ARTICLE IN PRESS

Industrial Marketing Management xxx (xxxx) xxx

Contents lists available at ScienceDirect

Industrial Marketing Management

journal homepage: www.elsevier.com/locate/indmarman

Research paper

Measurement, mitigation and prevention of food waste in supply chains: An online shopping perspective

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ARTICLE INFO

Keywords:
Online food retail supply chain
Food waste management
Natural resource based view

ABSTRACT

This study introduces a framework and model, although applied in a practical setting, sets the stage for further theoretical development of mid-range theory. The methodology applied in the study has four main stages, namely interviews with managers from an online food retail supply chain, analysis of soft and hard data using questionnaire-based surveys of customers and suppliers, archival and factual information gathered from the supplier and the online food retailer to measure food waste across the supply chain and analytical models to quantify various effects. A number of propositions emerged from our multiple methodologies and observations. The major research contribution of this work is to advance Natural Resource Based View (NRBV) to the supply chain and various complexities involved in food waste management. Dynamic capabilities were clearly evident and necessary in rapidly changing industrial contexts such as online food supply chains. This paper also proposes a food waste minimization-and-mitigation model, establishes the direct and indirect outputs of food waste and brings attention of the food waste debate in the context of an exemplar online food supply chain, as well as provides a middle range theoretic framework to enhance understanding on theory and its application to this field informed mainly NRBV.

1. Introduction

Agricultural and food supply chains are central to nourishing the world's population. Poverty relief while simultaneously limiting resource depletion and environmental burden is a sustainable supply chain management (SSCM) goal. They can benefit greatly from improved efficiency and waste reduction, addressing multiple sustainability concerns.

According to EU-27 stats published by the Independent in December, 2015, the UK is the most wasteful of the EU's 27 member states, needlessly throwing away 14.3 million tonnes per year. In the UK alone the annual amount of wasted food is worth approximately £13 billion with 8.4 million people struggling to afford a meal (FAO, 2019). Food supply chains would appear third as an aggregated nation-level ranking of top waste emitters, only after the U.S. and China (WRI 2012).

Given these issues, this study focuses on a UK grocery retail perishable food supply chain. The total estimate for UK post-farm gate food waste (2015) is 10.2 million tonnes; total household food waste is about 7.1 million tonnes (WRAP, 2018).

Food waste may be generated anywhere along the supply chain and has embedded environmental impacts (De Lange & Nahman, 2015)—such as water losses at the agricultural supplier level (Tsagatakis et al., 2016) and carbon dioxide (CO_2) emissions generated from food distribution and decomposition (Kummu et al., 2012). Poor growth and harvesting practices in upstream supply chains lead to sizeable environmental and resource waste (Davies & Legg, 2018). Poor demand management originating along the supply chain also contribute to food waste (Kiil, Dreyer, Hvolby, & Chabada, 2018; Kitinoja, Tokala, & Brondy, 2018). Inventory and supply chain practices for supply chain intermediaries, transporters, wholesalers, and distributors cause significant food waste burdens. This waste is also attributable to control and infrastructure concerns. Furthermore, wasteful food effluents occur in the downstream supply chain, retailing and customer stages.

Electronic commerce—online presence and purchasing—has seen greater emphasis in food supply chains and grocery sales. Research on food waste and sustainability from online purchasing practices is very limited. Even with this increased importance of online grocery sales, little is known about food waste and sustainability externalities in an e-commerce context from practical, scholarly and theoretical perspectives. This study contributes to knowledge in this area. It also provides

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https://doi.org/10.1016/j.indmarman.2020.09.020
Received 16 May 2019; Received in revised form 20 August 2020; Accepted 30 September 2020
Available online 9 October 2020
0019-8501/

opportunity for further expansion of sustainable supply chain management research and theory in a rapidly nascent industrial setting.

This study also aims to draw connections between food waste reduction practices and the Natural-Resource-Based View (NRBV) of the firm, specifically, by identifying and explaining relations among food waste reduction practices and the three NRBV capabilities – product stewardship, pollution prevention and clean technologies. NRBV is an important theoretical underpinning because NRBV stipulates that a firm's success and competitive advantage depend on managing natural resources (Hart, 1995). This competitive advantage is embedded in the food waste reduction practices covered by the case study online grocery food supply chain. Food and its embedded environmental resources as they supply chains major natural resources. We expand NRBV focus to include supply chain entities and other stakeholders; we also take NRBV from a strategic theoretical perspective to include operational theoretic dimensions.

This study introduces a framework and models for food waste performance at three stages of a typical online food supply chain – the supplier, retailer, and customer. The framework and model, although applied in a practical setting, sets the stage for further theoretical development through mid-range theory, which is an approach to sociological theorizing aimed at integrating theory and empirical research.

The aim of this study is to evaluate *the connections between NRBV and food waste with regards to factors that cause food waste, metrics and practices that are used to control, minimize, and mitigate the direct and indirect impacts of food waste along a supply chain*.

In this study, food waste is any waste of perishable products. This food waste can be generated at different online food retailer supply chain stages, including growing, harvesting, packaging, distribution, retail, and consumer households. This study uses the definitions of food waste and food surplus from Food Loss + Waste Protocol (2016), which are:

- '*Excess food that is not redistributed for animal feed, compost manufacturing, anaerobic digestion for energy regeneration or food charities, is considered food waste.*'
- '*Alternatively, food surplus is defined as food that is not used for its primary purpose within the supply chain. Food surplus includes surplus generated by sales from supplier to the retailer and from the retailer to the customer.*'

In addition, for the purpose of this study, food waste minimisation is defined as any measure that can be applied by the supplier or the retailer to minimize the output of food waste through strategies, such as greater collaboration among these two entities and enhanced supplier order forecast, as previous found by Mena, Adenso-Diaz, and Yurt (2011) and Göbel, Langen, Blumenthal, Teitscheid, and Ritter (2015). Alternatively, food waste mitigation can be defined as tactics adopted by the supplier, the retailer and customers to minimize end-of-pipe disposal of food waste through diversionary measures such as anaerobic digestion for energy production and food donations. Food waste mitigation has been previous studied by Aschemann-Witzel, De Hooge, Amani, Bech-Larsen, and Oostindjer (2015), Vandermeersch, Alvarenga, Ragaert, and Dewulf (2014) and von Kameke and Fischer (2018).

Our paper contributes to the supply chain literature by:

1. Developing a food waste minimization-and-mitigation model in an online grocery retail supply chain setting, which includes food waste metrics, minimization and mitigation strategies tailored for online supply chain environments;
2. Establishing the direct and indirect outputs of food waste generated in an online retail supply chain, as well as the causes of food waste and mitigation strategies of supply chain actors;
3. Bringing greater attention of the food waste debate in the online retail sector;
4. Providing a middle range theoretic model (framework) to enhance understanding on theory and its application to this field. Although NRBV is the overall theory, it is also informed by: life cycle assessment (environmental theory, Curran, 1996); critical success factors and key performance indicators (KPI, from critical success factor theory and performance measurement theory, Grimm, Hofstetter, & Sarkis, 2014); and organizational information processing (information theory, Galbraith, 1973).

The remainder of this paper begins with the literature review, gaps in knowledge, research questions and theoretical framework developed for the study. The methodology section includes case study details, followed by the results and analysis obtained in the case study. The discussion section includes comparisons between case study findings obtained and previous literature, resulting in a refined middle range theoretical framework. The paper concludes with a section summarizing the main contribution, research and managerial implications, limitations, and further research directions.

1.1. Sustainable supply chain management, food waste and the Natural Resource Based View Theory

This study adopts an NRBV theoretical perspective to food waste minimisation and mitigation. At the core of NRBV is the establishment of activities to help organizations build competitive advantages through environmental strategic benefits for organizations and their supply chains (Hart, 1995; Hart & Dowell, 2011). The environmental capabilities aspects of NRBV include pollution prevention, product stewardship, and clean technology initiative constructs. These activities help organizations gain 'win-win' advantages. A core aspect of our study is investigating the management of food waste in the online food supply chain (FSC) through the theoretical lens of these NRBV capabilities.

Pollution prevention initiatives within NRBV, are critical FSC strategies (Graham, Graham, & Holt, 2018; Graham & Potter, 2015; Islam, Tseng, & Karia, 2019; McDougall, Wagner, & MacBryde, 2016; Papargyropoulou, Lozano, Steinberger, Wright, & Ujang, 2014). Minimization of food surpluses and avoidable food waste occur with pollution prevention. Food surplus redistribution to groups affected by food poverty have linkages with product stewardship. Food waste conversion to animal feed and anaerobic digestion are example clean technology practices (Mourad, 2016).

NRBV—although usually viewed as a strategic theory—also informs operational theoretic elements to manage supply chain food waste. One important operational aspect of NRBV is information sharing; aligning with the online environmental characteristics of our case environment. Food waste minimisation in fresh FSCs, may be enhanced from sharing demand and shelf-life data among supply chain actors, ultimately reducing waste and facilitating improved sustainability performance (Kaipia, Dukovska-Popovska, & Loikkanen, 2013). Parallel process changes in information management and in material flow are necessary for effective transformation to negligible FSC food waste (Lusiantoro, Yates, Mena, & Varga, 2018). Information management capabilities can also benefit the product stewardship elements of NRBV for food waste management (Perey, Benn, Agarwal, & Edwards, 2018). Clean technology is another important NRBV capability construct. This capability is evident by green information systems support tools and 'Industry 4.0' playing key roles in managing FSC food waste (Miranda, Ponce, Molina, & Wright, 2019). These various NRBV capability elements provide operational theoretical support for the online case study.

Effective information and knowledge sharing helps develop and incorporate new sustainability-oriented capabilities in FSCs. This dynamism includes integrating traditional supply chain with sustainability-oriented capabilities (Beske, Land, & Seuring, 2014). Building *dynamic capabilities* for sustainable natural resource use is central in emergent NRBV literature (McDougall et al., 2016).

The remainder of this literature review section focuses on identification, measurement, minimisation, and mitigation of food waste adopted in supply chain operations—each of which relates to NRBV.

There is an emerging literature stream on food waste and SSCM related to **causes and mitigation of food waste**. Direct food waste causes include marketplace demand structure, product and process characteristics, and practical organizational policy patterns (Göbel et al., 2015; Mena et al., 2011). Supply chain activities that play vital roles in food waste mitigation, include transparency and demand information, food quality management and process control, shelf life management, and packaging design (Gardas, Raut, & Narkhede, 2017). Information sharing and communication are central to these inter-organizational food waste quantities and reduction efforts—and why we believe they are critical NRBV capabilities as well. The literature on food waste causes and mitigation also include customer behaviour as a source of food waste (Aschemann-Witzel et al., 2015; Vandermeersch et al., 2014; von Kameke & Fischer, 2018). Customer motivation to avoid food waste, their management skills of food provisioning and food handling, and trade-offs between their priorities are how customers remain crucial actors for food waste mitigation in the downstream supply chain.

Studies maintain the importance of metrics for managing supply chain and waste performance. **Metrics that are used to measure food waste** help quantify direct food waste impacts among the sustainability three pillars of the supply chain. Several recent studies on sustainable food supply chains focus on the metrics and implications of food waste across various food supply chain (FSC) stages (e.g. Brindley & Oxborrow, 2014; León-Bravo, Caniato, Caridi, & Johnsen, 2017) and consider broader FSC functional metrics relating to breeding or growing, processing, distribution, retail, and consumption. Food safety, an important social sustainability metric, plays a large role in FSC (Wang, Huili, & Goh, 2018), which exemplifies that metrics may go beyond the NRBV related ones but may influence environmental issues.

The need for food waste measurement systems in FSC is evidenced when three-quarters of all food waste-related global warming impacts originates from greenhouse gas (GHGs) emissions in agricultural production (Scherhaufer, Moates, Hartikainen, Waldron, & Obersteiner, 2017). Nevertheless, measuring food waste environmental burdens in isolation fails to account for other externalities food waste generates; including social and economic impacts (Dreyer, Dukovska-Popovska, Yu, & Hedenstierna, 2019). Measurement systems need to consider numerous issues across the supply chain. Broadly, Mena et al. (2011) found that food processing activities contribute 6%, retail and distribution 7%, food consumption 8%, and food disposal 6% and emphasize that environmental degradation generated by food waste occurs across multiple supply chain stages. Kibler, Reinhart, Hawkins, Motlagh, and Wright (2018) highlight that another potential environmental concern, and requirement for FSC measurement systems and metrics, is water resource depletion from water embedded in food waste. Ridoutt, Sanguansri, and Sellahewa (2010) and Vanham, Bouraoui, Leip, Grizzetti, and Bidoglio (2015) identify water and nitrogen resource losses as significant environmental resource impacts of food waste. These studies are only exemplary and further show the need for broader metrics and measurement systems to help determine FSC performance and mitigation activities.

1.2. Gap in knowledge, conceptual model, and research questions

In the literature review, we observe a very close linkage between NRBV and food waste management; even though the literature has not tied their results specifically to this theory. However, the food industry is evolving. The retail food portion of the supply chain has achieved greater *online* and *e-commerce* presence. Food waste in this environment has not seen much research. A basic question is whether NRBV can help gain insight on food waste in an online context.

The online, e-commerce, environment has not been well studied, in general from a SSCM perspective. The NRBV framework can help build relevant theory and understanding for an environmentally sustainable digital supply chain. Digitization along the supply chain is a major emergent concern., the internet-of-things and mobile communication can each play roles in this environment (Kamble et al., 2019; Miranda et al., 2019 Saberi, Kouhizadeh, Sarkis, & Shen, 2018).

Building performance measurement information sharing based on more specific performance metrics is a critical capability, given the breadth of sustainability and supply chain data. These systems can also be considered as clean technology. In this study, the clean technology construct of NRBV is an information sharing technology that would give organizations insights for SSCM. The product stewardship and pollution prevention NRBV constructs enable food waste minimisation and mitigation practices covered in this study. One of the research enquiries this study intends to investigate is whether information sharing technology is effective for FSC food waste management.

Fig. 1 shows the conceptual mid-range theory framework initially developed for the study. Fig. 1 was constructed using literature and theory (see Table 1 for literature supporting inclusion and relationships—some of this literature was reviewed in the previous section). In addition to inputs from various food supply chain experts—see the case study section for expert information—helped to inform initial framework development.

This mid-range theory helps scope and guide the research undertaken in this study. The conceptual framework shows a one-way causal relationship between factors affecting food waste and food waste itself. The food waste also has economic, environmental and social impacts – greater food waste represents larger impact. The food waste has a relationship with food waste minimisation and mitigation, since food waste itself will likely originate different measures of food waste minimization and reduction activities. The conceptual model includes dual-causal links food waste minimisation and mitigation to the NRBV capabilities, because some food waste management measures can be categorized as product stewardship activities or one of the other NRBV capabilities. In some cases, some NRBV measures represents a dynamic or supportive/overlapping relationship among the three NRBV elements, that is why product stewardship and clean technology has a dual-causal link among them.

Table 1 records the previous studies used to construct the conceptual framework presented in Fig. 1.

This study identifies main causes of food waste at different stages of the supply chain. Food waste mitigation improvements and minimisation solutions linked to three NRBV dynamic capabilities – pollution prevention, product stewardship and clean technologies – are identified and evaluated. This conceptual mid-range theoretic model is examined and underpinned in the context of an exemplar online food retail supply chain. Inputs from various actors in the food supply chain provide insights for additional examination and refinement of the framework.

In our review of the literature, utilizing NRBV and critical success factor theoretical lenses, we identify four major issues:

- Previous research does not focus on how food waste should be measured holistically for a sustainability-driven food waste measurement system.
- Current studies do not seem to concentrate on food waste mitigation tactics and strategies across multiple supply chain stages.
- The literature ignores the online supply chain and especially online grocers; and
- There is limited broader theoretical linkage of food waste within operations and supply chain management.

Within this context, the conceptual mid-range theory framework is used to investigate the following research questions:

RQ1 - Which main factors generate food waste throughout the online FSC?

RQ2 - Which metrics are useful for measuring the direct and indirect

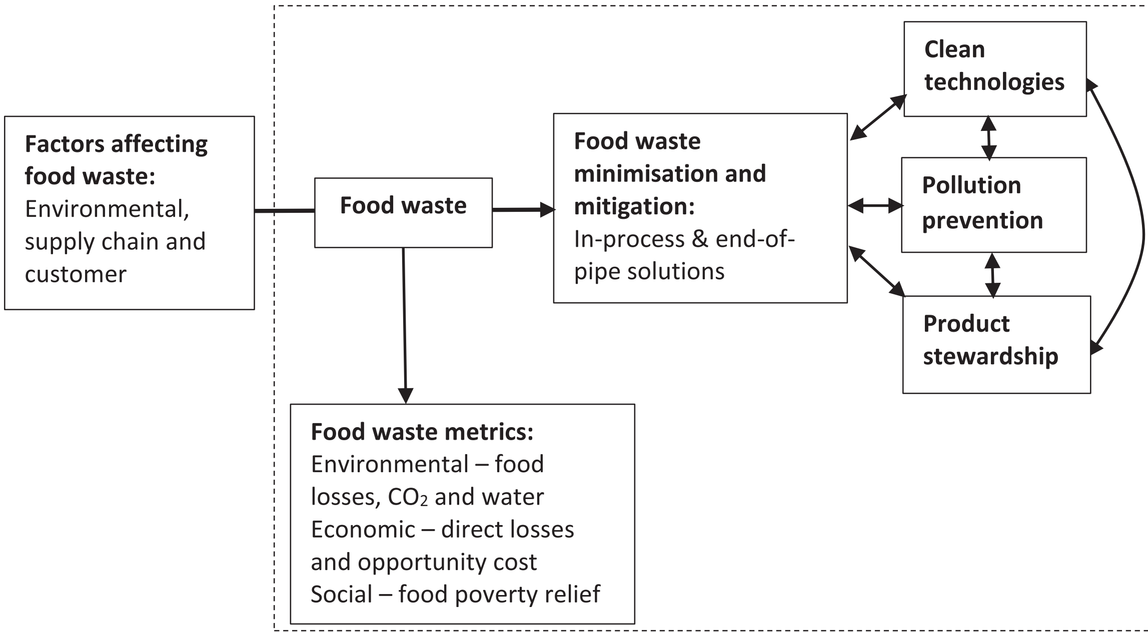

Fig. 1. Middle-range theoretical framework drawing from NRBV, critical success factor, stakeholder, and organizational information processing theories.

Table 1
Literature consulted to build the conceptual framework.

Reference	Factors	Metrics	Food waste minimisation and mitigation	NRBV capabilities		
				Pollution prevention	Product stewardship	Clean technology
Alexander and Smaje (2008)		X				
Beretta, Stoessel, Baier, and Hellweg (2013)		X				
Betz, Buchli, Göbel, and Müller (2015)		X				
Chaboud and Daviron (2017)		X				
Davies and Legg (2018)			X			
De Lange and Nahman (2015)		X				
Gardas et al. (2017)	X		X			
Göbel et al. (2015)	X					
Graham et al. (2018)						
Graham and Potter (2015)				X		
Hart (1995)				X	X	X
Hart and Dowell (2011)				X	X	X
Islam et al. (2019)				X		
Kaipia et al. (2013)	X		X			
Kiil et al. (2018)			X			
Kitinoja et al. (2018)			X			
Kummu et al. (2012)						
McDougall et al. (2016)						
Mourad (2016)			X			X
Reference	Factors	Metrics	Food waste minimisation and mitigation	NRBV capabilities Pollution prevention	Product stewardship	Clean technology
Mena et al. (2011)	X		X			
Papargyropoulou et al. (2014)				X		
Shafiee-Jood and Cai (2016)			X			
Tsagatakis et al. (2016)		X				
Xu, Li, Ge, Yang, and Li (2018)			X			

impacts of food waste generated throughout the online FSC?

RQ3 - What are the main food waste minimisation solutions adopted within the online food retail supply chain?

RQ4 - What are the main food waste mitigation end-of-pipe improvements adopted throughout the online food retail supply chain?

RQ5 - How could NRBV, critical success factor, organizational information processing and stakeholder theories provide insight into online food retail supply chain to minimize and mitigate food waste?

2. Methodology

The conceptual framework and propositions developed from the case study research support theory building research (Carter & Rogers, 2008). Middle-range (mid-range) theoretical frameworks (Meredith, 1993; Weick, 1989) attempt to meet the criteria of a good theory but require additional improvement and revision. As a result, these frameworks require multi-methodological approaches for mid-range theory refinement (Seuring, 2011).

Theory development is a main justification for this research to use a multi-methodological approach; albeit a single supply chain case study. Given the 'wicked problem' of food waste across a complex supply chain, there is a need for multi-dimensional data from suppliers, retailers and customers. Food waste and hunger are wicked problems, largely because the food system is highly complex with many interdependencies, nonlinear feedbacks, and uncertainties (Pereira & Drimie, 2016). The necessary data to help build solutions to wicked problems is not always accessible when a single method, such as interview-based case studies, is applied.

A mid-range theory that links various antecedents and pressures causing food waste, to various organizational resources and capabilities – in this case performance systems and metrics – makes two contributions. First, it provides an explanation for the diversity of potential solutions across the supply chain for sustainable food waste management. Secondly, it contributes to a descriptive theory for food waste management in a supply chain setting. Mid-range theory and frameworks are valuable and formed in environments where multiple theories and methodologies are integrated into a systemic approach for theory development and refinement.

An important initial step, as in our study, is to state the explicit research questions (Carter & Rogers, 2008), which we have done in the previous section. Although NRBV is the major theoretical perspective from which we draw, organizational information processing theory, stakeholder theory, and critical success factor theory, are also contributors, as part of a multi-theoretic perspective. The transition from framework to formal theory occurs as frameworks are evaluated against practice. Our research stimulates additional theory-building and conceptual development within the SSCM field using this approach.

This study uses a deep exemplar supply chain case study from the UK online food retail sector. As recommended by Yin (2009), an exemplar case study is one with unique characteristics and that can be used for theory development. Case studies are exceptional vehicles for mid-range theory development (George, Bennett, Lynn-Jones, & Miller, 2005). Although this is a single case study, there are opportunities to evaluate some of the existing theories, e.g. NRBV, and provide avenues for further theorizing and middle-range theory development (Flyvbjerg, 2006).

The case study includes the following partner organizations:

- **The focal company**: An online food retailer with sustainability, entrepreneurship and innovation as their main strategic priorities.
- **The supplier**: A salad supplier with an objective to become a zero waste and carbon neutral company in the next decade.
- **The not-for-profit consultancy**: A non-governmental organization (NGO) whose main priority is to facilitate best practices implementation to minimize organic and plastic waste from retail grocery supply chains.

In this case, the food retailer is the focal company, the salad supplier is the supplier in the case study, and salads are the product. Our justification is as follows:

- The online food retailer is one of the biggest and fastest growing food retailers in the world;
- The online food retailer has devised a food surplus redistribution network with a number of food charities, redirecting 2200 t of food and donating eight refrigerated distribution vans to the Ocado food partners;
- The online food retailer has access to end-to-end supply chain data, including customer data;
- Salads is one of the top 10 most wasted food products across the supply chain; and;
- The salads supplier includes various practices including circular economic practices in their operations model.

This study's online supply chain consists of five stages: supplier – in charge of farming and packaging processes; retailer – manages distribution centres (DC) and spokes; customer, food partners, and sales staff. The entity in this case study seeking food waste control and reduction across the supply chain is the retailer, a leading player in the online supermarket sector. Fig. 2 presents a graphical representation of the supply chain studied, including the inbound, outbound and reverse supply chain stages of the online food retailer.

The research was undertaken by adopting a multi-method approach, following Frankle, Naslund, and Bolumole's (2005) recommendation on using multiple methods in supply chain management and logistics research due to the complexities of this discipline. Jack and Raturi (2006) also recommend that researchers should choose methods with complementary strengths and non-overlapping weaknesses. The methods used for this case study complement each other, the interviews undertaken provide an explanatory angle to the case; the customer and supplier surveys complement the interview data collected by adding the perspectives of a representative sample of suppliers and customers to the analysis. Furthermore, a supply chain simulation presented in the discussion section demonstrates the impact that enhanced supply forecasts can have on food waste.

The methodology has four main stages with multiple interacting data gathering and analyses, namely interviews with managers, suppliers, and an NGO provide qualitative data, acquisition and analysis of soft and hard (quantitative) data using questionnaire-based surveys of customers and suppliers, archival and factual information gathered from the supplier and the online food retailer to measure food waste across the supply chain and analytical models to quantify various effects. Fig. 3 summarizes the case study methodology stages.

This multiple-methodology approach allows data collection from multiple stakeholders that caused or are affected by food waste to help refine the middle-level theory framework (Seuring, 2011). Multiple approaches provide a deeper picture, since collecting data from one or a limited number of stakeholders through interviews constrains the research problem.

This study consists of a four-stage methodology that includes the conceptual, expert opinion, empirical and framework refinement stages. The research process started with scoping meetings with the online retailer that took place between May and June 2018. The supplier and customer surveys, and raw data gathering occurred between July and December 2018. The conceptual model, semi-interviews, data analysis and refinement of the conceptual model were undertaken between January and April 2019. The research process was rolled out in two phases since the research team needed further qualitative evidences gathered from interviews, comprehensive literature review and exhaustive data analysis to develop the paper.

Also, the conceptual framework stage is informed by recent academic literature and theory on food waste in supply chains, and food waste reports published by WRAP and FAO. The conceptual model was refined using expert opinion gathered from the participating companies; and with archival data gathered from the supplier, the online food retailer, and the customer questionnaire. Data was collected from the different stages of the research, and then compared with previous literature. Iterations occurred to refine the conceptual framework, but also various data from methodological stages was revisited in further refinement and for validity and reliability evaluation, as described later in our description of the validity and reliability measures taken for this study. The iterations shown in Fig. 3 represent comparisons in the study from various data sources and is addressed with the iterations and arrows.

During the expert opinion stage, a structured questionnaire instrument helps to acquire information from a representative supplier sample (see Appendix 1). Initially, all 20 major food suppliers of the online food retailer were invited; five suppliers responded to the questionnaire. Semi-structured interviews (see Appendix 2) with online food retail managers, their main salads supplier, and an NGO waste consultant occurred. The questions included in the interview protocol – see

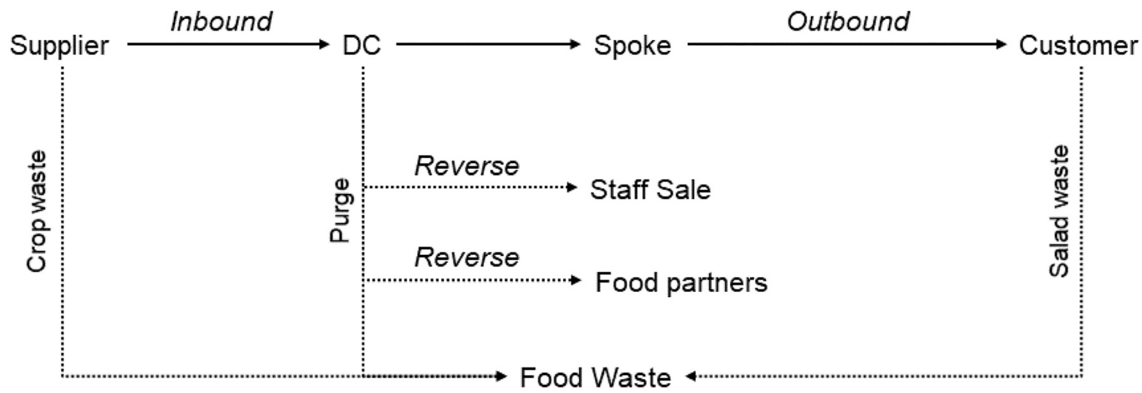

Fig. 2. – Graphical representation of the extended online supply chain studied.
Note: 'Purge' is excess food that may become food waste. It is used, as further identified later in the paper, by the online retailer to describe this excess food phenomenon.

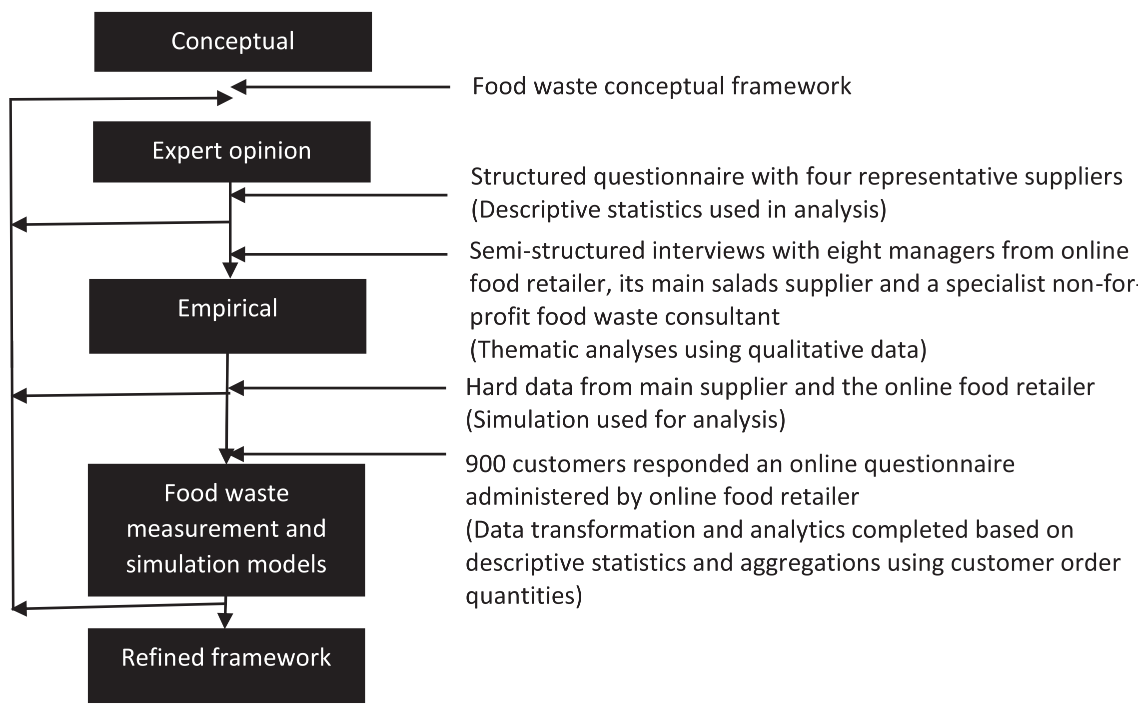

Fig. 3. Stages and methodologies undertaken during the case study.

Appendix 2 – were directly linked to the research questions investigated in the study. All the elements of the mid-range theoretical framework presented in Fig. 1 were included in the interview protocol. These elements include food waste causes, minimisation and mitigation strategies, as well as the three components of the NRBV theory. During the semi-structured interview, when interviewees mentioned specific causes of food waste the interviewer asked them whether or not the causes mentioned were *primary* or *secondary* causes of food waste. Similarly, participants were queried on whether the food waste mitigation end-of-pipe improvements and minimisation in-process solutions were *already implemented* by their organizations, *being piloted*, *currently considered*, *planning to be considered* or *not considered*.

The supplier questionnaire queries were aimed at undertaking an initial screening of all the online food retailer's salad suppliers, a total of 20 suppliers, to determine their percentage of food waste. The surveys also enquired about food waste causes and food waste mitigation end-of-pipe improvements; actions that were identified by the literature informed the questions used. Questions 2 and 3 were aimed at determining the main food waste causes generated by the supplier and the food waste mitigation end-of-pipe improvements adopted by them. The lists provided in these two questions were initially derived from the literature review and an 'Other' option was also provided to respondents. A group of managers from the not-for-profit consultancy and the purchasing department of online food retailer informed the supplier questionnaire, initial responses from two close online food retailer suppliers were also received. This initial feedback helped refine the questionnaire.

The empirical stage includes data collection on food waste practices from the online food retailer and its main suppliers, as well as structured questionnaire survey (See Appendix 3). It was administered by the online food retailer, resulting in 900 customer respondents. The food waste causes listed in question 3 and the food waste mitigation end-of-pipe improvements listed in question 4 of the customer questionnaire were derived initially from the literature review with an 'Other' option provided to respondents. The customer questionnaire was revised by managers from the not-for-profit consultancy, and the sustainability and marketing departments of the online food retailer. Also, the customers invited to take part in the survey are a representative sample of customers in terms of gender, income, number of people living in customer households and geographical location. Selected customers order salads products from the online food retailer at least on a monthly basis. As Appendix 4 shows, this sample is diverse in terms of gender, income and number of people in customer households.

The roles, company type and years of experience of the practitioners who participated throughout this case study period appear in Appendix 5.

The refinement stage includes a comparison between findings gathered from the study and previous literature; as well as various theories to inform the middle theory.

It is also pertinent to evaluate the research quality by considering its validity and reliability. Given reliance on the case study methodology in this study, we use Yin (2009) guidelines to evaluate these characteristics. Table 2 shows the evaluation criteria recommended by Yin (2009) against tactics adopted in the different stages of the case study.

Table 2
Yin's (2009) tactics to evaluate the research quality.

Test	Tactics applied in the research	Research stages
Construct validity	• Multiple evidence was gathered during the four stages of the case study, namely data collected from 8 semi-structured interviews, survey responses from 900 customers (out of a representative sample of 5000) and 5 suppliers (out of a total of 20 suppliers) and a simulation based on perishable goods inventory models. • The data gathered during the four stages were appropriately triangulated. • Drafts of the notes produced during the interviews were written and sent to participants for their approval. • A report was generated and sent to participants to give them a final opportunity to provide feedback.	Data collection and analysis
Internal validity	• The data gathered from the four stages was analysed based on themes found during the literature review and the semi-structured interviews. • The data gathered during the interviews was analysed by comparing the responses provided by participants. • The consumer survey data was used to add the consumer perspective on the research questions.	Data analysis
External validity	• Two supply chain actors (the supplier and the online retailer) and a representative sample of the retailer customers and suppliers took part in the study. • A not-for-profit consultancy from the food retailer that has specialised knowledge on food waste was included in the study to provide a wider perspective on the research questions. • The online retailer is one of the biggest and fastest growing in the world and has access to end-to-end supply chain data. • The three participating companies and the practitioners interviewed are regarded as experts in specialist areas relevant to the case study. • The NRBV theory—along with other supporting theories—were used to enhance the theoretical underpinnings of the case study.	Research design process
Reliability	• A protocol was developed to conduct the case study. • The semi-structured interviews, and the customer and supplier surveys were completed using a well-developed protocol. • This protocol was produced based on themes found in the literature review and based on theory.	Data collection

The three types of validity suggested by Yin (2009)—construct, internal and external validity—have been addressed. A wide range of evidence was gathered during the case study and all the data sources were appropriately triangulated. The themes gathered in the case study were used in the analysis to cross-compare the findings. Furthermore, a protocol was developed to undertake the case study to ensure reliability during the data collection process; specific tactics appear in Table 2.

During the case study, data was collected based on a protocol which was produced based on themes found in the literature. The data collected from the interviews, customer and supplier surveys, and the simulation are complementary of each other. Also, the data gathered from the interviews were recorded and transcribed. Transcripts were sent to participants seeking their validation. A report was produced and sent to the case study companies to give a final opportunity to the participating practitioners to provide feedback on the research and results.

3. Results and analysis

This section presents the case study analysis and results to inform the refinement of the mid-range theory framework related to factors affecting the generation of food waste, food waste metrics, food waste minimization and mitigation improvements and solutions. This in-depth study occurred over a year's worth of meetings, discussions, data gathering and evaluation. The research team, although not using an ethnographic study, had over a dozen planned interactions throughout this study period. Many informal contacts with different actors in the study, through short phone calls, emails, and correspondences were also completed.

We begin by providing general observations concerning food waste factors, specifically focusing on fresh prepared salads. These observations from the case and data, in addition to the literature as summarized in Table 1, help arrive at several propositions.

3.1. Factors affecting food waste across the salad online grocery retail supply chain case study

Food waste generation factors appear from supplier and customer structured questionnaire-based surveys, interviews, and face-to-face meetings with the online food retailer. The main supplier food waste antecedents included poor forecasts of supply and demand (Mena et al., 2011; Thyberg & Tonjes, 2016), insufficient information sharing between the supplier and the online food retailer (Kaipia et al., 2013), and arbitrarily determined short shelf life (Spada, Conte, & Del Nobile, 2018). The online food retailer attributes its food waste mainly to customer demand uncertainty. Customers think their buying, consumption, and eating habits are the principal factors of food waste generated at their end.

According to the online food retailer, the top factor of waste generation at the retailer stage is customer demand uncertainty caused by weather sensitive and seasonal demand that affects customer order quantities. Food waste is also due to the online retailer customer guarantee (Göbel et al., 2015). The guarantee is to provide customers with arbitrary freshness guarantees on all the perishable product families. This policy forces the company to apply discounts to products that are approaching their expiration date; furthering demand disturbances across other fresh products.

The online retailer stated that some external factors cause small amounts of food waste generated at their DCs.

A senior supply chain manager stated: '*when our supplier sends a short shelf-life product we do not expect, that would lead us to throw away more*';

The head of operations excellence added: '*…in addition to short shelf-life product, changes in weather can play a role, changes in weather cause* *unexpected demand changes generated from the customer side. It is harder to achieve high degrees of forecast accuracy and that can cause food waste'.*

The retailer's head of corporate responsibility and corporate affairs retailer added: '*one of the main causes of food waste is customer over purchase. Though, other significant causes of food waste include customer demand uncertainty and disturbances originating at the supplier such as supply uncertainty and lack of information sharing between the supplier and our company*'.

The five suppliers who responded to the survey identify poor forecasting of supply and demand as the top cause of their food waste. Three of the five participating suppliers identify insufficient information sharing caused their food waste. They also replied that retailer rejections due to poor product quality causes food waste. Only two suppliers mentioned crop issues with mould and diseases as a cause of crop waste; but these responses show that such events do occur.

These results are summarized in Table 3.

The salad supplier provided another perspective:

'The main factor causing organic waste at the supplier end is unpredictable weather. This situation affects supply forecast accuracy in the long term. Although inaccurate forecasts of supply and retailer's demand are other important factors that cause food waste. Another less important factor is unexpected damaged crops caused by pests and diseases.'

This supplier statement suggests the retailer has a very small surplus of salad in comparison to the supplier and the order forecasting process can negatively affect their demand forecast accuracy.

The salad supplier also stated that: *'if customers are being encouraged by retailers to buy more than they actually need or can consume, then this can lead to inaccurate supplier order forecast, having a knock-on effect of the amount of surplus their company produces.*'

Based on these initial observations and, from literature summarized in Table 1, we arrive at our first research proposition, previously confirmed by Mena et al. (2011), Thyberg and Tonjes (2016) and Kaipia et al. (2013).

Proposition 1. : In the online food supply chain, variability and uncertainty in demand forecasting and supply capabilities contribute greatly to food waste in the upstream supply chain.

These initial interviews and surveys of suppliers represent waste factors in the upstream portion of the supply. Downstream, from the online retailer, concerns also exist. A customer survey informs the study to determine food waste factors from the downstream, customer perspective. Fig. 4 summarizes major customer household food waste causes. According to the customer survey results, 47% of salad waste from customer households is from customer behaviour and consumption habits. Not consuming due to quality defects was mentioned by 31% of customers surveyed as a reason for food waste. Customers do not consume all the salad products they purchase because of poor product quality at the point of intended consumption; however, customers could be educated on the best storage and control means to avoid food waste coming from refrigeration.

The NGO's food waste technical specialist, provided some insights:

'At the supplier side, the main factor is crop condition affected by weather and climate, pest pressure and soil conditions. From the supply chain perspective, the main factors are inadequate product quality specifications, and inaccuracy of demand and supply forecasting. On the customer side, currently there is no education available for the customer. They need to be made aware of the consequence of their purchasing decision in terms how much waste output is generated at the retailer and supplier due to unexpected amendments in their orders'.

Table 3
Top four causes of salad waste as identified by suppliers.

Cause	Number of suppliers
Poor supply and demand forecasting	4
Poor quality, reject by retailers.	3
Insufficient information sharing between farmers and retailers	3
Issues like mould and diseases	2

The food waste research manager added:

'The retailer should agree with the supplier on the true impact their quality specifications have on food waste. They need to establish whether there is demand for lower-but-edible fresh produce products. The studies undertaken by our company on the introduction of this type of product adopted by other UK retailers have proved how this policy measure can generate significant reductions in food waste across retail supply chains'.

These concerns are similar to "best-before-date" marketing and potentially health policy settings for food (Aschemann-Witzel et al., 2015). Although it is difficult to change customer behaviour, many theories exist in marketing to address pro-environmental behaviour (Groening, Sarkis, & Zhu, 2018). Organizational activities could include careful customer-related food waste management decisions such as date labelling, packaging design, and price strategies to help shift customer priorities (Aschemann-Witzel, de Hooge, & Normann, 2016; von Kameke & Fischer, 2018). These observations and literature lead to our second proposition, which is true for the online FSC environment.

Proposition 2a. : Organizational policies and routines play significant roles in food waste generation; especially within the retailer-customer supply chain partnership.

Proposition 2b. : Poorly aligned marketing and customer promotion policies cause unpredictability and uncertainty in demand leading to greater food waste in the system.

Proposition 2c. : Quality and product performance policies can greatly influence food waste generation throughout the supply chain.

3.2. Food waste measurement along the supply chain– Environmental, economic and social metrics

The management processes and routines used to mitigate the food waste problem are dependent on identifying problem areas and improving their performance. Metrics are critical for these endeavours.

Metrics help prioritize and identify problem areas. The case study also sought to evaluate how various metrics, data, and models are useful to the organization. According to critical success factor theory (Grimm et al., 2014), identifying and focusing on specific critical success factors, in this case sustainability factors and metrics, is a corporate enabler. Metrics help prioritize NRBV-based capabilities, further described in the next section. The metrics management tools developed from the case study are important for food waste prevention and mitigation.

For holistic sustainability management along the supply chain, the KPIs in the three sustainability domains must be regularly monitored and evaluated. For example, if there are limited economic returns or environmental impacts, management efforts and building capabilities for minimizing food waste might be ignored by the relevant supply chain actor.

In order to enhance our understanding of food waste, we implemented an Excel-based tool to measure and report on three dimensions of sustainability by using the data collected during the research. The tool is coded in Excel Visual Basic for Applications and is tested by both the academic team and the focal company. A summary of the food waste measurement and metrics tool KPIs appear in Table 4.

As seen in Table 4, the proposed tool was designed to consolidate data derived from suppliers to customers and provide relevant KPIs and metrics with an acceptable level of accuracy. A representative sample of perishable products has been studied in the application this tool; since not all products and information were initially available. Table 5 highlights the data required from each supply chain partner to estimate the food waste measurement tool KPIs. This data helps to identify, develop, and acquire required information. It also highlights aspects of waste, measure, and location requiring waste minimization.

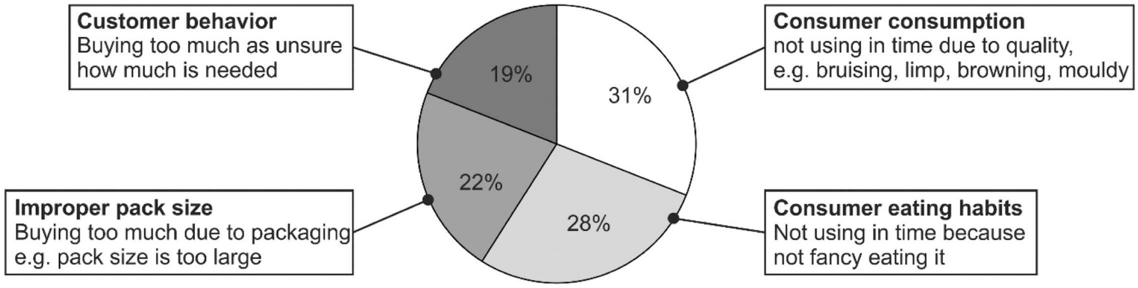

Fig. 4. Top four causes of salad waste by customers.

Table 4
Food waste metrics information developed in the case study.

Environment		Economic		Social	
KPIs	Unit	KPIs	Unit	KPIs	Unit
CO_2e emissions (organic)	Kg	Supplier waste	%	Donation rate to foodbanks	%
CO_2e emissions (transportation)	Kg	Supplier waste	kg	Donation rate to charities	%
Blue water footprint	liter	Retailer waste	%		
Anaerobic digestion	%	Retailer waste	kg	Discounted sales to employees	£
		Customer waste	%		
		Customer waste	kg		
		Opportunity cost	£		
		Lost sales	£		

From a methodological perspective, the tool takes the data listed in Table 5 as input and classifies the data provided by focal company data for a given period.

This classification is based on the origin depot, destination spoke, time period, and SKU. The tool considers all order data and calculates the net amount sold from a specific origin to a specific spoke. The tool can calculate quantity sold to customers and the redistributed food surplus. The tool also calculates individual food factors such as whether food was sent to the company shop, charities, and food banks. After identifying product sales quantities, the total received and total ordered amounts from the supplier are determined. The supplier side total production percentage that is redistributed or wasted is then determined. Based on the actual sales, for a given period – such as a week or month – the tool determines the total amount of waste of a specific product at the customer side. Given limited customer data, it is assumed that all customer generated food waste is landfilled or redistributed for anaerobic digestion.

All wastes generated along the supply chain are calculated as explained. Other sustainability KPI metrics are calculated using the relevant emissions models and Bluewater footprint ratios. Economic KPIs are also calculated from the date provided by the focal company, including opportunity cost and lost sales. The tool along with sustainability metrics discussion and standardization allows stakeholders to arrive at comparable evaluations. Metrics and units of measurements agreement helps stakeholders benchmark and identify major factors and capabilities solutions, as highlighted by Scherhaufer et al. (2017) and Dreyer et al. (2019).

Proposition 3. : Standardized sustainability metrics and information processing are needed to support KPI development for food waste management along the supply chain.

The current metrics tool waste information output is specific to the case company (Table 6 is one example). Table 6 presents an example of annual aggregated sustainability and environmental analysis of food waste for a single product. Table 6 categorizes metrics across three supply chain stages—inbound, outbound, and reverse supply chain stages.

To have a better understanding of Table 6 values, a number of assumptions hold and include:

- A single perishable product is investigated.
- Analysis is based on a yearly data obtained from the focal company, single supplier (i.e., grower and packager in this example) and a sample of customers who purchased this type of product.
- All customer orders are sold from a single depot to customers via several geographically scattered and smaller depots.
- Since there is no data on customer location; average distance from the closest depots are assumed for the calculation of outbound-related transportation.
- All other related data regarding the type of vehicles used, capacities and emissions are calculated using the latest NAEI (National Atmospheric Emissions Inventory) model.
- A specific coefficient has been used for calculating Bluewater footprint for the amount produced at supplier side.
- It is assumed that all waste generated at the supplier side is sent for anaerobic digestion and all wastes generated at the customer side are sent to landfill.

The focal company and its supply chain partners viewed this information as valuable since it identified various stages, standardized data, and various stakeholders. Standardization, within organizational information processing theory, is critical for performance measurement effectiveness (Gattiker & Goodhue, 2004; Yadav, Garg, & Luthra, 2020).

Table 5
Data requirements from each supply chain partner, including the online retailer.

Supplier		Customer			Online retailer
Grower	Packer	Actual customer	Charities	Foodbank	Focal company
Production plan & schedule	Order quantity (kg); required quantity; waste	Sales (units or kg); Delivery window	Required amount (units or kg); Time window	Required amount (units or kg); Time window	Received quantity (units or kg); delivery plan
Delivery plan; redistributed amount (anaerobic digestion)	Delivery plan	Waste	Waste	Waste	Quantity sold to customer; sent to charities and food banks; anaerobic digestion; discounted sales to staff

Table 6
An example output of annual aggregated sustainability analysis of food waste for a chosen single product.

			Supply chain stage		
Impact	Metric	Total	Inbound	Outbound	Reverse
Environmental	CO_2e emissions (organic) (kg)	541,307		X	X
	CO_2e emissions (transportation) (kg)	75,546 (104,325)	X	X	
	Blue water footprint (litres)	3,413,467	X		
	Anaerobic digestion (kg)	44,451*			X
Economic	Supplier waste (%)	13.61			
	Supplier waste (£)	44,451	X		
	Retailer waste (%)	0.00			
	Retailer waste (kg)	3	X		
	Customer waste (%)	12.00			
	Customer waste (kg)	33,845		X	
	Opportunity cost (£)	349.68			
	Lost sales (£)	6925		X	
Social	Total donated amount (charities & food banks) (kg)	2820			X
	Discounted sales to employees (£)	1046			X

* The total amount sent for anaerobic digestion by the focal company and the supplier.

The multiple stakeholder perspective is also critical for effective adoption and trust in this system (Bundy, Vogel, & Zachary, 2018; Mena, Hult, Ferrell, & Zhang, 2019); multiple stakeholder information and input was used in the development of this tool. It has also been found that more effective sustainability performance measurement and sustainability practices occur when multiple stages of the supply chain are carefully considered (León-Bravo, Caniato, & Caridi, 2019; Scherhaufer et al., 2017).

To support this tool, information from each supply chain actor – grower, packer, customers, charities, and food banks – is needed. Instead of only monitoring company operations waste, the company now has access to broader supply chain waste information. This broader information provides a holistic perspective to better develop supply chain capabilities and identify the resources for SSCM.

A different set of sustainability metrics exist for upstream and downstream supply chain activities. These KPIs were specifically selected to help the organization reduce wastes and identify sustainability co-benefits or trade-offs.

Proposition 4a. : Effective FSC waste management requires various stakeholder inputs to sustainability metrics development and standardization.

Proposition 4b. : Inter-organizational and stakeholder-specific sustainability KPIs aid reduction of food waste along the supply chain.

3.3. Prepared food waste generated along the supply chain

This section exemplifies some output of the metrics tool and data from the case study. It is useful to help identifying the waste flows along the supply chain to help identify and mitigate food waste (de Moraes, de Oliveira Costa, Pereira, da Silva, & Delai, 2020). The Sankey diagram–see Fig. 5—is one such important mapping.

These results help identify major problem areas, potential stakeholder interests, and food waste causes. The metrics tool is an organizational capability that did not exist previously. General analysis from the metrics tool, that is used to generate Fig. 5 and that informs the mid-theory framework and relationship (Fig. 1) is presented.

The supply chain food waste measurement tool includes suppliers of lettuce, baby leafs and celery. The metrics tool application results indicate the scope and location to reduce food waste. Fig. 5 shows 11% of the supplier production is crop food waste. Wastes (surpluses) not

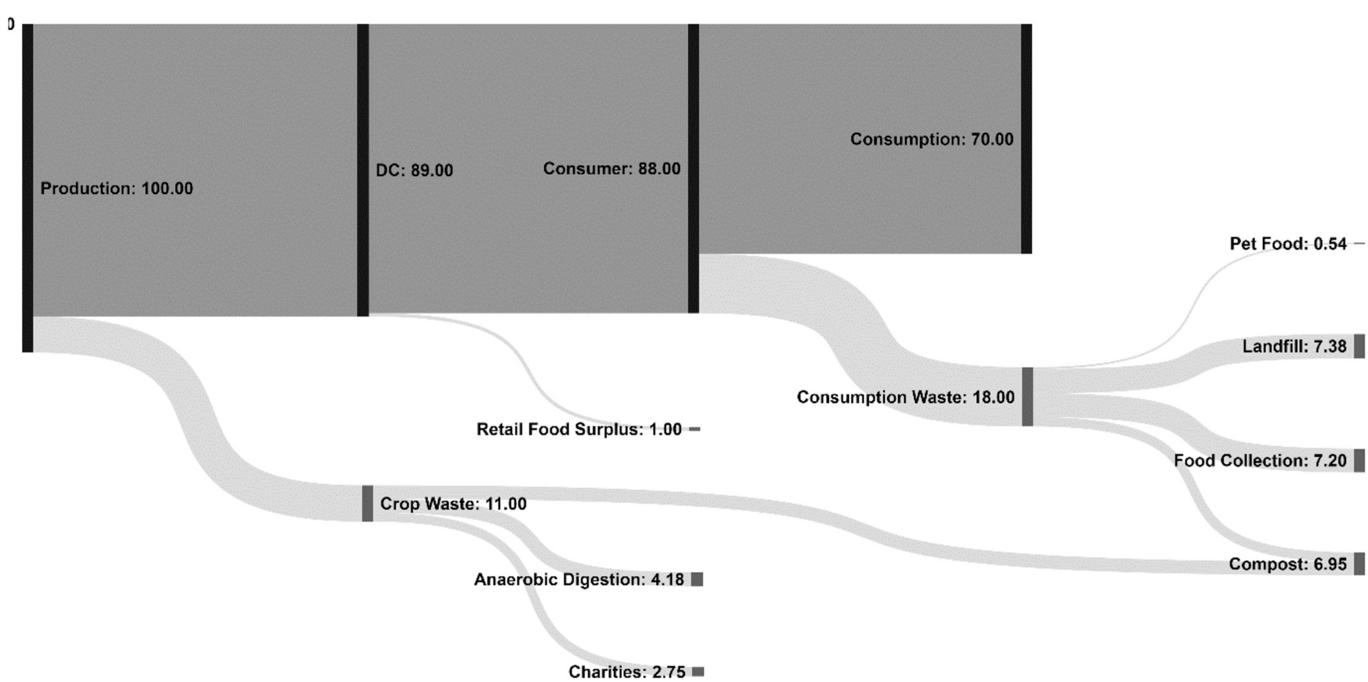

Fig. 5. Overall share of waste (%) in tonnes for the three salad categories included in the case study.

disposed may flow to other uses, e.g. 4.18% of food waste goes to anaerobic digestion and 2.75% donated to charities. These flows may not be 'by-products' and considered wastes since they are not made into new products or chemicals from which the suppliers generate revenue (Lin et al., 2013); although composting and energy generation may generate revenue or as resources for other processing activities.

The supplier food surplus is not landfilled, it is redistributed for food waste mitigation purposes, which contrasts with waste generated at customer households. Customer food waste represents 18% of purchases from the retailers. Of this food waste, 7.38% goes to landfills. There are no dedicated food waste collection systems for a significant proportion of the participating customers. However, customers use approximately 7% of their food waste to make compost for gardening proposes or as pet food.

The final food stream shows that 70% of the product was consumed as intended. Ample opportunity exists to manage the remaining food waste.

The metrics tool supports the economic, environmental and social measurement of food waste. Its environmental KPIs use food waste to calculate the total emissions created during transportation, the total emissions emitted during production at the supplier site, and the total blue water footprint generated at the supplier site. The analysis includes two online retailer distribution centres. As shown in Table 4, knowing the waste leads to determining unnecessary CO_2e emissions and blue water footprints.

These numbers are valuable because not only is the food—salad—wasted, but the waste embedded energy and water related to production and transportation of salad. These measures help identify opportunities and capabilities for managing emissions and blue water footprint. Table 6 highlights the need for monitoring the waste and its three pillars of sustainability implications. Even though an online retailer may perform better compared to other retailers, the food waste environmental impacts are still significant. Thus, there is an argument to utilize critical success factors, from critical success factor theory (Grimm et al., 2014; Sellitto, Vial, & Viegas, 2018), to help identify what supply chain stakeholders, related to stakeholder theory (Freeman, 1984; Shankar, Gupta, & Pathak, 2018), contribute to these measures. The results from this information and sources need to be managed by building supply chain capabilities that include – according to NRBV (Hart, 1995; Hart & Dowell, 2011) – end-of-pipe, in-process, and prevention solutions. This type of solutions are pollution prevention capabilities critical to NRBV (Graham et al., 2018; Graham & Potter, 2015; Islam et al., 2019; McDougall et al., 2016; Papargyropoulou et al., 2014).

These observations lead to a general proposition related to the interactions between the tool, causes, and capabilities development.

Proposition 5. : Supply chain information processing aids food waste management and capability requirements identification. Dynamic supply chain-specific resources and capabilities are needed to address food waste along the supply chain.

3.4. Food waste mitigation end-of-pipe improvements

The online retailer generates salad waste at about 1%, and with this amount representing 0.02% of food wasted across all the perishable product ranges (just 1 in 6000 items); evidence of progress made on their nearly zero-waste journey. In 2017, instead of disposing food, the online retailer redistributed 2200 t of fresh food to 17 food partners – the company shop "70% discount", food banks, charities, and zoos.

The online retailer viewed these efforts as food waste mitigation end-of-pipe improvements; specifically, the online retailer operations excellence director stated:

'If there is any purge, a very small percentage of purge, then tactically we could sell it on or offer it to charities, homeless charities and foodbanks…. Even local zoos who are very keen to take some, and they offer discounts to staff from the online retailer to visit those local zoos'.

The online retailer head of corporate responsibility and corporate affairs also commented on this issue:

'There is a wide range of charities that we work with, and we try to work with local charities that are close to our distribution centres. We donated vans to the local charities since they do not have the means to redistribute the food we donated to them. We also donate small proportions of our food surplus to AD (anaerobic digestion) and zoos. Historically, we also look at carbon in transportation, ensuring goods and food being moved between sites are as low carbon as possible. With this in mind, we recently purchased a fleet of CNG natural gas trucks to compliment this approach'.

There are a range of corrective tactics for suppliers and customers to mitigate food waste—see Fig. 6.

According to the survey results, upstream, 37% of supplier crop waste is composted, 25% goes to charity and 25% is used for anaerobic digestion energy plants. Additionally, 13% of suppliers responding to this survey used surpluses (purge) for other types of energy generation. According to crop waste measurement and analysis from the case study supplier, the total production output surplus was 11%. Anaerobic digestion uses 2.75% and other types of energy generation technologies use 1.45%; another 2.75% is donated to charities.

The supplier technical innovation and sustainability manager stated:

'Surplus generated from harvesting is ploughed back into the fields to retain some of the carbon that has been used by the plants in the soil. We also have our own anaerobic digestion plant to counter some of the energy from our crops that has been wasted. We produce our own compost by using any waste we generate and sell some waste products as animal feed … We send about a quarter of our waste to anaerobic digestion (AD), since AD is probably the most effective food waste mitigation tactic. We try to achieve carbon neutrality because we are able to capture heat and electricity that we can use them again in our factories'.

In this example, there are environmental mitigation strategies especially associated with CO_2e reduction. The focus was to be able to reuse embedded energy, carbon, and even water resources to help mitigate the environmental damage caused by food waste. As part of this effort, they began to realize how much of each waste can be used in different areas. In some cases, the benefit was environmental and some were economic (generating revenue through resale). Some research has investigated supply chain position for some environmental mitigation strategies and position may differ in terms of impact (Garnett, 2011).

We make the following observation. The capabilities developed to reduce supply chain food waste see support from multiple sustainability metrics (Brindley & Oxborrow, 2014; de Moraes et al., 2020; Gardas et al., 2017; León-Bravo et al., 2017). These metrics consider various activities, by multiple supply chain stakeholders. Capabilities, metrics,

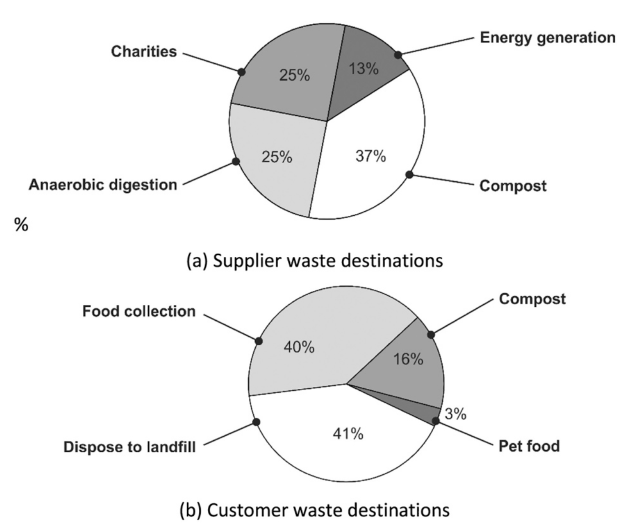

Fig. 6. Salad waste outcomes for suppliers and customers.

and resources can support particular stakeholder and sustainability concerns given the resources available, their supply chain positioning and the type of waste utilized (Aschemann-Witzel et al., 2017; Mena et al., 2011; Muth et al., 2019). This leads to the following research proposition:

Proposition 6. : There exists a contingent NRBV, based on stakeholder and KPI concerns, where capabilities and actions are dependent on supply chain actor, metric used, and product processing aspects.

Mitigation rather than reduction is the main goal of food waste management programmes since the online food supply chain takes meeting market demand as its main priority. In the downstream supply chain, 40% of the customer waste is recycled through municipal circular economic channels for animal feed and renewable energy generation. This circular economic approach is an NRBV-based, product stewardship capability-building example (Lehtokunnas, Mattila, Närvänen, & Mesiranta, 2020; Miranda et al., 2019; Perey et al., 2018). These circular economy practices can also generate additional funds from food waste by-products (Garcia-Garcia, Stone, & Rahimifard, 2019; Göbel et al., 2015; Teigiserova, Hamelin, & Thomsen, 2020).

A fraction (16%) becomes customer compost for gardening purposes; 3% becomes pet food. The remaining, and largest percentage (41%) of household food waste goes to landfills. A significant proportion of local council across the UK do not provide dedicated food waste collection service from the customer households.

The NGO food waste technical specialist summarizes:

'On the supplier side, salad producers send their surplus to livestock holders for animal feed. They use part of their surplus in their anaerobic digestion plants, if they have one, or for making their own compost'.

The NGO food waste research manager also confirms the observation:

'*UK retailers redistribute a large proportion of their fresh food surplus to charity, similar to the case of the online food retailer; and, UK retailers are currently redistributing a very small proportion of their fresh produce waste to anaerobic digestion plants, since anaerobic digestion technology requires heavy up-front investment. Retailers, including the food online retailer, continue to join the debate ensuring that landfill should not be a preferred financial mechanism for food that can be redistributed*'.

Proposition 7a. : Mitigation strategies seek to minimize costs or generate additional revenues from food waste.

Proposition 7b. : The NRBV holds in the food supply chain as 'win-win' opportunities are sought.

Proposition 7c. : Product stewardship and clean technology initiatives for mitigation create 'win-win' opportunities.

Anaerobic digestion is a clean technology that helps mitigate the food waste impact. This mitigation tactic benefit generates enough revenue to offset costs. These benefits represent additional resources and capabilities to help mitigate the food waste environmental burden. This initiative is a joint effort that includes their supply chain partners and the non-profit technical experts.

3.5. Food waste minimization in-process solutions

Whereas food waste end-of-pipe solutions mitigate food waste impact; food waste prevention in-process activities are available supply chain tactics.

Poor customer demand forecasting is a major food waste generation factor. According to the senior supply chain manager:

'The online food retailer supply chain department works with the ICT (information and communication technology) team on customer demand forecast accuracy. They develop algorithms to improve supplier order forecast. We are also planning to bring in new technologies such as machine learning to improve our demand forecast further. When we realise that an SKU (stock keeping unit) is not selling as fast as we predicted, we introduce a website discount promotion driven by food waste minimisation. These promotions are introduced automatically by connecting our website sales portal with our livestock data.'

The senior supply chain manager mentioned clean technology efforts, e.g. decision support and information technology as valuable approaches for preventing food waste (Zhu & Kouhizadeh, 2019). These technologies can help managing inventory and ordering along the supply chain for effective demand management. The online characteristics, given big data generation (Li, Chi, Hao, & Yu, 2018), support information technology as a critical, NRBV-based, clean technology capability.

Customers were surveyed for suggestions to minimize household salad waste; 97.5% of surveyed customers felt the online food retailer can help them minimize their salad food waste. Interestingly, about 45% of respondents stated that if the online food retailer offers smaller size packs of salads, they could waste less. A significant portion (i.e., 24%) of surveyed customers asked for extended salad product life.

Customers (20%) also felt that alternative packaging can enhance the salad product life, including re-sealable salad bags and packaging to order. Other food waste minimization suggestions include educating customers on product storage and handling (6.1%); and improving product handling by the online food retailer so the product does not arrive to their households crushed (2.9%).

Given these concerns, the online food retailer head of corporate responsibility and corporate affairs provided insights into responses:

'In our website, there are symbols that suggest the current storage practices of each product with the aim of extending product life. In particular, we give advice on when products can be frozen. Also, our company is planning to share more information on stock quantities and future demand with strategic suppliers with the aim of helping suppliers to reduce their own waste'.

The case company found other potential actions in their processes, packaging, or approaches to help reduce downstream, customer food waste. Through the survey they realize that the level of customer waste can be quite substantial. Using pollution prevention and product stewardship ideals with appropriate serving sizes identifies substantial win-win opportunities as espoused by NRBV.

The supplier CSR manager, also chimed in with a summary of the in-process waste minimization efforts taking customer and supplier feedback into consideration:

'We are currently investing in a number of improvement projects that will lead to food waste reduction. They include technologies and models to make the supply forecast more accurate, more effective methods of capturing data that inform our food waste reduction decision making, more accurate waste composition analysis, more frequent food waste reporting around the business. In particular, we are about to implement a new technology developed by Cambridge University capable of remote sensing and take pictures of crop plants that it can feed into a supply forecasting model to predict when the crops will be ready for harvesting'.

Not only were sources of solutions from the customers and suppliers, but third-party stakeholders, the NGO partner, also provided feedback and solutions. The NGO food waste research manager stipulated:

'The online retailer and their fresh produce suppliers need to improve their communication and information sharing. They need to make their stock levels at the retailer visible to the supplier, and vice versa. This approach serves the purpose of increasing supplier order forecast accuracy; as well as, collaborating on their reverse supply chains. These approaches help ensure that redistribution of food surplus is managed by applying a more joint approach. Food surplus can be redirected to other parts of the food retail supply chain, which currently does not happen'.

The NGO food waste technical specialist expressed a slightly different view:

'It is the sole responsibility of the supplier to improve quality and consistency of their production, match demand and supply, and improve the accuracy of their crop planning'.

In both cases, the NGO recommended in-process solutions for prevention by the supplier and the online retailer. The feedback included a product stewardship – reverse logistics – and clean technology –

information technology – alternatives.

One such response is the online food retailer undertook supply chain simulation to estimate the potential reductions in stock levels and waste an improved supplier order forecast method could generate. The simulation is based on a perishable inventory model (Nahmias, 1982). This model is suitable for salad products as it incorporates a fixed shelf life, and products must be purged afterwards. It also allows for a periodic (daily) order process, which is currently in use by the retailer. We assume a first-in, first out system which means that the retailer always dispatches products with the shortest life remaining. In the improved method, the retailer adjusts the calculation of the safety stock level, an essential component in determining the order quantity. Specifically, the safety stock is calculated as a proportion of the standard deviation of forecast error, in contrast with the conventional method where it is a multiple of average demand. For performance evaluation, we measure several KPIs including the purge rate (ratio between purged products and total sales), availability (likelihood of demand being satisfied), average inventory level, and the amplification degree of inventory level and order quantity with respect to the sales.

Table 7 summarizes the inventory system KPI for a sample of SKUs. Inventory fluctuations measured by inventory amplification reduce by 48% due to the new order policy. Improvements in both the purge rate – reduced by 40% – and availability – increased by 2%, occur. The average inventory level also reduces by 43%. Meanwhile, the order fluctuation shows a mild reduction of 3.6%. The online retailer benefits without adding operational difficulty to the suppliers.

The evidence shows some product stewardship improvements, by managing orders throughout a supply chain – using the clean technology. It also exemplifies how various KPIs can help address multiple supply chain stakeholder needs, including lowered purge for communities and society, improved availability for customers, improved inventory efficiency for the case company, and reduced order volatility for suppliers.

Overall, we see that information management in an online supply chain requires information sharing and technology to aid in building and supporting its capabilities to reduce food waste along the supply chain. The literature has considered this as one of the important transitions in food waste management (Harvey, Smith, Goulding, & Illodo, 2019; Weymes & Davies, 2019). Information processing is critical to these items that result in the metrics and information necessary to manage the flows of wastes and materials. These results further confirm Proposition 1, but we extend that proposition by adding an additional related research proposition building further on food waste management information needs in supply chains with an explicit linkage to NRBV elements (Lusiantoro et al., 2018; Miranda et al., 2019).

Proposition 8. : Information processing and information sharing tools support food waste reduction in online food supply chain business environments. These tools can support product stewardship, clean technology, and pollution prevention capabilities.

4. Discussion

This section evaluates case study information in the mid-range theory framework context, Fig. 1, informed by NRBV and critical success factor theories—later supported by stakeholder and organizational information processing theories. We take a closer look to determine what aspects of the framework may require refinement using case analyses details. We also seek to borrow from other theories, specifically stakeholder theory, to inform the mid-range theory framework.

The mid-range theory developed and refined through the case study and various propositions, guides this discussion, highlighting similarities and differences between the initial framework and case study findings. The factors affecting food waste, food waste metrics, food waste prevention and mitigation, and NRBV capabilities—product stewardship, pollution prevention and clean technologies – are evaluated. The food waste metrics, mitigation end-of-pipe improvements, and minimization in-process solutions evaluation uses their level of implementation (Zhu & Sarkis, 2004). This evidence provides progress insight of the framework elements in relation to their implementation at the supplier and online food retailer.

4.1. Factors affecting food waste

A food waste factor comparative summary of case study factors and those mentioned in the literature appears in Table 8.

Several food-waste generation factors from the previous literature exist in this study (Aschemann-Witzel et al., 2015; Göbel et al., 2015; Mena et al., 2011; Vandermeersch et al., 2014). Product demand forecast affectations, including weather, perishability, and customer buying and consumption behaviour are overlapping factors between the broader literature and this case study. The main factors affecting food waste – according to interviewed managers - are categorized as primary and less important factors as secondary.

The supply, weather, product quality, and insufficient technology generate food waste. The suppliers, online retailer and the NGO each state that unpredictable demand from retailer decisions or weather are central food waste generating factors. The retailer, customer and NGO felt a short product shelf life policy contributes greatly to food waste since throughout the supply chain products are wasted due to very tight expiration dates. Such a strategy provides freshness to the customer at the expense of food waste generated at the supplier and customer ends.

The literature does not explicitly mention supply forecasting as an important factor. This result contrasts with views of supplier managers and the NGO. They emphasize that it is one of the top food waste causes in the upstream supply chain. They strongly felt that food waste reduction relies on accurate forecasting.

Proposition 9a. : Uncertainty and risk management through improved data capture, manipulation, and processing are needed for NRBV capability technological solutions in online food supply chain business environments.

Proposition 9b. : Effective NRBV capabilities support both internal organizational and external supply chain partner and stakeholder requirements.

Proposition 9c. : NRBV needs to consider supply chain and consider operational routines, not just strategic goals.

The literature also ignores some supplier factors, ***inappropriate specification or quality failures*** and ***crop damage***, are two such factors. The supplier manager considers them as secondary factors from their company's perspective. The NGO felt these factors are important for all salad producers supplying UK retailers.

4.2. Food waste metrics and relationships to stakeholders, causes, and capabilities

Online food retailers can reduce their waste by improving their business practices and information sharing systems. The waste measurement tool introduced earlier helps to achieve this goal. The metrics include KPIs from the three sustainability pillars, using elements of life cycle assessment. These KPIs support organizational and supply chain

Table 7
Simulation results of food SKUs under varying policies as identified by the inventory decision support and simulation 'clean technology'.

	Current policy	Alternative policy
Purge rate	4.955	2.970
Availability	0.977	0.999
Avg. inventory level (standardized)	1.000	0.573
Inventory amplification	1.135	0.589
Order amplification	1.136	1.095

Table 8
Factors found in the case study compared to previous literature.

Factor	Mentioned by				Literature
	Supplier	Online retailer	Customer	Non-for-profit consultancy	
Inaccurate supply forecast	P	N	N	P	Not found
Unpredictable demand caused by retailers or weather	P	P	N	P	Mena et al. (2011) & Göbel et al. (2015)
Lack of insufficient technology and advanced techniques	S	N	N	N	Gardas et al. (2017)
Short product shelf life	N	P	P	P	Mena et al. (2011)
Inappropriate pack sizes	N	N	P	P	Mena et al. (2011) & Gardas et al. (2017)
Customer's buying behaviour	N	N	P	N	Vandermeersch et al. (2014) & Aschemann-Witzel et al., 2015
Customer's consumption	N	N	P	N	Aschemann-Witzel et al. (2015) & von Kameke and Fischer (2018)
Customer's eating habits	N	N	P	N	Not found
Crop damages caused by weather changes or pests	S	N	N	P	Not found
Inappropriate specifications or quality failures	S	N	N	P	Not found
Customers not educated on the implications of their buying behaviour	N	N	N	P	Not found

(P – Primary factor, S – Secondary factor and N – Not mentioned).

initiatives. Extant food waste studies do not consider online food retailers from the perspective of the three pillars of sustainability and multi-stakeholders. Table 9 highlights stakeholder views on food waste metrics.

In addition, stakeholders provided level of metrics adoption in the supply chain. There is some agreement on case study metrics acceptance, but differences also exist.

The three NRBV capabilities have relationships with the set of food waste metrics. Links include pollution prevention that encourages more environmentally friendly behaviour across the supply chain. Clean technology advances in ICT integrate these metrics for supply chain measurement systems and product stewardship practices. Stakeholder coordination is also required for their implementation.

Proposition 10. : Direct and indirect feedback relationships exist between stakeholders through the metrics used for monitoring and improvement and through NRBV capabilities.

4.3. Food waste mitigation end-of-pipe, minimisation in-process solutions and NRBV capabilities

The mid-range theory framework focuses on two types of supply chain food waste management activities, mitigation and minimization approaches. These approaches also link to the three NRBV capabilities. Implementations and pilot programs exist for the supply chain food waste management approaches in this case study. The metrics, stakeholders, and waste causes relate to capabilities development; furthering support for Proposition 10.

Table 10 shows the food waste mitigation end-of-pipe improvements and minimisation in-process activities identified for the three stages of the online food supply chain; supporting literature is also identified.

There are several mitigation end-of-pipe improvements adopted in each supply chain stage. For example, the supplier and the online retailer manage food surplus by redistributing to charities, animal feed, and AD. The supplier and the NGO view AD as an effective way to reduce CO2e emissions generated from food waste. These organizations believe AD is a clean technology capability commonly applied by agri-food suppliers.

The use of food surplus for AD and donation to charities are product stewardship and pollution prevention capabilities. These activities require transfer of ownership of food surplus. These activities mitigate emissions generated from food surplus transportation and decomposition. The supply chain partners consider redistribution of surplus to animal feed and making compost as product stewardship capabilities. The supplier managers and NGO believe these two tactics are not necessarily pollution prevention capabilities; mostly because their emissions mitigation effectiveness is rather limited.

Several minimization in-process solutions appear in this study. The supplier has recently ***implemented technological advancements improving their supply forecasting methods***, which consists of a supply forecasting system enhanced by new remote-sensing technology. The information helps predict supplier production quantities. The supply chain manager felt the forecasting system has a pollution prevention capability. The forecasting system application reduces their food surplus generation and transportation emissions.

There are other food waste minimisation in-process solutions piloted along the online supply chain. The KPI metrics tool, described earlier in this paper, is under evaluation by the supplier and the retailer for other

Table 9
Food waste metrics found in the case study compared to previous literature.

Sustainability pillar	Metric	Mentioned by			Example literature
		Supplier	Online retailer	NGO consultant	
Environmental	Food waste ratio	I	I	I	León-Bravo et al. (2017) & De Lange and Nahman (2015)
	CO2e emissions per Kg of food waste	P	P	P	Tsagatakis et al. (2016) & Scherhaufer et al. (2017)
	Lt of water per Kg of food waste	P	P	P	Kummu et al., 2012 & Kibler et al. (2018)
Economic	Food surplus opportunity cost	C	P	N	Ridoutt et al. (2010) & Chaboud and Daviron (2017)
	Food surplus loss of sales	C	P	N	Vanham et al. (2015); Shafiee-Jood and Cai (2016) & Betz et al. (2015)
Social	Food donations	I	I	I	Alexander and Smaje (2008)
	Calories of food donated per food surplus quantity	C	N	N	Beretta et al. (2013) & Dreyer et al. (2019)

Notes: I – Implemented successfully, P- Piloted, C- Currently considering, PC- Planning to consider and N – Not being considered. CO_2e is carbon dioxide emissions equivalence.

Table 10
Food waste mitigation end-of-pipe improvements and minimisation in-process solutions linkage to NRBV capabilities.

		Supporting literature	Originated from			Connected to		
			Supplier	Online food retailer	Customer	Pollution prevention capability	Product stewardship capability	Clean technology
Food waste mitigation end-of-pipe improvements	Donation of surplus to charities	Mourad (2016)	I	I	N/A	X	X	
	Redistribution of surplus to animal feed	Mourad (2016)	I	I	I		X	
	Usage of surplus for Anaerobic Digestion	Xu et al. (2018)	I	I	I	X	X	X
	Making compost for local use	Mourad (2016)	I	N	I		X	
Food waste minimization in-process solutions	Improved supply forecasting through technological advancements	Kitinoja et al. (2018); Kiil et al. (2018)	I	N/A	N/A	X		
	More accurate measurement and monitoring of food surplus and externalities	Davies and Legg (2018)	P	P	N/A	X	X	X
	Improved supplier's order policy	Gardas et al. (2017)	N/A	C	N/A	X		
	Greater supplier-retailer information sharing	Kaipia et al. (2013)	C	C	N/A	X	X	
	More suitable product pack sizes	Mena et al. (2011)	P	N	N/A	X		

(I – Implemented successfully, P - Piloted, C- Currently considering, PC - Planning to consider, N – Not being considered, and N/A – Not applicable). The "X" is a relationship marker between the solutions and the NRBV capabilities.

fresh product families. The buyer and seller considered this solution as a clean technology capability for broad implementation. The technology enables accurate measurement of environmental, economic and social implications of their food surplus. They also view this solution as a product stewardship and pollution prevention capability, given the ownership of food surplus transfers across different supply chain stages. It enhances decision-making for food waste generated pollution reduction.

There are three food waste minimization in-process solutions under consideration by the supplier and/or the retailer, namely ***more suitable product pack sizes***, ***improved supplier order policy*** and ***greater supplier-retailer information sharing***.

The buyer and supplier are initiating a new project to evaluate alternative ***supplier order policies*** and an ***enhanced supplier-retailer information sharing*** system. These two solutions are effective for food waste reduction purposes (Gardas et al., 2017; Kaipia et al., 2013). Improved supplier order policies are a pollution prevention capability due to food-waste emissions reduction from food surplus minimization. Smaller surplus means fewer emissions generated from transportation and food surplus decomposition.

The supplier is also piloting and testing alternative and more suitable packaging sizes to reduce customer food waste. This approach of efficient package sizing is effective in food waste minimization practice (Gardas et al., 2017; Mena et al., 2011).

We build on proposition 10 concerning various interactions among the food waste metrics, causes, and interactions with a general proposition 11. This proposition also integrated stakeholder practices and their implementation.

Proposition 11a. : There is an interaction between in-process and mitigation solutions with various NRBV capabilities.

Proposition 11b. : Feedback mechanisms from NRBV capabilities help reduce food waste along the supply chain.

The propositions and findings derived from this study help refine the original middle range theoretical framework linking NRBV, critical success factor, stakeholder and organizational information processing theory (Fig. 1).

Overall, we found overlap between NRBV capabilities and that they are not mutually exclusive; while their adoption is influenced by multiple stakeholders across the supply chain.

In addition, there are multiple interactions and feedback mechanisms within and between practices, metrics, stakeholders that are used for monitoring and control purposes. We also found that there are significant informational requirements to help reduce uncertainty and risks of food waste. Finally, another important characteristic is that operational and routine level analyses are needed for NRBV; NRBV is not just a strategic perspective.

Fig. 7 presents the refined middle-range theory framework.

5. Conclusions

Food waste generated across a FSC is one of our world's wicked problems. Multiple theories and methodologies are needed to inform and address this complex problem. We started with multiple theories to help derive an initial middle-range theory framework linking NRBV, critical success factor, stakeholder, and organizational information process theories. These theories, although typically applied at strategic and organizational levels of analysis, also have significant operational, supply level implications.

A number of propositions, unsurprisingly some that were complex, emerged from our multiple methodologies and observations. Feedback from various partners in the supply chain through surveys and from semi-structured interviews helped to refine the framework and our understanding. We utilize data and findings from analytical and data tools to formulate additional insights.

Together these multiple theories and methodologies resulted in a framework that shows a broader systemic and contingent set of relationships. The complexity of the relationships, as identified in the propositions, require significantly more research. The propositions provide a stream of additional research by operations, supply chain, marketing, and information technology researchers to understand supply chain food waste; especially, in online food supply chains that generate and handle rich data sets.

The major research contribution of this work is to advance NRBV to the supply chain and various complexities involved in food waste management. A resulting dynamic NRBV environment existed within this study. Dynamic capabilities were clearly evident and necessary in rapidly changing and emerging industrial contexts such as online food supply chains.

The practical implications are many. For the sake of brevity, we identify three major managerial implications:

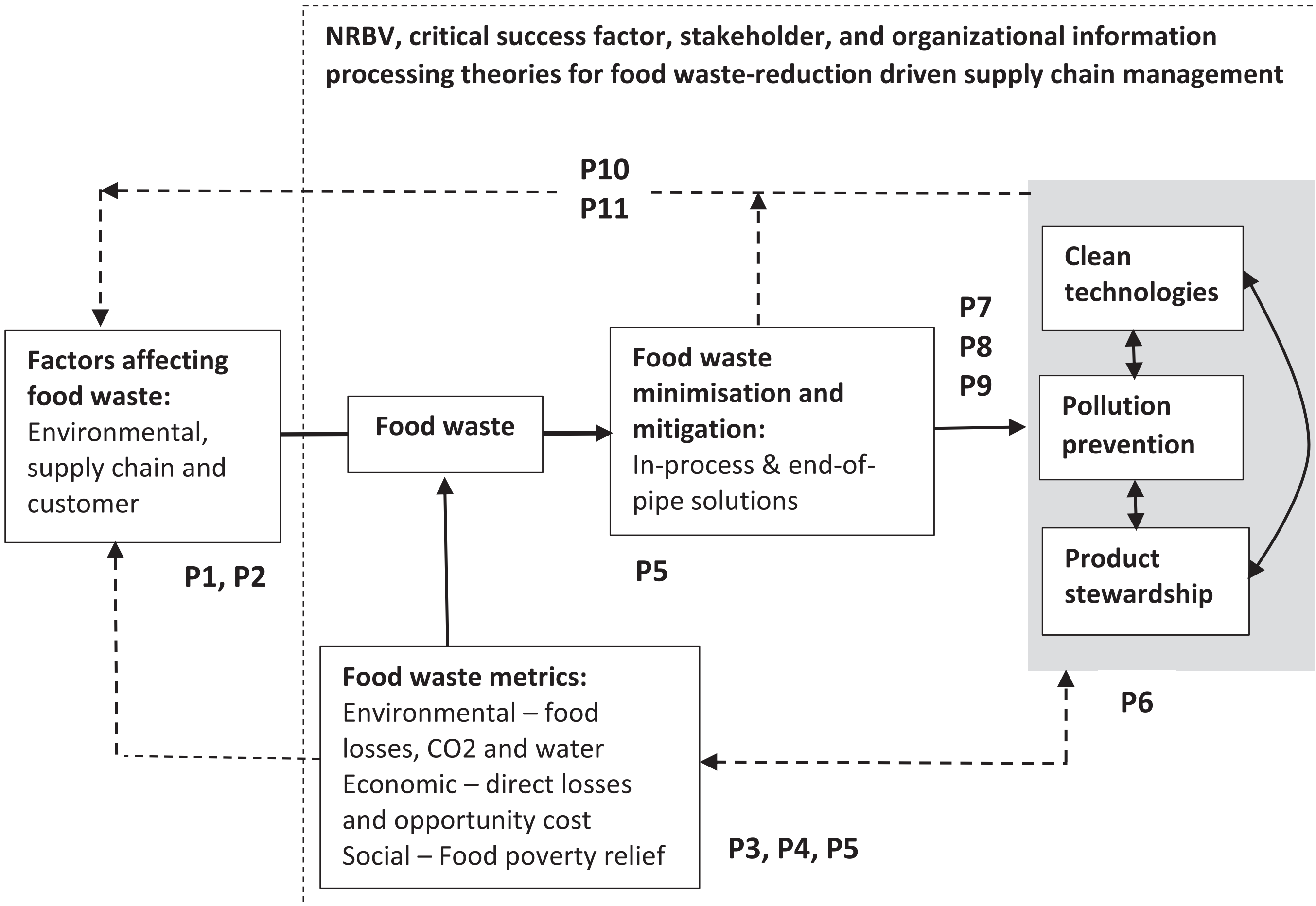

Fig. 7. Refined middle-range theoretic framework linking NRBV, critical success factor, stakeholder, and organizational information processing theories with case study propositions.

- Managers need to be aware of stakeholder needs and goals disparities. Supply chain positioning may require distinctions in food waste solutions. Understanding the needs and requirements can help build important practices, incentives and relationships.
- Working across organizations and functions is necessary to provide comprehensive and effective solutions. For example, the role of information technology partners and relationships goes beyond the goal of profit in an online environment, but also of the need to utilize the data and information to help improve food waste management.
- Metrics selection, food waste causes, and solutions need to be carefully evaluated and integrated. Continuous improvement and learning are necessary to keep updating and evaluating the monitoring tools, metrics, and relationships by management teams.

This paper sets a foundation for additional research in food supply chains, but also in other supply chains based on online relationships. Although the players, technologies, and solutions may differ, we believe this general framework has applicability and can be further refined in general SSCM research. Additional theories can inform this environment. We limited this research investigation to just four theories. That is a limitation of this study. Although we used multiple methodologies, we used a single online food supply chain case study, there is a need for multi-case study research for generalisability purposes. Many other food waste reduction business models and approaches exist in e-commerce environments; for example, food-sharing supply chains, non-for-profit, and governmental waste exchange models are other examples. Whether the framework, propositions, solutions and perspectives exist in these other situations need investigation.

Another limitation is the many complex relationships that exist. At present, we are in a general set of relationships and there is a question on how well this middle range theory can be translated into a simple and clear, testable theoretical framework. We do not offer a panacea for understanding SSCM, but it is an important step for helping industrial marketing, operations, and supply chain advancement in this field.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.indmarman.2020.09.020.

References

Alexander, C., & Smaje, C. (2008). Surplus retail food redistribution: an analysis of a third sector model. *Resources Coservation and Recycling, 55*(11), 1290–1298.
Aschemann-Witzel, J., De Hooge, I., Amani, P., Bech-Larsen, T., & Oostindjer, M. (2015). Consumer-related food waste: causes and potential for action. *Sustainability, 2015*(7), 6457–6477.
Aschemann-Witzel, J., de Hooge, I., & Normann, A. (2016). Consumer-related food waste: role of food marketing and retailers and potential for action. *Journal of International Food & Agribusiness Marketing, 28*(3), 271–285.
Aschemann-Witzel, J., De Hooge, I. E., Rohm, H., Normann, A., Bossle, M. B., Grønhøj, A., & Oostindjer, M. (2017). Key characteristics and success factors of supply chain initiatives tackling consumer-related food waste–A multiple case study. *Journal of Cleaner Production, 155*, 33–45.
Beretta, C., Stoessel, F., Baier, U., & Hellweg, S. (2013). Quantifying food losses and the potential for reduction in Switzerland. *Waste Management, 33*(3), 764–773.
Beske, P., Land, A., & Seuring, S. (2014). Sustainable supply chain management practices and dynamic capabilities in the food industry: a critical analysis of the literature. *International Journal of Production Economics, 152*, 131–143.

Betz, A., Buchli, J., Göbel, C., & Müller, C. (2015). Food waste in the Swiss food service industry–magnitude and potential for reduction. *Waste Management, 35*, 218–226.

Brindley, B., & Oxborrow, L. (2014). Aligning the sustainable supply chain to green marketing needs: a case study. *Industrial Marketing Management, 43*(1), 45–55.

Bundy, J., Vogel, R. M., & Zachary, M. A. (2018). Organization–stakeholder fit: a dynamic theory of cooperation, compromise, and conflict between an organization and its stakeholders. *Strategic Management Journal, 39*(2), 476–501.

Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: moving toward new theory. *International Journal of Physical Distribution and Logistics Management, 38*(5), 360–387.

Chaboud, G., & Daviron, B. (2017). Food losses and waste: navigating the inconsistencies. *Global Food Security, 12*, 1–7.

Curran, M. A. (1996). Environmental life-cycle assessment. *The International Journal of Life Cycle Assessment, 1*(3), 179.

Davies, A. R., & Legg, R. (2018). Fare sharing: interrogating the nexus of ICT, urban food sharing, and sustainability. *Food Culture & Society, 21*(2), 233–254.

De Lange, W., & Nahman, A. (2015). Costs of food waste in South Africa: incorporating inedible food waste. *Waste Management, 40*, 167–172.

Dreyer, H., Dukovska-Popovska, I., Yu, Q., & Hedenstierna, C. (2019). A ranking method for prioritising retail store food waste based on monetary and environmental impacts. *Journal of Cleaner Production, 210*(10), 505–517.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry, 12*(2), 219–245.

Food Loss + Waste Protocol. (2016). Food loss and waste accounting and reporting standard. http://flwprotocol.org/wp-content/uploads/2017/05/FLW_Standard_Exec_Summary_final_2016.pdf (Accessed on 30/04/2019).

Frankle, R., Naslund, D., & Bolumole, Y. (2005). The "white space" of logistics research: a look at the role of methods usage. *Journal of Business Logistics, 26*(2), 185–208.

Freeman, R. E. (1984). *Stakeholder management: framework and philosophy, Pitman, Mansfield, MA*.

Galbraith, J. R. (1973). *Designing complex organizations*. Reading, MA: Addison-Wesley.

Garcia-Garcia, G., Stone, J., & Rahimifard, S. (2019). Opportunities for waste valorisation in the food industry–A case study with four UK food manufacturers. *Journal of Cleaner Production, 211*, 1339–1356.

Gardas, B., Raut, R., & Narkhede, B. (2017). Modeling causal factors of post-harvesting losses in vegetable and fruit supply chain: An Indian perspective. *Renewable and Sustainable Energy Reviews, 80*, 1355–1371.

Garnett, T. (2011). Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)? *Food Policy, 36*, S23–S32.

Gattiker, T. F., & Goodhue, D. L. (2004). Understanding the local-level costs and benefits of ERP through organizational information processing theory. *Information & Management, 41*(4), 431–443.

George, A. L., Bennett, A., Lynn-Jones, S. M., & Miller, S. E. (2005). *Case studies and theory development in the social sciences*. Cambridge Massachusetts: MIT Press.

Göbel, C., Langen, N., Blumenthal, A., Teitscheid, P., & Ritter, G. (2015). Cutting food waste through cooperation along the food supply chain. *Sustainability, 2015*(7), 1429–1445.

Graham, S., Graham, B., & Holt, D. (2018). The relationship between downstream environmental logistics practices and performance. *International Journal of Production Economics, 196*, 356–365.

Graham, S., & Potter, A. (2015). Environmental operations management and its links with proactivity and performance: a study of the UK food. *International Journal of Production Economics, 170*(Part A), 146–159.

Grimm, J. H., Hofstetter, J. S., & Sarkis, J. (2014). Critical factors for sub-supplier management: a sustainable food supply chains perspective. *International Journal of Production Economics, 152*, 159–173.

Groening, C., Sarkis, J., & Zhu, Q. (2018). Green marketing consumer-level theory review: a compendium of applied theories and further research directions. *Journal of Cleaner Production, 172*, 1848–1866.

Hart, S. L. (1995). A natural-resource-based view of the firm. *Academy of Management Review, 20*(4), 986–1014.

Hart, S. L., & Dowell, G. (2011). Invited editorial: a natural-resource-based view of the firm: fifteen years after. *Journal of Management, 37*(5), 1464–1479.

Harvey, J., Smith, A., Goulding, J., & Illodo, I. B. (2019). Food sharing, redistribution, and waste reduction via mobile applications: a social network analysis. *Industrial Marketing Management, 88*, 437–448.

Islam, S., Tseng, M. L., & Karia, N. (2019). Assessment of corporate culture in sustainability performance using a hierarchical framework and interdependence relations. *Journal of Cleaner Production, 217*(20), 676–690.

Jack, E. P., & Raturi, A. S. (2006). Lessons learned from methodological triangulation in management research. *Management Research News, 29*(6), 345–357.

Kaipia, R., Dukovska-Popovska, I., & Loikkanen, L. (2013). Creating sustainable fresh food supply chains through waste reduction. *International Journal of Physical Distribution and Logistics Management, 43*(3), 262–276.

Kamble, S., Gunasekaran, A., & Arha, H. (2019). Understanding the Blockchain technology adoption in supply chains-Indian context. *International Journal of Production Research, 7*, 2009–2033.

von Kameke, C., & Fischer, D. (2018). Preventing household food waste via nudging: an exploration of consumer perceptions. *Journal of Cleaner Production, 184*, 32–40.

Kibler, K. M., Reinhart, D., Hawkins, C., Motlagh, A. M., & Wright, J. (2018). Food waste and the food-energy-water nexus: a review of food waste management alternatives. *Waste Management, 74*, 52–62.

Kiil, K., Dreyer, H. C., Hvolby, H. H., & Chabada, L. (2018). Sustainable food supply chains: the impact of automatic replenishment in grocery stores. *Production Planning and Control, 29*(2), 106–116.

Kitinoja, L., Tokala, V. Y., & Brondy, A. (2018). Challenges and opportunities for improved postharvest loss measurements in plant-based food crops. *Journal of Postharvest Technology, 6*(4), 16–34.

Kummu, M., De Moel, H., Porkka, M., Siebert, S., Varis, O., & Ward, P. J. (2012). Lost food, wasted resources: global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. *Science of the Total Environment, 438*, 477–489.

Lehtokunnas, T., Mattila, M., Närvänen, E., & Mesiranta, N. (2020). Towards a circular economy in food consumption: food waste reduction practices as ethical work. *Journal of Consumer Culture, 1469540520926252*.

León-Bravo, V., Caniato, F., & Caridi, M. (2019). Sustainability in multiple stages of the food supply chain in Italy: practices, performance and reputation. *Operations Management Research, 12*(1–2), 40–61.

León-Bravo, V., Caniato, F., Caridi, M., & Johnsen, T. (2017). Collaboration for sustainability in the food supply chain: a multi-stage study in Italy. *Sustainability, 2017*(9), 1253.

Li, L., Chi, T., Hao, T., & Yu, T. (2018). Customer demand analysis of the electronic commerce supply chain using Big Data. *Annals of Operations Research, 268*(1–2), 113–128.

Lin, C. S. K., Pfaltzgraff, L. A., Herrero-Davila, L., Mubofu, E. B., Abderrahim, S., Clark, J. H., … Luque, R. (2013). Food waste as a valuable resource for the production of chemicals, materials and fuels. Current situation and global perspective. *Energy and Environmental Science, 6*(2), 426–464.

Lusiantoro, L., Yates, N., Mena, C., & Varga, L. (2018). A refined framework of information sharing in perishable product supply chains. *International Journal of Physical Distribution and Logistics Management, 48*(3), 254–283.

McDougall, N., Wagner, B., & MacBryde, J. (2016). Exploring dynamic natural-resource-based capabilities for sustainable agri-food chain. *Sustainable Design and Manufacturing, 455-465*.

Mena, C., Adenso-Diaz, B., & Yurt, O. (2011). The causes of food waste in the supplier–retailer interface: evidences from the UK and Spain. *Resources, Conservation and Recycling, 55*, 648–658. Issue 6, April 2011.

Mena, J. A., Hult, G. T. M., Ferrell, O. C., & Zhang, Y. (2019). Competing assessments of market-driven, sustainability-centered, and stakeholder-focused approaches to the customer-brand relationships and performance. *Journal of Business Research, 95*, 531–543.

Meredith, J. (1993). Theory building through conceptual methods. *International Journal of Operations & Production Management, 13*, 3–11.

Miranda, J., Ponce, P., Molina, A., & Wright, P. (2019). Sensing, smart and sustainable technologies for agri-food 4.0. *Computers in Industry, 108*, 21–36.

de Moraes, C. C., de Oliveira Costa, F. H., Pereira, C. R., da Silva, A. L., & Delai, I. (2020). Retail food waste: mapping causes and reduction practices. *Journal of Cleaner Production, 256*, 120124.

Mourad, M. (2016). Recycling, recovering and preventing "food waste": competing solutions for food systems sustainability in the United States and France. *Journal of Cleaner Production, 126*, 461–477.

Muth, M. K., Birney, C., Cuéllar, A., Finn, S. M., Freeman, M., Galloway, J. N., … Meyer, E. (2019). A systems approach to assessing environmental and economic effects of food loss and waste interventions in the United States. *Science of the Total Environment, 685*, 1240–1254.

Nahmias, S. (1982). Perishable inventory theory: a review. *Operations Research, 30*(4), 680–708.

Papargyropoulou, E., Lozano, R., Steinberger, J., Wright, N., & Ujang, Z. (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. *Journal of Cleaner Production, 76*, 106–115.

Pereira, L., & Drimie, S. (2016). Governance arrangements for the future food system: addressing complexity in South Africa. *Environment: Science and Policy for Sustainable Development, 58*(4), 18–31.

Perey, R., Benn, S., Agarwal, R., & Edwards, M. (2018). The place of waste: changing business value for the circular economy. *Business Strategy and the Environment, 27*(5), 631–642.

Ridoutt, B., Juliano, P., Sanguansri, P., & Sellahewa, J. (2010). The water footprint of food waste: case study of fresh mango in Australia. *Journal of Cleaner Production, 18* (16/17), 1714–1721.

Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2018). Blockchain technology and its relationships to sustainable supply chain management. *International Journal of Production Research*, 1–19.

Scherhaufer, S., Moates, M., Hartikainen, H., Waldron, K., & Obersteiner, G. (2017). Environmental impacts of food waste in Europe. *Waste Management, 77*, 98–113.

Sellitto, M. A., Vial, L. A. M., & Viegas, C. V. (2018). Critical success factors in short food supply chains: case studies with milk and dairy producers from Italy and Brazil. *Journal of Cleaner Production, 170*, 1361–1368.

Seuring, S. (2011). Supply chain management for sustainable products–insights from research applying mixed methodologies. *Business Strategy and the Environment, 20*(7), 471–484.

Shafiee-Jood, M., & Cai, X. (2016). Reducing food loss and waste to enhance food security and environmental sustainability. *Environmental Science & Technology, 50* (16), 8432–8443.

Shankar, R., Gupta, R., & Pathak, D. K. (2018). Modeling critical success factors of traceability for food logistics system. *Transportation Research Part E: Logistics and Transportation Review, 119*, 205–222.

Spada, A., Conte, A., & Del Nobile, M. A. (2018). The influence of shelf life on food waste: a model-based approach by empirical market evidence. *Journal of Cleaner Production, 172*, 3410–3414.

Teigiserova, D. A., Hamelin, L., & Thomsen, M. (2020). Towards transparent valorization of food surplus, waste and loss: clarifying definitions, food waste hierarchy, and role in the circular economy. *Science of the Total Environment, 706*, 136033.

The Independent. (2015). How much food does the EU waste?. https://www.independent.co.uk/news/world/europe/how-much-food-does-the-eu-waste-a6778351.html (Accessed on 30/04/2019).

Thyberg, K., & Tonjes, D. J. (2016). Drivers of food waste and their implications for sustainable policy development. *Resources, Conservation and Recycling, 106*, 110–123.

Tsagatakis, I., Brace, S., Jephcote, C., Passant, N., Pearson, B., Kiff, B., & Fraser, A. (2016). *Report: UK emission mapping methodology 2014*. UK Air, DEFRA.

UN FAO. (2019). Food Loss and Food Waste, Food & Agricultural Organisation of the United Nations. http://www.fao.org/food-loss-and-food-waste/en/ (Accessed on 1st March, 2019).

Vandermeersch, T., Alvarenga, R., Ragaert, P., & Dewulf, J. (2014). Environmental sustainability assessment of food waste valorization options. *Resources, Conservation and Recycling, 87*, 57–64.

Vanham, D., Bouraoui, F., Leip, A., Grizzetti, B., & Bidoglio, G. (2015). Lost water and nitrogen resources due to EU consumer food waste. *Environmental Research Letters, 10*(8), 1–15.

Wang, J., Huili, Y., & Goh, M. (2018). Empirical study of sustainable food supply chain management practices in China. *British Food Journal*. https://doi.org/10.1108/BFJ-09-2017-0525.

Weick, K. E. (1989). Theory construction as disciplined imagination. *Academy of Management Review, 14*(4), 516–531.

Weymes, M., & Davies, A. R. (2019). [Re] valuing surplus: transitions, technologies and tensions in redistributing prepared food in San Francisco. *Geoforum, 99*, 160–169.

WRAP. (2018). The Courtauld 2025 baseline and restated household food waste figures, 22/Oct/2018. http://www.wrap.org.uk/content/courtauld-2025-baseline-and-restated-household-food-waste-figures (Accessed on 30/04/2019).

Xu, F., Li, Y., Ge, X., Yang, L., & Li, Y. (2018). Anaerobic digestion of food waste–Challenges and opportunities. *Bioresource Technology, 247*, 1047–1058.

Yadav, S., Garg, D., & Luthra, S. (2020). Development of IoT based data-driven agriculture supply chain performance measurement framework. *Journal of Enterprise Information Management*. https://doi.org/10.1108/JEIM-11-2019-0369.

Yin, R. (2009). *Applications of case study research*. Newbury Park, CA: Sage Publishing.

Zhu, Q., & Kouhizadeh, M. (2019). Blockchain technology, supply chain information, and strategic product deletion management. *IEEE Engineering Management Review, 47*(1), 36–44.

Zhu, Q., & Sarkis, J. (2004). Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operations Management, 22*, 265–289.