Reducing food loss through sustainable business models and agricultural innovation systems

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Abstract

Purpose – This study aims to explore how sustainable business models (SBM) can be developed within agri-innovation systems (AIS) and emphasize an integration of the two with a systemic understanding for reducing food loss and value loss in postharvest agri-food supply chain.

Design/methodology/approach – This study conducted longitudinal qualitative research in a developing country with food loss challenges in the postharvest supply chain. This study collected data through multiple rounds of fieldwork, interviews and focus groups over four years. Thematic analysis and "sensemaking" were used for inductive data analysis to generate rich contextual knowledge by drawing upon the lived realities of the agri-food supply chain actors.

Findings – First, this study finds that the value losses are varied in the supply chain, encompassing production value, intrinsic value, extrinsic value, market value, institutional value and future food value. This happens through two cumulative effects including multiplier losses, where losses in one model cascade into others, amplifying their impact and stacking losses, where the absence of data stacks or infrastructure pools hampers the realisation of food value. Thereafter, this study proposes four strategies for moving from the loss-incurring current business model to a networked SBM for mitigating losses. This emphasises the need to redefine ownership as stewardship, enable formal and informal beneficiary identification, strengthen value addition and build capacities for empowering communities to benefit from networked SBM with AIS initiatives. Finally, this study puts forth ten propositions for future research in aligning AIS with networked SBM.

Originality/value – This study contributes to understanding the interplay between AIS and SBM; emphasising the integration of the two to effectively address food loss challenges in the early stages of agri-food supply chains. The identified strategies and research propositions provide implications for researchers and practitioners seeking to accelerate sustainable practices for reducing food loss and waste in agri-food supply chains.

Keywords Food loss and waste, Agri-food supply chains, Sustainable business model, Agricultural innovation system

Paper type Research paper

1. Introduction

Food loss and waste in value chains present multi-faceted challenges associated with food security (Hamann, 2020), access to smart and resilient agriculture (Kim *et al.*, 2021), reducing greenhouse gases emissions (Winans *et al.*, 2020), enabling circular economy solutions (Dora *et al.*, 2020), bringing transparency in food supply chains (Vasanthraj *et al.*, 2023) and identifying ways to reduce postharvest losses (Mohan *et al.*, 2023). Agricultural innovation systems (AIS) are relevant in this context, as it is about facilitating linkages and synergies among several actors for innovations within a food system. AIS refers to the network of actors and institutions in agricultural and related sectors that bring purposeful innovations into social and economic use (Klerkx and Begemann, 2020). However, operationalising the AIS needs a business model understanding that is networked and sustainability oriented (Neumeyer and Santos, 2018). There is

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an increasing need for actors at multiple levels in food supply chains to move towards sustainable business models (SBM) with food loss and waste reducing solutions and activities (Luo *et al.*, 2022). Moreover, a networked SBM goes beyond the traditional product- and firm-centric functions and innovation, to a multi-actor configuration of systems-level innovation and action for creating economic, social and environmental value in the bottom-of-pyramid markets (Lüdeke-Freund and Dembek, 2017; Schoneveld, 2020).

The "business model" concept has been traditionally understood as a set of firm-level activities for value proposition, creation, capture and delivery (Zott *et al.*, 2011). Recent research articulates the concept of "business model" as a boundary spanning from being firm-centric to systemic (Klang *et al.*, 2014). The systemic approach, which examines the whole in terms of its contextual complexity in contrast to the linear approach, attempts at creating synergies between actors while implementing innovation systems for systemic change (Midgley and Lindhult, 2021). In a networked understanding of SBMs with sustainable innovation, this would mean enabling multiple actors to re-organise and re-align themselves with increased interconnectedness in dealing with sustainability challenges (Zucchella and Previtali, 2019). The networked SBM moves beyond product-centric solutions to a systemic understanding of implementing innovation for sustainability (Schaltegger *et al.*, 2016; Lüdeke-Freund and Dembek, 2017). This requires re-organising the business model through technical innovation, organisational innovation, institutional innovation and social innovation, with a sustainability agenda (Klerkx and Begemann, 2020). This posits the need for exploring how to move from a non-sustainable business model that creates food loss and value loss at early stages of the supply chain, to a networked SBM operationalised with AIS for mitigating the losses.

The Indian agri-food value chain presents us with a distinct context to study the links between AIS and networked SBM for reducing food loss along supply chains, particularly postharvest losses as emphasised in Sustainable Development Goal (SDG) 12.3. India is the world's second-largest producer of agri-food and has the largest bases of small-holder producers operating with other informal and formal actors, allowing us to study their food loss business models as these are underrepresented in AIS literature. The Indian Government has started aggregating smallholders as farmer producer organisations (FPOs), which allows us to compare and contrast a network perspective of business models to individual actor-specific business models with respect to implementing AIS for food loss reduction. By examining this context, we aim to contribute to the broader discourse on reducing food loss and waste through sustainable innovation, by unearthing the conceptual elements that link AIS and a networked SBM. For that, we explore empirically how the agri-food value chain actors in our research setting of a low- and middle-income country, interpret the role of business models and innovative practices in reducing the postharvest loss of fresh produce at early stages in the supply chain.

We address the overarching research aim with three "how" research questions (RQs) related to the agri-produce supply chain at the postharvest level:

RQ1. How does the current business model lead to postharvest food loss and value loss?

RQ2. How do the experiences of the value chain actors reveal the strategies needed for transitioning to a networked SBM?

RQ3. How can these strategies contribute to creating a networked SBM within AIS?

A qualitative research study was conducted over four and half years through focus groups, fieldwork and interviews, for inductively generating in-depth knowledge from the lived experiences of the study participants from agri-food supply chain in an emerging economy context. The subsequent sections first highlight the key literature background of this study. Then the methodology section elaborates the qualitative research design, followed by the findings. The findings are organised in such a way that Sections 4.1–4.3 provide answers to *RQs* 1–3 consecutively. The article ends with the limitations of this study and directions for future research.

2. Literature background

2.1 Agricultural innovation systems

One-third of all the food grown globally is lost within value chains. While most research focuses on retail- and household-level food waste in developed countries, a significant portion of food losses occur between farmgate and retail (Dora *et al.*, 2020). "Food loss" refers to the gradual loss in the value of food produce (nutritional and economic value) as it moves from upstream to downstream, losses due to lack of second life value chains for food surpluses and losses due to lack of circular systems and end of life management, rather than an absolute physical loss of the product (Centobelli *et al.*, 2021). To address these losses in an informally and formally networked, institutionally complex and uncertainty-prone (economic, climatic, political) environment, an AIS view appreciates the interconnectedness of multi-actor action and innovation for capturing value that can be translated to waste or food loss reduction (Klerkx and Begemann, 2020). AIS is "a network of organisations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organisations into social and economic use, together with the institutions and policies that affect their innovative behaviour and performance" (Hall *et al.*, 2006). From the AIS perspective, innovation could be technical, such as smart agriculture; organisational, such as creating communities of practice; institutional, such as new policies and business models; social, such as revising livelihood models and strengthening self-help groups (Watkins *et al.*, 2015). For open innovations, such as AIS, to work within supply chains, recent research suggests that ambidextrous capabilities (purpose, span and orientation) are required to co-exist within the same framework to cater to values of a variety of stakeholders (Solaimani and van der Veen, 2022). However, most of the deployment of AIS in the literature would focus on one capability or the other. For instance, in terms of purpose, some focus on exploiting knowledge regarding AIS scalability (Cronin *et al.*, 2022) while others explored IoT deployment for operationalising AIS (Parmar and Kumar, 2022) depending on whether they are working on top-down or bottom-up research.

Recent literature on the application of AIS to deliver values for multiple actors found that there are two major forms of

failures that can occur in complex innovation systems: *Multiplier* failure – where the failure of innovations in one business model cascades into failures in other interconnected business models (Cronin *et al.*, 2022; Fieldsend *et al.*, 2022) and *Stacking* failure – where failures in infrastructure or data innovations in a business model within a value chain undermines the entire AIS (Cronin *et al.*, 2022; Parmar and Kumar, 2022). Although multiplier failures cascade through innovation systems from a critical failure point to the other, stacking failures undermine the entire system because of failures in critical nodes related to data or infrastructure requirements. Previous research has examined how these failures occur in AIS (Brewster *et al.*, 2017; Blash *et al.*, 2020); however, the implications on SBM are underexplored. Given that AIS goes beyond digital transformation within a single part of the agricultural system and instead involves coordinated innovations across various actors in the system, it becomes clear that failures in AIS and their impact on networked SBMs are closely intertwined and cannot be separated (Lerman *et al.*, 2022).

We argue that actualizing this requires a transition from the loss-incurring current business model to a sustainable business model (SBM) with renewed actor relationships, resource constitution, exchange of knowledge artefacts and value addition through co-creation of innovation. While SBM research has grown by developing typologies (e.g. green supply chain, circular supply chain), it has scarcely examined the context of post-harvest food loss and how it is intertwined with AIS for farm-to-retail supply chain actors to reduce food loss and create additional value.

2.2 Sustainable business model

Business models are understood differently in different industries. However, in general, a "business model" consists of actors and actions that propose, create, deliver and capture value (Preghenella and Battistella, 2021). At the firm level, a business model can be a set of attributes and inter-related activities, an operational design or schema or a formal blueprint of doing business (Massa *et al.*, 2017). The firm has value exchanges (e.g. resource streams, revenue streams and cost structures), value-adding activities (e.g. operations, processes, product/service offerings) and value objects (e.g. delivery channels, communication channels, logistical streams, infrastructure) (Méndez-León *et al.*, 2022). In sustainability transitions, particularly for the bottom-of-pyramid markets, a "sustainable business model" is a business model that goes beyond traditional product- and firm-centric innovation to a multi-actor configuration encompassing interconnected relationships and resources for creation and embeddedness of systems innovation that contributes to environmental, social and economic value creation (Lüdeke-Freund and Dembek, 2017; Schoneveld, 2020).

The networked understanding of SBMs makes a shift from a hub and spoke model (single actor with multiple suppliers and buyers) to a multi-actor model (innovation network of small to large actors cooperating and coordinating on a common goal) (Hansen and Schmitt, 2021). In the context of agri-food value chains, it means that actor groups (such as farmers, transporters, distributors, processors and retailers) organise input flows, agri-business and supply chain capabilities and information systems to create value-added outputs (Barth *et al.*, 2017). Operationalising this is challenging because of reasons such as complex contextual dynamics, different value creation activities by different actors, resource efficiency needs in physical systems and compliance practices as per institutional directives (Best *et al.*, 2022).

Studies on SBM in agri-food value chains have focused on sustainable innovation through operational optimisation, organisational transformation or system building (Nosratabadi *et al.*, 2019), but these mean differently to different actors. For instance, operational optimisation means resource efficiency to some and energy efficiency to others. Organisational transformation means functional improvements to some and changing of ownership structures to others (Ulvenblad *et al.*, 2019). Some actors view system building as creating new value streams from waste while others see it as harnessing new value from alternative supply chains (Bocken *et al.*, 2014). Recent research reviewed 15 food supply chain models and identified similar gaps in literature with regard to some value streams not being captured within the core business model by the key actors in agri-food supply chains (Corallo *et al.*, 2023). These value streams (e.g. food loss/waste, disposal) are not owned by any one stakeholder. They proposed future studies should look into the roles of external stakeholders in enabling SBMs to capture the values. These external stakeholders form the links between the core business models in a network.

The networked perspective of SBM emphasises shared value creation to include different actor interpretations of agri-food supply chains owing to socio-economic conditions (e.g. livelihood, ownership, beneficiaries, stewardship) and institutional arrangements (e.g. regulations, finance, insurance), thereby enabling resilience and sustainability outcomes (Acquier *et al.*, 2019). Hence, research on networked agri-food SBMs needs to explore the "value intention" of the actors, as contextual dynamics tacitly affect actor-led actions in a value network (Barth *et al.*, 2017). Therefore, certain strategies and mechanisms are needed as per context to act as enablers for a networked agri-food SBM, capturing the value intentions of the local actors and making a shift from the norm of top-down business model principles (Nosratabadi *et al.*, 2019).

2.3 Research gap

Configuring a networked SBM within AIS in farm to retail agri-food supply chain needs to draw upon actor-interdependencies in roles and responsibilities, actor interpretations of value chain and institutional practices and actor needs for collaborative arrangements. This is particularly crucial when the operating context is a low-income setting with formal and informal economies, resource scarcity, institutional complexity, market and climatic uncertainties and several regional and local supply chain operators interpreting value in many different ways within the network. Hence, our findings make a major contribution to how to make a transition to a networked SBM with AIS for reducing postharvest loss of fresh produce in a developing economy context (Corallo *et al.*, 2023). Despite the significance of the problem in vast and emerging economies such as India, it has received insufficient attention not only in AIS, SBM and food supply chain literature but also in management and business research in general. Among the

developing economies, India offers one of the most complex contextual settings for this problem (Guha, 2016). Contextual understanding through exploratory work matters in food loss and waste research when the context is characterised by populations and places that are difficult to reach and suffer from harsh socio-economic and climatic conditions (Filimonau and Ermolaev, 2021).

Loss of food and its value at post-harvest level is a major challenge in low- and middle-income countries, and India offers a significant research setting to understand that problem. Globally, 25% of arable lands are smallholder farms in countries which produce nearly 30% of the food consumed worldwide (Ritchie, 2021). Smallholder farmers and other upstream supply chain actors in India are affected by post-harvest food loss on an everyday basis (Kaza *et al.*, 2018). Artiuch and Kornstein (2012) reported that 20% to 40% of the food grown in India was spoiled before it reached customers. Nearly a decade later, vegetables comprised 25% of the total weight of food loss and waste worldwide, with India losing 31% of its vegetable produce (Chen *et al.*, 2020). WWF-UK (2021) reported that in South and Southeast Asian countries, the economic loss because of food loss at the farm stage was estimated to be $15bn per year, in which India was among those with the highest losses. Challenges include long-distance transportations in a variety of climatic conditions, need for more affordable temperature and humidity-controlled logistics, replacing open-air dumping or impoverished storage infrastructure with affordable and replicable cold chain infrastructure for vegetables and greens. This is alarming for a country which is the second-largest global producer of fresh agri-food (Sagi and Gokarn, 2022; Mohan *et al.*, 2023). However, very little research has been produced on preventing or reducing food loss and value loss across the supply chain in developing countries with thriving agrarian production, but with institutional and infrastructural complexities that are different from more industrialised countries (Dora *et al.*, 2020).

3. Methodology

3.1 Theory

We use "sensemaking" as the theoretical lens to draw upon the experiences and practices of individual actors in the agri-food supply chain. Sensemaking is an intentional act of comprehending and explaining past and present practices, while also anticipating potential futures (Gephart *et al.*, 2010, Vanderlinden *et al.*, 2020; Moqaddamerad and Tapinos, 2022). This activity enables comprehending an ongoing complexity, explicitly in the form of how people interpret and give meaning to their action and their context, thereby generating shared meanings that create grounds for new action (Weick, 1995; Ancona, 2012). Epistemologically, this perspective views actors as knowledgeable agents (Gioia *et al.*, 1994; Gehman *et al.*, 2018) capable of retrospective sensemaking (meaningfully constructing everyday activities, gains and challenges based on past and present experiences) and prospective sensemaking (meaningfully constructing a potential future that is persuasive and necessary). The actors implicate the challenging and complex context that they experience (Brown *et al.*, 2015; Weber and Glynn, 2006) through this retrospective and future-oriented sensemaking (Moqaddamerad and Tapinos, 2022), which contributes to building in-depth knowledge on actor-level mechanisms that would trigger new patterns, linkages or opportunities, which would stimulate a systemic change for addressing a sustainability challenge (Köhler *et al.*, 2019).

This constructionist approach (Gehman *et al.*, 2018) views actors as agential (capacity to bring change) through collaboration and cooperation (Emirbayer, 1997; Vanderlinden *et al.*, 2020), as the context is shaped through their interpretations and actions (Sengupta and Lehtimäki, 2022). They are not powerless beings but individuals with the capacity and propensity to create a sustainable future by playing an active role (Teerikangas *et al.*, 2021). As an agri-food system has multiple actors deploying different business models, there is a need to understand how these actors relate to each other in the networked business model. Incorporating the shared sensemaking of different actors in the supply chain around particular issues or challenges brings forth different constructions of the business model, rather than taking to them the idea of a business model that comes from the most dominant actors (Hayden *et al.*, 2021). When this is overlooked, top-down solutions for sustainability risk failing in implementation. Thus, sustainable futures can emerge through strategies constructed from the retrospective and prospective sensemaking of a range of actors who are expected to work together in a coordinated way, even though they pursue different interests within the same supply chain (Markard *et al.*, 2012).

3.2 Data collection and analysis

We adopted a multi-method qualitative research design suitable for creating new knowledge on nascent topics (Ketokivi and Choi, 2014). We used multiple sources of primary data through focus groups, fieldwork and interviews (Table 1), mostly in the natural settings of the study participants (Lincoln and Guba, 1985). Secondary data sources included sectoral reports. Primary data was periodically collected between June 2018 and December 2022 as part of a larger project, through 18 focus groups, 43 unstructured and 15 semi-structured interviews along with 98 days of fieldwork to gather observation data. The interviews lasted between 45 and 90 mins and focus group discussions lasted between 90 and 120 mins. The research setting being institutionally complex with a range of small to medium-scale actors with different roles and challenges in formal-informal settings, elaborate data collection enabled data sufficiency with inclusion of diverse voices, triangulation through different data collection methods and theoretical saturation with no additional strategies/mechanisms and propositions emerging during the analysis (Andrade, 2009).

A purposive selection (Patton, 1990) was conducted in this study: identifying value chain actors with long experiences of working in the agri-food supply chain with multiple stakeholders (both public and private) at the local and regional levels (see Table 1). Some were identified during fieldwork and others were reached through snowballing. "What" questions were used to initiate conversations while interviewing, such as: What, in your experience, are the pain points of various stakeholders in the current post-harvest value chain of fresh produce? How do you manage your own operations? What

Table 1 Interview and focus group participants with mnemonics

Individual/Organisation	Description of study participant	Mnemonics
Organisation details and associated unstructured interview (walk-along) and field observations mnemonics		
Farmer 1	Small-scale vegetable farmer practising conventional farming (mostly growing tomatoes), supplying to market yards	F1
Farmer 2	Small-scale vegetable farmer practising conventional farming (mostly growing fresh leafy greens), supplying to private collection centre	F2
Farmer 3	Small-scale vegetable farmer practising conventional farming (growing a mix of vegetables on small plots), supplying to FPO owned CC	F3
Farmer 4	Small-scale vegetable farmer practising Organic farming for more than 15 years (mostly growing tomatoes), supplying to FPO-CC	F4
Farmer 5	Small-scale vegetable farmer recently converted to practising Organic farming for 2 years (mostly growing leafy greens) supplying to FPO-CC	F5
Farmer 6	Small-scale vegetable farmer practising conventional farming (mostly growing tomatoes), supplying to private CC and local market	F6
Farmer 7	Small-scale vegetable farmer practising conventional farming (growing a mix of vegetables on small plots), supplying to local market	F7
Farmer 8	Small-scale vegetable farmer practising conventional farming (mostly growing leafy greens), supplying to market yards	F8
Farmer 9	Small-scale vegetable farmer practising organic farming for more than 10 years (growing a mix of vegetables on small plots), supplying to FPO-CC	F9
Farmer Producer Organisation (FPO) 1–3	FPO sourcing from multiple local farms and connecting to different collection and distribution centres owned by private retailers	FPO1-3
Farmer Producer Organisation (FPO) 4	FPO sourcing from 100% certified organic farms and connecting to the specialist retailers	FPO4
Farmer Producer Organisation (FPO) 5	FPO sourcing from 100% certified organic farms and connecting to the hybrid CC-DC for high end hospitality and specialist e-tailer market	FPO5
Farmer Producer Organisation (FPO) 6	FPO sourcing from multiple local farms and connecting to distribution centre owned through public-private partnerships	FPO6
Collection centre 1 – 3 (Procurement managers)	FPO-owned Village Level Procurement Centre (FPO-CC) for specialist retailers and other distribution centres	CC1-3
Collection centre 4–6 (Procurement managers)	Privately owned Collection Centre by different organised retailers	CC4-6
Collection centre 7 (Managing director)	CC run by a hybrid Public private partnership	CC7
Distribution centre 1–3 (Procurement managers)	Privately owned Distribution Centre by different organised retailers	DC1-3
Distribution centre 4 (co-founder)	A hybrid CC-DC services for connecting food producers directly to retailers, restaurants and service providers, through technology and digitisation	DC4
Distribution centre 5 (Managing director)	Wholly owned subsidiary of a national development board that is into manufacturing, marketing and selling dairy products, edible oil, fruits and vegetables	DC5
Local Farmers market 1–2 (mostly female farmers)	Located within 3 km from the farms; a group of farmers (7–10) sell their fresh produce on a daily/ weekly basis in a lower volume in a state government provided open infrastructure	LM 1–2
Local Farmers market 3 (a mix of male and female farmers)	Located within 3-5km from the farms; a group of farmers (15–25) sell their fresh produce on a daily/ weekly basis in a bulk volume in a state government provided open infrastructure	LM3
Market Yard 1 (Auctioner)	National Traders Market	MY1
Market Yard 2 (Auctioner; Bidder)	Regional Market Yard (Delhi)	MY2
Market Yard 3–4 (Auctioner, Bidder, Govt. agents)	Regional Market Yard (Telangana, Andhra Pradesh)	MY3-4
Organised Retailers 1–2	National Supermarket (Brick-and-Mortar)	R1-2
Organised Retailer 3	Regional Supermarket (Specialist)	R3
Organised Retailer 4	E-tailer (National)	R4
Unorganised Retailers 5–7	Pushcarts providing door-to-door vegetables	R5-7
Unorganised Retailers 8–9	Local static retailer with temporary shades for local communities	R8-9
Semi-structured interviews and associated mnemonics		
Farmer Producer Organisation (FPO) 7	FPO owning end-to-end supply chain and sourcing from 100% certified organic farms and processed at certified organic processing facilities.	FPO7
Distribution centre 6 (General Manager)	Wholly owned subsidiary of a national development board that is into marketing, distribution and selling of fruits and vegetables	DC6
Distribution centre 7 (co-founder)	Fresh produce supplier connecting food producers to retailers, restaurants and service providers	DC7
National Government official	National regulatory authority in the development and regulation of storage and supply chain of 100+ agricultural commodities	G1
NGO 1 (Managing Director)	A local NGO providing market linkages and digital linkages between farmers, input providers, equipment providers and financial institutions	NGO1
NGO 2 (Cofounder)	A National NGO creating solutions in emerging markets on regenerative agriculture, organic farming, inclusive market systems, agri-management and enterprise development for farmers	NGO2
NGO 3 (Cofounder)	Social enterprise offering economic and social solutions to farmer communities in low-income markets in order to improve farming practices and market linkage opportunities	NGO3
Technology/ Service provider 1 (Cofounder)	Platform company offering digital capability to integrate supply with demand, minimize wastage, create value and offer transparent transaction support to stakeholders in fresh produce supply chain	TP1
Technology/ Service provider 2 (cofounder)	Making cloud enabled AI, blockchain, IoT solutions for data interpretation and applications in the agri-food sector	TP2
Technology/ Service provider 3 (Head of Products)	Technology-enabled value chain and financial services for inclusion and prosperity of farmers and rural entrepreneurs	TP3
Technology/ Service provider 4 (Senior Agriculture Analyst)	Offering research and advisory service on a range of capacity building and developmental solutions for rural development and agriculture	TP4
Organised retailer 10	Agri-business entity retailing, bulk selling and exporting vegetables, fruits and fresh greens	R10
Organised retailer 11	Specialist Retailer Organic producer company wholly owned by organic producers with extensive consumer-producer network for procurement and supply	R11
Media 1 (Agri-Journalist)	Leading national media, information and communications company	M1
Total participants		*58*

Focus group participants and associated workshop mnemonics				
Focus groups categories	Workshop 1 (WS1); 2018	Workshop 2 (WS2); 2019	Workshop 3 (WS3); 2019–20	Workshop 4 (WS4); 2022
Upstream supply chain (farmers, FPOs)	6 (FU1)	6 (FU2); 8 (FU3)	7 (FU4)	6 (FU5)
Midstream supply chain (processors: collection centres, distribution centres)		6 (FM1)	7 (FM2)	
Downstream supply chain (retailers, hospitality)	6 (FD1)		8 (FD2)	
Logistics/ distribution services		6 (FL1)	6 (FL2)	
NGOs	6 (FN1)	7 (FN2)		8 (FN3)
Government organisations (national, state-level)	6 (FG1)		6 (FG2)	7 (FG3);
Financiers	7 (FF1)			6 (FF2)
Total participants	*31*	*33*	*34*	*27*

Source: Authors' own creation

affects your business model the most? What are your observations and experiences on the access to resources and capital? What are the current support systems for farmers and other actors? What is needed more in the business model for enabling solutions to prevent waste? What institutional support is available for implementing new tech support in the value chain? Questions like these led to snowballing interactions. Focus group questions enabled more information on the value chain activities, exploring challenges leading to food losses in current business models and identifying the root causes of those challenges by asking: Who are the actors involved just after production and during distribution, infrastructural and logistical challenges and complexities, the roles of supporting organisations: government and non-governmental organisations (NGOs), food loss and value loss at each node in different seasons and who bears the loss and identifying root causes of all challenges and possible solutions. A second round of interviews was conducted with a few participants, as and when required.

The interviews and focus group discussions were transcribed verbatim. The inductive analysis of the transcriptions followed a coding technique for identifying thematic patterns and categories (Table 2) (Braun and Clarke, 2006). The first-level themes were broadly informant-centric, which were aggregated for thematic similarities to construct the second-order themes. The third-level synthesis created conceptual categories through a constant comparison between data, first-level and second-level themes. The interviewing and thematic analysis stopped on reaching theoretical saturation (Eisenhardt and Graebner, 2007). Further, a back-and-forth analysis spotting the interplays between data, themes and literature to arrive at a set of propositions, enabled us to achieve more rigour in the qualitative analysis (Grodal *et al.*, 2021).

The observation and field interaction data also included information on key supply chain actors and their activities, their experiences with food and value loss at different nodes, storage and transportation conditions, grading and sorting practices, activities and everyday records at the collection and distribution centres and information on key resources and governmental support. Copious notes were made from observations and interactions. Close to a hundred photographs were taken as visual data to depict the context which aided researchers' discussions. Reflexive note-making and consolidation through discussions within research teams happened at the end of each day of the fieldwork.

4. Findings and discussions

4.1 Current business model

Our findings on the current business model for food loss and how this relates to AIS failure are detailed in Table 3. This section discusses the key internal and external actors, their roles and responsibilities, the challenges leading to food loss and the different forms of food value loss as a result.

4.1.1 Production function and actors in the current business model for food loss management

Farmers are key decision-makers in food production and their role in the current business for food loss management pertains to generating and utilising relevant data for planning and aligning food production to market requirements. The farmers, who were interviewed, explained that the loss in food value in the current business model includes pre-production losses (e.g. weather, seasonality), production losses (e.g. input, pest) and post-harvest losses (e.g. distress selling of food surpluses and non-market grade produce). Payment delay coupled with poor management of pre-production and production losses lead farmers "to depend on borrowing from CAs (Commission Agents), money lenders and local cooperatives and incur heavy losses in produce value to maintain the cash-to-cash cycles", FN2. As smallholders require collective handholding to develop standard operating procedures (SOPs) and share best practices for food loss management, farmers lose food value through distress selling and getting locked-in to unfavourable forward contracts with market agents to secure loans and hedge against market price fluctuations.

The focal farmgate actors that play an aggregation role in the current food loss business model are FPOs. FPOs comprise farmers, landowners, producer groups and other beneficiary collectives tasked with pooling production capacity to improve farmers' price bargaining power and access to markets as well as facilitate handholding to link farmer beneficiary groups to finance, infrastructure, capacity building and other AIS innovation. FN1 explained that:

> Many large cold storage investments are concentrated in some regions [Uttar Pradesh, Gujarat, West Bengal and Punjab] and are designed to the temperature and humidity requirements of specific products [potatoes]... the same applies to investment in cold chain transport.

FN2 further explained that most smallholders are not represented by FPOs; hence, food losses in the current business model between harvest and the time to markets:

> arise mainly from poor access to market and price information... lack of ownership of simple cold chain solutions needed to preserve rural production... reduce distress selling and justify large or multiple mobile small cold chain infrastructure investment by FPOs.

4.1.2 Logistics and processing function in the current business model for food loss management

From focus group discussions with private sector actors in the current business model, we identified logistics providers and processors (comprising collection centres and distribution centres) as the linking nodes whose primary functions are to minimise losses arising from "extrinsic" operations associated with product logistics scheduling, planning and routing as well as losses linked to "intrinsic" operations of sorting, grading and handling in collection and distribution centres. Their role in the current model is extrinsic, implying that "food losses occurring during logistics are not owned by the first party logistics [local truck owners] that carry farmers to local markets and collection centres" [**FU2**]. As a result:

> The time value of food lost in the process is reflected in the amount for food that is downgraded from A to B and C grades due to logistics delays and poor scheduling and route planning to markets [CC7].

In addition, farmers carry out their own grading and sorting in line with market requirements. CC2 noted that "the loss in (extrinsic) value must be reassessed through additional grading and sorting" to re-evaluate the quality of deliveries. Moreover, the intrinsic operations required to sort and grade food produce are unstandardised, hence, the repetitive function results in losses associated with repetitive intrinsic quality assurance processes carried out on farms, collection centres and

Table 2 Example of the inductive thematic analysis

Representative data	First-level abstraction	Second-level abstraction	Conceptual categories
There is always a debate whether we should take care of requirement of farmers, which require higher prices for their produce or we see the worries of consumer who requires procuring at very low cost, so the government has to play in between these two. I think lots of initiatives are being taken by government specifically, and the farmers are leveraging. [. . .] The ease of doing business that government is promoting, I think that this is a very good approach to the ease of doing business so that farmers can easily avail land where they can put necessary infrastructure, resources, and they can easily avail credit *(TP 4)*	Increasing governmental role in multi-actor cooperation	Redefining ownership towards stewardship	Ownership configuration
Government should be consulting us, our community for where we want the cold storages [. . .] whether for this produce we want at panchayat level, for that produce we want at district level, what size, capacity do we need [. . .] and then provide us with a solution that reduces our loss (*FU3*)			
Farmer intake is more in a government facility. That is major advantage. [. . .] If it is government, they feel it is theirs. The farmer intake will also be more. [. . .] They feel it is govt project *(DC 6)*			
Organizations like FPOs can become the last mile connectors for delivery of solutions and gateway to the market. These FPOs can play the necessary role. But it needs investments into human resources, infrastructure or financial access *(FPO 7)*	FPOs as frontline for institutional push		
FPOs aggregate smallholders by beneficiary groups . . .. to link smallholders to different markets (*FF1*)			
The capacity should be built at the FPO level [. . .] making it a mass solution or offering for wider public *(TP 4)*			
But some kind of aggregation is needed so that cost of production can be reduced and maybe a model cluster should emerge, so that they can absorb these costs. The Federation based model can employ some good professionals they are involved in the infrastructure creation and aggregating FPOs, because all these require infrastructure and investment done collectively as per policy directions, thus making a different kind of business model *(TP 4)*	Collectivisation at local level through multi-actor aggregation	Mobilising stewardship	
Government has aggregated farmers and other small processors as FPOs [. . .] We have been actively involved in establishing market linkages for these FPOs, facilitating access to credit and finance, and promoting technology adoption for efficient farming practices [. . .] empowering farmers, improving their livelihoods, and enhancing overall agricultural productivity (*FN2)*			
Let's say certain set of farmers come and they put up a farmer market cluster on certain days in certain slots in certain societies and we use them. Right now, if you see such things are happening and that is good. If we say there is a solution which is now made available for a local community or a set of farmers in one particular cluster, that makes a lot of sense because they can actually build up or begin put up a capacity out there, and all of the supply chain can be aligned with that *(R 11)*			
The organized players are certainly in a better position. They can come together and put up capacities to manage new solutions, then there would be more takers. [. . .] Whoever has a bigger stake in this can certainly be the one who can be considered as the first stakeholder where we should provide the solutions *(TP 2)*	Organised players sharing responsibility for solutions		
Retailers have a lot of potential to be powerful advocates for loss prevention and sustainable food systems. They can source responsibly, manage their inventory, educate consumer, educate farmers how their farming practices impact on food value (FN1)			
A model would be the involvement of different multi stakeholder players to come together within policies promoted by government. Some state governments are very active, they are engaging various stakeholders, including private players, financials organizations, have number of state level schemes, specifically with horticulture department. They can leverage these ones and subsidise for farmer production clusters, so that the necessary investment is done *(FPO 7)*			

(*continued*)

Table 2

Representative data	First-level abstraction	Second-level abstraction	Conceptual categories
In business model, each node does not need to generate revenue. But what data does the node generate and how that can be used in the revenue model is important. There are certain things where public investment should come in, such as for data that will go for government decision making. [. . .] You are not selling the data. The data which shows. . .this intervention was used and this is the result. That kind of data is valuable data. If you can show a trend, there are certain things where public investment should come *(FPO 7)*	Collaborative planning for information feedback	Improving farm-level planning	Value Addition
Access to both demand side and supply side information is crucial in our efforts to facilitate food loss reduction for farmers. By understanding market demand trends and aligning them with how and when farmers should sow and harvest [. . .] we can bridge the gap, minimise waste and maximise value (*FN2*)			
I believe how much needs to be produced if that data and dashboard information is sent back to the farmer, then it will be more meaningful so that the storage can be planned well ahead and waste is less. . .so the feedback is missing now *(TP 2)*			
If you are producing something, you should be aware of what is going out of your farm. If there is a rotten material, you got to throw it away, or you're going to compost it to make up some organic farmyard out of it, the rest will go. So doing that sorting at the farm is the first necessity, which is based on the precondition that these farmer co-operatives and FPOs are skilled, adept and good in doing that *(NGO 3)*	Sorting and storing at farm level		
[. . .] absence of storage facilities near production clusters is problematic as this leads to losses during transportation, especially for perishables. There is an urgent need for better planning and investment to ensure that storage and sorting infrastructure is appropriately positioned to serve the needs of farmers, collection centres, distributors, retailers, etc.			
There are a few farmers who got convinced with grading and sorting at the farm level and then having different grades of the produce. But these particular changes are still limited to those who are convinced. [. . .] More awareness is needed on this particular activity, as far as the supply chain is concerned, because it actually carries a garbage or it carries a waste which actually can be consumed at the farm level *(TP 1)*			
For certain product, shelf life maybe 4 to7 hours, but then there is transportation loss. We can may be reduce by putting those commodities in the storage for maybe half a day or full day so it gets a very good valuation, because we are reducing the wastage. Large wastage happens in transportation *(TP 4)*	Improving pre- and post-harvest procedures	Aggregating quality management in upstream	
we believe that seed selection is also linked with the losses farmers have during and after harvest [. . .] Each seed variety interacts uniquely with the soil, climate and other environmental factors. When we manage these linkages effectively, we can minimize crop failures, reduce pest and disease incidences and improve overall farm productivity (FPO 5)			
A value addition will be how quickly you can transport, without a delay and if it can be sold at retailer point or directly to home. [. . .] The loss of transportation is another thing. The time taken in transportation that can also be reduced. *(NGO 1)*			
So what I'm saying is what is it that needs to be done, as far as the the price volatility is concerned. Now there is a farmer who had harvested, or who is about to harvest. [. . .] Suddenly there is a change in the market prices and things are not going right. He should have an option of basically storing it for a while, or something like that. From that perspective, I was talking about short term storage *(FPO 7)*	Building local level capacities for maintaining food value		
We do not have access to infrastructure like shades, louvers on farm [. . .] we do not get loans on these so we cannot invest in such infrastructure by ourselves but this would be life changing for us [. . .] because generally the products lie in the farms for 2-4 hours after harvesting [. . .] sometimes there are issues when the labour is available and sometimes when the tempo comes to pick these up [. . .] and if this is peak summer when the temperature is 40-45 C then we know that our produce would have started deterioting and have started losing significant value before even it leaves our farm (*FU 4*)			
There is always a scenario where there is no zero sum game. So you are left with some quantities. And those left out quantities get sold over a period. Probably a day or two and the chances of that which is not sold in time is the thing which is going to get stored. So, it is going to be a residual type of produce, which is left out with you and that needs to be now taken care of in the best possible way. Otherwise, it increases the cost, it also increases the inefficiencies and I would say it also multiplies the food waste *(TP 1)*			

(*continued*)

Table 2

Representative data	First-level abstraction	Second-level abstraction	Conceptual categories
So, if there a staggered production, so the entire production is not coming on time. Based on this stagger in the sowing period, the harvest is coming in different time periods, so they need some buffer time in hand to market the produce *(TP 4)*	Reducing gap between harvesting time and pick-up time	Strengthening producer-market and market-market connections	
We are encouraging staggered sowing and staggered harvesting through our SHGs so that not all of them reach the market with the same produce as that causes a dip in price and then everybody losses (FG2)			
In order to ensure that there is limited loss of quality and perishability, the order needs to be taken in not much in advance because of the necessary logistics, which again, is a big challenge to quantify *(TP 1)*			
So right from the farm to enterprises, there are a lot of aggregators and there are a lot of people who have come up with different type of solutions, right from the whole chain solutions to even the storage solutions. There are some village level agents, or some farmers, who are slightly entrepreneurial. What they do is that they pick up material from their own farm and some fellow farmers and drive it down to the urban place and they open up a shop which is a mobile shop right on the vehicle only and they sell from the vehicle only *(R 11)*	Entrepreneurial innovation in linking producers to nearest markets		
Beside strengthening producer-market relationships which is really important, we should also look into strengthening market-market linkages. . .. there are many formal organised retailers whose grade B and C can be used by other informal retailers, push carts or even local roadside hotels, dhabas (FN1)			
Care has to be taken for connecting both farmers and buyers together. [. . .] We worked on a concept called veggie cart. That was focused on direct B2B and B2C. We would basically take them out and send it to low-income parts of the city. We would basically organize the low-income vendors in those areas so that they can actually be more aligned to sell those kinds of vegetables *(NGO 3)*			
There is organized retail market, and then there is unorganized retail market – push carts, weekly local mandis, petty shops, these three together. What are the different things impacting them? The losses in the mandi is huge. At the retail end there is a loss. So what can help all of them? Till date, no improvement has been done for the push carts *(NGO 1)*	Informal retail as beneficiary	Identifying informal sector beneficiary	Beneficiary Identification
In our region, around 60-70% produce is sold by push carts or local petty shops [. . .] you cannot understand loss without understanding that segment. These have to be identified and mapped to decide which interventions are best for them to reduce their losses, else the best interventions would be missing out of the largest segment of the market actors responsible for value that is lost (FN2)			
So, retailers, I can see that, who certainly benefit from them as retailers who are typically the smaller size or the midsize one because the bigger one already has pending and design their retail outlets with air conditioning and temperature control and all those things *(TP 1)*			
It is mainly aggregation. Beyond the grading and sorting there is no value addition. Mostly it is fresh veggies that are sold. That case maximum of the price should go to the farmer. The product cycle is also very low – 2 to 3 days. Maximum share of consumer price should go to the farmer. But that is not happening *(NGO 1)*	Farmers as beneficiary		
Ideally farmers should be part of the value chain and gain most of the premium if they are doing farming practices that benefits retailers and their labelling, say organic or natural products (FN 3)			
Immediate gain actually happens for the people who are the organizations, or they are middle men, or traders, or people controlling the mandis. If we come to policy making part of it, many state governments are trying to remove the middleman and mandi concept. It is very tough. Farmer and market yards will have benefit in long term. In short term it is those people who are investing in it *(TP 2)*			
Then there should be some commission of some part of that cake should go to meet the cost of the infrastructure *(TP 3)*			

(*continued*)

Table 2

Representative data	First-level abstraction	Second-level abstraction	Conceptual categories
Our company (retailer) has invested heavily in grading, sorting facilities here and it makes our life easier to quickly complete these tasks which use to take a lot of time and people (DC1) We should be able to bring sprinkled temperature controls under one funding infrastructure so that it can be run using a service oriented model where maybe farmers who needs access to that can do it through the farmer producer cooperative *(NGO 3)*	Infrastructure cost bearing entities	Identifying formal sector beneficiary	
It is integral to install something which was allows a buyer who is willing to pay a premium price or a better price, which cuts off the intermediaries so that there could be a direct transaction between the farmer and the farm gate and the off-taker *(TP 3)* Aggregating farmers and producers as FPOs using right criteria such as farmers livelihood is crucial for capturing right values that contribute to food loss reduction [. . .] FPOs are the first formal level of small holders so including them as beneficiaries allows us to capture and standardise local knowledge about food that can contribute to reducing food losses [. . .] to dessiminate local innovations around food loss reduction (FPO 6) The person who is buying the produce and another guy who is quality input supplier, these are the two critical ones other than the farmers, who are basically investing into the whole supply chain. . .Right? The farmer is a seller trying to sell it is as fast as possible as they don't want to keep it into custody. Assuming that the intervention is going to increase the shelf life right, then it is the aggregator and the retail side. . .there's basically a responsibility of the stakeholders who are there in the supply chain *(TP 1)*	Upstream functionary as beneficiary		
Strengthening the people, community institutions, so that they can handle their businesses and their problems at grass root level, is significantly very important. [. . .] There is another way to look at it. That is how we improvise unorganized sector. Building their skills, organizing them in a better way; 70-80 percent of the market is unorganized. How we organize that also is important rather than displace that and replacing it with current modern retail *(NGO 1)* Small holders, whether they are farmers or processors, they all need practical assistance and guidance tailored to their specific businesses [. . .] training programs, workshops, mentorship initiatives are all needed for empowering them with the necessary skills and knowledge for organic farming, processing, packaging for getting premium value from that market [. . .] can empower farmers to effectively engage with various organisations and access the resources they require for sustainable agricultural practices (FPO 4) To understand the requirement on the ground level, another element is to build the capacity and handling mentoring, but more from a block level kind of a incubation centre approach [. . .] that could be a game changer because we then demonstrate a few things and others can of course replicate *(NGO 2)*	Skill development at community level	Building managerial capacity	Community capacity-building
The only way farmers will start doing this is if you keep on providing them necessary tools, bear the cost of certification, which is for three years, and provide them the access to key markets and a premium every other time. [. . .] So doing that at the farm gate is the first necessity, which is based on the precondition that these farmer co-operatives and FPOs that are being formed should be skilled, adept and good in doing these things *(NGO 3)* Currently, farmers are expected to connect with over 20-25 different organizations to access the information they need [. . .] assuming they even know where to find them and what services they offer. This fragmented approach creates immense challenges for farmers and hampers their ability to make informed decisions [. . .] As NGOs, it is our responsibility to provide handholding capacity building to farmers, particularly in areas such as insurance, finance and access to government programs [. . .] but then government should also recognise the importance of this handholding responsibility and enable us with resources, policies and linkages (*FN 3*) When we are ambitious enough to let's say put up cold storages at micro level and do certain innovations there. But people at that level need proper hand holding or support to come to the nearest bank and submit a proposal which would be processed. [. . .] Because it's a cross cutting technologies, you need that kind of a demonstration, if you create a model where you have demonstration of such units at the micro level that could surprise the lot of stuff in the whole area *(NGO 2)*	Handholding for accessing institutional support		

(*continued*)

Table 2

Representative data	First-level abstraction	Second-level abstraction	Conceptual categories
Data digitisation from a register to an app is not really a real challenge as much as it is shown. So they know it, but they don't want it. Digital transformation and change management is always a problem. It is more of a mindset issue than technology. There are a few people who will get benefit of it but there are others who won't; they are looking at short term gains *(TP 2)*	Digital awareness and training for mindset change	Building digital capacity	
Government has started a really good initiative like Agri-Stack but how many of us know about it? How do we contribute, what do we get from that, who is collecting our data? [. . .] same with e-NAM, great initiative but again what data needs to be there in place, how should it be collected, everything should make sense to both the community and the market (*FN 3*)			
There are some people who don't have access to internet don't have access to data portals. They may not even know the existence of portals. And there is a somebody who knows, but he does not have the skill to do this, click, click, click. So though there is a demand, but they're not visible. Well only if it comes from the portal, then it is visible. Right. So even if it does not come to the portal, it is invisible, but demand does exist. Okay. So, what you need to do is digital training, digital awareness and you bring that invisible demand into the visible *(TP 1)*			
Digital platform is enabled with three very critical things. One is the sowing date, the planting date [. . .] forecasting a planting date for a farmer, depending upon multiple variables that may affect the right sowing and seeding of the plant. Second is we know the seed rate and the germination rate, depending upon the recommended seed variety and the seed brand, the farmer purchases from a marketplace only. And that allows us to determine what will be the plausible harvest dates *(NGO 1)*	Digitalising access to farm data		
Farmers are blind folded when it comes to market demand, I mean future market demand, 3-6 months down the line [. . .] when they know this, they would plan accordingly, we can then aggregate this and plan for capacity and shift to different markets [. . .] some of the bigger FPOs who are working with 2-3 products, they have done this successfully but with low cost vegetables and staples it is difficult (*FPO 5*)			
I believe how much is to be produced if that data and dashboard information is sent back to the farmer, then it will be more meaningful so that the storage can be planned a little well and waste is less. . .so the feedback is missing now *(DC 6)*			
Best practice is early hours or late hours. But farmers are doing after 9 to 10 o'clock because labour available from 9.30. Obviously, the shelf life will lose 30% because of the temperature. When you are harvesting the tomato, you are harvesting at 35 degrees. From then onward degradation starts. They will heap in one place, that is also not in shade. So inside temperature will increase. In evening hours they will collect the material and send to collection centre or the market. From there we need to collect the requirements. From there to here it takes 4 hours if it in near, if far, it takes 12 hours *(DC 7)*	Predicting sowing and harvesting time		
There's material flowing from farm to market [. . .] wish there was information flow from market to farm telling us when to sow, when to harvest so that we can plan production scheduling and aggregating products accordingly for different markets and different seasons (*FPO 6*)			
I am very particular about harvest date and time. The moment they harvest, I want them to send me on the same day. Sometimes what they do is that, because this is all labour oriented, they will do some other order. They will harvest yesterday, and then pack and sell today *(R 10)*			
Today I am doing 100 kgs. If there is no cold storage, I will lose around 25% to 30%. If you can provide those interventions, the quality of the material will be good and the price will be high. Today it is 6 rupees tomato, tomorrow is holiday for the rest of the states. The local farmers know very well about the holidays. If those storage facilities are there, they will keep the material in the storage *(NGO 1)*	Installing storage solutions at local level	Building infrastructural capacity	

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Table 2

Representative data	First-level abstraction	Second-level abstraction	Conceptual categories
We need (community level needs assessment for infrastructure) storages for staples, fisheries, high value products at district level and for others with lower shelf life at panchayat level (*FU 4*)			
So, one that's essentially the concept that I'm trying to build with them is how might we be able to build a decentralised network of off-grid modular, structured, uh, called cold. And it was very controlled systems so that the farmers would have an opportunity to look at high value crops, such as tamarind or turmeric, or, uh, more, uh, finger millets and others, which requires not only cooling, but also certain kinds of moisture control *(NGO 3)*			
Also when you look at when processing steps in, storage need not be only about fresh produce, but also pulp. The kind of intrinsic value and storage value if you calculate for that one, where pulp can be used *(TP 4)*	Increasing value with processing opportunities		
We need more information and training on packaging [. . .] because of weather, logistics, multiple grading processes, packaging is really important for preserving the grade and nutritional value of our products [. . .] gap at our community level (*FU 5*)			
Very few FPOs at dealing with processed product [. . .] largely with the raw produce, because that is completely a complex thing. So what initially, I was talking about the Federation part *(NGO 1)*			

Source: Authors' own creation

Table 3 Actors and associated aspects in current business model leading to food loss

Actor/Role	Description	Functions/Activities	Challenges leading to food loss	Associated losses and impact	Type of AIS failure
Production					
Farmers	- Small and marginal farmers - Single Women harvesters	- Production planning and grading, market access, quality assurance, sharing information downstream -Other value-added activities like solar drying by women entrepreneurs	-Poor understanding of input and production datasets to capture and digitise -Lack of managerial, technical and infrastructural capacity to reduce loss in food value (ecological, nutritional and economical)	**Losses in production value** - Pre-harvest food loss (related to agricultural input) - On-farm food loss (related to farming practices) - Post-harvest food loss (related to on-farm infrastructure and post-harvest practices)	**Pre-harvest food loss:** *Multiplies to On-farm food loss* (**multiplier**) Pre-harvest food losses can directly contribute to on-farm food losses by propagating and accumulating throughout the production process. **On-farm food loss:** *Multiplies to Post-harvest food loss* (**multiplier**) On-farm food losses, if not properly managed, can lead to increased post-harvest losses as the inefficiencies and damages persist from the farm to the post-harvest stage **Post-harvest food loss:** *Multiplies to extrinsic value loss* (**multiplier**) Post-harvest food losses can multiply the extrinsic value loss as the damage or degradation of the food increases the costs associated with handling, storage and transportation
FPO	- Semi organised and registered farmers' and producers' cooperatives - Organised based on commonalities (e.g. similar location, similar infrastructure or input requirements, same market region)	- Facilitating production and market planning, training, logistics planning, access to finance, insurance, auditing - Aggregation roles including product consolidation, grading, input/infrastructure allocation, risk management, needs assessment and production/ market analysis	- Managing various data types, input formats and communication channels for sharing information with farmers of different technical capabilities and digital maturity. - Allocating value to farmers, input suppliers and market - Identifying and reducing non-value-added activities and task duplication (e.g. farmgate grading and handing)	**Losses in production value** - Pre-harvest food loss (lack of sufficient capacity for aggregating and sharing input data for fertilisers, seeds, weather, pests) - On farm production food loss (Lack of sufficient capacity for training on best labour practices, new farming methods, agricultural planning and identification of non-hazardous pest control) - Post-harvest food loss (Lack of analytics for demand-supply matchmaking)	
Logistics					
Logistics providers	- First party logistics (1PL) at farm and village level - Second party logistics (2PL) for local and regional markets - Third Party Logistics (3PL) (Organised retail)	-First mile product handling (loading, transport, offloading) from farm to collection centres (CC) is managed by farmers or 1PL -Last mile product handling from CC through distribution centres (DC) to retail is managed by FPO or private logistics (2PL & 3PL)	—1PL is mostly done through open three wheelers, two wheelers-motorbike or non-reefer trucks leading to high food value degradation between farm & CC. -Lack of shared production data for logistics planning and scheduling for 2PL and 3PL leading to poor freight consolidation and high transport costs	**Losses in extrinsic value** - Inventory management and transportation management (time value, volatility and uncertainty value with direct impact on shelf-life grade and quality of produce) - Operations of other actors that affects time and uncertainty	**Extrinsic value loss:** *Stacks onto intrinsic value loss* (**stacking**) Extrinsic value losses can stack onto intrinsic value losses as they represent external factors or inefficiencies that affect the inherent value of the food product

(***continued***)

Table 3

Actor/Role	Description	Functions/Activities	Challenges leading to food loss	Associated losses and impact	Type of AIS failure
Processing					
Collection centre (CC)	- FPO owned CC (e.g. Village level procurement Centre) - Publicly owned CC - Privately owned CC	- Receiving and aggregating produce from different farmers - First-level sorting and grading by quality, product classification and market specifics - Other data management responsibilities	- Challenging to follow different quality assurance standards (grading and handling), procedures, monitoring and reporting - Duplication of grading and handling tasks by different actors (e.g. farmers, FPOs, CCs) - Lack of data aggregation (how much comes in and how much goes out)	**Losses in intrinsic value** - Inability of SOPs to guarantee decent price, premium and reduced cost for powerless actors (farmers, logistics)	**Intrinsic value loss:** *Multiplies to Market Value loss* (**multiplier**) Intrinsic value losses can lead to increased market value losses as the diminished quality, nutritional value, or other intrinsic attributes reduce the product's desirability
Distribution centre (DC)	- Privately owned DC - Public Private Partnership owned DC	- Receiving and aggregating produce from CCs - Second-level grading and sorting as per orders from buyers - Logistics planning and handling of produce between DC and market/buyers - Related data management tasks	- Mismatches between production scheduling from farms to CC and demand scheduling from DC to market leading to long waiting time and loss of value - Poor access to aggregate data for capacity planning and scheduling. Relies on historical demand-side forecast with minimal access to real-time production side data	**Losses in intrinsic value** - Similar to CC due to overlapping functions	
Market					
Local market (LM)	Located 3 to 5 km from farms, set up by farmers to supply informal retailers (B2B) or sell directly to consumers (B2C) based on daily auction prices at regional market yards	- Serves as an alternative market for unscheduled production, unplanned surpluses and farmers with no access to markets through CCs or regional market yards	- Losing market value due to spot pricing of all products regardless of the grading or quality - Inability to forecast demand leading to poor production planning for local market and higher transportation and obsolescence cost	**Losses in market value** accruable to produce in - existing markets (Pricing) - accessing specialist markets for premium - accessing new markets for by-products, second life (grade B, C) and end of life produce	**Market value loss:** *Multiplies to accessing specialist markets* (**multiplier**) Market value losses can multiply when the reduced quality or value prevents access to specialist markets where premium prices could be obtained for specific product characteristics
Market Yard (MY)	- National Traders Market (located 50 to 500 kms from farmgate) and regional MY (25 to 100 km) comprising middlemen, including (i) auctioneers getting produce from multiple regional markets; (ii) bidders bidding wholesale prices for produce, (iii) APMC monitors bidding process, keeps records of bids and fixes minimum commodity prices for different market	- Auction for farmer producers to find the best spot price per day irrespective of the grades (mixed grades) - Use market data and experience to develop informal bids daily - Fixing daily minimum guarantee price for the product	- Mismatch between: (i) "farmgate price" which is determined by input costs, transport costs and production conditions (ii) "wholesale price" which is fixed at the market yard (iii) "demand price" which is determined by the wholesale price plus market premium	**Losses in market value** accruable to produce in - existing markets (Pricing) - accessing specialist markets for premium	**Market value loss:** *Stacks onto existing markets* (**stacking**) Market value losses due to lack of data and infrastructure in local markets and at production stage can stack onto existing markets when excess availability of the produce leads to lower premium and loss of quality or value in the established market channels

(*continued*)

Table 3

Actor/Role	Description	Functions/Activities	Challenges leading to food loss	Associated losses and impact	Type of AIS failure
Organised retailers	- Physical Stores (Brick-and-mortar) - Specialist retailers (e.g. Retailers for Organic Produce) - E-tailers	- Provides physical infrastructure for storing, handling and selling conventional and specialist produce in temperature-controlled environments - Provides digital platforms and logistics for direct selling and delivery to consumers	- Lack of data-driven standards for maintaining shelf life - Lack of sufficient data/indicators on food quality, shelf life and value depreciation - Lack of sufficient real-time production data for demand forecasting and logistics planning	**Losses in market value** accruable to produce in - establishing new specialist market for premium consumer segments - establishing new markets for by-products, second life (grade B, C) and reuse of end-of-life produce (e.g. composting)	**Market value loss:** *Stacks onto establishing new markets for existing products and accessing new markets for second life and end-of-life in collaboration with other stakeholders* (**stacking**) Market value losses can stack onto the establishment of new markets as the reduced product quality or value hinders successful market entry and acceptance. It can also stack onto the establishment and access to markets for second life and end-of-life products through collaborations with NGOs or other hospitality actors as the reduced value limits the successful implementation of recycling, repurposing, or recovering values
Informal retail	- Petty Shops (Neighbourhood shops selling vegetables) - Pushcarts (Mobile market)	- Procure from LM, store, handle and sell produce in open spaces without temperature-control solutions - Procure from LM and sell produce door to door (with no controlled environment): 50-60% of urban buying happens from these	- No support for demand forecast - Poor understanding of production data: quantity, quality and availability - Rely on daily spot prices at MY, which vary - Lack of affordable infrastructure and information for extending and maintaining shelf-life	**Losses in market value** accruable to produce in - accessing specialist market for premium - accessing new markets for second life (grade B, C) and reuse of end of life produce	**Market value loss:** *Stacks onto accessing new markets for by-products, second life and end-of-life* (**stacking**) Market value losses can stack onto accessing second life (for other actors' grade B and C), by-products and end-of-life (for their own surpluses, waste) markets as the reduced value limits opportunities for diversifying product utilisation, value creation, reusing or repurposing the produce Market Value Loss: *Multiplies to establishing and accessing new markets for second life and end-of-life* (**multiplier**) Market value losses can multiply when the reduced quality or value from grade B, C accelerates the deterioration of food and diminishes shelf-life for the second use and end-of-life value

(*continued*)

Table 3

Actor/Role	Description	Functions/Activities	Challenges leading to food loss	Associated losses and impact	Type of AIS failure
Hospitality	- 4-5* hotels - Local restaurants and budget hotels	- "Vendor A" buyers of grade A produce (4-5* hotels) and Vendors B buyers of grades B and C produce	- Manual inventory and order management for replenishment - Managing multiple supplier agreements - Poor forecasts on consumer demand - Lack of data-driven strategies - Lack of circular economy solutions for second life/ end-of-life inventory	**Losses in market value** accruable to produce in - establishing and accessing new markets for second life (grade B, C) and end of life produce in collaboration with NGOs or circular economy companies	**Market value loss for high end hospitality:** *Stacks onto accessing premium markets* (**stacking**) Market value losses can stack onto the access to premium markets as the reduced quality or value prevents capturing the higher prices associated with premium market segments **Market value loss for high end and budget hotels:** *Multiplies to establishing and accessing new markets for second life and end-of-life* (**multiplier**) Market value losses can multiply when the reduced quality or value inhibits the establishment and access to markets for second life and end-of-life products
External institutions (secondary actors)					
Secondary actors	**Government actors:** - Governmental bodies (Central/ federal and provincial) instituting and financing FPOs, women self-help-groups, natural resource management and rural livelihood initiatives - NGOs supporting farmers to make transition towards sustainable production, improve the efficiencies of producer organisations and facilitate market access for better income and livelihood	- Supporting FPOs with initial establishment and management, approve/support pilot innovations, rural entrepreneurship, skills development, livelihood improvement and access to credit/ capital and infrastructure and access to knowledge resources - NGOs are resource organisations which (i) implement government or market-oriented programs (e.g. organic and natural farming initiatives), (ii) support data management (iii) facilitate training and advisory services and (iv) co-develop production, market access and livelihood interventions for FPOs, in partnership with government	- Availability of centralised and comprehensive data-driven strategies for managing, monitoring and appraising progress of FPOs - Insufficient understanding of provincial and regional diversity and challenges with funding, grassroot problems, training needs, production and livelihood requirements of farmers - Coordination challenges between national and provincial departments, lack of centralised information on best-practices across different provinces and FPOs - Lack of convergence of resources for farm level infrastructure	**Loss in institutional value** of Investment made for food production - Food security - Nutrition quality - New export markets - Sustainability reporting (e.g. environment impact of new markets through reduced food loss, social – livelihood impact by capturing value for farmers) **Loss in future value of food** through: - predictive analysis on weather, soil, etc. - strategic surveillance for disease, cropping patterns, market trends - preventive or resilience strategies for predicting and managing losses	**Institutional value loss:** *Stacks onto future value of food* (**stacking**) Institutional value losses can stack onto the future value of food as the inadequate investment in food production and its associated values undermines long-term sustainability and resilience **Future food loss:** (**Stacking**) The future value of food loss is not directly related to subsequent types of losses since it encompasses broader factors and considerations beyond the immediate cascading effects

(***continued***)

Table 3

Actor/Role	Description	Functions/Activities	Challenges leading to food loss	Associated losses and impact	Type of AIS failure
			(cleaning, grading, sorting, assaying, processing, branding & transportation) - Gaps between government interventions, community needs and FPOs' objectives - Lack of access to data and resources to support capacity building and advisory services - Lack of communication channels for feedback on success or failure cases	from future shocks (social, economic, ecological, political)	

Source: Authors' own creation

distribution centres. Despite investments in infrastructure and data management by government, fragmented ownership and control of these losses imply that "there are currently no generally accepted SOPs for minimising processing losses, and there is a lack of shared ownership to allow the infrastructure and capacity utilisation solutions by FPOs to cascade to other beneficiary groups", FF1. While FPOs are currently generating very useful data that could inform reductions in logistics and processing-related food losses, fragmented ownership and management of food losses arising from extrinsic logistics and intrinsic quality assurance operations have resulted in "fragmented data which is insufficient to pool logistics" [FL1].

4.1.3 Market function in the current business model for food loss management

Our study included two broad categories of market actors in the current business model: informal (market yard, local market, informal retail) and formal markets (organised retailers, e-tailers and hospitality). In the current business model, transactions between farmers and licensed buyers occur mainly in informal market yards that are overseen by locally elected Agricultural Produce Marketing Committees (APMC) comprising few large farmers, traders, weighmen and local marketing agents. FN2 noted that:

> There is a lot of market food losses because farmers have to make uninformed decisions to sell their products to commission agents of APMC through open auctions or through informal auctions organised by market yard traders' associations during a short time window in early mornings when prices are set by auctioneers and bidders with informal market rules.

Upon arriving at local markets or regulated market yards, farmers must initiate sales by offering their produce for sorting, grading and packaging and take whatever price is offered by the agents in good faith, because they depend on these agents for advance finance. Moreover, FN3 explained that farmers are forced:

> to sell mixtures of product grades and qualities that have been poorly aggregated at minimum acceptable prices [. . .] to avoid lengthy and complicated bargaining and pricing processes but they incur significant market value losses in the process.

Regarding formal wholesale markets dealing with the bulk purchases through formal channels such as retail and hospitality are more amenable to regulations, but a majority of transactions are still conducted among market intermediaries and middlemen (agents and brokers). Furthermore, we found that for most formal actors, relying on informal market prices that are prone to fluctuations results in purchase contracts to hedge against fluctuations in wholesale market prices, which leads to surplus purchases. In this regard, the government has set up a National Agriculture Market Electronic Trading (e-Nam) platform to provide market access and improve price discovery for farmers, but FN3, cautioned that:

> such systems can only work if the FPOs themselves are grouped into collectives to capture the needs of most underrepresented beneficiary groups that bear most of the losses in food value from both production processing and market inefficiencies.

4.1.4 Government function in the current business model for food loss management

The government is the primary custodian of the whole food chain losses in the current business model. However, most actors' food loss value is derived from the ability to retain as much of the value lost from production, extrinsic logistics, intrinsic processing and market access, government returns on investment in the food loss business model according to FG3 is "*about meeting centrally set targets such as local consumption, food security, food availability and sustainability and improved livelihoods*".

FU5 explained that in the current model, farmers are unable to realise better prices and premiums due to a "lack of transparency in the trading process, price cartelisation, and payment delays". The lack of government oversight of the aggregation function for marketing infrastructure and data coupled with the fragmented landholding and differentiated production landscape upstream has:

> prevented a lot of private players, landowners and other entities from investing in developing specialist markets, and e-markets because they are unable to guarantee returns to shareholders on such investments outside of government support, FN3.

In the current food loss model, cluster-based business organisations (e.g. NCDC) serve as resource institutes working with central, state and local governments to ensure that FPOs can reduce food losses to farmers. However, "'smallholder beneficiaries' have complex livelihood, socio-economic and socio-ecological challenges that are difficult to effectively represent through cluster-based organisations pursuing the government agenda" FN3. The key challenge with instituting a centrally managed aggregation function is that the current cluster-based approach for aggregating FPOs has the unintended consequence of excluding smallholders.

4.1.5 Non-governmental organisations functions and current business model for food loss

In the current business model, the fragmented nature of NGOs' role at national and state levels has led to inefficiencies in facilitating the data, infrastructure and capability aggregation functions, for which NGOs are better positioned to link to the private actors. Furthermore, with the devolution of FPO aggregation function to several agencies and sub-department of the government, the relevant data is managed in silos, thus making it challenging for NGOs to perform a defined aggregation role. The challenge with the undefined role (through policy) for NGOs is lack of data sharing which is:

> [. . .] is necessary to enable partnerships that are transparent, result-oriented and complementary [. . .] to establish clear targets for measuring and monitoring co-leadership and coordination of food loss management by various actors FN3.

In this regard:

> NGOs clustering roles need to be clear and should ideally entail bridging the silos [. . .] data and infrastructure created by FPO clusters to establish co-lead roles among governments, FPO clusters and NGOs and identify activity areas [data management, infrastructure, capacity building] where actor's roles in food loss management complement [. . .] enhance [. . .] or substitute each other FF2.

4.2 Strategies for transitioning to a networked sustainable business model

The following emerged as potential strategies (Table 4) for transitioning to a networked SBM for reducing loss of fresh produce at early stages in the agri-food supply chain: ownership configuration, value addition, beneficiary identification and community capacity building. The following subsections explain these in relation to the context.

Table 4 Strategies for transitioning to a networked SBM for reducing post-harvest food loss and value loss

Strategies	Mechanisms
Ownership configuration	• **Redefining ownership towards stewardship:** Multi-actor collaboration and co-designing of interventions with governmental impetus and increased participation of FPOs • **Mobilising stewardship:** Enabling local level aggregation of organised players to share responsibilities for developing feasible ground-up solutions that augment policy benefits
Value addition	• **Improving farm-level planning:** Using information feedback solutions for enabling joint planning and decision making, while also enabling farm level sorting and storage solutions • **Aggregating quality management in upstream:** Improving pre- and post-harvest operating procedures in local supply chain activities and building locally feasible capacities for reducing food loss and maintaining value • **Strengthening producer-market connections:** Reducing the gap between harvesting time and pick-up time by connecting producers to buyers, while also enabling entrepreneurial innovation in linking producers to different markets
Beneficiary identification	• **Identifying informal sector beneficiaries:** Strengthening inclusion and participation of informal retail that is incurring losses logistically and farmer producers who are incurring losses during and after production • **Identifying formal sector beneficiaries:** Identifying most organised players among infrastructure cost bearing entities and upstream functionaries incurring post-harvest and processing related losses
Community capacity building	• **Building managerial capacity:** Skill development campaigns at community level and hand holding micro-level actors for accessing institutional support • **Building digital capacity:** Digital awareness and training for mindset change, digitalizing access to farm data and for predicting harvesting time • **Building infrastructural capacity:** Installing cold solutions at local level and increasing value with processing opportunities

Source: Authors' own creation

4.2.1 Ownership configuration

There is a need for redefining ownership to stewardship through multi-actor participation for shared value creation and capture, while at the same time increasing governmental role and presence in taking some ownership of the losses and operationalising infrastructural solutions. Multi-actor participation, both public and private, in SBM refers to cooperative participation in the network for sharing value creation and costs in recognising and addressing sustainability challenges (Freudenreich *et al.*, 2020). Without that, there is risk of innovation getting staggered due to ownership disputes as found by some studies (Mohan *et al.*, 2023). Interestingly, we find that the existence and visibility of institutional coalition are interpreted by the supply chain actors as an indication of a potentially conducive environment in the ease of doing business and in access to subsidies, input resources, infrastructure and credit. Farmers tend to have more trust in government-promoted collection and distribution centres. In creating a hub-based aggregation of organised players to share responsibilities for developing feasible solutions, FPOs also need to bring the government's participation for legitimacy and outreach, while at the same time working on synergies in policy-making, planning and implementing.

Networked SBMs need value networks created through informal–formal collaboration in the value chain (Comin *et al.*, 2019). Collectivization is essential to connect formal and informal actors (farms, supply chain operators and marketplaces) to absorb cost and achieve economies of scale with new interventions. According to TP4:

> Some kind of aggregation is needed so that cost of production can be reduced and maybe a model cluster should emerge, so that they can absorb these costs. The Federation based model can employ some good professionals who are involved in the infrastructure creation and aggregating of FPOs, because all these require infrastructure and investment done collectively as per policy directions, thus making a different kind of business model.

However, mobilising such stewardship has challenges at scale. For local-level collectivization, farmers and farmer groups need support to form their supply clusters and generate supply information for estimating demand for affordable and portable temperature and humidity-controlling solutions. However, this would need public–private partnerships, as the product eventually travels through them. Recent research finds that cooperation between upstream and downstream actors is crucial for managing food supply chains (Luo *et al.*, 2022). We find that formal players owning collection and distribution centres need to come forward and invest in novel solutions at a network level, because they are the largest market-oriented beneficiaries of a streamlined supply chain with minimal loss.

4.2.2 Value addition

In this study, we find that solutions for reducing the loss and waste of fresh produce at the most local level need quick logistics, distribution and market infrastructure to make the solutions viable. Frontline operators lose value due to poor quality of transportation, logistical delays or unavailability of vehicles and manpower. Short-term cooling solutions are not available to increase the shelf-life of fresh and fast perishable produce, to tackle uncertainties found in this study as well as in past studies, such as uncertainties in transportation, market

fluctuations, climatic conditions and fluctuating prices (Mohan *et al.*, 2023). Easily accessible and affordable solutions are needed to preserve and assure food quality at pre- and post-harvest stages, to wait out potential value loss and to manage surplus. TP1 says:

> what needs to be done, as far as the price volatility is concerned! Now there is a farmer who has harvested, or who is about to harvest. [. . .] Suddenly there is a change in the market prices and things are not going right. He should have an option of basically storing it for a while, or something like that. From that perspective, I was talking about short term storage.

Past research signifies the role of digitalisation in overcoming sustainability challenges in agri-food value chains (Corallo *et al.*, 2023). We find that business decisions that would prevent or reduce food loss at the post-harvest stages of the supply chain, need to be driven by information feedback among the actors in each node of the supply chain, most importantly with the farmers for planning sowing, harvesting and farm-level facilities.

> I believe how much needs to be produced if that data and dashboard information is sent back to the farmer, then it will be more meaningful so that the storage can be planned well ahead and waste is less [. . .] so the feedback is missing now, says TP2.

Without a feedback loop between actors there is limited scope for new value addition to mitigate loss of value due to food loss. "Value" is at multiple levels in a multi-actor networked SBM, thereby necessitating a systemic understanding of solving sustainability problems at the micro-level for creating win-win situations (Comin *et al.*, 2019). With real-time information, a viable sorting and storage facility and market linkages at the very farm level, farmers can not only deal with uncertainties but also have better planning and can also reuse poor-quality produce in creating organic farmyards. This calls for solutions to ensure that low-quality food at the farm level is put through circular economy practises implementable for the benefit of the farmer, reinforcing the need of a circular mindset in agri-food (Corallo *et al.*, 2023) starting from the grassroots value chain. Climatic and soil conditions, poor seed quality and staggered production, alter the sowing and harvesting times. This challenges decision-making on when to take market orders and order transportation. Estimating harvesting and pick-up becomes problematic, thereby needing a solution to cover for time and value lost. Further, the producers and their excess produce need to be brought closer to urban consumers, such as in the form of mobile shops, or to low-income markets with low rejection rate, to generate additional value through informal settings, over value creation through the formal economy value chain.

4.2.3 Beneficiary identification

Two types of beneficiaries emerged from the analysis: informal sector beneficiaries and formal sector beneficiaries. Informal markets are of enormous capacity, with no access to cold chains. They need low-scale, highly affordable and portable temperature and humidity-controlling solutions that can create value for them. Although the informal sector actors constitute an important part of the agri-food value chain in developing economies (Wegerif, 2020), they are undercapitalised, severely affected by rapid change and ineligible/unaware of support that may exist (Christiaensen *et al.*, 2021). A networked SBM within AIS would require practices that make dominant actors higher up in the value chain include informal sector actors in designing and implementing systemic solutions. We find that while large retailers can invest in temperature-controlled infrastructure, solutions are desperately needed for small and informal retailers who face worse challenges with unsold produce. With Currently, the demand-supply match-making in our research setting was found to be based on premonition. In the current configuration of the business model, the majority income share goes to market agents and aggregators, rather than the farmer producers. "The product cycle is also very low – 2 to 3 days; maximum share of consumer price should go to the farmer, but that is not happening," says DC5.

SBMs are inclusive as they engage income-constrained groups in the value chain for addressing long-neglected social and economic problems (Schoneveld, 2020). We find in our research setting that a lease and service-oriented model might allow multiple users (actors) access to a shared infrastructure of agri-tech solutions, for everyday decisions at the grassroots level. The cash and service model can be routed and operated through producer cooperatives for transparency and consolidation.

> We should be able to bring sprinkled temperature controls under one funding infrastructure so that it can be run using a service-oriented model where maybe farmers who need access to that can do it through the farmer producer cooperative, says NGO3.

The cost-bearing entities can be producer groups/cooperatives and the off-takers who can give access to the infrastructure through micro-leasing. For the produce that has consumers paying premium price, direct transaction is desirable between the farmer producer groups and those offering farming contracts, to increase farmer income and enable win-win capital infusion.

4.2.4 Community capacity building

A networked SBM materialises through multi-actor participation for value creation, which is inclusive in ways that support the sustainability of participating groups/collectives instead of individual actors (Schoneveld, 2020). Capacity building is necessary for developing the organising skills of small- to medium-scale actors in the post-harvest supply chain so that they become beneficiaries of innovation rather than being displaced by it. Enabling resilience at the community level and creating community-level resources is crucial to becoming a sustainable agri-food supply chain, rather than focusing on the economic viability of an individual actor in the supply chain (Stone and Rahimifard, 2018). Incubation and hand-holding are needed for farmers and other front-line actors accessing institutional support and managing new technologies. Organised collectives such as farmer cooperatives and FPOs need training on professionally managing everyday operations, accessing finance and meeting certification requirements. This goes beyond the focus on the business community in the generic food supply chain (Van Beusekom–Thoolen *et al.*, 2023), to recognise the social economy actors in the agri-food value chains of the developing world, who need support for addressing their sustainability challenges.

The three-month period between demand estimation, buyer identification and sowing seeds, can be used for forecasting demand for off-grid cold-chain equipment. This is also the time in between crop cycles where digital solutions are needed for real-time market linkages and for predicting harvesting time, pricing and demand. However, digitalizing through platform-

based applications and making it accessible to local supply chain actors is a significant behavioural change in these locations.

> Data digitisation from a register to an app is not really a real challenge as much as it is shown. So, they know it, but they don't want it. Digital transformation and change management is always a problem. It is more of a mindset issue than technology. There are a few people who will benefit from it but there are others who won't; they are looking at short term gains, says TP2.

It calls for extensive campaigning on digital awareness and training of the farmers and supply chain operators, alongside capacity development in infrastructure for access to internet and data.

Affordable off-grid cold-storage capacities at the farm level can prevent the loss of produce, respond to delay in market demand and even create opportunities for cultivating high-value crops. Another possibility for achieving higher intrinsic value is to use these capacities for alternative value propositions, such as food processing.

4.3 Integrating AIS with networked sustainable business model through proposed strategies

We argue that proposed strategies would enable a networked SBM infused with AIS for reducing multiplier and stacking food value loss. We elaborate on the relations between the enabling strategies and two forms of food value losses in networked SBM using ten propositions. These propositions are developed through an interplay between existing literature, proposed strategies and causes of food value loss in the current business model (Cf. Sections 4.1, 4.2, Table 5). Further considerations and potential questions for future research are presented in Section 4.3.2 and captured in Table 6.

4.3.1 From a siloed to a network view of sustainable business model

From our findings, we argue that to design an SBM within AIS, the value that is derived from siloed business models has to be networked and aligned. There are two broad categories of value creation in networked SBM infused with AIS, namely, multiplier (Cronin *et al.*, 2022; Fieldsend *et al.*, 2022) and stacking value (Cronin *et al.*, 2022; Parmar and Kumar, 2022). We argue that to achieve inclusive and sustainable value creation within AIS with a networked SBM, the enabling strategies are crucial.

Firstly, in line with previous studies (Srai *et al.*, 2021), we see that the business models used by the actors for food loss reduction in the Indian fresh food AIS are fragmented. Despite government investments in FPOs and digital initiatives, varying, competing or conflicting policies make different actors pursue different scopes of food value loss (Srai *et al.*, 2021; Sagi and Gokarn, 2022). For instance, while farmers are more concerned with minimising production value losses, the FPO business model captures the institutional value of food through livelihood, food security and other broader sustainability-driven initiatives. Owing to a lack of linkages between formalised government top-down initiatives and informal business models for managing production (pre-production, on-farm and postharvest), intrinsic and extrinsic losses diminish the realisation of market, institutional and future food values for actors through government AIS initiatives, particularly small-holders (Méndez-León *et al.*, 2022). Furthermore, we found that supply chain actors and policymakers have competing values which are not aligned, leading to double marginalisation of farmers, i.e. farmers bear most of the losses in other actors' business models as the competing policies do not reward or penalise any other actors for food loss (Srai *et al.*, 2021). For instance, through state FPOs, the government incentivised production of particular crops, such as tomatoes, but there were conflicting policies for accessing the markets, storage and pricing leading to massive food loss, all borne by farmers. In response to this, the Federal Indian Government has recently launched the "Tomato Grand Challenge" in 2023 (Department of Consumer Affairs, 2023).

Secondly, in line with previous literature on multiplier and stacking effects in AIS (Cronin *et al.*, 2022), our study proposes two forms of interdependencies that enable or hinder value realisation for operationalising a networked SBM for reducing food loss. We argue that the ownership of the values generated in the current business models is fragmented and certain categories of values, particularly those generated by informal actors, have no formalised ownership and business models. Hence, those affected most by these value losses are farmers. We characterise this form of networked food loss as the *multiplier* food loss, which results when production value losses in pre-production, on-farm and postharvest food loss management has a multiplier effect in other scopes of food losses in the chain, including intrinsic value, extrinsic value and market value.

Thirdly, we found that there are gaps in community-level capacities (managerial, digital, infrastructure) that are required to realise production, intrinsic and extrinsic values despite government-led AIS deployments for market value realisation. In line with previous studies on stacking effects in AIS (Brewster *et al.*, 2017; Blash *et al.*, 2020), we characterise this form of food loss as *stacking* food value loss. From our findings, we argue that there are significantly important data stacks at the farm gate for managing pre-, on-farm and postharvest food losses, such as data related to weather, soil, pest, production planning, etc. and if any of these data stacks are missing because of lack of capacity to generate and use them, it leads to losses stacking up in other parts of the food chain (cf. Table 3).

4.3.2 Propositions for achieving networked sustainable business model through AIS

While previous studies have identified multiplier and stacking effects in AIS, our findings about the current business models show that multiplier losses arise from the lack of shared ownership of production value due to largely informal pre-, on-farm and post-harvest practices. These losses in production value cumulate in diminished market value. Further, our findings show that stacking losses in food value arise because of gaps in infrastructure and data stacks for managing food losses arising from inadequate community-level capacities (managerial, digital, infrastructure) for generating and sharing crucial production, processing and logistics data stacks (Fieldsend *et al.*, 2022). These losses cumulate in diminished institutional and future food value because of the lost opportunity to discover new values (e.g. net zero, carbon trading, new connections to market, competitive pricing, etc.). We emphasise that these two forms of food value losses are not mutually exclusive, however, they are analytically distinct

Table 5 From data and literature to propositions

Key challenges	Strategies/ Mechanisms	Examples of supporting literature	Propositions
Challenges in defining shared responsibilities, potential conflicts among actors, resistance to shared ownership create multiplier losses	*Redefining ownership towards stewardship:* Multi-actor collaboration and co-designing of interventions with governmental impetus and increased participation of FPOs	Cronin *et al.* (2022) demonstrated that shared ownership in multi-actor projects reduces multi-level system failures. This was achieved by encouraging cooperation among various actors in the system for aligning their goals and mitigating losses at different stages of the value chain to ensure they contribute to reducing each other's value loss. In addressing sustainability challenges for which a single actor is not responsible in a value chain, innovation has the risk of failing if ownership of problems and solutions is not shared through cooperation Mohan *et al.* (2023), more so for managing loss of resources or products that are highly perishable Luo *et al.* (2022)	**Proposition 1:** Organising actor groups in shared ownership of AIS enables a networked SBM by reducing multiplier losses
Inadequate stewardship, resistance to collaborative efforts, potential disruptions in value streams create stacking losses	*Mobilising stewardship:* Enabling local level aggregation of organised players to share responsibilities for developing feasible ground-up solutions that augment policy benefits	Brewster *et al.* (2017) found the significance that a collaborative stakeholder approach has in implementing IoT solutions in agriculture across multiple countries. Large-scale pilots aimed at validating IoT technologies and their impact on agriculture, need mobilising stewardship to prevent food losses and create new value streams within the agri-food value chain. This would mean that both value creation and cost-bearing capacities are network level activities needing cooperative participation Freudenreich *et al.* (2020).	**Proposition 2:** Mobilising stewardship prevents food losses from stacking in the agri-food value chain and transforms any loss incurred into new or alternative value streams
Data sharing resistance, lack of cooperation in planning, challenges in collective decision-making create multiplier losses	*Improving farm-level planning:* Using information feedback solutions for enabling joint planning and decision making, while also enabling affordable farm level sorting and storage solutions	Digitalisation plays an important role in overcoming sustainability challenges in agri-food supply chains Corallo *et al.* (2023) but needs the participation of different actors to enable multiple data generation and usage points. Méndez-León *et al.* (2022) introduced a holistic framework for sustainable value analysis in business models, with a focus on sustainable development. The framework encouraged information-driven decision-making, collective grassroots planning and synergistic capacity building for addressing key challenges leading to food losses	**Proposition 3:** Information driven and collective grassroot planning enables AIS actors to collaboratively identify root causes of multiplier food losses
Resistance to quality management changes, difficulties in alignment with market requirements create multiplier losses	*Aggregating quality management in upstream*: Improving pre-and-post-harvest operating procedures in local supply chain activities and building locally feasible capacities for reducing food loss and maintaining value	Past research finds that overcoming barriers in implementing innovation needs innovation communities with collaboration mechanisms that underscores the importance of promoters operating on linkages in the actors' networks Hansen and Schmitt (2021). Actors serving as intermediaries help bridge gaps between different levels for a seamless flow of information,	**Proposition 4:** Aggregating quality management and assurance procedures in pre- and post-harvest operations can reduce market losses arising from mismatches between demand-supply specifications

(***continued***)

Table 5

Key challenges	Strategies/ Mechanisms	Examples of supporting literature	Propositions
		collaboration and innovation that aligns with the idea of effective intermediation being crucial in reducing market losses. Introducing the idea of moving to a "networked business model" that comprises transition goals, system-building activities, resources, benefits for stakeholders and associated costs, is instrumental in aligning network views of quality and sustainability efforts for reducing market losses Planko and Cramer (2021)	
Communication barriers, resistance to collaboration, potential disruptions in linkages creates stacking losses	*Strengthening producer-market connections:* Reducing the gap between harvesting time and pick-up time by connecting producers to buyers, while also enabling entrepreneurial innovation in linking producers to different markets	The complexity of innovating business models at the level of social and sustainability oriented enterprising closer to the ground, is that it has to deal with unique governance structures, funding arrangements and the need to align value processes across various stakeholders with limited resources Best *et al.* (2022). It illustrates that FPOs must consider and align a range of issues to successfully realise value co-creation, such as connecting producers to different markets, ensuring timely harvest-to-pick-up connections and encouraging entrepreneurial innovation as part of business model innovation	**Proposition 5:** Strengthening producer-market and market-market linkages within AIS prevents the stacking of market losses and enables value realisation
Exclusion of informal actors, challenges in integration, resistance to change create multiplier losses	*Identifying informal sector beneficiaries:* Strengthening inclusion and participation of informal retail that is incurring losses logistically and farmer producers who are incurring losses during and after production	Multi-actor co-innovation partnerships in agriculture and related sectors provides valuable insights into the co-innovation process and its various forms, but mostly from the developed economy contexts Fieldsend *et al.* (2022). But in developing economies, innovation bears fruit when there are informal-formal economy partnerships that create empowering structures Christiaensen *et al.* (2021). It is learnt from past research that co-innovation can take different forms based on the contextual contingencies encountered by partnerships, thereby suggesting that the choice of co-innovation depends on actor capacities, aspirations and networks for reducing multiplying food losses Fieldsend *et al.* (2022). This again depends on partnership size, workplan structure, types of outputs, multi-stakeholder engagement for an enabling environment	**Proposition 6:** Identification and aggregation of informal beneficiaries mitigates multiplier food losses from informal producer and market linkages
Misidentification of formal beneficiaries, mismatch in facilitation roles, coordination challenges create stacking losses	*Identifying formal sector beneficiaries:* Identifying most organised players among infrastructure cost bearing entities and upstream functionaries incurring post-harvest and processing related losses	The study by Baygi *et al.* (2021) provided a significant shift in how we approach the study of socio-technological transformation by understanding how changes in a dynamic digital world complements the idea that formal beneficiaries play essential roles in addressing food losses within evolving agricultural	**Proposition 7:** Identification of formal beneficiaries and their facilitation roles mitigates food losses from stacking on to each other

(***continued***)

Table 5

Key challenges	Strategies/ Mechanisms	Examples of supporting literature	Propositions
		systems. The shift from fixed, single-actor approaches to more connected and flow-based perspectives aligns with the notion that identifying and facilitating formal beneficiaries within AIS should be viewed as part of an ongoing, dynamic process that responds to the fluidity of the digital age	
Resistance to capacity building, difficulties in behavioural change, challenges in implementing new practices create multiplier losses	*Building managerial capacity:* Skill development campaigns at community level and hand holding micro-level actors for accessing institutional support	Inclusive business models are of increasing importance as they prioritise value creation over value capture Schoneveld (2020), which can be assessed based on the net value they create for income-constrained groups. In the context of AIS, this aligns with the idea that managerial capacity building at the community level can help community members, particularly income-constrained groups, to understand the value they can create in the system. As managerial capacity is built within these communities, they become better equipped to identify and reduce multiplier losses, as creating community-level resources is crucial to becoming a sustainable agri-food supply chain Stone and Rahimifard (2018). This capacity-building process empowers them to play a more active and informed role within the AIS	**Proposition 8:** Managerial capacity building at community level enables formal and informal beneficiaries to identify and reduce multiplier losses
Digital literacy gaps, resistance to technology adoption, data security concerns create stacking losses	*Building digital capacity:* Digital awareness and training for mindset change, digitalizing access to farm data and for predicting harvesting time	Acquier *et al.* (2019) provides a comprehensive typology of sharing economy business models, which encompasses shared infrastructure providers, commoners, mission-driven platforms and matchmakers, each representing distinct value-creation logics, scalability challenges, sustainability impacts and potential controversies. Strengthening connections between producers and markets in the AIS can be approached through various lenses, mirroring the diversity of sharing economy models and the potential for shared resources and infrastructure within AIS. Preventing market losses and enhancing value realisation through AIS is achievable through a diverse configuration of actors strengthening producer-market connections. IoT enabled data collection and analysis can help agricultural stakeholders make informed decisions about resource management, crop conditions and more Parmar and Kumar (2022). These data-driven decisions are essential for reducing losses and improving efficiency of the overall community of actors in the supply chain	**Proposition 9:** Digital capacity building at community level enables formal and informal beneficiaries to identify and reduce stacking losses

(***continued***)

Table 5

Key challenges	Strategies/ Mechanisms	Examples of supporting literature	Propositions
Infrastructure investment challenges, difficulties in infrastructure management, financial constraints create stacking losses	*Building infrastructural capacity:* Installing cold solutions at local level and increasing value with processing opportunities	Food loss mitigation strategies at the postharvest level in developing countries necessitates moving the focus on the business community in the generic food supply chain Van Beusekom–Thoolen *et al.* (2023), to recognising the role that social economy actors play in the agri-food value chains of the developing world, as they have to take everyday decisions and need support for addressing their sustainability challenges. In dealing with informal and marginalised stakeholders aligning with the broader theme of reducing food losses in the agricultural value chain a multi-level engagement is needed by involving informal beneficiaries, such as small-scale farmers and local market participants, at various stages of the value chain Best *et al.* (2022). This can help identify and address the root causes of food losses at different points in the chain. Moreover, just as FPOs often have unique governance structures due to their social mission, agricultural systems may require innovative governance models to accommodate informal beneficiaries. These structures should be flexible and inclusive to ensure that the needs and challenges of informal participants are considered in decision-making processes	**Proposition 10:** Creating capacity and access to storage and processing infrastructure that is not available at the community level can be enabled with the identification of opportunities offering new value propositions to local formal and informal actors

Source: Authors' own creation

Table 6 Future research questions

Related propositions	Future research questions	Indicated variables	Possible methodologies
Proposition 1	How does shared ownership influence collaboration and resource sharing within AIS? What factors contribute to the success of networked business models in reducing multiplier losses?	Collaboration intensity (e.g. frequency of interactions), resource sharing (e.g. sharing of physical and knowledge resources), ownership structure (e.g. distribution of ownership rights), network centrality (e.g. actor's position within the network)	Longitudinal studies, network analysis, case studies, action research
Proposition 2	How does stewardship influence the adoption of circular economy practices in the agri-food value chain? What are the key factors that enable the transformation of losses into new value streams?	Stewardship practices (e.g. resource conservation and waste reduction initiatives), resource utilisation (e.g. identification and utilisation of underutilised resources), value creation (e.g. generation of new value streams), circular economy adoption (e.g. integration of circular economy principles)	Case studies, action research, socio-technical system modelling
Proposition 3	How does information-driven planning contribute to the identification of root causes of food losses? What are the barriers and enablers of collective grassroots planning within AIS?	Information sharing practices (e.g. sharing of data and knowledge), collaborative planning processes (e.g. joint decision-making and problem-solving), systemic feedback loops (e.g. identification and analysis of feedback mechanisms)	Action research, participatory methods, case studies
Proposition 4	How do strengthened linkages between producers and markets impact market losses and value realisation? What are the key drivers of successful producer-market and market-market linkages within AIS?	Market connectivity (e.g. degree of integration between producers and markets), information flow (e.g. accuracy and timeliness of market information), transaction costs (e.g. costs associated with intermediaries), value realisation (e.g. revenue generation)	Network analysis, case studies, optimization studies
Proposition 5	How does information flow and coordination among actors impact the reduction of stacking losses in AIS? What are the key factors that facilitate efficient decision-making in AIS?	Market information access (e.g. availability and utilisation of market data), market fluctuations (e.g. price volatility), alternative market channels (e.g. diversification of market outlets), decision-making effectiveness (e.g. quality and timeliness of decisions)	Quantitative analysis, social network analysis, surveys
Proposition 6	What are the challenges faced by informal actors in the agri-food system, and how can they be supported to reduce food losses?	Access to finance (e.g. availability of credit and microfinance services), technology (e.g. access to appropriate tools and equipment), training (e.g. participation in skill development programs), market information (e.g. access to market prices and trends)	Participatory approaches, interviews, focus groups
Proposition 7	How can the identification and support of formal actors in the agri-food system prevent stacking problems and reduce food losses?	Resource allocation (e.g. allocation of financial and physical resources), data alignment (e.g. information sharing and coordination among formal actors), value discovery (e.g. identification of new opportunities and partnerships)	Stakeholder analysis, case studies, surveys

(***continued***)

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Table 6

Related propositions	Future research questions	Indicated variables	Possible methodologies
Proposition 8	How does improving managerial capacity in agri-food systems enhance the ability to identify and mitigate multiplier losses?	Loss identification (e.g. ability to identify sources of losses), decision-making (e.g. adoption of loss mitigation strategies), resilience (e.g. capacity to adapt to changing circumstances)	Optimization models, simulation, statistical analysis
Proposition 9	How does digital capacity building in agri-food systems impact the identification and reduction of stacking losses throughout the value chain?	Data management (e.g. ability to collect, store and analyse relevant data), data-driven decision-making (e.g. utilisation of data for loss mitigation), stacking losses (e.g. identification and reduction of losses at different stages)	Network analysis, data analytics, quantitative modelling
Proposition 10	How does improved access to storage and processing infrastructure in agri-food systems reduce stacking losses and enhance market access?	Infrastructure availability (e.g. access to storage facilities and processing equipment), market access (e.g. direct market entry), value chain capture (e.g. ability to capture a larger share of the value chain)	Comparative analysis, case studies, supply chain analysis

Source: Authors' own creation

as one is primarily based on coordination and relational dynamics of the actors while the other pertains to the flows and allocation of tangible (e.g. infrastructure) and intangible (e.g. data, finance) resources in AIS (Cronin *et al.*, 2022; Elias and Marsh, 2020). Considering the interplay between these value losses due to siloed business models and the enabling strategies (see Section 4.2) identified by actors in the Indian agri-food system, we make the following ten propositions for developing networked SBM within AIS (also see Table 5).

4.3.2.1 Ownership

P1. Organising actor groups in shared ownership of AIS enables a networked SBM by reducing multiplier losses.

Regardless of the purpose of AIS, the actors would usually execute their own business model in silo to achieve their innovations, with or without clarity on ownership. Where there is no clear ownership, any losses accrued from one actor cascade and multiply through the chain irrespective of the strategies in place (Cronin *et al.*, 2022; Fieldsend *et al.*, 2022).

P2. Mobilising stewardship prevents food losses from stacking in the agri-food value chain and transforms any loss incurred into new or alternative value streams.

AIS is underpinned by multiple innovations that depend on overlapping infrastructure and data stacks owned by different actors. As the values of data and AIS infrastructure are created through their use, a stewardship framework (rather than siloed owners of data/infrastructure) is required to mobilise all key primary actors that contribute to fundamental stacks or infrastructure pools that are required to realise networked business value (Brewster *et al.*, 2017).

4.3.2.2 Value-addition

P3. Information-driven and collective grassroots planning enables AIS actors to collaboratively identify root causes of multiplier food losses.

Information-driven planning allows AIS actors to access comprehensive data on various factors such as postharvest handling, storage, transportation and market situations, to form a better understanding of the root causes of food loss. Collective grassroots planning allows for a comprehensive assessment of the value chain interdependencies, bottlenecks and inefficiencies in the multi-actor-network (Méndez-León *et al.*, 2022). This ensures that contextual knowledge is integrated into AIS to address food losses faced by the local community.

P4. Aggregating quality management and assurance procedures in pre- and post-harvest operations can reduce market losses arising from mismatches between demand-supply specifications.

The traditional top-down audits and assurances that characterise the current business model cannot work in a networked business model because the assurances required are bottom-up. To enhance compatibility in quality management and assurance procedures in a networked SBM, robust monitoring from a bottom-up (participatory) approach at the primary loss prevention stages (pre-production and postharvest) are necessary to provide the baseline data on which other assurances within a networked SBM can be accessed (Hansen and Schmitt, 2021; Planko and Cramer, 2021).

P5. Strengthening producer–market and market–market linkages within AIS prevents the stacking of market losses and enables value realisation.

Communication and data exchange between producers, markets (formal and informal) and other actors reduces the chances of stacking problems where relevant data or infrastructure from different parts of the agri system remains isolated or unused. Information flow also enables the discovery of new values and the realisation of institutional values (Best *et al.*, 2022). When producers and market (formal and informal) actors in AIS have access to shared information on production scheduling, demand data from different markets, consumer preferences, quality standards, pricing dynamics, among others, actors can make informed decisions to enhance the retention of values across networked SBM (production, intrinsic, extrinsic and market values), thereby enhancing resilience and sustainability of networked business model.

4.3.2.3 Beneficiary identification

P6. Identification and aggregation of informal beneficiaries mitigate multiplier food losses from informal producer and market linkages.

Informal actors, such as small-scale farmers, local traders and informal market vendors, often lack access to finance, technology, training and market information, which hampers their productivity and market competitiveness. By recognising their needs and connecting them to relevant support systems, informal beneficiaries can enhance their capacity to reduce food losses and improve their overall performance (Fieldsend *et al.*, 2022). As these actors possess traditional knowledge, skills and practices, integrating them into formal networks and platforms can lead to innovation, improved practices and reduced food losses within networked SBM.

P7. Identification of formal beneficiaries and their facilitation roles mitigates food losses from stacking onto each other.

Connecting formal actors for a networked SBM, including their needs, operations, resource requirements and expected payoffs, needs to take into account how they can facilitate financial support, technical assistance, infrastructure and market access. This is needed to ensure that the necessary support is provided to mitigate food losses and reduce the risk of stacking problems resulting from resource mismatches or inefficiencies because of poor data or infrastructure. This reduces the likelihood of food losses being hidden or passed on without accountability and enables the discovery of new value by discouraging stacking problems where losses accumulate unnoticed (Baygi *et al.*, 2021). Identifying formal asset-bearing actors unlocks opportunities for sharing best practices, technical knowledge and innovative solutions. Capacity-building programs can then be designed to enhance the skills and capabilities of formal beneficiaries, empowering them to address food losses more effectively.

4.3.2.4 Community-level capacity building.

P8. Managerial capacity building at community level enables formal and informal beneficiaries to identify and reduce multiplier losses.

Managerial capacity building fosters problem-solving capabilities among formal and informal beneficiaries by providing them with tools and techniques to analyse complex issues, identify root causes of losses and develop innovative solutions. This enables them to address challenges early on and prevent losses from accumulating and multiplying throughout the value chain. Managerial capacity building also cultivates a sense of responsibility and agency that enhances actors' understanding of the agricultural value chain, market dynamics and best practices (Schoneveld, 2020). This allows both formal and informal beneficiaries to make informed decisions for better-assessing risks, identifying opportunities for improvement and implementing appropriate strategies to mitigate losses at different stages of the value chain.

P9. Digital capacity building at community level enables formal and informal beneficiaries to identify and reduce stacking losses.

Digital capacity building equips formal and informal beneficiaries with the skills and tools to collect, store and analyse real-time information on market prices, supply and demand trends, weather conditions, their own operations, such as production quantities, quality parameters, transportation routes and storage conditions. For instance, beneficiaries can combine the use of accessible low-tech solutions, e.g. mobile applications for inventory management, temperature monitoring, pest detection and quality control to generate relevant inputs (data stacks) (Parmar and Kumar, 2022; Acquier *et al.*, 2019). This enables beneficiaries to minimise stacking losses throughout the value chain by making data-driven decisions, anticipating potential losses, identifying patterns, detecting inefficiencies and adjusting their strategies accordingly.

P10. Creating capacity and access to storage and processing infrastructure that is not available at the community level can be enabled with the identification of opportunities offering new value propositions to local formal and informal actors.

Within a networked business model, access to facilities such as cold storage, drying units, milling equipment, packaging facilities and decisions to locate these at a right aggregation stage (e.g. at village level (micro) vs at a district level (mesoscale), can reduce stacking losses by extending the shelf life of agricultural products, improving product quality and diversifying local actors' value-added products (Best *et al.*, 2022). Optimal facility location decisions based on local actors inputs (e.g. network configurations, livelihood needs) are necessary to reduce the reliance on intermediaries, increase direct market access for producers (local, regional, national distribution networks) and reduce losses incurred because of data and infrastructure gaps (cf. Propositions 5, 9) or through the involvement of multiple intermediaries.

Overall, these ten propositions contribute to the alignment of AIS and SBM literature which has been developing independently. In SBM literature, the food loss is predominantly examined based on different typologies or categories in silos. This kind of siloes view makes it difficult to incentivise networked SBM. Our research identifies networked level value or losses (multiplier and stacking) and strategies that actors can use to manage or mitigate them through the above ten propositions. We further provide future research directions, potential research questions and methodology that can be adopted to test these propositions in Table 5. In addition, our research advances the literature on AIS by introducing system-level networked SBM for food loss reduction and proposing strategies for facilitating such models which can be applied to other networked sustainable systems where actors may be running different business models in silos (e.g. energy, water, critical minerals, fashion, etc.). This analytical distinction between the two sources of networked business model value (and losses) is useful for facilitating future investigations on system-level dimensions of (food) value loss within a networked business model (see Table 6 for details).

5. Contributions, limitations and future directions

5.1 Contributions, limitations and future directions for theory and research

This study contributes incrementally to the field of supply chain management (SCM) by presenting a structured framework that clarifies the shift from traditional isolated business models to collaborative, networked approaches, aligned with the innovation literature in SCM (Planko and Cramer, 2021). It extends the discourse on food losses in SCM by introducing an innovative categorization across different business models in the food chain, emphasising the importance of value creation over value capture, echoing previous research that takes a holistic view of value that incorporates social, economic and environmental considerations of various stakeholders (Schoneveld, 2020). In the complex context of AIS and SCM, this study distinguishes between two types of losses, multiplier and stacking losses, advancing SCM theory and highlighting the need for value alignment in collaborative supply chain models. These findings align with discussions on risk management and offer significant insights into mitigating food losses in supply chains (Cronin *et al.*, 2022; Fieldsend *et al.*, 2022). Additionally, the research emphasises the alignment between AIS and SBM, underscoring the importance of identifying value owners and beneficiaries within a network of AIS actors, identifying potential strategies that can enable moving from an unsustainable business model to a sustainable one and facilitating equitable and sustainable value distribution throughout the supply chain (Best *et al.*, 2022; Acquier *et al.*, 2019). This contribution showcases the potential for creating value from otherwise lost resources, ultimately reducing food losses in supply chains and advancing SCM towards more sustainable and efficient practices.

Although this study takes an essential first step in creating contextual knowledge about the phenomenon, the findings have some limitations which set the stage for future research.

Generated from lived experiences through induction, the results are naturalistically generalizable to other developing countries but lack statistical generalizability (Lincoln and Guba, 1985; Ketokivi and Choi, 2014). A potential quantitative study would be an impact measurement of the

operationalizing the strategies and mechanisms while being implemented by a coalition of actors. Another objective could be to identify the variables of each mechanism and examine the implicit relationships and moderated mediations (see Table 6).

There is also a need for qualitative enquiries to generate a processual understanding of the project management in enabling an AIS with a networked SBM for addressing food value loss. With these actor-centric findings on potential actions, the next step in creating a process framework entails identifying the action flows, decision-making and resource allocation, to create a conceptual schema of practice loops in a relational, temporal and performative sense (Baygi *et al.*, 2021; Garud *et al.*, 2013) (see Table 5).

5.2 Contributions, limitations and future directions for practice and policy

The study demonstrated critical roles of external actors in AIS in facilitating the development of a networked sustainable business model for optimising supply chain management. This facilitates more effective operations and reduces food losses. The study also aligns AIS with SBM, enhancing actors' ability to deploy coordinated efforts to address food losses and promote sustainability. Furthermore, fostering mission-driven strategies that target collective goals such as reducing multiplier and stacking losses systematically empowers actors' collaborative interventions for improving resource allocation and risk management practices. Additionally, governments, NGOs and financiers can develop more targeted interventions to reduce food losses, improve value co-creation, enhance resilience by optimising resource utilisation across the agricultural value chain. These external actors have the know-how and potential to generate a variety of innovation models that are required to be managed holistically. However, as they are external actors their roles are often excluded from the development of sustainable agri-food business models. The study included key external actors, such as, government, financial institutions and NGOs. However, other external actors (e.g. research institutes, exporters, schools, etc.) whose roles might be important in understanding the value from reducing the food loss, were outside the scope of the study. These external actors play a vital role in facilitation and aggregation of values within an AIS.

The study identified four interconnected actions required to translate strategic AIS goals to specific mission-oriented business models e.g. food loss. Causal links (e.g. which action leads to which) among these actions to inform prioritisation by AIS actors need to be addressed in future studies. For instance, for more mature FPOs that have a well-structured beneficiary identification system, future studies should investigate how such actors should prioritise their actions for initiating and operationalising a networked SBM.

From the practice point of view, it is often observed that many of these innovations to business models occur outside the configuration of important actors and such innovations are integrated into the business models at a later stage. Future studies may expand on the findings of this study by exploring the efficiencies and impact of an integrated approach to operationalise an SBM while all important actors are placed within the AIS to create a supportive ecosystem. From the policy perspective, misalignment could be found between policy expectations and actors' requirements within a configuration. Future studies could explore the best possible direction for policy formulations that can encourage a bottom-up approach and align the goals of different actors with the governmental interventions to create an SBM (see Table 6).

6. Conclusion

AIS can create SBMs if there are deliberate attempts to design a configuration of actors around a specific value chain (meaning, what is the value to different actors for reducing food loss). AIS remains like a top-down tool that informs policy development but such policies would often be misaligned with the business needs of the actors because AIS literature and SBM have evolved separately. This study contributes to linking these two fields and calls for future research on building this interdisciplinary research further with bottom-up knowledge for reducing food loss and value loss in food supply chains, particularly at postharvest level (SDG 12.3). By bridging the AIS and SBM literature, we identified two forms of networked business value (*multiplier* and *stacking* values) and four enabling strategies from the perspectives of supply chain actors required to operationalise a specific SBM for reducing food loss with broader AIS goals.

With the evolution of industrial-level technologies such as Industry 4.0 and system-level sustainability models such as circular economy, our study bridges the need for networked SBM literature to align with a system-level innovation concept such as AIS by highlighting how actors derive system-level values (multiplier, stacking) using a range of innovations. We offer ten propositions for future research and areas for further exploration on how such networked SBM can be operationalised within AIS or other innovation systems (e.g. technology, energy, water, critical minerals, fashion, etc.). These propositions aim to explore areas such as collaborative governance mechanisms, data-sharing protocols and impact assessment frameworks to further enhance the effectiveness and sustainability of networked SBM. Our study offers pathways for businesses and other AIS actors to map value streams associated with other broader sustainable goals such as circular economy, carbon accounting that share similar principles for value co-creation.

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References

Acquier, A., Carbone, V. and Massé, D. (2019), "How to create value (s) in the sharing economy: business models, scalability, and sustainability", *Technology Innovation Management Review*, Vol. 9 No. 2.

Ancona, D. (2012), "Sensemaking: Framing and acting in the unknown", in Snook, S., Nohria, N. and Khurana, R. (Eds), *The Handbook for Teaching Leadership*, Vol. 3 No. 19, SAGE, London, pp. 198-217.

Artiuch, P. and Kornstein, S. (2012), "Sustainable approaches to reducing food waste in India", *Journal of Massachusetts Institute of Technology*, pp. 1-19.

Barth, H., Ulvenblad, P.O. and Ulvenblad, P. (2017), "Towards a conceptual framework of sustainable business model innovation in the Agri-food sector: a systematic literature review", *Sustainability*, Vol. 9 No. 9, p. 1620.

Baygi, R.M., Introna, L.D. and Hultin, L. (2021), "Everything flows: studying continuous sociotechnological transformation in a fluid and dynamic digital world", *MIS Quarterly*, Vol. 45 No. 1, pp. 423-452.

Best, B., Miller, K., McAdam, R. and Maalaoui, A. (2022), "Business model innovation within SPOs: exploring the antecedents and mechanisms facilitating multi-level value co-creation within a value-network", *Journal of Business Research*, Vol. 141, pp. 475-494.

Blash, G., Li, Z. and Taylor, J.A. (2020), "Multi-temporal yield pattern analysis method for deriving yield zones in crop production systems", *Precision Agriculture*, Vol. 21 No. 6, pp. 1263-1290.

Bocken, N.M., Short, S.W., Rana, P. and Evans, S. (2014), "A literature and practice review to develop sustainable business model archetypes", *Journal of Cleaner Production*, Vol. 65, pp. 42-56.

Braun, V. and Clarke, V. (2006), "Using thematic analysis in psychology", *Qualitative Research in Psychology*, Vol. 3 No. 2, pp. 77-101.

Brewster, C., Roussaki, I., Kalatzis, N., Doolin, K. and Ellis, K. (2017), "IoT in agriculture: designing a Europe-wide large-scale pilot", *IEEE Communications Magazine*, Vol. 55 No. 9, pp. 26-33.

Brown, A.D., Colville, I. and Pye, A. (2015), "Making sense of sensemaking in organization studies", *Organization Studies*, Vol. 36 No. 2, pp. 265-277.

Centobelli, P., Cerchione, R. and Ertz, M. (2021), "Food cold chain management: what we know and what we deserve", *Supply Chain Management: An International Journal*, Vol. 26 No. 1, pp. 102-135.

Christiaensen, L., Rutledge, Z. and Taylor, J.E. (2021), "The future of work in Agri-food", *Food Policy*, Vol. 99, p. 101963.

Comin, L.C., Aguiar, C.C., Sehnem, S., Yusliza, M.-Y., Cazella, C.F. and Julkovski, D.J. (2019), "Sustainable business models: a literature review", *Benchmarking: An International Journal*, Vol. 27 No. 7, pp. 2028-2047.

Corallo, A., De Giovanni, M., Latino, M.E. and Menegoli, M. (2023), "Leveraging on technology and sustainability to innovate the supply chain: a proposal of Agri-food value chain model", *Supply Chain Management: An International Journal*, doi: 10.1108/SCM-12-2022-0484.

Cronin, E., Fieldsend, A., Rogge, E. and Block, T. (2022), "Multi-actor horizon 2020 projects in agriculture, forestry and related sectors: a multi-level innovation system framework (MINOS) for identifying multi-level system failures", *Agricultural Systems*, Vol. 196, 103349.

Department of Consumer Affairs (2023), "Tomato grand challenge", available at: https://doca.gov.in/gtc/(accessed 15 September 2023).

Dora, M., Biswas, S., Choudhary, S., Nayak, R. and Irani, Z. (2020), "A system-wide interdisciplinary conceptual framework for food loss and waste mitigation strategies in the supply chain", *Industrial Marketing Management*, Vol. 93, doi: 10.1016/j.indmarman.2020.10.013.

Eisenhardt, K.M. and Graebner, M.E. (2007), "Theory building from cases: opportunities and challenges", *Academy of Management Journal*, Vol. 50 No. 1, pp. 25-32.

Elias, M. and Marsh, R. (2020), "Innovations in agricultural and food systems sustainability in California", *Case Studies in the Environment*, Vol. 4 No. 1, pp. 1-14.

Emirbayer, M. (1997), "Manifesto for a relational sociology", *American Journal of Sociology*, Vol. 103 No. 2, pp. 281-317.

Fieldsend, A.F., Varga, E., Biró, S., Von Münchhausen, S. and Häring, A.M. (2022), "Multi-actor co-innovation partnerships in agriculture, forestry and related sectors in Europe: contrasting approaches to implementation", *Agricultural Systems*, Vol. 202, p. 103472.

Filimonau, V. and Ermolaev, V.A. (2021), "Mitigation of food loss and waste in primary production of a transition economy via stakeholder collaboration: a perspective of independent farmers in Russia", *Sustainable Production and Consumption*, Vol. 28, pp. 359-370.

Freudenreich, B., Lüdeke-Freund, F. and Schaltegger, S. (2020), "A stakeholder theory perspective on business models: value creation for sustainability", *Journal of Business Ethics*, Vol. 166 No. 1, pp. 3-18.

Garud, R., Tuertscher, P. and Van de Ven, A.H. (2013), "Perspectives on innovation processes", *Academy of Management Annals*, Vol. 7 No. 1, pp. 775-819.

Gehman, J., Glaser, V.L., Eisenhardt, K.M., Gioia, D., Langley, A. and Corley, K.G. (2018), "Finding theory method fit: a comparison of three qualitative approaches to theory building", *Journal of Management Inquiry*, Vol. 27 No. 3, pp. 284-300.

Gephart, R., Topal, Ç. and Zhang, Z. (2010), "Future-oriented sensemaking: temporalities and institutional legitimation", Process Sensemaking and Organizing, *Oxford*.

Gioia, D.A., Thomas, J.B., Clark, S.M. and Chittipeddi, K. (1994), "Symbolism and strategic change in academia: the dynamics of sensemaking and influence", *Organization Science*, Vol. 5 No. 3, pp. 363-83.

Grodal, S., Anteby, M. and Holm, A.L. (2021), "Achieving rigor in qualitative analysis: the role of active categorization in theory building", *Academy of Management Review*, Vol. 46 No. 3, pp. 591-612.

Guha, R. (2016), *Democrats and Dissenters*, Penguin Books, India.

Hall, A., Janssen, W., Pehu, E. and Rajalahti, R. (2006), *Enhancing Agricultural Innovation: How to Go beyond the Strengthening of Research Systems*, World Bank, Washington, DC.

Hamann, S. (2020), "The global food system, agro-industrialization and governance: alternative conceptions for Sub-Saharan Africa", *Globalizations*, Vol. 17 No. 8, pp. 1405-1420.

Hansen, E.G. and Schmitt, J.C. (2021), "Orchestrating cradle-to-cradle innovation across the value chain: overcoming barriers through innovation communities, collaboration mechanisms, and intermediation", *Journal of Industrial Ecology*, Vol. 25 No. 3, pp. 627-647.

Hayden, M.T., Mattimoe, R. and Jack, L. (2021), "Sensemaking and the influencing factors on farmer decision-making", *Journal of Rural Studies*, Vol. 84, pp. 31-44.

Ketokivi, M. and Choi, T. (2014), "Renaissance of case research as a scientific method", *Journal of Operations Management*, Vol. 32 No. 5, pp. 232-240.

Kim, J.H., Hilleary, R., Seroka, A. and He, S.Y. (2021), "Crops of the future: building a climate-resilient plant immune system", *Current Opinion in Plant Biology*, Vol. 60, p. 101997.

Klang, D., Wallnöfer, M. and Hacklin, F. (2014), "The business model paradox: a systematic review and exploration of antecedents", *International Journal of Management Reviews*, Vol. 16 No. 4, pp. 454-478.

Klerkx, L. and Begemann, S. (2020), "Supporting food systems transformation: the what, why, who, where and how of mission-oriented agricultural innovation systems", *Agricultural Systems*, Vol. 184, p. 102901.

Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., … Wells, P. (2019), "An agenda for sustainability transitions research: state of the art and future directions", *Environmental Innovation and Societal Transitions*, Vol. 31, pp. 1-32.

Lerman, L.V., Benitez, G.B., Müller, J.M., de Sousa, P.R. and Frank, A.G. (2022), "Smart green supply chain management: a configurational approach to enhance green performance through digital transformation", *Supply Chain Management: An International Journal*, Vol. 27 No. 7, pp. 147-176.

Lincoln, Y.S., Guba, E.G., 1985. *Naturalistic Inquiry*, Vol. 75, Sage, London.

Lüdeke-Freund, F. and Dembek, K. (2017), "Sustainable business model research and practice: emerging field or passing fancy?", *Journal of Cleaner Production*, Vol. 168, pp. 1668-1678.

Luo, N., Olsen, T., Liu, Y. and Zhang, A. (2022), "Reducing food loss and waste in supply chain operations", *Transportation Research Part E: Logistics and Transportation Review*, Vol. 162, p. 102730.

Markard, J., Raven, R. and Truffer, B. (2012), "Sustainability transitions: an emerging field of research and its prospects", *Research Policy*, Vol. 41 No. 6, pp. 955-967.

Massa, L., Tucci, C.L. and Afuah, A. (2017), "A critical assessment of business model research", *Academy of Management Annals*, Vol. 11 No. 1, pp. 73-104.

Méndez-León, E., Reyes-Carrillo, T. and Díaz-Pichardo, R. (2022), "Towards a holistic framework for sustainable value analysis in business models: a tool for sustainable development", *Business Strategy and the Environment*, Vol. 31 No. 1, pp. 15-31.

Midgley, G. and Lindhult, E. (2021), "A systems perspective on systemic innovation", *Systems Research and Behavioral Science*, Vol. 38 No. 5, pp. 635-670.

Mohan, A., Krishnan, R., Arshinder, K., Vandore, J. and Ramanathan, U. (2023), "Management of postharvest losses and wastages in the Indian tomato supply chain—a temperature-controlled storage perspective", *Sustainability*, Vol. 15 No. 2, p. 1331.

Moqaddamerad, S. and Tapinos, E. (2022), "Managing business model innovation uncertainties in 5G technology: a future-oriented sensemaking perspective", *R&D Management*, Vol. 53 No. 2, pp. 244-259.

Neumeyer, X. and Santos, S.C. (2018), "Sustainable business models, venture typologies, and entrepreneurial ecosystems: a social network perspective", *Journal of Cleaner Production*, Vol. 172, pp. 4565-4579, doi: 10.1016/j.jclepro.2017.08.216.

Nosratabadi, S., Mosavi, A., Shamshirband, S., Zavadskas, E.K., Rakotonirainy, A. and Chau, K.W. (2019), "Sustainable business models: a review", *Sustainability*, Vol. 11 No. 6, p. 1663.

Parmar, M. and Kumar, R. (2022), "Overview of IoT in the Agroecosystem2", *Agri-Food 4.0*, Emerald Publishing, Bingley.

Patton, M.Q. (1990), *Qualitative Evaluation and Research Methods*, SAGE Publications, London.

Planko, J. and Cramer, J. (2021), "The networked business model for systems change: integrating a systems perspective in business model development for sustainability transitions", in Aagaard, A., Ludeke-Freund, F. and Wells, P. (Eds), *Business Models for Sustainability Transitions*, Springer Nature, Cham.

Preghenella, N. and Battistella, C. (2021), "Exploring business models for sustainability: a bibliographic investigation of the literature and future research directions", *Business Strategy and the Environment*, Vol. 30 No. 5, pp. 2505-2522.

Ritchie, H. (2021), "Smallholders Produce One-Third of the Worlds Food, Less than Half of What Many Headlines Claim", *Our World in Data*, Oxford, UK, available at: https://ourworldindata.org/smallholder-food-production

Sagi, V. and Gokarn, S. (2022), "Determinants of reduction of food loss and waste in Indian Agri-food supply chains for ensuring food security: a multi-stakeholder perspective", *Waste Management & Research: The Journal for a Sustainable Circular Economy*, Vol. 41 No. 3, doi: 10.1177/0734242X221126421.

Schaltegger, S., Hansen, E.G. and Lüdeke-Freund, F. (2016), "Business models for sustainability: origins, present research, and future avenues", *Organization & Environment*, Vol. 29 No. 1, pp. 3-10.

Schoneveld, G.C. (2020), "Sustainable business models for inclusive growth: towards a conceptual foundation of inclusive business", *Journal of Cleaner Production*, Vol. 277, p. 124062.

Sengupta, S. and Lehtimäki, H. (2022), "Contextual understanding of care ethics in social entrepreneurship", *Entrepreneurship & Regional Development*, Vol. 34 Nos 5/6, pp. 1-32.

Solaimani, S. and van der Veen, J. (2022), "Open supply chain innovation: an extended view on supply chain collaboration", *Supply Chain Management: An International Journal*, Vol. 27 No. 5, pp. 597-610.

Srai, J.S., Joglekar, N., Tsolakis, N. and Kapur, S. (2021), "Interplay between competing and coexisting policy regimens within supply chain configurations", *Production and Operations Management*, Vol. 31 No. 2, pp. 457-477.

Stone, J. and Rahimifard, S. (2018), "Resilience in Agri-food supply chains: a critical analysis of the literature and

synthesis of a novel framework", *Supply Chain Management: An International Journal*, Vol. 23 No. 3, pp. 207-238.
Teerikangas, S., Koistinen, K., Onkila, T. and Mäkelä, M. (2021), " "Introduction to the research handbook of sustainability agency", *Research Handbook of Sustainability Agency*, Edward Elgar Publishing, New York, NY, pp. 1.-27.
Ulvenblad, P.O., Ulvenblad, P. and Tell, J. (2019), "An overview of sustainable business models for innovation in Swedish Agri-food production", *Journal of Integrative Environmental Sciences*, Vol. 16 No. 1, pp. 1-22.
Van Beusekom–Thoolen, P., Holmes, P., Jansen, W., Vos, B. and de Boer, A. (2023), "Interdisciplinary challenges associated with rapid response in the food supply chain", *Supply Chain Management: An International Journal*, doi: 10.1108/SCM-01-2023-0040.
Vanderlinden, J.P., Baztan, J., Chouinard, O., Cordier, M., Da Cunha, C., Huctin, J.M. and Thomson, K.T. (2020), "Meaning in the face of changing climate risks: connecting agency, sensemaking and narratives of change through transdisciplinary research", *Climate Risk Management*, Vol. 29, p. 100224.
Vasanthraj, A., Kaur, V., Potdar, L. and Agrawal, H. (2023), "Industry 4.0 adoption in food supply chain to improve visibility and operational efficiency—a content analysis", in *IEEE Access*, Vol. 11, pp. 73922-73958, doi: 10.1109/ACCESS.2023.3295780.
Watkins, A., Papaioannou, T., Mugwagwa, J. and Kale, D. (2015), "National innovation systems and the intermediary role of industry associations in building institutional capacities for innovation in developing countries: a critical review of the literature", *Research Policy*, Vol. 44 No. 8, pp. 1407-1418.
Weber, K. and Glynn, M.A. (2006), "Making sense with institutions: context, thought and action in Karl Weick's theory", *Organization Studies*, Vol. 27 No. 11, pp. 1639-1660.
Wegerif, M.C. (2020), "Informal" food traders and food security: experiences from the covid-19 response in South Africa", *Food Security*, Vol. 12 No. 4, pp. 797-800.
Weick, K.E. (1995), *Sensemaking in Organizations*, Sage Publications, Thousand Oaks, CA.
Winans, K., Marvinney, E., Gillman, A. and Spang, E. (2020), "An evaluation of on-farm food loss accounting in life-cycle assessment (LCA) of four California specialty crops", *Frontiers in Sustainable Food Systems*, Vol. 4, p. 10.
Zott, C., Amit, R. and Massa, L. (2011), "The business model: recent developments and future research", *Journal of Management*, Vol. 37 No. 4, pp. 1019-1042.
Zucchella, A. and Previtali, P. (2019), "Circular business models for sustainable development: a "waste is food" restorative ecosystem", *Business Strategy and the Environment*, Vol. 28 No. 2, pp. 274-285.

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