delivery, forecasting demand, inventory level, etc. By sharing the information continuously, firms will be able to identify, trace, and quantify the occurrence of waste along the supply chain. The information sharing capability has been proved to be critical to the firms in our study, especially when adopting a CE to tackle FLW. We therefore propose that

Proposition 5: *In the context of agri-food supply chains, firms that have an effective information sharing capability will support the adoption of CE principles.*

The third group of antecedents of CE principles falls into the *sustainable development* strategy of NRBV (Hart, 1995). Here, firms may need to implement the relevant technologies for reducing negative environmental impacts and to address the social aspects of the firm's trajectory of growth. This implies that the future position of firms will depend on their capability to reconfigure their resources and upgrade their technologies. The *technology innovation* capability is needed to support waste elimination (Rodrigues et al., 2021), which in turn will enable economic optimisation. Advanced communication technologies enable multiple stakeholders to cooperate and share best practices. In our field study, small growers collaborated and shared food processing equipment leading to yield increase and the reduction of FLW.

Proposition 6a: *In the context of agri-food supply chains, technology innovation capability supports waste elimination.*

Proposition 6b: *In the context of agri-food supply chains, technology innovation capability enhances economic optimisation.*

The growers and distributors in our study evidently demonstrated the *social collaboration* capability as part of their effort in cutting FLW. Many of them are backed up by social enterprises and non-governmental organisations (NGOs) to redistribute excess fruit and vegetables to underprivileged communities and poor people with limited access to healthy food. As such, we posit that

Proposition 7: *In the context of agri-food supply chains, social collaboration capability enables social responsibility.*

6.4. The Circular Capability Framework

Having identified the antecedents of the CE principles, this section presents a conceptual framework that is contextually grounded in the agri-food supply chain and elaborates the organisational theory of NRBV (Hart, 1995). As illustrated in the preceding argument, FLW reduction, through the adoption of a CE approach, is developed on overarching propositions that link *pollution prevention*, *product stewardship* and *sustainable development* capabilities to the CE principles. Ultimately, the implementation of CE principles will subsequently lead to several outcomes, and this is stated in our final proposition:

Proposition 8: *In the context of agri-food supply chains, applying CE principles will result in reduced FLW, increased food security, food price stability, economic resilience, preservation of natural resources, and reduction of greenhouse gas emissions and global warming.*

In the conceptual framework, we first consider the pollution prevention strategy, within which the *continuous improvement* and *environmental commitment* capabilities link to waste elimination, environmental consciousness and leakage minimisation of the CE principles (P1, P2a and P2b). Within the product stewardship strategy, *stakeholder engagement* and *information sharing* capabilities act as the antecedents of all the CE principles (P3 and P5 respectively), whilst *market monitoring* links to both economic optimisation and maximisation of retained value principles (P4a and P4b). The last two capabilities are *technological innovation* and *social collaboration*, which are the antecedents of the waste elimination (P6a), economic optimisation (P6b) and social responsibility (P7) principles. Figure 4 shows how we formulate our conceptual idea into the Circular Capability Framework to support the implementation of the CE principles, grounded in the context of agri-food supply chains in the developing countries.

[Insert Figure 4 here]

7. Conclusions

FLW poses a critical threat to future food security in developing nations and undermines efforts to curtail emissions to meet climate change targets. Whilst the adoption of CE practices has been positioned as an important strategy for SMEs within the agri-food supply chain to engage with, there has been limited research undertaken to evaluate how the CE can be successfully implemented in practice. This was highlighted in the literature review, noting the lack of studies of FLW along the agri-food supply chain in developing countries and the need for a conceptualisation on how, by better management of natural resources through the employment of CE thinking, businesses can address FLW.

In the light of the above, this paper set out to better understand the reasons for FLW in agri-food supply chains in developing countries, and to conceptualise how CE approaches can be better incorporated in tackling FLW. The NRBV was put forward as a theoretical basis for this to be realised. Hart's (1995) concept of how sustainability can be incorporated into a businesses' strategic advantage in the form of environmental capabilities has been progressed in this paper. We postulated that the antecedents of the CE principles and outcomes can be connected to a firm's capabilities for FLW mitigation in the agri-food supply chain. This approach enables us to propose mechanisms whereby businesses can prosper and compete by aligning their organisational capabilities with CE strategies in order to tackle FLW.

In order to construct this framework, research was undertaken in the agri-food supply chain in Java, Indonesia, focusing upon three business types: growers, distributors and retailers. The findings first highlighted the five different ways in which the term FLW was understood by them. Growers were shown to waste food due to harvesting practices, pests and production surplus. For distributors, the main reasons of FLW were handling practices, meeting retailer expectations and existing stock levels preventing further supply. For the retailers, FLW was driven by incorrect forecasting and ordering, stock rotation and quality expectations of customers. The findings revealed how the majority of businesses involved in the study dispose of food via landfill – the least preferable action according to the food waste hierarchy. This was driven by the beliefs that food waste decomposes naturally and does not harm the environment. Current strategies to mitigate food waste were various, from reducing crop loss through the use

of ‘superior’ seeds, to upskilling staff, re-purposing and redistributing food, together with better planning and scheduling.

7.1. Implications for theory

We have offered an alternative food waste hierarchy to the one proposed by Papargyropoulou et al. (2014a) and Eriksson et al. (2017) that better represents the practical challenges, and the context of SMEs in the agri-food sector in the developing world, whose characteristics are comparable to those of Indonesia. We mapped the components in the FLW hierarchy, showing the manifestation of the CE cascading orientation, to the rest of the CE principles proposed by Ripanti & Tjahjono (2019). Finally, we formulated the Circular Capability Framework to better conceptualise the capabilities and resources that SMEs in agri-food supply chains need to have to implement the CE principles that lead to the achievement of FLW reduction and other sustainable outcomes.

The novel framework we propose can aid participation in the CE by conceptualising CE antecedents as business capability pathways, set out as eight propositions, and also adds value in two ways. Firstly, it addresses the lack of knowledge on the firm’s role in agri-food supply chains with regard to resource use, specifically FLW. Secondly, it offers a conceptualisation of how the NRBV-related capabilities of businesses act as the antecedents to a more sustainable, circular approach to tackle FLW.

7.2. Implications for practice

Although the Circular Capability Framework was developed using the context of SMEs within the agri-food supply chain in a developing country context, it is open to customisation for other supply chain contexts with some adjustment to the waste hierarchy and the mapping to the relevant CE principles. In our opinion, the NRBV capabilities are sufficiently generic to be adapted as antecedents for the relevant CE principles, although care must be taken to ensure that the linkages remain coherent. The framework could be deployed into a practical FLW workbook consisting of self-assessment procedures, so that practitioners can further explore their NRBV capabilities, allowing a fuller understanding of their roles in supporting the CE principles, relevant to the specific application of a CE model (possibly) beyond the agri-food sector.

7.3. Future work

We are mindful that our work could generate different interpretations and opinions simply because of the way in which FLW, CE and NRBV are formulated together as a contribution of our research to the body of knowledge. Nonetheless, we hope that this paper can stimulate a healthy discourse on the practical realities of how the CE can be best employed in the agri-food sector in developing countries where obtaining effective solutions is a pressing imperative requiring informed research input. In order to progress our research, we intend to further validate the generalisability of the Circular Capability Framework by conducting a large survey of SMEs representing various actors in the agri-food supply chain.

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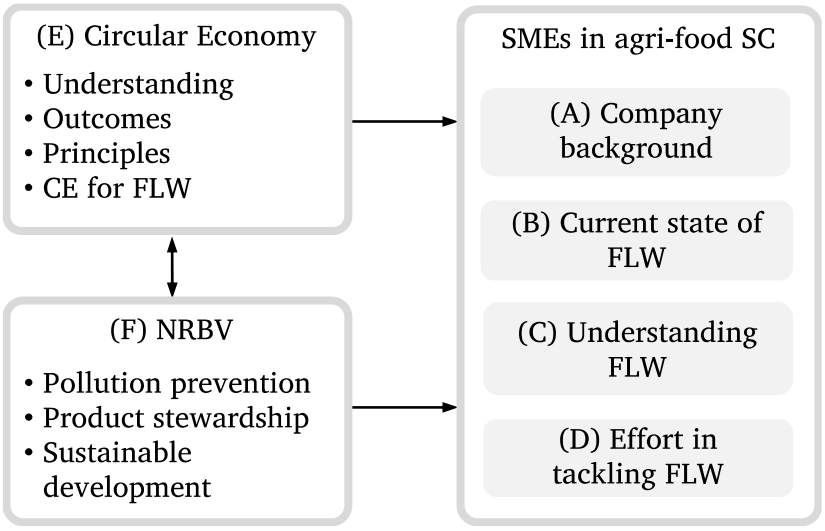

Figure 1. The initial framework to guide the research

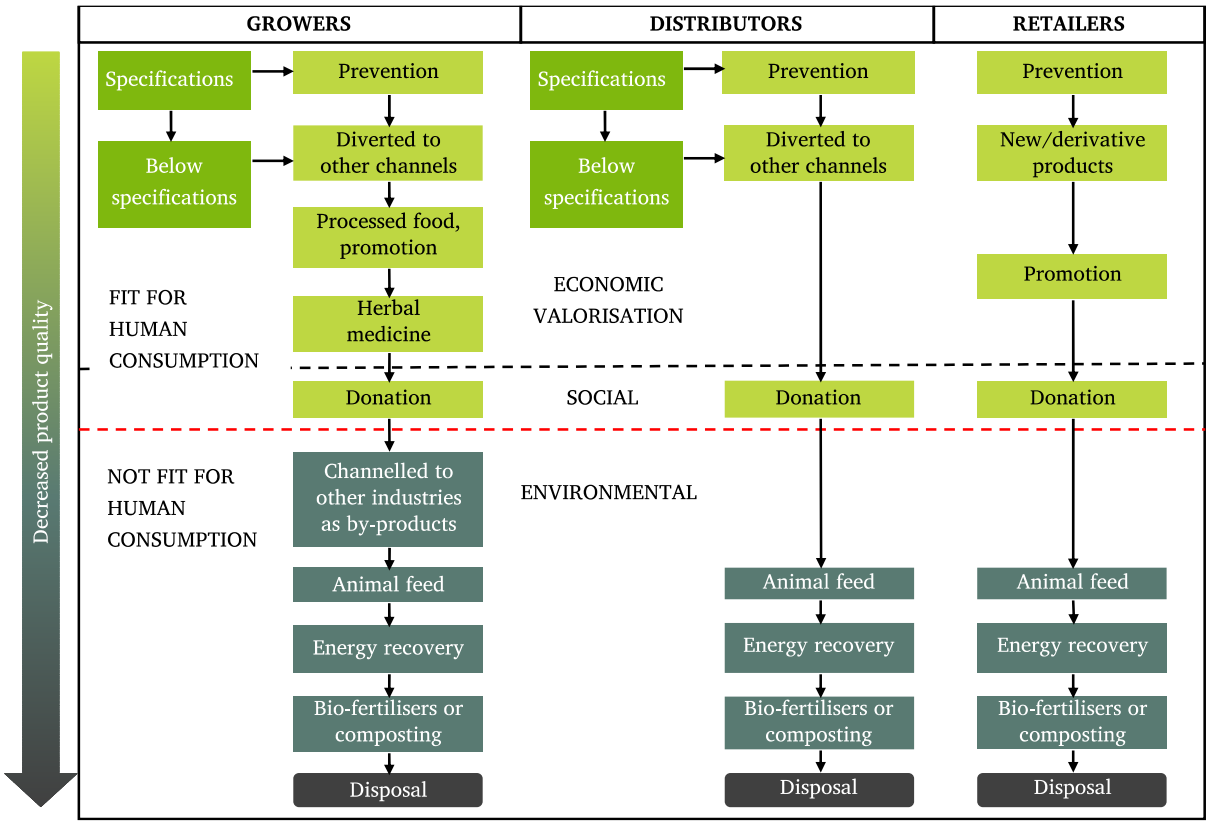

Figure 2. Agri-food waste hierarchy

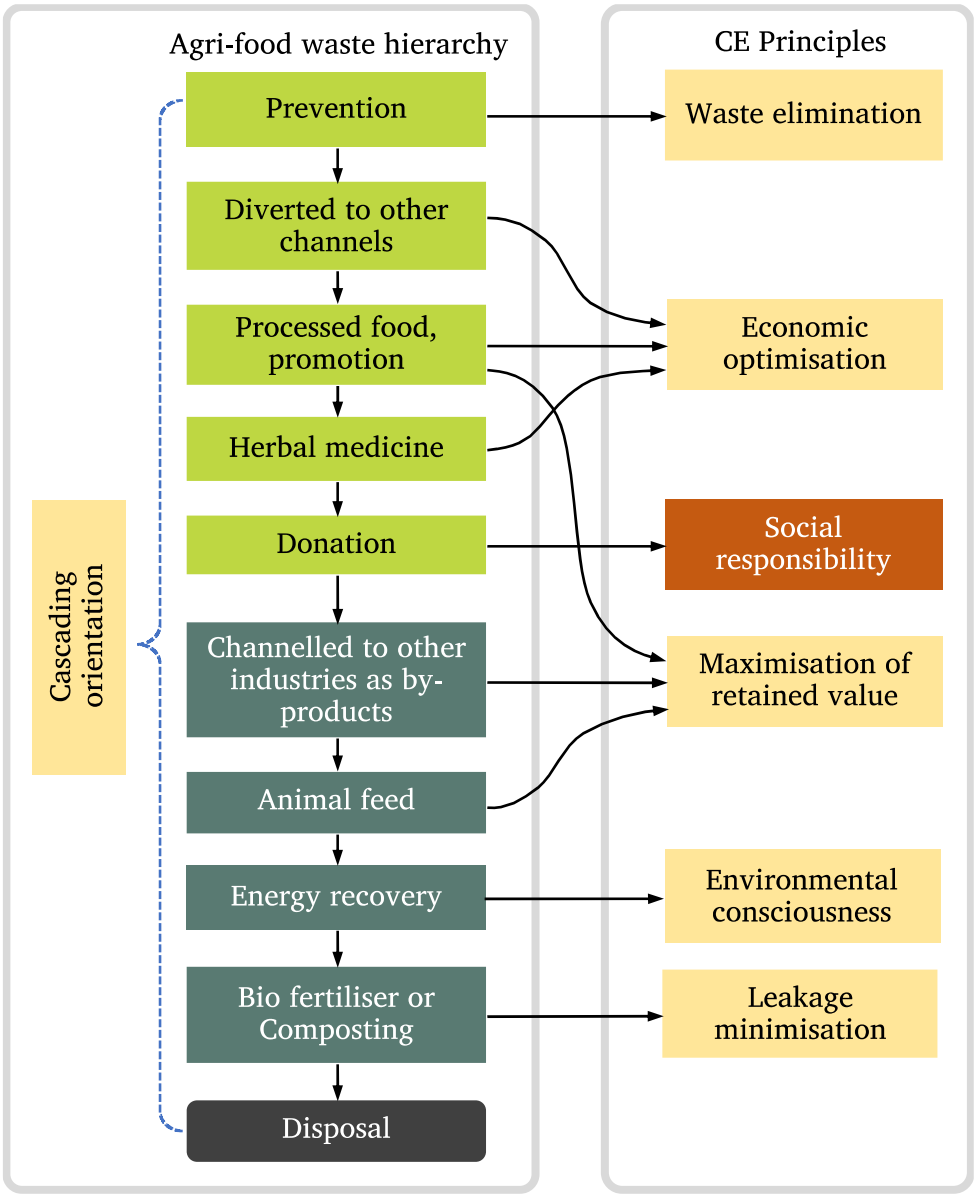

Figure 3. Mapping the agri-food waste hierarchy to the CE principles

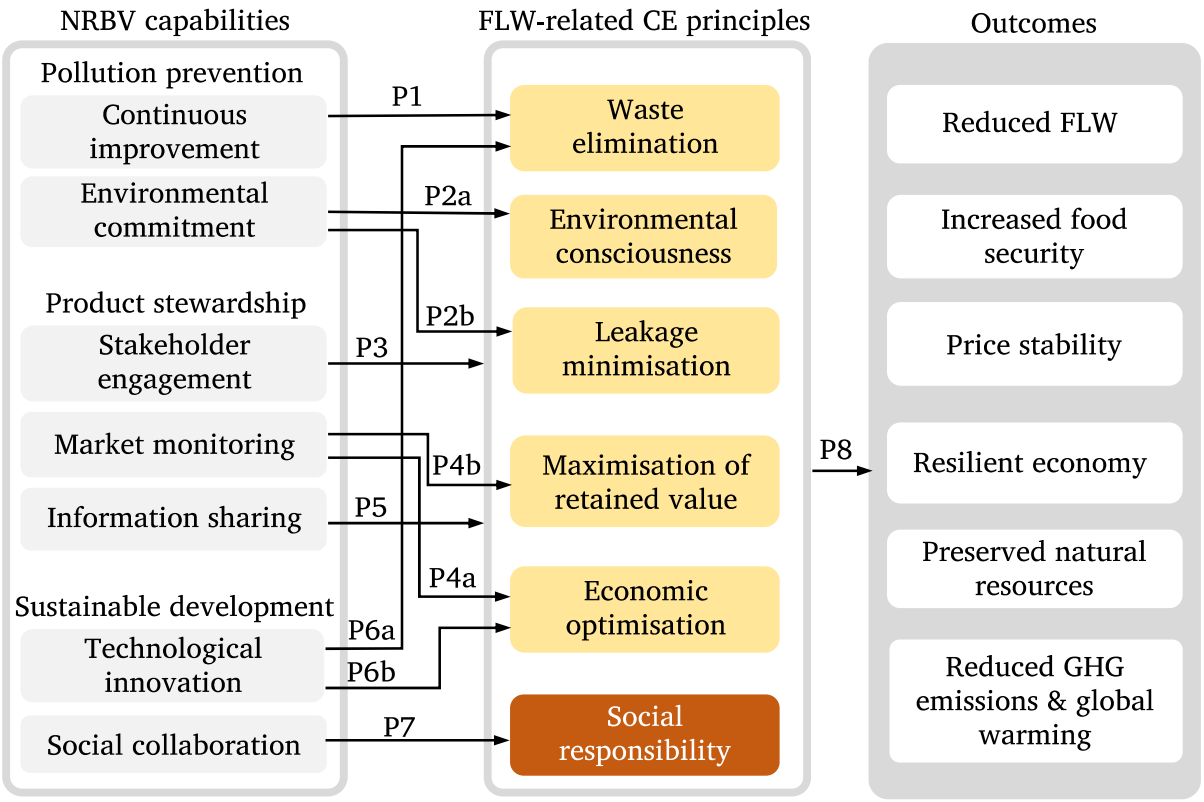

Figure 4. Circular Capability Framework for the application of CE principles to tackle FLW in agri-food supply chains

Table 1. Description of informants and sample selection

Case	Informant	Position in supply chain	Role	Company details
A	1	Grower	Site manager	Medium-scale grower. Direct supplier to modern retailers, hotels, restaurants. Employees: 70.
B	2	Grower	Head of farmer cooperative	Medium-scale grower who is incorporated into a cooperative of farmers with 80 members.
C	3	Grower	General manager	Medium-scale grower. Operates in West Java. Supplier to modern retailers and multinational fast-food chains. Employees: 50.
D	4	Grower	General manager	Medium-scale grower supplying directly to modern retailers, food processors and fast-food chains. Employees: 95.
E	5	Grower	Owner	Small-scale grower. Operates in West Java. Supplier to modern retailers. Employees: 20.
F	6	Grower	Owner	Small-scale grower, a member of a cooperative of farmers. Operates in Central Java. Employees: 15.
G	7	Grower	Owner	Small-scale grower. Owns a combined distribution channel, directly supplying modern markets or through intermediaries. Operates in East Java. Employees: 19.
H	8	Grower	Director	Medium-scale grower supplying directly to modern retailers, traditional markets and food services. Operates in West Java. Employees: 50.
I	9	Distributor	Director	Medium-scale distributor supplying leading modern retailers in Jakarta and Central Java. Supplies ~160 items of vegetables. Located in West Java. Employees: 98.
	10		Director	
	11		Marketing	
J	12	Distributor	Owner	Medium-scale distributor of tropical fruits, supplying to modern retailers. Operates in Central Java. Employees: 20.
K	13	Distributor	Owner	Medium-scale distributor of vegetables and fruits operating in East Java. Supplier to leading modern retailers. Employees: 25.
L	14	Retailer	Fresh produce senior manager	A modern retailer operating hypermarkets and supermarkets across Indonesia. Selling almost all local products and other household needs.
	15		Store manager	
	16		Head of sales	
M	17	Retailer	Fresh produce manager	A modern market providing a range of food products and other household goods, including fresh produce both local and imported.
N	18	Retailer	Fresh produce manager	Premier retail chain selling a wide variety of food products, clothing, electronics etc.
O	19	Retailer	Senior manager	Indonesian retail chain selling fresh produce, household needs, electronics etc.

Table 2. Example of codes and the emerging themes

Primary codes	Secondary codes	Themes
▪ Colour ▪ Size ▪ Not meeting the required weight	Product specifications	Terms used by informants in the supply chain to describe FLW
▪ Spoilage	Not fit for human consumption	
▪ Part of business strategy	Business risks	
▪ Low selling price	Surplus production	
▪ Perfect look for display	Cosmetic appearance	
▪ Poor on farm cultivation system ▪ Human error ▪ Unmarketable products due to surplus ▪ Poor infrastructure	Growers	Causes of FLW in various stages of the supply chain
▪ Poor handling practice ▪ Products rejected by retailers	Distributors	
▪ Excessive order ▪ Slow selling ▪ Damage because of customer handling	Modern retailers	
▪ Derivative products ▪ Diverting to other channels ▪ Promotion	Economic valorisation	CE-related recovery initiatives to tackle FLW
▪ Animal feed ▪ Composting	Environmental	
▪ Charity donation	Social	
▪ Best practice cultivation ▪ Investment in the infrastructure ▪ Planning ▪ Repurpose and resupply ▪ Training needs	Capabilities and resources	NRBV-related capabilities needed in preventing FLW

APPENDIX

Semi-structured interview guideline

Research questions

- How can SMEs within the agri-food supply chains incorporate CE to tackle FLW problems?
- What are the capabilities and resources do they need to possess to tackle FLW?

(A) Informants background

- Please begin by telling me about your job role and what you are responsible for
- What products do you grow/ manufacture here?
- Who are these products supplied to? How long have you supplied these products? <Further leading questions depending upon the role and remit>

(B) Food loss and food waste

- What do you consider as food waste in the context of your business?
- What do you think are the principal causes of food waste in Indonesia?
- What about in your business?
- Can you name some specific actions that might lead to food waste on this site? What are the causes of this?
- How does your business tackle the problem of food waste?
- Do you provide any training to your employees around preventing food waste?
- Do you receive any guidance from the business that your supply to?
- Are there any standards imposed?
- Are you required to record how much food does not meet specification? What happens to it?
- Prompting further questions about this depending upon participant's knowledge of the problem

(C) Distribution

- Tell me about how products exit this facility? Where do they go to?
- Do you deliver products yourself or are the products collected?
- What system is used to keep track of what food is distributed to where? How is this managed?
- How are tasks then handed down to your employees?
- Are there specific timings to keep to in order to mitigate food deteriorating?
- What happens to the food that businesses you supply to won't take?

(D) Implementation of CE in surplus and recovery

- Do you recover any food that is spoilt here?
- Are there any links with charities in terms of redistributing the surplus?
- Are you impacted by take back agreements?

(E) Food waste mitigation (NRBV capabilities)

- What do you do here to mitigate/ reduce/ prevent food being wasted?
- What about food waste prevention actions?
- What are the main challenges in implementing these?
- Further prompts around the difference between these

- Are there more preferable actions that are taken first over less desirable actions?
- Further prompts related to the food waste hierarchy

(F) Coordination across the supply chain

- What across supply chain actions are taken to mitigate food waste?
- To what extent is the collaboration between processes or sectors to prevent food waste?

Closing questions

- How do you think your business can have an impact on this problem?
- What do you see as the main challenges related to the problem of food waste for your business?
- Is there anything else that you want to add?