“I am because we are”: The role of sub-Saharan Africa’s collectivist culture in achieving traceability and global supply chain resilience

Abstract

Prior studies on traceability as an enabler of supply chain resilience (SCRes) have focused on large-scale disruptions and developed country contexts. Few studies have focused on developing countries where chronic, small-scale disruptions are common and resource scarcity means advanced digital technologies are rarely adopted. This research explores how traceability is achieved across upstream actors in two Ghanaian agri-food supply chains and how this affects global SCRes. Social characteristics are shown to influence the risks inherent in supply chains, while traceability is both a direct and indirect SCRes enabler. Informed by the relational view, the roles of relation-specific assets and governance mechanisms in maintaining traceability are explored. Supply chain-wide relation-specific assets are prioritized over dyadic relation-specific assets. This original finding is explained by the importance of maintaining social ties over short-term economic gains in a collectivist culture, leading to greater relational rents in the long term. A novel, informal third-party governance mechanism that reduces formal contracting costs and provides flexibility and continuity to interfirm relationships is also identified, further facilitating the attainment of relational rents. The findings are explained in light of sub-Saharan Africa’s collectivist culture, encapsulated in the philosophy of *ubuntu*. Overall, the research theorizes on achieving supply chain traceability and thus enhancing global SCRes as a sociotechnical system incorporating technological and nontechnological systems that are socially embedded in the local context.

Keywords Traceability; Supply chain resilience; Relational view; Agri-food industry; *Ubuntu*.

INTRODUCTION

The recent spate of high-profile uncertainties, risks, and disruptions to global supply chains has underscored the need for supply chain resilience (SCRes), enabling firms to persist, adapt, and transform operations in response to or anticipation of a disruption (Stone & Rahimifard, 2018; Wieland & Durach, 2021). Despite significant attention on SCRes, extant empirical research has mainly focused on developed countries (Tukamuhabwa et al., 2015). This is despite the importance of developing countries at different stages of maturity to global supply chains (Scholten et al., 2020; Tukamuhabwa et al., 2017). It is argued here that findings cannot simply be transferred from a developed to a developing country context. Varying infrastructures and supply chain conditions expose firms to different risk types, while the response to and impact of the same risk type can also vary according to context. Thus, further empirical research on SCRes is needed across a range of developing country contexts.

In 2022, developing countries accounted for more than 40% of global exports (United Nations Conference on Trade and Development, 2023). In particular, Africa's contribution has increased significantly in recent years because of its competitive primary sectors that provide raw materials, components, and semi-processed products at lower production costs (Kauppi et al., 2018; World Bank Group, 2019). Going forward, the continent is expected to expand its contribution to the global economy even further. For example, Ghana's president recently expressed an intent to increase the nation's agricultural productivity by shifting from a reliance on exporting primary agricultural commodities (including cocoa and fruits) to providing more value-added semi-finished products (Cocoa Post, 2021). Therefore, implementing SCRes strategies that reflect suppliers' conditions in this context is critical to ensuring that local upstream disruptions do not escalate into severe global supply chain crises (Dolgui & Ivanov, 2021).

Implementing an effective traceability system is critical to African suppliers if they are to expand their trading relationships with European, North American, and other major international

partners (World Economic Forum, 2019). Traceability refers to a firm's ability to identify an item (input, output, or asset) and ensure information on its provenance, location, status, and composition is maintained throughout all stages of the supply chain (Timmer & Kaufmann, 2017; Zhao et al., 2017). By generating, updating, and transferring relevant information, traceability facilitates the detection and transmission of early warning signals between supply chain partners (Brusset & Teller, 2017; de Vries et al., 2022). Despite growing research interest in the role of traceability in enhancing SCRes in multi-tier supply chains, to date, the traceability literature has focused on the role of emerging technologies (e.g., artificial intelligence, blockchains, and unmanned aerial vehicles; Razak et al., 2023). Resource constraints mean this work offers limited insights to firms in African and other developing countries, where sophisticated traceability technologies are rarely employed (Kshetri, 2021; Utoikamanu, 2018). Hence, greater clarity on how traceability can be employed in these contexts as a strategy for enhancing SCRes is needed. Therefore, this research asks the following question: *In the absence of sophisticated technologies*, *how do African suppliers enhance their traceability systems to enable global SCRes?*

Given that global SCRes is in the collective interest of all supply chain actors, partners may collaborate to enhance the capacities of firms (Scholten & Schilder, 2015). For example, some supply chain partners exchange, combine, or invest in resources to advance a given relationship (i.e., relation-specific assets) while ensuring that no party behaves opportunistically by employing effective governance mechanisms (Dyer & Singh, 1998; Feng et al., 2020). For this research, the relational view is adopted to empirically explore the interfirm linkages between African suppliers as a source of relational rent in the form of an improved traceability system that fosters global SCRes. The relational view strengthens the research as it reflects the network-centric practices of contemporary supply chains that encourage capability sharing, co-learning, and co-innovating in order to achieve superior performance outcomes together (Kumar et al., 2020; Silvestre et al., 2023).

A qualitative multi-case study approach is adopted involving the upstream tiers of the cocoa and fruit supply chains of Ghana, a major global agri-food supply chain (AFSC) market (World Economic Forum, 2019). As in many other countries in sub-Saharan Africa, Ghana's AFSCs are predominantly characterized by "*ethnic-based business networks*" that thrive on locally-accepted customs and culture (Fold, 2008, p. 104). While each country will have its own unique customs, the renowned Global Leadership and Organizational Behavior Effectiveness (GLOBE) project categorized sub-Saharan Africa as a distinct cluster with shared cultural values, including a strong attachment to and recognition for authority and status privileges (House et al., 2004). Within the cluster, interpersonal and interfirm relationships predominantly thrive on non-individualistic, collectivist characteristics epitomized by the philosophy of *ubuntu* (loosely translated as "I am because we are") (Kauppi et al., 2018; Morris et al., 2023). Data are first analyzed to identify the types of disruptions encountered, to explore how traceability is achieved, and to understand its impact on SCRes before aggregated themes are linked to constructs from the relational view.

This research makes five key contributions. First, it shows that African suppliers are often plagued by small-scale, chronic, nonlinear disruptions that originate from socially embedded chacteristics. Second, it unpacks how the social characteristics of sub-Saharan Africa shape the way in which traceability is achieved in the absence of sophisticated technologies. Third, empirical insights explaining the conceptual link between traceability and SCRes are provided. Fourth, it extends the relational view by revealing how investments in supply-chain wide relation-specific assets can enhance traceability systems and thus SCRes, as well as the role played by effective informal third-party governance in harmonizing interfirm relationships. More specifically, the collectivist culture of sub-Saharan Africa limits the utility of dyadic relation-specific assets and emphasizes the possibility of more effective supply chain-wide relation-specific assets that benefit more members of the supply chain. Moreover, the legitimacy given to community leadership creates a novel form of informal third-party governance played by

traditional local community leaders. Finally, the limits of applying a Western-centric theoretical lens to understand global supply chain phenomena are emphasized. Specifically, the research explains the need to consider the collectivist culture of sub-Saharan African communities, represented by the concept of *ubuntu*, in order to understand local supply chain practices and behaviors toward global supply chain innovations.

LITERATURE REVIEW AND THEORETICAL BACKGROUND

Supply Chain Resilience

While there remains no consensus on a single definition of SCRes (Castillo, 2023), most scholars broadly agree on four key aspects: preparation ahead of a disruption, response to the disruption, recovery from the disruption, and a return to normality, or growth to a more desirable state, after the disruption (e.g., Brandon-Jones et al., 2014; Scholten et al., 2020). This view naturally leans toward studying acute, large-scale disruptions, such as natural disasters, wars, terrorist attacks, and financial crises (e.g., Jüttner & Maklan, 2011; Scholten et al., 2014). Although this focus is understandable, it ignores the potential for chronic, seemingly small-scale disruptions to escalate and have larger consequences throughout the network (Castillo, 2023; Dolgui & Ivanov, 2021).

Recent research has emphasized that the different sociocultural characteristics across supply chains mean that a one-size-fits-all approach to SCRes does not exist (Wieland & Durach, 2021; Wieland et al., 2023). Insights generated from a few European- and North American-based empirical studies on SCRes do not conveniently transfer to supply chains in sub-Saharan Africa or other developing countries/regions (Tukamuhabwa et al., 2017). Specifically, the sources of disruption, such as poverty, geopolitical threats, conflicts, and infrastructural deficits, that are prevalent in sub-Saharan Africa remain under-researched (Craighead et al., 2017; Tukamuhabwa et al., 2017). Even for globally disruptive events, such as the COVID-19 pandemic and the Russia–Ukraine war, evidence shows that response strategies vary considerably between contexts (Bundervoet & Davalos, 2021). For example, the importance of social and religious gatherings to

the sociocultural disposition of sub-Saharan Africa limited the effectiveness of lockdowns and social distancing measures during the pandemic (World Economic Forum, 2020).

Accordingly, there have been increasing calls for more in-depth empirical insights into how SCRes enablers, including collaboration, flexibility, agility, visibility, velocity, and traceability (e.g., Brandon-Jones et al., 2014; Scholten et al., 2020; Stone & Rahimifard, 2018; Zhao et al., 2017), can be deployed in different supply chain environments (Castillo, 2023; Harvard Business Review Analytic Services, 2023). The current supply chain environment demands holistic SCRes strategies that can simultaneously enhance efficiency and ensure the transparency of sustainable practices (Harvard Business Review Analytic Services, 2023). Traceability is a key strategy that supports the simultaneous pursuit of efficiency and sustainability (Razak et al., 2023); however, further empirical research into the relationship between SCRes and traceability, especially in particular developing country contexts, is needed.

Traceability as an Enabler of Supply Chain Resilience

Extant research suggests that traceability enhances a firm's ability to uncover potential risks, to facilitate the communication of risks along the supply chain, and to ensure response measures are coordinated with minimal delays and errors (Razak et al., 2023). The traceability literature distinguishes between forward traceability or tracking, which ensures that relevant product-related information can be determined as it moves downstream; and backward traceability or tracing, which ensures that a product's journey and upstream origin can be determined (Bosona & Gebresenbet, 2013; Timmer & Kaufmann, 2017). Given that an effective supply chain traceability system "requires information for the total product's lifecycle" (Kelepouris et al., 2007, p. 187), both types of traceability are necessary to achieve effective traceability in multi-tier supply chains. Notwithstanding the impact of digital technologies on the effectiveness of traceability, the quality and trustworthiness of traceability information depend on factors beyond technology, including who collected the information, how and when it was collected (Bager et al., 2022; Bradley et al., 2018).

For customer-driven and safety-critical industries, such as agri-food and pharmaceuticals, traceability plays an important role in providing evidence that assures consumers, governmental agencies, nongovernmental organizations, and the media of the quality and safety of products and of adherence to ethical sourcing standards (Montet & Dey, 2017; Razak et al., 2023). As most threats to business operations are external, enhancing SCRes requires actors to work together to explore risk sources and potential solutions (Kurniawan et al., 2017; Razak et al., 2023). Accordingly, at the supply chain level, traceability benefits SCRes by enhancing responsiveness and early risk detection via real-time monitoring and improved visibility (e.g., Ringsberg, 2014; Sumukadas, 2021), transparency and trust among supply chain partners (e.g., Feng et al., 2020; Kumar et al., 2015), and reliability and security to eliminate counterfeiting and fraud (e.g., Hald & Kinra, 2019; Hastig & Sodhi, 2020). Given that effective traceability relies on supply chain interconnectedness (Kelepouris et al., 2007; Razak et al., 2023), this research adopts the relational view and the notion that generating a competitive advantage relies on access to specific interfirm network resources (Dyer & Singh, 1998).

The Relational View

Theories that seek to explain the source of better firm performance and competitive advantage have received significant attention in supply chain management (Huang et al., 2022). Prominent amongst them are the resource-based view (RBV), which suggests firms can achieve competitive advantage by accumulating resources and capabilities that are valuable, rare, and hard to imitate or substitute (Barney, 1991); and the industry structure view, which opines that firms can achieve supernormal returns through their involvement in a favorable industry (Porter, 1980). However, the increasing interdependence of contemporary supply chain partners has evolved the dynamics of competitive advantage beyond individual firm boundaries (Dyer & Singh, 2008). For example, a firm may generate firm-specific advantage from resources fully owned or controlled by another firm but available to them via a network alliance (Lavie, 2006). Thus, the relational view was proposed by Dyer & Singh (1998) to complement the industry structure and

resource-based views by explaining that competitive advantage can reside in interconnected firms (Dyer & Singh, 2008).

The relational view posits that a firm's competitive advantage may extend beyond its internal resources and require critical external resources and capabilities embedded in dyadic or broader network relationships (Dyer & Singh, 1998; Lavie, 2006). The theory has been used extensively to explore how a dyad or network of autonomous entities that are willing and able to uniquely combine their resources toward a common goal may outperform the competition (Huang et al., 2022). Dyer & Singh (1998) argued that relational rents are generated based on four elements: relation-specific assets, knowledge-sharing routines, complementary resources and capabilities, and effective governance. Relational rent (i.e., the outcome variable) is defined as "a supernormal profit jointly generated in an exchange relationship that cannot be generated by either firm in isolation and can only be created through the joint idiosyncratic contributions of the specific alliance partners" (Dyer & Singh, 1998, p. 662). Subsequent studies have extended understanding of a relational rent to incorporate any mutual benefit or competitive advantage borne out of an interfirm relationship (Chen et al., 2013; Lavie, 2006).

Accordingly, this research posits that attaining a greater level of traceability and its benefits, such as enhanced SCRes, is a relational rent that arises when partnering firms invest in relation-specific assets and use an effective governance mechanism to control opportunism in the relationship. The research is focused on the relation-specific assets and effective governance elements of the theory since they emerged from the data aggregation process as being the most relevant to the context and objectives of this research (as described in the Methodology section).

For relation-specific assets, the relational view proposes that sustained competitive advantage requires a firm to intentionally invest in assets—whether material or immaterial—that align with those of a partner, which is called co-specialization (Dyer & Singh, 1998). This may take the form of high geographical proximity between successive production stages (site specificity),

acquiring assets to facilitate a particular supply chain relationship (physical and nonphysical asset specificity), or accumulating knowledge, skills, and expertise primarily to facilitate an interfirm relationship (human asset specificity; Huang et al., 2022). For traceability, relation-specific assets lower costs, increase trust among supply chain partners, and enhance partners' willingness to cooperate. Relation-specific assets may involve symmetric investments by alliance partners or sole investments by one partner (Dyer et al., 2018). While the former presents an avenue for mutual value creation and long term relationship commitment, the latter may be an avenue for opportunism by the partner that has not made the investment (Dyer et al., 2018).

An effective governance structure is required to influence supply chain partners' willingness to engage in interfirm routines and to moderate interfirm activities within the agreed boundaries of the supply chain relationship in order to avoid opportunism (Dyer & Singh, 1998; Lavie, 2006). It is also necessary to ensure that any knowledge and information shared between parties is used for the stipulated purpose. Thus, boundaries on the rights and responsibilities of the relationship may be set and administered by the supply chain actors involved (i.e., self-enforced governance) or by an external body (i.e., third-party-enforced governance) (Dyer & Singh, 1998). Effective governance must not only ensure adherence but also minimize costs. Hence, Dyer and Singh (1998) suggested that self-enforced governance is more effective for generating relational rents because third-party enforced governance mechanisms rely on formal structures, such as legal contracts, that are usually costly, fixed term, and less flexible to unforeseen changes. Specifically, informal self-enforced governance is based on goodwill trust; it is difficult for competitors to imitate, able to accommodate contract modifications, and can lower contracting costs (Dyer et al., 2018).

According to Lavie (2006), the nature of relationships can be more significant in generating relational rents than the resources available in the dyad or network. Most formal business and supply chain relationships are shaped by people's informal relationships and behaviors, which emerge from cultural elements such as social values, customs, and beliefs (Howe & Jin, 2022;

Wu & Pullman, 2015). Local culture and customs determine whether informal practices are accepted as legitimate or not (Abushaikha et al., 2021). In effect, collaborative and competitive relational dynamics between individuals and firms may be aligned with non-economic objectives and governed by informal traditional institutions (Pathak et al., 2014; Webb et al., 2020). Despite the inefficiencies of informal networks, they are critical to global supply chains when formal alternatives are absent (Abushaikha et al., 2021). Yet the relational view says little about how the context (i.e., the cultural norms of a locality) influences the generation of relational rents. This research therefore posits that the non-individualistic, collectivist culture and institutionally weak characteristics of sub-Saharan African communities may vary their rent-seeking behaviors from those that have been widely studied in a Western context (Lutz, 2009).

METHODOLOGY

Research Design and Case Selection

A qualitative multi-case study approach was adopted to gain insights into traceability in a particular developing country context and to explore its role in enhancing SCRes. This approach was chosen because the interplay between traceability and SCRes in developing countries is at a nascent development stage and requires a rich, contextualized understanding (Yin, 2018). Meanwhile, using multiple cases enhances robustness, as the similarities and differences between cases help develop more reliable theory (Gustafsson, 2017; Yin, 2018).

The cocoa and fruit supply chains (named Cocoa Case and Fruit Case, respectively) of Ghana were selected because they encompass the general characteristics of AFSCs in Ghana and sub-Saharan Africa. For example, the key actors in Ghana's cocoa supply chain (farmers, collectors/licensed buyers, marketers and exporters, processors, etc.) are also evident in the AFSCs of other sub-Saharan African countries, such as Côte d'Ivoire, Cameroon, Nigeria, and Sierra Leone, and even other developing countries, such as Costa Rica, Ecuador, and Indonesia (Haynes et al., 2012; Stoop et al., 2021). Ghana is globally recognized for exporting these crops, providing evidence of a traceability system spanning more than 20 years (Stoop et al., 2021;

World Integrated Trade Solution, 2021). Moreover, as Ghana looks to strengthen its economy through increased global trade, its AFSCs have been urged to improve provenance information, mitigate food safety concerns, and validate sustainability claims (World Economic Forum, 2019).

Given the safety-critical nature of food and the many historical examples of food scares, such as the European horsemeat scandal and the peanut butter *E. coli* and salmonella contamination in the US, traceability is crucial in global AFSCs (Ringsberg, 2014; Smith & McElwee, 2021). Fresh Del Monte, a multinational fruit and vegetables company, recently underlined its commitment to traceability by investing a 39% stake in Decapolis, a food safety and quality traceability technology company, to facilitate traceability across its global business divisions (Lore, 2022). Hershey Company and Cadbury's have also pledged their commitment to increasing supply chain traceability to ensure that all their cocoa beans from Ghana and West Africa are sustainably sourced (Cadbury Cocoa Life Report, 2020; Hershey Sustainability Report, 2022). Thus, AFSCs in Ghana represent a suitable focus for this study's research question.

Data Collection

Thirty-two semi-structured interviews with at least three participants from each tier of both supply chains, and at least one participant from the regulatory bodies relevant to each supply chain, were conducted. As illustrated in Figure 1, the Cocoa Case is composed of farmers (CF), licensed buying companies or LBCs (CL), marketers and exporters (CM), processors (CP), and regulatory bodies (CR), while the Fruit Case includes farmers (FF), processors (FP), packers and exporters (FE), and regulatory bodies (FR).

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CP, FP, and FE companies were chosen purposefully based on their contributions to Ghana's export volumes and their professed commitment to quality. For CL and FP, companies that source from farmers operating in different regions were contacted. CL and FP were also gatekeepers (Creswell, 2013) that could help with gaining access to farmers they had done business with for more than five years. The gatekeepers were briefed about the research and

invited to participate via email and LinkedIn. Follow-up discussions to schedule interviews and obtain referrals to other supply chain participants were held via phone and other virtual media. Farmers with differing farm sizes and production methods were also selected. Finally, although the CM role is limited to only one organization, individual interviewees were chosen based on their knowledge of the company's traceability system and their past disruption experiences. Table 1 provides a summary of the interviewees' details.

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An interview protocol that included open-ended questions (see Supplement 1) was developed to encourage detailed responses and improve reliability (Yin, 2018). All interviews were conducted remotely because of COVID-19 restrictions, and all participants were guaranteed anonymity. The interviewees were briefed on the research concepts and objectives, and the interviews were audio-recorded with the interviewees' consent. Interviews were transcribed following Eisenhardt's (1989) 24-hour rule and sent to the interviewees for validation. Secondary data sources, including company websites, reports, industry statistics, and news bulletins, were also used, where available, to triangulate the interview data.

Data Analysis

Each supply chain was first analyzed individually (i.e., within-case analysis), followed by cross-case integration and code comparison (Eisenhardt, 1989). Considering the scale and complexity of multi-tier supply chain research, this research mainly focused on discussing the most prominent cross-case results. However, the within-case analysis is summarized in tables to provide an audit trail back to individual respondents.

A two-level data analysis approach overlapping with the data collection was adopted, providing the authors with the flexibility to adjust the process (Creswell, 2013; Eisenhardt, 1989). At the first level, the data were analyzed following Miles and Huberman's (1994) three-step model for qualitative data analysis: data reduction, data display, and drawing conclusions. QSR NVivo12 was instrumental in organizing codes and themes, which were generated abductively by

moving back and forth between the data and extant literature. This level focused on outlining the risks and disruptions, explaining how traceability was achieved, and describing its impact on SCRes. At the second level, the aggregate themes were linked to the four constructs from the relational view to unpack the theoretical contributions. However, the data were revisited through subsequent rounds of the abductive approach to clarify themes that had initially aligned with more than one construct. At this stage, themes were merged and renamed based on the most representative constructs from the relational view. As a result of this process, the research proceeded with the two most apparent constructs (i.e., relation-specific assets and effective governance mechanisms). This is summarized in Figure 2.

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Validity and Reliability

Similar to other case studies in the field (e.g., Hendry et al., 2019; Wilhelm et al., 2016), Yin's (2018) four measures of research quality were adopted to ensure rigor and trustworthiness. In addition, the definition of each criterion was extended to incorporate other measures of research quality suggested by Creswell (2013), such as rich and thick descriptions of cases, prolonged engagement with interviewees, debriefing among co-authors, and triangulation. This is summarized in Table 2.

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FINDINGS

First-Level Analysis: Risks, Traceability, and SCRes in a Developing Country Context

This section outlines the following: (1) the key risks to AFSCs in this developing country context; (2) the scope of traceability among suppliers, including the models of traceability and the (non)technological systems employed; and (3) the role of traceability in enhancing SCRes, both directly and indirectly, via other SCRes strategies.

Overview of Risks in Sub-Saharan Africa

Twelve prominent risks are explained below, supported by Table 3. Supplement 2 provides a comprehensive summary of all the risks identified from the data (with those evidenced in Table 3 marked with an asterisk), along with the risk outcomes, and the SCRes strategies adopted to prevent or restrict their impacts. In line with the participants' understanding of risk as either a threatening condition or its resulting consequences, this section takes a broad view of risk that includes uncertainties, threats, disturbances, and disruptions.

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Input risks are associated with the acquisition of planting materials (e.g., seeds, suckers, and seedlings), agrochemicals (e.g., insecticides, weedicides, and pesticides), fertilizers, and packaging materials. Farmers favor resistant, high-yielding, and early fruit-bearing planting materials; for example, CF1 argued, "Because chemicals are expensive, it's good to have a resistant crop that can withstand the outbreak of pests and diseases; otherwise, all your crops will wither away without yield." An inability to acquire the right agrochemicals increases the risk of pests and diseases, affecting crop yields and creating shortages. Farmers may therefore resort to using lower-grade counterfeit substitutes, with consequences for the environment and human health. Moreover, the unscrupulous activities of some dishonest employees, such as tampering with weighing scales (Cocoa Case), making false organic claims (both cases), and using food colorings (Fruit Case; CF1-3, CP1, CP3, FP1-3, FE1-3), were also identified. Such activities reduce the quality of products and hamper supply chain relationships.

The data show that unfair competition emerging from the influx of large multinational companies led to some small-scale supply chain actors closing down or resorting to lower-quality raw materials and cheaper processing methods (CL1-4, FP2-3, FE2-3). This has knock-on effects on export volumes and the country's reputation for producing high-quality products. Furthermore, upstream supply chain actors' remote geographical locations, which distance them from major European and North American customers, limit their ability to physically monitor supply chain activities or quickly respond to capacity disruptions (CR1, CP1-3, FP1-3,

FE1-4, FR1-2). As a result, small-scale issues can escalate globally. Meanwhile, the smuggling of cocoa beans between Ghana and neighboring countries, especially Côte d'Ivoire, increases uncertainty over annual crop volumes. Smuggling into Ghana affects the perceived quality of Ghana's cocoa beans (CM1-3, CR1), and local farmers may be wrongly blamed (CF1-3), whereas smuggling out of Ghana prevents expected volume targets from being achieved (CM1-3).

Uncertainty surrounding government policy and regulatory measures is also detrimental to supply chain operations and long-term strategic decision making. For example, actors were skeptical about the effectiveness and continuity of policies following changes in government. This limits the impact of programs intended to revitalize farming and agribusiness, such as free seedling distribution and mass farm spraying, and of flagship policies, such as *Planting for Export and Rural Development*, *One-District-One-Factory*, and the *Ghana Exim Bank*. The data also pointed to the problem of deforestation and forest degradation because of increased encroachments into protected forests to expand farm sizes, harvest wood for fuel, and engage in small-scale mining activities. Such activities hinder environmental sustainability and negatively affect farm yields in the long run.

Risks originating from informal processes and control systems were also evident at all tiers of both supply chains. For example, informal labor among farmers (both cases), LBCs (Cocoa Case), processors (both cases), and packers and exporters (Fruit Case) meant that workers earned less than their counterparts in the formal sectors and so were quick to switch jobs or encroach on forests to increase their farm sizes (CF1-3, CL1-4, CP1, FF1-3, FP1-3, FE1-3). The high labor turnover required additional resources to train new staff frequently. The informal nature of the sector also limited firms' access to financing and enabled tax avoidance, adversely affecting productivity, economic growth, and sustainable development. The findings further revealed the negative impact of an insecure land tenure system. Access to land for large-scale farming was restricted, and smallholder farmers were vulnerable to losing their lands to

other sectors, such as mining and real estate development, as landowners were mostly interested in short-term benefits.

In-transit risks that may alter the quantity or conditions of products were also identified. Contractual breaches among supply chain actors were prevalent, usually leading to litigation, erosion of supply chain relationships, and reputational damage. The financial implications of contractual breaches were severe for supply chain actors, especially farmers who relied on farming activities for their household income. Farmers were often frustrated by formal legal procedures if they pursued redress through the courts and therefore sought alternative solutions to contract use and enforcement.

Overall, both supply chains were characterized by informal intrafirm and interfirm relationships, and they encountered risks that can be described as follows:

- Predominantly small-scale and chronic risks, including those originating from socially embedded constraints. Large-scale, discrete disruptions, such as droughts, floods, and bushfires, were rarely experienced. Therefore, the interviewees were more concerned about adapting their operations in anticipation of reoccurring disruptions rather than discrete disruptions.
- Interrelated such that the inability to curb a disruption meant that it gradually evolved into another form. For example, shortages and poverty among farmers forced them to patronize cheaper counterfeit inputs that were ineffective against weeds, pests, and diseases, leading to reduced farm yields and lower earnings, which in turn impoverished farmers again.
- Transferable such that the impacts/outcomes of risks were not limited to the originating firm and small-scale risks could escalate into more significant disruptions if allowed to traverse downstream. The potential escalation and transferability of risk underscored the importance of ensuring transparency over the provenance of a food crop and that its characteristics could be linked back to a processed batch.

Achieving Traceability in Sub-Saharan Africa

Seventeen interviewees used a “one step forward” and “one step backward” traceability approach, in which records are received and transferred between only immediate downstream and upstream supply chain partners, respectively. Thus, end-to-end traceability relies on connecting a series of dyadic exchanges, with different practices employed at different supply chain stages to maintain records.

In the Fruit Case, farmers generate product information on the farm by completing a unique *traceability form* supplied by their customers; in the Cocoa Case, traceability starts at the first purchase point, where a purchasing clerk generates an *identity mark* based on information provided by the farmer (CF1-2, CL1-3). However, some vital traceability information required the use of specific instruments and equipment that were too expensive for individual farmers (FF1-2). FF2 explained, “Processors send their officers with equipment [refractometer] to confirm the maturity and brix value [sugar content] of our pineapples at least three times before harvesting.” The extent to which a raw material’s origin can be tracked and identified in a final product depends on the traceability model adopted. The traceability models identified are discussed below:

AFSC Traceability Models. Two broad models were identified. *Product segregation* involved physically separating conforming and non-conforming materials in the supply chain. This was either at the bulk commodity level, in which conforming materials from different producers are bundled together, or at the identity preservation level, in which conforming materials sourced from different farmers/cooperatives are separated. The former was common in the cocoa supply chain to achieve economies of scale, as the LBCs consolidated the cocoa beans from different farmers/cooperatives in their regional depots (CL1-4). The latter was encouraged in the fruit supply chain to ensure that the final products were traceable to the originating farm or cooperative (FP1-2, FE1, FE3).

Mass balance involved combining conforming and nonconforming materials at later supply chain stages. This required strict transparency and documentation to ensure that the

volume of conforming materials entering the supply chain is equivalent to the volume of conforming final products declared at the end of the supply chain (CL1-2, CM1-3, CP1-3). Smallholder farmers favored this model because it was cheaper, easier to achieve, and permitted by some globally recognized certification bodies (FF1-2, CF1-3, CL2-4). It was employed in both supply chains to reduce costs, maximize space usage during transportation, and reduce shortages during processing and manufacturing.

The State of Traceability Technologies. A blend of technological and nontechnological structures was evident for achieving the six functional capabilities of a traceability system: identification, location, sensing, communication, data storage, and logic (Razak et al., 2023). These are summarized in Table 4.

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Technologies supported various traceability functions across the cocoa supply chain. Some firms combined two technologies to meet one traceability function, depending on the level of reach required. For example, for locating items in-house, the position and quantity of a product may be entered onto a digital platform and a barcode used to retrieve and update product information (CL3, CP3). Meanwhile, digital platforms may be combined with geographic information systems that standardize raw global positioning system data to retain product information, facilitate its timely exchange, and determine product location across the supply chain (CL3-4). Similarly, in the fruit supply chain, multiple actors relied on technology, such as refractometers (FE2-4, FP1-4), to determine the maturity of fruits before harvesting. Harvested fruits were subsequently sanitized, cut, processed, packaged, stored, and transported at temperatures less than 5°C using temperature loggers (FE1-3, FP1-3).

Some traceability functions were undertaken manually in both supply chains, as the technological solutions were either too expensive or unnecessary. Eighteen interviewees argued that products could be easily identified by eye through simply observing a unique code. As CR1 explained, “When any quality control examiner gets into the depot and sees cocoa beans labeled

as AS13/01/12, they can identify the origin of the cocoa beans. AS13 represents the region, 01 represents the LBC that purchased it, and 12 represents the specific society within the region." Meanwhile, inconsistencies in product appearance (e.g., quality issues caused by water, sweat, or vapor damage to cocoa beans), volume shrinkages during storage and transportation, and temperature lapses for sensitive fruits and juices were manually determined by positioning staff at critical points in the supply chain (e.g., takeover centers and ports). As FP1 stated, "We have trained quality assurance staff who follow every consignment to within 100m of the aircraft and a representative in London [destination] who receives the consignment and tests to confirm adherence to quality standards."

The processors (both supply chains) and the packers and exporters (fruit supply chain) recommended the use of technology, where possible, to reduce mislabeling and misreading while improving information consistency and security. Therefore, at the upstream end of both supply chains, basic technological devices were used to facilitate the generation, storage, and transfer of traceability information from farmers' paper records, including via mobile phones. This was important to achieve an integrated traceability system, as confirmed by FP3: "Because of farmers' low literacy levels, we prefer to take their information and convert it into an acceptable format for entry into the digital platform." Such traceability information was made available to eligible actors by physically presenting it to the designated recipient (CF1, CF3), sending it electronically (CF2-3, FF1-3), or granting virtual access (CL3-4, CP3, FP1-3, FE1, FE4). Farm-level traceability data are segmented and differentiated by the date of harvest (fruit supply chain) or the plot of land harvested (both supply chains) so that they can be matched with the respective crops at the point of purchase.

Ultimately, both supply chains were focused on using traceability to maintain or enhance Ghana's reputation as a leading global supplier, thereby ensuring that products meet quality standards and enabling the detection of damages or spoilages before delivery (CR1, FR1-2). Despite the advantages of traceability technologies, significant barriers limited their full

deployment, including the high cost of acquisition and maintenance (CF, CL, CP, FF, FP, FE), users' low literacy rates (CF, CL, FF), lack of associated infrastructure (e.g., reliable Internet access and electricity; CL, CP, FP, FE), and the biological characteristics of food crops (CF, CL, FF, FE, FP). Nevertheless, achieving end-to-end traceability was critical to ensure that failings at the farm end do not ripple downstream (CL1-3, CM1-3, CP1-2, CP4, CR1, FP1-3, FE1, FE3-4, FR1-2). Therefore, asynchronous rather than real-time access to information was created by integrating the basic traceability systems initiated by upstream smallholder farmers with complex downstream traceability systems.

Meanwhile, the interviewees emphasized the influence of a collectivist culture on fostering long-term interfirm cooperation (CF1-3, CL1-4, CM1-3, CP1-2, FF1-3, FP1-3, FE1-2). A farmer cited an Akan proverb, which translates as, "Unlike a palm tree, which can be self-sufficient, the prosperity of one man depends on another man" (FF2). Accordingly, interfirm practices that affirmed trust and the intrinsic value of humanity and community were identified as key to enhancing traceability, as illustrated in Table 5. For example, employing personnel from the local community and engaging traditional leaders, rather than entrusting a relatively unfamiliar person with their information, enhanced their willingness to participate. Hence, despite the presence of both formal local and international agencies, existing informal relationships were critical to the effectiveness of intermediaries in overseeing traceability practices.

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Enhancing Supply Chain Resilience: The Role of Traceability

This section discusses the contribution of an effective upstream traceability system to building SCRes, both directly and indirectly by enhancing other strategies (see also Supplement 3).

Direct Role of Traceability as a SCRes Strategy. Traceability helped establish the provenance of products, providing evidence of adherence to the agreed-upon quality and safety specifications throughout the supply chain. The unique identity of products helped keep track of significant events and all product-handling staff along the supply chain. This increased the

transparency of supply chain activities, ensuring that all tiers acted appropriately despite the physical distances between actors. For example, according to FP1, "Being able to determine if every raw material meets our specifications before processing helps us avoid any disruption resulting from unwholesome raw materials." Thus, traceability facilitates a proactive approach to identifying and eliminating potential threats.

Moreover, traceability enables the early detection of nonconformance and helps limit damages. As FE1 noted, "Since we know the destination of each batch, we're able to quickly withdraw such products from the supply chain, and because we know the quantity, if the products recalled don't match the expected quantity, we can inform the appropriate public health authorities to also act accordingly." If customers complain, traceability enables a swift, efficient, and targeted response focused on specific items or batches and can aid in diagnosing the root cause of a problem. FP1 argued, "When a customer complained about the presence of *Listeria monocytogenes* [bacteria] in our coconut, we quickly recalled all products affected. However, it was the traceability records over the period that helped us identify storage on the floor as the root cause, which then informed our new sanitization standard."

Indirect Role of Traceability as a SCRes Strategy. The data emphasized the role of traceability in promoting nine other strategies that enhance SCRes, as discussed below.

- *Demand and Supply Planning* – By providing a central database that can be connected back to individual farmers and customers, traceability ensures that any major inconsistencies in new estimates are detected and investigated. This aids supply chain actors in determining causes and in adopting effective measures that avoid or limit the impact on the supply chain. As CM1 noted, "Because farmers don't admit to smuggling their cocoa beans and usually claim that whatever they have is their total output, knowing the expected volume of cocoa beans from all regions, districts, and farmers lowers the tendency for them to smuggle their output elsewhere."

- *Collaboration* – Traceability creates a collaborative environment that reduces supply chain grievances and ensures a fairer cost distribution. For instance, according to CP1, "Traceability presents an avenue that identifies the role played by all actors along the supply chain [...] since our global partners rely on other suppliers, traceability helps avoid accusing a supplier wrongly [by providing evidence of the origin of the problem]." This is necessary for building loyalty, trust, and confidence among supply chain partners, which encourages concerted efforts toward detecting and responding to a disruption.
- *Coopetition* – Coopetition is important because the failure of a competitor to meet global specifications can discredit other firms within the country. Therefore, competitors share resources, experiences, and knowledge to build resilience against common industry risks. As FP1 explained, "We're sometimes invited as stakeholders to contribute toward fostering Ghana's image in relation to fruit products [...and] we advise new entrants on market requirements, procedures for market entry, minimizing costs, and maximizing opportunities." Traceability also helps build trust among competitors by enhancing the transparency of their activities and outcomes. By sharing information, competitors can foster compliance by collectively avoiding unethical partners (e.g., forest encroachers, credit defaulters, and fraudsters).
- *Risk Management Culture* – Given that traceability requires product inspection and verification and corresponding information along the supply chain (CP1-4, FP1-3, FE1-4), it enables early risk identification and limits the escalation of a disruption downstream. Moreover, "[Traceability] ensures the thorough review of what was brought to you before confirming its appropriateness to be moved onto the next supply chain stage" (CR1). Therefore, there is increased responsibility for officers to monitor risks at all supply chain stages to prevent them from developing into hotspots for disruption.
- *Visibility* – Traceability forms are completed by farmers, and the information is successively updated, transformed, and transferred until a product reaches the final consumer, thereby

enhancing visibility. FP1 argued, “For any customer complaints, they only have to give us the expiry date displayed on the product; we’ll then use it to trace our processing, storage, and transportation and [refer] to the traceability forms submitted by each farmer [...] seeing through to the initiating stage of the complaint.” Given the globalized nature of both supply chains, consistent information increases supply chain awareness and enables informed decision making.

- *Sustainability* – Traceability increases the ability to authenticate that a product has been sustainably produced. This includes environmental issues (e.g., farm mapping data for preventing encroachment on protected forests) and social issues (e.g., records of the use of forced and child labor). FP3 said, “Traceability information from farmers outlines the agrochemicals used and the pre-harvesting interval [days between chemical application and harvest] to ensure less risk to the environment and consumers’ health by checking chemical residual levels.”
- *Product Recall Management* – Traceability expedites product recall management through a data-driven strategy that determines the affected batches, quantities, and locations. By maintaining product records upon entry and exit at every supply chain tier, actors can quickly determine any irregularities and intercept unsafe products before they reach consumers. FP2 argued, “Knowing the origin of the contamination helps make justified calls for compensation [cash refunds or damaged product replacement] and prevents the shifting of blame, which usually affects smallholder farmers the most.” Thus, traceability improves product recall efficiency and ensures that all participants act responsibly.
- *Flexibility* – Traceability facilitates access to information on machine breakdowns, demand changes, raw material delays, and other issues, thereby enhancing adaptation to disruptions. FP1 argued, “Based on the traceability information received, confirmed after running a series of quality checks, we can prompt our suppliers and customers and quickly adjust our operations to meet the specific requirements determined after laboratory testing.”

- *Scheduling* – Scheduling optimizes the use of available space and resources to prevent congestion and delays. Traceability enhances scheduling by tracking movement in and out of the warehouse. It also provides updates on the status of machinery, ensuring that work is not assigned to an offline machine. FP1 explained, "Being aware of our factory capacity at all times helps us maintain our short soil-shelf duration [of 48 h] by ensuring that we only order fruits based on the available capacity [... We're] also able to allocate time for maintenance checks and machine repairs." This ensures that quality specifications are met and other activities remain on schedule.

Second-Level Analysis: Linking Empirical Evidence and Theory

This section discusses the data using two constructs of the relational view: relation-specific assets and governance mechanisms.

Relation-Specific Assets

In this research, relation-specific assets are structures created or obtained to improve traceability and subsequently enhance SCRes between supply chain partners (Dyer & Singh, 1998). Relation-specific assets were classified as site specificity, physical and nonphysical asset specificity, and human asset specificity.

First, the physical proximity of successive supply chain actors (i.e., site specificity) limits the need for intermediaries, which reduces supply chain complexity and upholds the efficacy of simple traceability technologies. According to FE1, "our source of fruits [supply] is short and directly handed from the farm; thus, any issues with the fruits can be traced to the farmer [source] [...] when there are multiple handling points before the fruits arrive, identifying the exact source of a problem becomes difficult and is highly likely to end up in shifting the blame." The findings suggest that direct interaction between buyers, suppliers, and some external supply chain actors enhances mutual trust and understanding, which fosters strong relationships. This influences the scope and reliability of the information that actors are willing to share.

Second, investments in physical and nonphysical asset specificity serve as a foundation for building collaborative relationships. Resource interdependence was also facilitated through physical and nonphysical assets, such as cloud-based digital platforms (owned and managed by multinational LBCs), and it required corresponding investments in intangible assets of time and effort to acquire the necessary knowledge and skills. This was crucial to increasing actors' willingness to commit to long-term supply chain relationships and interfirm practices, including traceability. Traceability information is also more likely to be encoded and decoded accurately. According to FE1, "interfirm communication is easy and fast via the DMS [Data Management System] [...]. We can quickly respond to requisitions, complaints, and customer feedback [...]. It also guides decisions at various stages, and rapid responses can be executed." The security and reliability of such encrypted platforms also enhance the consistency of traceability information.

Third, human asset specificity accommodates the acquisition and dissemination of relationship-specific knowledge, skills, and expertise. The accumulation of relationship-specific knowledge reduces communication errors, fosters quality adherence, and facilitates the transfer of traceability information and understanding across the supply chain. In both supply chains, this was facilitated by periodically sending experts to visit farms and processing facilities, and by organizing regular training events. These initiatives assured farmers of their partners' commitment, fostered trust, and induced their desire to collaborate. CL1 explained, "the early and regular face-to-face interfirm interactions establish that level of trust and confidence between us [supply chain participants], which makes it easier for us to establish long-term relationships at various levels of our supply chain."

In the Cocoa Case, the direct participation of a governmental body created relation-specific assets that were devoted to multiple supply chain tiers (supply chain-wide assets). For example, CM provides a local aggregation point and a common marketplace as they are responsible for promoting and selling Ghana's cocoa locally and internationally. According to CM1: "All of Ghana's cocoa beans must pass through one of our takeover centers before

exportation [to] ensure that all cocoa beans are subjected to the required phytosanitary and quality control activities". Therefore, CM's role was valuable for all CFs, CLs, and CPs. By ensuring that all products arriving at the takeover centers matched the corresponding traceability information, they fostered trust and the building of relationships (CM1-3). Meanwhile, the large number of LBCs providing competing relation-specific assets (CF1-3, CL1-4) meant that farmers could quickly switch between LBCs. As a result, the longevity of relationships was uncertain, and transaction volumes were usually shared among competitors.

In the Fruit Case, relation-specific assets were mostly between a firm and its immediate supply chain partner (dyadic assets), and there were fewer options. Therefore, farmers were more incentivized to meet supply chain partner requirements in order to maintain trust and a superior relationship. According to FF1, "Our partners only train us on their preferred traceability standards, so we're more inclined to join their certification bodies [as] they [processors] purchase almost 90% of our harvest; meeting their requirements is a priority for us." Although fewer customers may breed competition among farmers, there was evidence of collaboration based on their social ties. Farms in close proximity are usually owned by people who are related to one another by family, clan, or ethnic group. As a result, despite the grounds for competitive rivalry, cooperation persisted.

Overall, while supply chain actors sought profit from their commercial transactions, their decision-making was hugely impacted by existing social ties. For example, despite the independence of farmers and their reliance on farms for most of their household income, local farmers were hesitant to invest in relation-specific assets that did not consider other farmers whom they mostly considered as relatives due to the geographical proximity of their farms and a long history of social interactions. According to CF3, "they said they'll spray my farm for free, but when you spray your farm, the pests may move to the neighboring farm. So, if you don't want him [neighboring farmer] to do it to you, you shouldn't do that to him, too." Moreover, farmers were skeptical about the durability of relation-specific assets (CF1-3, FF1-3). They deemed dyadic

relation-specific assets as conditional, temporary, and threatening to their existing family and kinship ties. Hence, they mostly preferred supply chain-wide relation-specific assets that created more communal, rather than individual, benefits.

Governance Mechanisms

A governance mechanism is an agreed-upon structure or safeguard for regulating a relationship that limits the potential for exploitation or opportunism by any actor (Dyer & Singh, 1998). This includes self-enforcing and third-party enforced agreements, as discussed below:

Self-Enforcing Agreements. Formal self-enforcing governance mechanisms motivate supply chain partners into playing their roles in enhancing traceability, knowing that financial incentives (e.g., premium prices) are lost if they do not participate. The existence of mutual respect and goodwill trust also enhances the effectiveness of traceability because all supply chain partners are focused on developing mutually beneficial solutions that protect every party and the supply chain's reputation. However, according to CL2, "They [farmers] will listen and trust their own rather than a total stranger. You know, as a community, you'll be pessimistic about the prospect of an idea from someone new, [someone] who doesn't know your plight. So, the chief farmer needs a better understanding of traceability or any new farming technique to offer any further explanation." This creates a sense of ownership that encourages collective curiosity to trial new and improved practices, including traceability.

Involvement in community betterment through socially responsible practices enhances supply chain actors' reputation and local citizens' perceptions of these actors' initiatives. Thus, 25 interviewees (CF1-3, CL1-4, CM1-3, CP1-4, FF1-3, FP1-3, FE1-4, FR2) agreed that informal safeguards based on unwritten rules and norms drive traceability efficiency more than formal safeguards. As argued by CP1, "The participants' [supply chain partners'] commitment to traceability is self-motivated, so their commitment isn't affected when incentives are delayed or reduced, as may be the case with formal safeguards." Thus, participants subscribe to such

traceability systems because they have the capacity to do so or are prepared to attain the capacity needed to ensure that the system is effective.

Third Party-Enforced Agreements. Despite the effectiveness of self-enforcing governance mechanisms, CR2 argued that "There must be a written document that states what's expected of each partner to avoid conflicting practices. [...] An independent body [that] sets conditions, and the associated punishments [...] avoid[ing] unnecessary exploitation of smallholder farmers who can, based on the set conditions, provide evidence of the fulfilment of roles and responsibilities." With regard to traceability, formally written rules and procedures stipulated by a third party (e.g., certification body) provide a uniform traceability system that enhances interoperability and increases the likelihood that all tiers will generate and transfer the right information, with each actor being equally confident of receiving reliable and timely information from its partners.

Third-party agreements, usually consolidated by a legal contract, can transcend fairness in cost-benefit sharing and limit opportunism risk. However, the high costs of subscription (CF1-3, CL3-4, FF1-3) and monitoring (CR1-2, FR1) discourage participation. The formalities and costs involved in courtroom settlements when contracts are breached made this unattractive to the small- and medium-sized businesses in the present study.

Instead, the influence of informal third-party governance, such as via traditional local leadership (i.e., chiefs, community elders, clan heads, and family heads), in ensuring parties adhere to arrangements is identified. CL4 stated, "If you explain traceability practices and their benefits to the chief farmer or other community leaders, such as chiefs and elders, they'll promote them to their subjects if they're worthy causes, and, of course, they can negotiate the rights and responsibilities based on village resources." Therefore, most traceability systems, especially those that incorporate deforestation risk, involve traditional leaders creating local awareness and generating endorsements at the community level.

According to CR3, “CFI [Cocoa & Forest Initiative] and RA [Rainforest Alliance] rolled out community-based initiatives [piloting farm-level mapping and traceability] to raise awareness and build consensus with traditional leaders for monitoring and spreading practices that restore forests in their communities.” The chiefs’ involvement transcends the assurance of fairness among their subjects because, in their capacity as custodians of the land and its occupiers, chiefs are trusted to restore justice and uphold what is considered right within the community. They also engage in informal arbitration processes that are considered appealing, especially to farmers who find it easier to defer to chiefs because of their local influence and intimate understanding of the context and local traditions.

DISCUSSION

This research emphasizes the prominence of small-scale, chronic disruptions in sub-Saharan Africa over the large-scale ones more commonly studied in the literature (see Scholten et al., 2020). In particular, a number of the identified risks and disruptions originated from socially embedded constraints, including inadequate infrastructure investments, the prevalence of informal intrafirm and interfirm relationships, and weak regulatory enforcement. Moreover, the sociocultural environment resulted in high interdependence within and among firms and with external actors, including competitors and regulators. Thus, by viewing the supply chain as a dynamic sociotechnical system (Gattorna & Pasmore, 2022), this research emphasizes that risks may not be entirely mediated by sophisticated technological investments. Considering the social characteristics in the firm’s supply chain and the wider environment in which they are embedded, including employees’ social behavior, the nature of interfirm relationships, and risk characteristics, is important to enhance the efficacy of traceability as a global SCRes strategy.

The research emphasizes the role played by the collectivist culture of sub-Saharan African communities in creating a routinised traceability system that enhances resilience in the absence of sophisticated technology. This collectivist culture is encapsulated in the philosophy of

ubuntu, which is loosely translated as "I am because we are." *Ubuntu* asserts that the success of one person depends on the success of all; therefore, it conveys the spirit of respect, trust, compassion, community, hospitality, responsiveness, reciprocity, and dignity (Lutz, 2009). Although the word *ubuntu* itself is derived from the Bantu Nguni languages of Southern Africa, it epitomizes a cultural ethic that is indigenous to and practiced across most traditional sub-Saharan African cultures (Nansubuga & Munene, 2020).

Given that individuals' informal relationships within a firm can affect the outcomes of formal supply chain relationships (Howe & Jin, 2022), this collectivist culture is instrumental in intrafirm and interfirm interactions. The mutual obligations that emerge from social ties, such as to family, clan, or ethnic group, superseded market logics (Wu & Pullman, 2015). Hence, in line with moral values and customs, local firms preferred to minimize direct competition among themselves and instead prioritized the pursuit of mutually beneficial solutions (Pathak et al., 2014). For example, in response to downstream pressure in Europe and North America for first-tier suppliers to ensure their products' full traceability, the supply chain actors in this research collectively reorganized and transformed their processes, interfirm norms, and routines to meet the new requirements. In this context, deploying legally binding contracts and formal audits that enforce traceability may signal distrust and erode supply chain partner commitment (Poppo & Zenger, 2002). In effect, interfirm relationships built on informal mechanisms aligned with the local culture, customs, and social norms are more favorable than those built on formal mechanisms, such as standards, contracts, or audits (Tachizawa & Wong, 2015).

In addressing the role of traceability in enhancing SCRes, this research theorizes traceability not only as a direct but also as an indirect enabler of SCRes. This provides case-based evidence that extends Razak et al.'s (2023) conceptual framework on traceability as an antecedent of other SCRes enablers. Traceability is confirmed to enhance collaboration, visibility, and flexibility. Moreover, this research extends understanding of the indirect enabling role of traceability by demonstrating that it enhances demand and supply planning, product

recall management, coopetition, a risk management culture, sustainability, and scheduling. Although prior literature has proposed that traceability also indirectly enables SCRes via velocity (Razak et al., 2023; Sumukadas, 2021), this was not supported in the present research as the chronic, small-scale nature of the risks meant that response speed was not essential. Moreover, the nontechnological components of achieving traceability meant that access to information was more asynchronous than real time.

Based on the relational view, a distinction is made between dyadic and broader supply chain-wide relation-specific assets, where the latter is usually spearheaded by a governmental body. Supply chain-wide relation-specific assets were viewed as more durable assets, depicting longevity and resulting in minimal competitive tensions among supply chain actors. That is, with supply chain-wide relation-specific assets, supply chain partners do not feel locked into a specific relationship and can easily switch if a particular dyadic relationship erodes over time. Moreover, the benefits are widely available for other supply chain actors and there is less contention over resources and no direct competition that may hamper existing social ties. Thus, although dyadic relation-specific assets are more tailored and aligned toward a specific interfirm relationship, they do not create durable synergies between the two parties involved. This contradicts findings in Weber et al. (2016), who conducted a survey of European corporate capital investors. With an emphasis on collectivism and the philosophy of *ubuntu*, local farmers viewed dyadic relation-specific assets as manipulative and immoral when co-farmers were unable to replicate or benefit from them. Given business ties are usually transactional and temporary, many did not consider the individual benefits to be worth losing their sense of community. In effect, generating relational rents transcended the provision of tailored relation-specific assets. Thus, the following are proposed:

P1a. *Dyadic relation-specific assets may generate relational rents, but these may be eroded over time in collectivist contexts in which suppliers are morally inclined to protect the interests of other actors in the community.*

P1b. *Broader supply chain-wide relation-specific assets are more robust to changes in relationships over time, meaning that they generate greater relational rents in the long run in collectivist contexts*.

Meanwhile, the research demonstrates how the informal nature of AFSCs in sub-Saharan Africa can inhibit the effectiveness of formal contracts between actors. Specifically, formalized legal contracts are expensive to administer and monitor, provide safeguards for the contract duration only, are difficult to adapt to market changes (Huang et al., 2022), and lack the human or social element that is such a major characteristic of sub-Saharan African culture. As a result, interfirm practices are more likely to be governed by flexible, informal agreements that can accommodate possible contingencies. Whereas Dyer and Singh (1998) asserted that self-enforcing safeguards can generate the greatest relational rents, it was found that opportunistic behaviors may persist in some relationships. That is, dominant firms may drive traceability systems that mitigate their own internal risks rather than supply chain risks (Sun & Wang, 2019). For example, in the fruit supply chain many pineapple farmers lost heavily when their ready-to-harvest pineapples were no longer needed during the COVID-19 pandemic.

Community leadership (e.g., chiefs, community elders, and chief farmers) embodied trust and respect, vouching for the oral agreements made between farmers in their community and with other supply chain tiers. The community leaders represented a form of informal third-party governance not previously established in the relational view literature that limited the abuse of power by a partner in times of conflict or disagreement and avoided the need for costly and restrictive contracts. As a revered independent mediator or adjudicator, they ensured transactions were based on accepted cultural and market conventions (Abushaikha et al., 2021). Moreover, the mediator's reliance on restorative justice through reconciliation fostered harmony and the continuity of supply chain relationships, which are conducive to continued relational rent generation. Therefore, the following are proposed:

P2a. *Traceability can be most effectively embedded to create supply chain resilience as a relational rent through informal third-party governance mechanisms in contexts where the role of community leaders is revered.*

P2b. *An informal third-party governance mechanism creates a more effective traceability system than self-enforcing agreements in contexts where the role of community leaders is revered.*

Like many other management theories, the relational view is based on an implicit Western understanding of relationships and ways of doing business. Moreover, the extant relational view literature has focused on understanding traditional supply chain relationships (Huang et al., 2022). This hinders the application of existing theory to underrepresented contexts and reveals a void that needs attention for an end-to-end understanding of socio-culturally diverse global supply chains (Lee Park et al., 2022). This research extends the relational view by emphasizing the role of nontraditional supply chain actors, local practices, and informal networks. In particular, the inability of other supply chain actors to replicate partnership-tailored dyadic relation-specific assets was not a foundation for creating a long-term interorganizational competitive advantage in a non-individualistic cultural setting. Thus, this research also emphasizes the importance of supply chain-wide relation-specific assets usually provided by a nontraditional supply chain actor (e.g., governmental body) that can cater for the needs of broader supply chain relationships.

In addition, the relational view asserts that third-party governance mechanisms are expensive and inflexible (Dyer & Singh, 1998). However, the informal third-party governance mechanism identified in this research eliminates contracting costs, reduces monitoring costs, and is adaptable to unforeseen circumstances. This reinforces calls to acknowledge the impact of national culture on supply chain practices (Lee Park & Paiva, 2018; Schorsch et al., 2017) and argues for the development of more culturally diverse management theories.

Ubuntu provides one direction for expanding theory in this regard. It has gained interest in the broader business management and ethics literature (Lutz, 2009; West, 2014), but for supply chain research specifically, it may explain how the unique characteristics of interfirm relationships in Africa define managerial decisions and supply chain practices. Researching *ubuntu* could be paralleled with the study of *guanxi* in China (Ding & Jie, 2021; Jia & Zsidisin, 2014; Lee Park et al., 2018), *jeitinho* in Brazil (Lee Park et al., 2018), *yongo* in South Korea (Horak, 2014; Lee Park et al., 2022), and *blat* in Russia (Darkow et al., 2015; Flynn et al., 2015). However, developing/emerging countries are at different development stages, and these other examples arguably portray characteristics closer to many developed countries than to the sub-Saharan African context (Oke & Nair, 2023).

CONCLUSIONS

This research provides insights into how firms can facilitate traceability and thus enhance SCRes in an underrepresented context. The research offers one of the first in-depth empirical insights into the role of upstream supply chain actors in attaining end-to-end traceability, an important direct and indirect enabler of global SCRes. By focusing on Ghana, this research highlights how broader sociocultural factors can compensate for a lack of sophisticated technology and regulatory enforcement. This builds on calls to understand how culture affects the adoption of supply chain practices and how it influences buyer–supplier relationships (e.g., Flynn et al., 2015; Lee Park & Paiva, 2018).

This research furthers the relational view perspective. Extant research has focused on dyadic investments in relation-specific assets (both symmetric and asymmetric) and argued that greater bargaining power rests with the partner who makes fewer investments in the relation-specific asset (Dyer et al., 2018). In contrast, this research identifies the role of a supply chain-wide relation-specific asset that is organized and administered by a third party. This guards against the natural business instincts of competition and opportunism since each partner has fewer investments at risk in the relationship. Moreover, relational rent will emerge and dissipate

based on the strength of individual dyadic relationships and not necessarily the resources invested (Lavie, 2006). Hence, as relationships become stronger and trust increases, the efficacy of flexible, informal governance mechanisms emerge to ensure higher relational rents.

Overall, the research frames achieving supply chain traceability—and thus enhancing global SCRes—as a sociotechnical system reliant on effectively combining technological and nontechnological traceability systems across the supply chain while acknowledging the important role of human capital and investments in appropriately governed supply chain relationships. Specifically, an awareness of a developing country's social characteristics is important, both to understand the risks inherent in the supply chain and to determine context-specific approaches for achieving effective upstream traceability. This facilitates the absorption of small-scale, chronic disruptions and ultimately enhances global SCRes by avoiding the escalation of upstream disruptions into larger-scale catastrophic events, as illustrated in Figure 3.

---------- Insert Figure 3 Approximately Here ----------

Practical and Societal Implications

For smallholder farmers, this research offers a route to safeguarding their investments and obtaining bargaining rights, as well as a framework for resolving disputes with other supply chain actors. For example, it highlights the governance mechanisms that can be used to ensure that farmers are compensated for any relation-specific investments in growing particular varieties or organic crops when processors breach agreements. Meanwhile, processors and traders should focus on collectively reorganizing and transforming supply chain relationships to enhance SCRes. This builds trust and enhances cooperation, leading to long-term supply chain benefits rather than temporary solutions that create other risks and disruptions. For example, demanding advanced traceability systems from farmers without providing the necessary equipment and training may lead to inaccurate traceability information or product shortages when farmers switch their focus to other less-demanding markets.

For global brands, the taxonomy of risks and SCRes strategies inherent to developing countries can inform strategic sourcing decisions. This includes elaborating on the importance of considering sociocultural characteristics that could hamper brands' ethical sourcing values and reputation. For regulators, the research stresses the criticality of traditional leaders in enforcing agreements and regulations in rural communities. Meanwhile, restorative justice and developing a sense of ownership can foster the commitment of supply chain actors to enhancing sustainability practices.

Finally, the research indicates ways in which traceability can enhance the resilience of global AFSCs to combat the climate and biodiversity crises, food insecurity, and labor issues. Global governing bodies, such as the UN, should be particularly interested in verifying upstream supply chain activities to ensure that land resources are used in an environmentally sustainable manner and that farm and factory conditions are socially sustainable. End-to-end traceability supports this by providing evidence of the source, composition, and associated processing activities to ensure the delivery of ethically sourced, safe, and nutritious foods that meet the dietary requirements of global consumers. This is key to strengthening industry sectors of critical importance to the economies of developing countries, such as Ghana.

Limitations

While the multi-case study approach adopted in this research offers greater breadth than a single case approach, the findings are inevitably influenced by the chosen context. Additional research could therefore be conducted in other industry sectors and in other developing countries. Furthermore, the scope of this research was limited to upstream supply chain actors, meaning that future research could examine whether the findings resonate with downstream supply chain actors, such as manufacturers, wholesalers, and retailers. Finally, this research is conducted with suppliers in a rural setting. The idea that urban populations are generally more individualistic than those in rural areas is not limited to sub-Saharan Africa. Hence, for future research, it would

be interesting to investigate whether rural supply chains in Western and other non-sub-Saharan African countries share the values of *ubuntu*.

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FIGURES AND TABLES

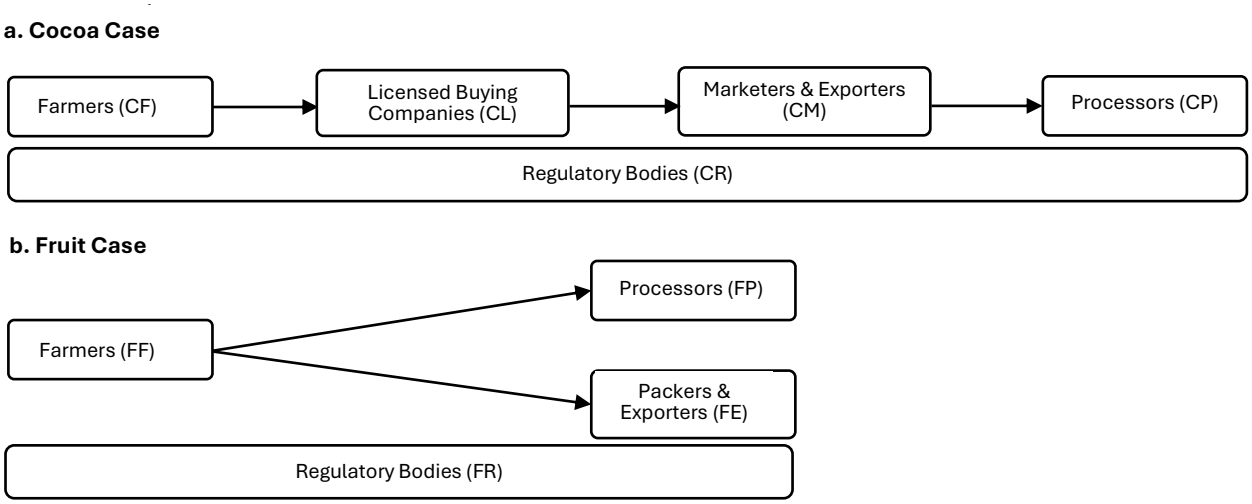

FIGURE 1 – Illustration of the supply chain structures of the (a) cocoa case and (b) fruit case

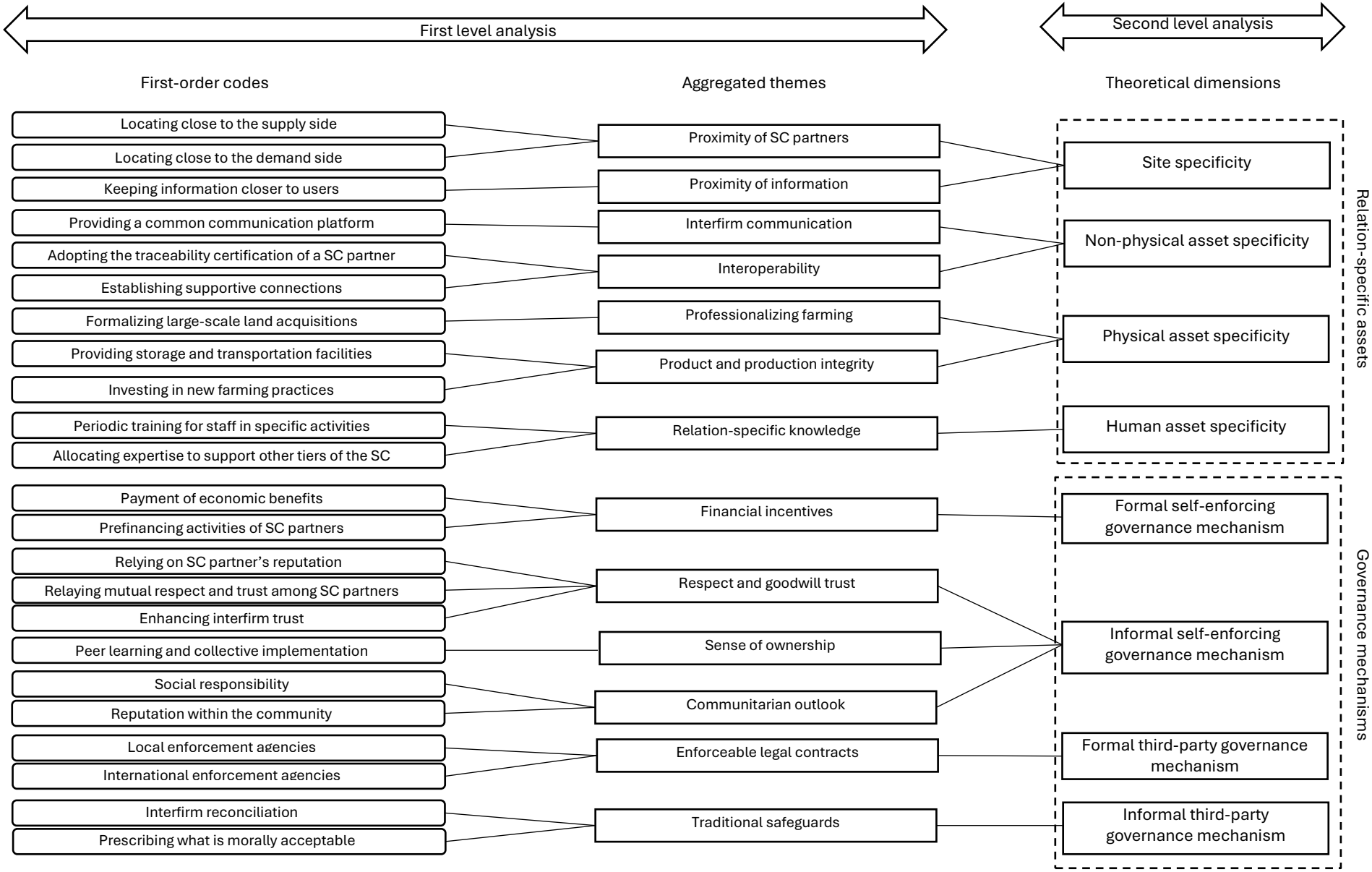

FIGURE 2 – Second level analysis coding structure

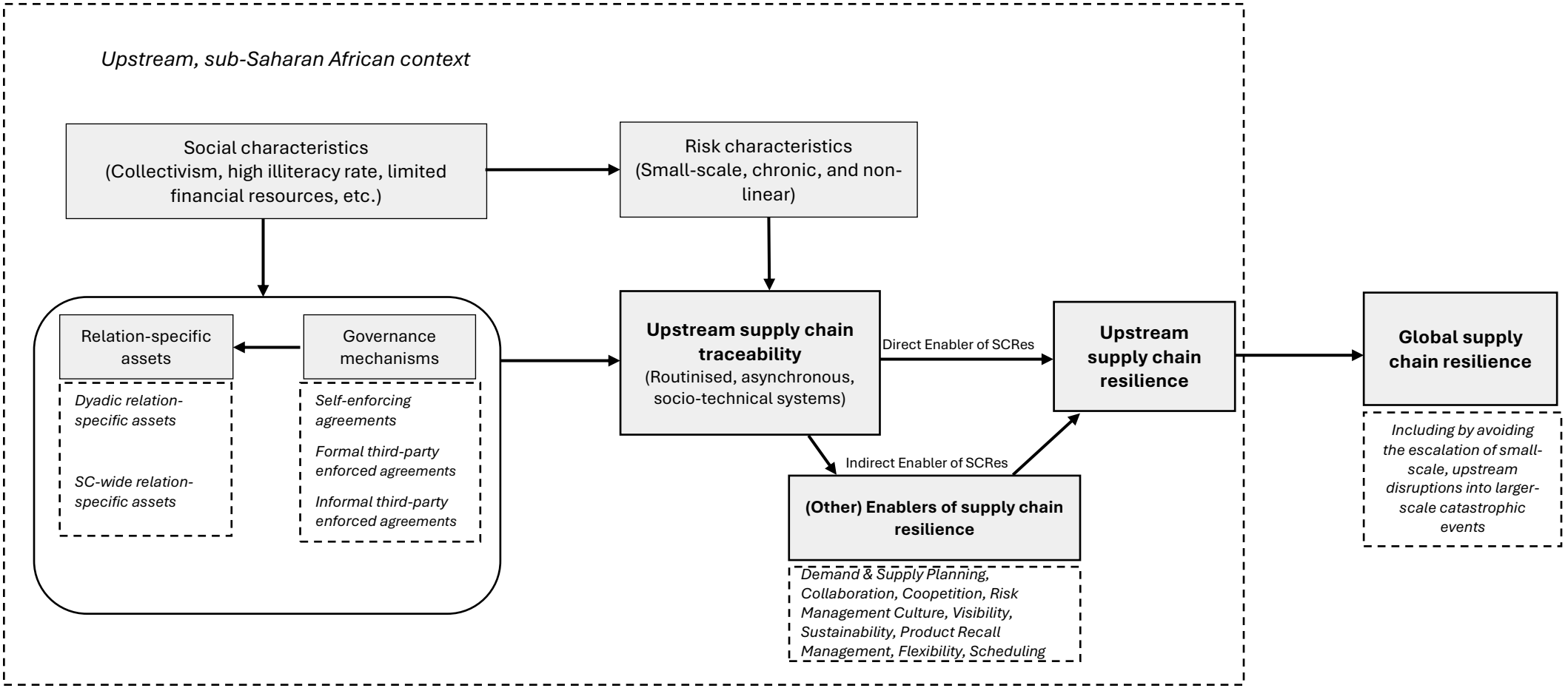

FIGURE 3 – The role of upstream traceability in enhancing global SCRes

TABLE 1 – Summary details of interviewees and organizations

SC Tier	Interviewee	Position (Years in Firm)	Firm Size*	Age of Business (& Years practicing traceability)	Medium & Duration (in minutes)	Other Data Sources
Farmers	CF1	Farm Owner (8)	5	8 (8)	Phone (75)	-
	CF2	Farm Owner (17)	5	17 (17)	Phone (60)	-
	CF3	Deputy Farm Manager (10)	22	25 (18)	Phone (60)	-
	FF1	Farm Owner (10)	5	10 (10)	Phone (70)	-
	FF2	Farm Manager (15)	12	22 (17)	Phone (80)	-
	FF3	Farm Owner (10)	3	10 (7)	Phone (70)	-
Licenced Buying Companies (LBC)	CL1	Traceability Officer (6)	>500	30 (30)	Phone (50)	Annual Report; Sustainability Report
	CL2	Sustainability Manager (8)	>500	32 (30)	Phone (80)	Annual Report; Newsletters
	CL3	Sustainability Officer (4)	>500	25 (25)	Phone (60)	Risk Report
	CL4	Regional Manager (12)	>500	25 (20)	Phone (45)	-
Marketers & Exporters	CM1	Technical Officer (10)	>500	70 (60)	Phone (70)	Annual Report; Website
	CM2	Snr Quality Manager (15)	>500	70 (60)	Zoom (50)	
	CM3	Traceability Manager (8)	>500	70 (60)	Phone (65)	
Packers & Exporters	FE1	Logistics Manager (4)	>500	21 (15)	Phone (60)	Annual Report; Sustainability Report; Website
	FE2	Administrator (3)	>500	14 (14)	Phone (50)	-
	FE3	Quality Manager (6)	>500	25 (10)	Phone (50)	-
	FE4	General Manager (15)	>500	25 (21)	MS Teams (70)	-
Processors	CP1	Supply Planner (5)	>500	30 (30)	Phone (60)	Annual Report
	CP2	Operations Manager (7)	>500	44 (44)	Zoom (50)	Annual Report
	CP3	Quality Assurance Officer (6)	>500	16 (16)	Phone (80)	Website
	CP4	Risk Manager (8)	150	22 (10)	Phone (65)	-
	FP1	Process & Product Development Manager (10)	>500	21 (21)	MS Teams (60)	Annual Report; Sustainability Report; Website; News media
	FP2	Quality Manager (15)	>500	14 (14)	MS Teams (45)	Annual Report
	FP3	Store Manager (5)	>500	25 (21)	Phone (70)	-
	FP4	Process & Logistics Analyst (8)	>500	26 (26)	Phone (50)	Annual Report; Website

Regulatory Bodies	CR1	District Technical Officer (15)	>500	70 (70)	Phone (45)	Website
	CR2	Standards Administrator (5)	>500	21 (21)	Zoom (50)	Website
	CR3	Regional Director (4)	>500	65 (65)	Phone (60)	News media
	CR4	District Director (2)	>500	50 (50)	Phone (90)	News media
	FR1	Snr Regulatory Officer (15)	>500	25 (25)	Zoom (90)	Website
	FR2	Administrator (5)	>500	21 (21)	Zoom (50)	Website
	FR3	District Director (2)	>500	65 (65)	Phone (60)	News media
				Total duration (minutes)	**1990**	

** Number of full-time employees*
CM – *subsidiary of Ghana Cocoa Board responsible for promoting and selling Ghana's cocoa locally and internationally*

TABLE 2 - Validity and reliability issues addressed in this study

Reliability/ Validity Criterion (*Yin, 2018*)	**Research Phase**			
	Design	**Case Selection**	**Data Collection**	**Data Analysis**
Reliability (*demonstrating that the same results will be achieved when the study is repeated under similar conditions*)	Developed a case study protocol Transparent research process	Documented the case selection criteria Defined the sources of data to be collected	Developed a semi-structured interview guideline Recorded and transcribed interviews Documented evidence from other data sources	Abductive coding process to avoid being limited by literature Regular review and debriefing of codes among authors
Internal Validity (*ensuring actual causal relationships are distinguished from apparent ones*)	Developed the research model based on the extant literature	N/A	Included multiple interviewees based on expertise Interview transcripts were validated by interviewees	Intra-case analysis Pattern matching between empirical data and literature Triangulation of multiple data sources
Construct Validity (*ensuring that the right measurements were chosen for the study*)	Developed an interview protocol based on the extant literature Piloted interview questions to eliminate ambiguity	N/A	Multiple sources of primary and secondary data Multiple interviewees from each SC tier of both cases Assurance of interviewee and company anonymity	Triangulating the data from multiple sources Using tables to show chain of evidence Iterative data analysis and data collection process receptive to emerging themes
External Validity (*determining the extent of generalisability of the findings*)	Focused on a globally relevant industry Used comparative multiple case studies Included the relevant external stakeholders	Based on replication logic – supporting both literal and theoretical replication	Defined the case context of interest in this study Interviewed selected participants using similar interview guidelines	Two level data analysis procedure Pattern matching with the RV theory literature

TABLE 3 – Sample risks with evidence from the data

Risk/Disruption/Threat	Description	Cocoa Case	Fruit Case	Sample Quotes
Inputs risk	Counterfeiting of inputs (e.g., agrochemicals, fertilizer)	CF1-3	FF1-3	"[…] the original pesticide dealers are usually unable to compete in the market because of the rise in less expensive counterfeits … some fake agro-chemicals are effective; however, most are destructive in the long run causing huge losses [crop failure and land destruction]." (CF1) "[…] some papaya varieties can bear maximum fruits for as long as four to five years and require less fertilizer but are usually hoarded and sold at higher prices by some dealers." (FF2)
	Limited access to quality seedlings	CF1-3	FF1-3	
	Limited and selective distribution of government's subsidized inputs and mass spraying activities	CF1-3	-	
	Limited availability and high cost of packaging materials	-	FP1-3, FE1-3	
Dishonest employees	Making false claims that products are "organic"	CP1, CP3	FP1-3, FE1	"We pay our PCs a commission based on the volumes of cocoa they are able to purchase, hence, without accurate estimated yields from certified farmers, they purchase conventional cocoa beans from other farms to earn a higher commission." (CL3) "[…] we don't receive a fair income for our beans because the PCs cheat us when we take our beans to be weighed and priced. They read the wrong weights or tighten the scales to reduce the weight of our beans." (CF1)
	Mixing decayed beans, fragments or foreign matter with acceptable cocoa beans	CL1-3	-	
	Altering weighing scales to pay less to farmers	CF1-3	-	
	Wrongly grading consignments either deliberately or obliviously	CM1-3, CR1	-	
	Altering expiry dates, ingredient composition and origin	-	FP1-3, FE1-3	
	Using food colorings to conceal low-quality fruits	-	FP1-3, FE1-3	
	Field officers buying cheaper fruits from unregistered farmers	-	FF1-3, FP4 FE1-2	
Unfair competition	Influx of larger multinational LBCs	CL1-4, CM1-3, CR1	FP2-3, FE2-3	"[…] venturing into cocoa processing requires that we pay for cocoa beans in US dollars, which doesn't favor us as domestic processors who have to deal with the depreciation of the cedi [local currency]. And local manufacturing into chocolate and other confectionery is also not encouraged because of the huge taxes on the semi-processed cocoa products and import duties on other raw materials such as sugar". (CP3) "[…] many countries have ventured into cocoa cultivation, posing stiffer competition for market shares while maintaining efficiency […] we therefore strive to maintain quality because we can't focus on quantity, especially with the growing interest from stronger emerging economies in Asia and Latin America." (CR1)
	Large companies lobbying to evade or pay lower taxes	CP1-3	-	
	Diversification of multinational LBCs into cocoa processing	CL4, CP1-3	-	
	Tax exemptions/subsidies set for processors that export >70% of their products favored multinational companies over smaller domestic processors	CP2	FP3 FE2-3	
	Emergence of cocoa production in Asia and Latin America	CM1-3, CR1	-	
	Influx of South American suppliers into the EU market	-	FP1-3, FE1-3	
Geographical location	International trade barriers	CP1-3	FP1-3, FE1-3	"The hot temperatures in Ghana slow down our work and sometimes we lose a lot of money […] it easily melts our products or delays the solidification of the chocolate" (CP3) "[…] unfair labor wages, child labor and deforestation are usually associated with the activities in our locations because of past experiences, so some countries demand that customers send their own inspectors and auditors to observe our processes as they do not trust our local licenses and certifications." (FP1)
	Predominantly hot temperatures	CF1-3, CP1, CP3	FF1-3, FP1-3, FE1-2	
	Restricted ability to physically monitor other SC tiers	CP1-3, CR1	FP1-3, FE1-4, FR1-2	
	Stricter international market restrictions based on the perception that production activities in developing countries conceal unethical practices	CP1-3	FP1-3, FE1-3	
Smuggling	Illicit trading of cocoa beans between Ghana and neighboring countries	CF1-3, CL1-2, CL4, CM1-3	-	"Some farmers prefer to take advantage of the fluctuations in international cocoa prices instead of selling at the guaranteed price in Ghana, hence, when international cocoa prices rise, farmers gain more selling in Cote d'Ivoire, so they smuggle their beans across the border and vice versa." (CM1).

				"They always blame us for chasing good prices in Cote d'Ivoire, but the same things happen here too, when they smuggle their cocoa in, they sell it cheaper to the purchasing clerks and they even want us to also reduce our prices." (CF3)
Policy and regulatory risk	Uncertainty of the effective enforcement and longevity of governmental policies and regulations	CF1-3, CP1-3	FF1-3, FP1-2, FE1	"The government announced that no cocoa beans will leave the shores of Ghana unprocessed without any significant new policy to support processors to increase their processing capacity [...] it is still more expensive to process in Ghana than in our parent company [in Europe]." (CP1) "They [government] only come out with incentive programs during election periods so you don't even know whether the policies will be as effective as it is after elections" (CF1)
	Unfair distribution of policy incentives	CF1-3	-	
	Bureaucratic and corrupt practices among government officers	CF1-3, CL1-3	-	
	Little/no tailored policy	-	FF1-3, FP1-3, FE1-4	
Deforestation	Encroaching on protected forests to increase farm outputs	CM1-3, CR1	-	"Most of them [farmers] rely on their farms for all incomes so as their family size increases, they resort to expanding cocoa farms into nearby forests." (CR3) "[...] we don't assume all fruits from a farm are the same. I know a lot of farmers that will cut down trees because fruits exposed to sunlight are sweeter than those growing under shade." (FR3)
	Illegal logging for commercial and domestic purposes	CR1, CR3	-	
	Perception that forest areas are more fertile for some fruits	-	FF2-3	
	Exposing fruits to sunlight by cutting down surrounding trees	-	FF1-3, FR3	
Informal labor	High labor turnover	CL1-4, CP1	FP1-3, FE1-3	"But we learn farming from our parents, so we know a lot. If you go to high school or university, people think you are better than those that work on farms, so farm work is for only us the dropouts." (CF1) "I recently understood why most people will work on the farms for free or little payment. They respect their family ties and assume it is morally wrong to charge a clan member for working for them, which is returned when you need help as well." (FP2)
	Prevalence of casual jobs that are not entitled to employment benefits (e.g., sick leave, severance pay)	CL3-4, CP1, CP3	FF1, FP3, FE1-2	
	Lack of requisite education and skills to gain formal employment	CF3, CL3-4, CP1	FP1-3, FE1-4	
	Prevalence of domestic labor	CF1-3	FF1-3	
Informal sector	Most farms are unincorporated and mostly owned and managed by individuals or households	CL1-4, CM1-3, CR1	FP1-3, FE1-3, FR1-2	"[...] though we visit farms regularly to ascertain the progress of their activities, they are usually unable to provide evidence of the quantity and destination of fruits sold at a specific period, hence we are mostly only able to confirm the origin of fruits from the processors and exporters when we encounter them at the points of entry into and exit out of Ghana." (FR2) "Farmers mostly don't understand the essence of new directives and feel reluctant to abide by them because they claim they have been successful in the past without it. [...] the lack of formal documentation for farmers allows them to register with multiple LBCs without being noticed, [...] agreements to supply us cocoa beans are usually non-binding; hence, they easily evade us and supply to others, especially when they are dodging the repayment of credit facility taken from us." (CL1)
	Small-scale operations and limited level of organization among farmers and local processors	CL1-4, CM1-3, CR1	FP1-4, FE1-3, FR1-2	
	Farmers are unreceptive to new directives	CL1-3, CM1-3	FP1-3	
	Prevalence of oral agreements instead of formal documentation	CF1-3, CL1-4	FF1-3, FP2-3, FE1-3	
	Limited corporate tax base	CM1-3, CR3-4	FR1	
	Limited local fruit market administration – hence, difficult to oversee	-	FR1-3	
Insecure land tenure system	Increased competition for farmlands for mining and palm oil plantations	CF1-3	FF1-3	"Our lands are leased to us, but you wake up every day worried that your landowner will claim back his/her land and resell at a higher price to galamsey or mining companies." (CF2) "Most farmers are focused on the short-term benefits from their activities [...] they will rather engage in farming activities that boost their yield in the short term because they don't have secured land rights." (FR2)
	Farmlands are mostly customary lands managed and allocated by family heads, clan heads, and/or chiefs	CF1-3	FF1-3	
	Land ownership based on oral agreements with landowners	CF1-3	FF1-3, FP2 FE3	
In-transit risk	Reduction in quantity – via theft, damages etc.	CL1-4, CM1-3	FF1-3, FP1-3, FE1-2	"Though we use tested thermal insulation packaging for our products, any small fluctuation of temperature above 5°C at any stage of its journey was likely to cause damages to the product." (FP1)
	Mixing different grades of cocoa beans	CL1-3	-	

	Water, sweat and vapor exposure during voyage creates mold patches, musty taste and increased moisture	CL1, CM1-3, CR1	-	"Cocoa of acceptable quality must be free from smoky beans, fragments, germinated beans, slaty beans and any other form of damages, hence, when we notice any of these signs, we have to withdraw them from the volume received." (CR1)
	Pest infestation in containers or stow space	CM1-3, CR1	-	
	Spoilages and blemishes due to temperature fluctuations		FP1-3, FE1-3	
Contractual breaches	Customers (processors/ manufacturers) unwilling to pay precontracted cocoa prices for beans when prices fall before receipt of beans	CM1-3	-	"They [processors, packers and exporters] collapsed our businesses during the COVID lockdowns [...] when they reduced/ cancelled the quantities they demanded, most of us [pineapple farmers] suffered huge losses because after forcing [preparing for harvest], the fruits must be harvested after 140-150 days [starts to rot in the soil afterwards]. (FF1) "We usually use incentives such as the provision of fertilizers and agrochemicals on credit basis to gain the loyalty of our existing farmers and also attract new farmers. This credit is expected to be repaid by deducting the outstanding amount from the value of cocoa beans supplied by the farmer. However, some farmers rather sell to other LBCs to avoid repayment." (CL2)
	LBCs may fail to deliver the agreed volume of cocoa beans for which they received seed funds	CL3, CM1-3	-	
	Farmers defaulting credit facilities offered to support their farming activities	CL1-4	-	
	Processors and packers & exporters cancelling/ reducing quantities demanded from farmers	-	FF1-3	

TABLE 4 – Current state of traceability technologies

SC Tier	Traceability Functions & Technologies Adopted					
	Identification	**Locating**	**Sensing**	**Communication**	**Data storage**	**Logic**
Cocoa Case						
Farmers	Manual (All)	N/A	Manual (All)	Mobile phone (CF1, CF3) Email system (CF2-3)	Laptops (CF2)	N/A
LBCs	Barcode (CL1, CL3) RFID (CL2, CL4)	Barcode (CL1, CL3) Cloud-based digital platform (CL3-4) GIS (CL1, CL3-4)	Manual (All)	Mobile phone (CL1-4) Barcode (CL1, CL3) RFID (CL2, CL4) Digital platform (CL3-4)	RFID (CL2, CL4) Digital platform (CL3-4)	Manual (All)
Marketers/ Exporters	RFID (CM1-3)	RFID (CM1-3)	Moisture meter (CR1)	RFID (CM1-3)	RFID (CM1-3)	Manual (All)
Processors	Barcode (CP1-3) RFID (CP4)	Barcode (CP1-3) RFID (CP4) Digital platform (CP3-4)	Manual (All)	Barcode (CP1-3) RFID (CP4) Digital platform (CP3)	RFID (CP4) Digital platform (CP3)	Manual (All)
Fruit Case						
Farmers	Manual (All)	N/A	Manual (All)	Mobile phone (FF1-3) Email system (FF1-3)	Laptops (FF1-3)	N/A
Packers & Exporters	Barcode (FE1-3)	Barcode (FE1-3) Digital platform (FE3-4) GIS (FE2-3)	Temperature Loggers (FE1-3) Refractometer (FE2-4)	Mobile phone (FE1-4) Barcode (FE1-3) Digital platform (FE1, FE4)	Digital platform (FE1, FE4)	Manual (All)
Processors	Barcode (FP1, FP3-4)	Barcode (FP1, FP3-4) Digital platform (FP1-3) GIS (FP1, FP3)	Temperature loggers (FP1-3) Refractometer (FP1-4)	Mobile phone (FP1-4) Barcode (FP1, FP3-4) Digital platform (FP1-3)	Digital platform (FP1-3)	Manual (All)

Notes:
Identification: The determination of the unique identity information of the product (i.e., either raw material, semi-finished product or final product).
Locating: The provision of timely and accurate information on the position of a product (i.e., either as a raw material, semi-finished or finished product).
Sensing: The capability to acquire and provide information on any object and environment-related changes in the status of the product along the SC.
Communication: The capability of accessing and exchanging product information along the SC.
Data Storage: The capability of retaining product history and other relevant product information for the purpose of facilitating information sharing among SC actors.
Logic: The capability that enhances the recognition of the critical events along the SC – such as temperature fluctuations, quality issues, etc. (Source: *Razak et al. (2023)*).

TABLE 5 – Summary of the inter-firm relational practices

Aggregated Themes	First-Order Codes	Tiers Involved (Sources)		Sample Quotes
		Cocoa Case	Fruit Case	
Proximity of SC partners	Locating close to supply side	CL ➔ CF CP ➔ CM (CL1-3, CP1-2)	FP ➔ FF FE ➔ FF (FP1-3, FE1-4)	"We position our purchasing sheds close to the farmers [...] depending on the volume of cocoa beans from the area, we may assign more than one purchasing clerk to increase the farmers' accessibility" (CL1) "[...] proximity is very important to us because we prefer fruits to naturally ripen before harvesting, [...] our fruits are perishable, hence any days delayed in transport will affect our desire to serve consumers with the health benefits of a true fresh-from-harvest fruit." (FP1)
	Locating close to demand side	CL ➔ CM CM ➔ CF (CL1-4, CM1-3)	-	"Our parent body [COCOBOD] locates the unit responsible for provision and distribution of quality farm inputs [seedlings and agro-chemicals] within the farming regions" (CM2) "Our regional warehouses serve as consolidation points where inspection and other quality checks are done and further moved to the takeover centers [final storage points controlled by CM]" (CL1)
Proximity to information	Keeping information close to users	CL, CM, CR (CL1, CL3, CM1-3, CR3)	-	"[...] most farmers report their problems, individually or through the chief farmer to the chiefs and elders. So, our officers usually start off with the chiefs to receive an overview of an implemented policy or even the prospects of an incoming initiative within the community." (CM3) "The traditional leaders represent the interests of their people and they can easily organize them or influence their activities. Our chiefs have authority and can summon all the people when necessary, so we use chiefs' palace or designated community centers for programs to train farmers and the community on good farming practices." (CR3)
Inter-firm communication	Providing a common communication platform	CL, CM, CR (CL1-4, CM1-3, CR1)	FP, FE (FP1, FP3, FE1-4)	"We invested in a peer-to-peer communication platform that enhances the privacy, speed and accuracy of our communication with partners" (CL4) "[...] the database picks orders from customers, updates the system and informs the departments of materials required, we inform farmers who then initiate the harvesting process. ...the feedback tool also allows customers to log in complaints when their satisfaction is not fully met to expedite the settling of any issues." (FE1)
Product and production integrity	Providing storage and transportation facilities	CL, CM (CL1-4, CM1-3)	FP, FE (FP1-3, FE1-4)	"We engage the services of transportation intermediaries for the transportation of cocoa beans from the farm gates to a specified takeover center" (CL3) "We are focused on ensuring customers experience the original taste of naturally sun-ripened fruits as if they were just plucked from the tree, so we provide temperature-controlled compartments for the storage and transportation of certain fruits at all times" (FP1)
	Investing in new farming practices	CF, CM (CF3, CM1-3)	FF, FP (FF1-3, FP1)	"Farming isn't easy anymore [...] I recently started organic farming because of one buyer, and it is not just about the farm techniques, it is risky too. Imagine the customer is no more interested after years." (CF3) "I had to clear all my existing pineapple farm to grow sugarloaf [a sweeter variety] because our customer demanded that. It is sweet and very juicy, but I don't think it matters much, it's just their preference, so we worked to deliver it." (FF2)
Interoperability	Adopting the traceability certification standard of a partner	CF, CL, CP (CF1, CL1-3, CP1-2)	FF, FP, FE (FF1-3, FP1-3, FE1-3)	"I choose the traceability system that aligns with what my preferred LBC requires to pay me the full premium amount for my cocoa beans" (CF1) "The farm-level traceability is as important to us as our own because we stand to lose on both sides if it doesn't turn out well. We pay the subscription fees for [anonymized] certification, to ensure farmers can provide all the adherence information our customers require." (FP1)
	Establishing supportive connections	-	FP, FE, FR (FP1-2, FE4, FR1)	"We create some important links for the smallholder farmers and local processors by connecting them with third-party organizations that sensitize them on new developments and new farming technologies, such as improved seed varieties, agrochemicals, and fertilizers, and provide farmer trainings." (FP1)

Professionalizing farming	Formalizing large-scale land acquisitions	CL, CM, CR (CL1-3, CM1-3, CR1, CR3)	-	"Cocoa farming is increasingly becoming a large-scale only venture, so chiefs have become the point of contact for investors [...] Chiefs play an important role in consolidating small parcels of land that belong to individual families and clans into one and issue indentures." (CL2) "Ask any farmer the size of his/her farm or its location address and maybe none of them will give you any concise response because it is usually not necessary. But with an increasing need for farm mapping, we can tell all the characteristics of the land, know when a land is encroaching protected forests and also [COCOBOD] can determine yield more accurately." (CR3)
Relation-specific knowledge	Periodic training for staff involved in specific activities	CL, CM, CR (CL1-4, CM1, CM3, CR1)	FF, FP, FE, FR (FF2-3, FP1-3, FE1-4, FR3)	"[...] our officers are trained to both generate dedicated codes for consignment as well as identify and understand the unique information coded on the jute bags." (CR1) "We learn improved and sustainable farming techniques, such as organic farming, that are globally acceptable" (FF3)
	Allocating expertise to support other tiers of the SC	CM, CR (CM1-3, CR1)	FP, FE, FR (FP1-3, FE1-4, FR1, FR3)	"[...] a dedicated extension officer that visits farmers to monitor their practices and give expertise knowledge where necessary will many times have to attend to farmers' clerical needs." (CM3) "We deploy full-time agronomists to registered farms to monitor farming activities to ensure they meet our standards and impart farmers with new expertise and improved farming practices" (FP2)
Financial incentive	Payment of economic benefits	CL → CF CM → CF, CL (CL1-3, CM1-3)	FP → FF FE → FF (FP1-2, FE1-3)	"The payment of premium prices for traceable cocoa motivates cocoa farmers to implement traceability in different forms, depending on their capacity, knowing that they won't get the same amount for conventional cocoa beans" (CL3) "We provide our suppliers with support, such as covering soft loans to expand their capacity and covering the cost of their traceability certifications, which conforms to our expected production standards" (FP1)
	Provision of economic incentives	-	FP → FF (FP1-3)	"To achieve our National Organic Program [US certification] and EU Organic certifications, we had to ensure farmers fully understood the concept and benefits, hence we offered a pre-financed demonstration for eleven farmers in the Eastern Region [of Ghana]" (FP3) "[...] the plight of the smallholder farmer is very important to us, so we ensure they remain in business beyond the crop season and provide start-up funding at the start of the season" (FP1)
Mutual respect and goodwill trust	Relaying mutual respect and trust among SC partners	CF → CL CP → CM (CF1,CL1-3,CP1-3)	-	"Ghana is globally known as a hub for quality cocoa beans, hence we ensure we only source Ghana's cocoa beans through the right [COCOBOD] division [...] we do our best to meet their requirement" (CP1) "Some LBCs are known to pay the right premium prices while others are accused of tightening up their weighing scales to cheat farmers. We therefore try our best to sell our cocoa to the LBCs that care about us, hence we try to meet their traceability standards" (CF1)
	Enhancing inter-firm trust	CL, CM, CP (CL1-3, CM1-3, CP1)	-	"We make our PCs [Purchasing Clerks] transparent and honest, to assure farmers that they are dealt with rightly by providing evidence of international cocoa prices in comparison to how much we are paying for their cocoa" (CL1) "Though regulatory bodies can enforce traceability, its effectiveness boils down to the actors being honest and dedicated to the benefits" (CL2)
	Relying on SC partner's reputation	-	FF → FP FF → FE (FF2-3, FP1-3)	"There are benefits to us in the local marketspace from being a supplier to Company X [a processor] and our local traders prefer our fruits, hence when our processors requested traceability from all suppliers, we were happy to do it because they are our main customers and other sales depend on them as well." (FF2) "They [processor] are known for buying with integrity and fairness, and only from farmers that work to high social and environmental standards, so our success in farming requires us to meet their traceability requirements" (FF3)
Sense of ownership	Peer learning and collective implementation	CF, CL, CM (CF1-3, CL2, CM1-3)	-	"We appoint an experienced chief farmer who represents us, we respect and revere him because he is one of us, he faces the same problems. When these buyers want to impose anything on us, he will consult us, and we make a collective decision" (CF3)
Communitarian outlook	Social responsibility	CL, CM, CR (CL1-4, CM1-3, CR3)	-	"[...] cocoa buying is very competitive, and the farmers choose to sell to their preferred LBCs at different periods, usually because of some benefits and other social interventions in the community." (CL2)

				"We engage in several activities to support livelihoods in the community [...] our activities within their environs automatically make them stakeholders in our success story, so we do our best to keep the relationship harmonious and depict our social responsibility through these engagements." (CM3)
	Reputation within the community	-	FP, FE (FP1-3, FE1-2)	"It's not just about the farmers, you need acceptance in the community too. We set up a foundation in the community, to make a positive impact on the local economy and engaging with communities to understand their needs and provide support within our means" (FP1) "The pandemic was challenging for the people in our local communities, the lack of health advice and access to hygiene supplies increased the risk in these communities. We provided hand sanitizers, veronica buckets and created communication materials to raise awareness" (FE1)
Enforceable legal contracts	Local enforcement agencies	CL, CM, CR (CL1-3, CM1, CR1-2)	FF, FP, FE, FR (FF1-2, FP1-2, FE1, FR1-2)	"[...] there should be an autonomous body to set standards for all of us to follow because if all players are to set their own standards, there won't be standards to align the system to, thus barring the chances of inter-system interaction" (CL1) "The Ghana Green Label certification scheme promotes good and sustainable agricultural practices and the production of safe fruit products. This is necessary to ensure farmers have access to a wider market locally and sometimes globally since some local standards meet international requirements, and they are not tied to only one processor" (FR1)
	International enforcement agencies	CL, CM, CR (CL1-4, CM1-2, CR1-2)	FP, FE (FP1-3, FE1-3)	"Certification bodies such as IMO, REES, Rainforest Alliance play an important role to regulate traceability systems [...] their role is very important because they set standards and enforce them to ensure all players comply" (CL1) "BRC [British Retail Consortium] and third-party agencies from customers have specifications and standards that our processes must conform to, [...] this gives traceability a direction to focus on and not just for practicing's sake." (FP1)
Traditional safeguards	Prescribing what is morally acceptable	CF, CL, CM, CR (CF1-3, CL1-3, CR1, CR3)	FF, FP, FE (FF1-3, FP1)	"Now we have the chiefs who are the opinion leaders on board, to champion our drive to prevent the destruction of forest reserves within their community. They know these forests and the people more than any law enforcement agency." (CR3) "The ADR [Alternative Dispute Resolution] allow chiefs to solve land litigation issues instead of waiting for the district court that is costly and takes too long. We are sure that chiefs will be more focused on what is morally right based on our customs than formal laws" (FF3)
	Inter-firm reconciliation	-	FF, FP, FE (FF1-3, FP1)	"They [processors, packers and exporters] collapsed our businesses during the COVID lockdowns [...] most of us [pineapple farmers] suffered huge losses because after forcing [preparing for harvest], the fruits must be harvested after 140-150 days [starts to rot in the soil afterwards]. But how can you sue [company anonymized], we hope the chief can do something to help us recover some losses from them [processors, packers and exporters]." (FF1)

SUPPLEMENT 1: Interview Questions

Interview Questions for SC Actors

1. General respondent information (position, years in firm, experience in role, other related duties)
2. General firm information (name, location(s), size, age, years practicing traceability)
3. How do you track and trace products? [*Prompt: breadth and depth of information you generate, store and transfer, technology used*]
4. Can you elaborate on the disruptions faced in your firm and SC? [*Prompt: sources, frequency, impact on your operations*]
5. What strengths/ structures do you have in place to prepare, contain and recover back to your normal status or even a better position after a disruption?
6. Do you rely on or support your SC partners to enhance your SC's preparedness for and/or recovery from these disruptions?
7. Do you feel traceability gives you a better control over the risks and disruptions across the SC?
8. How does your traceability system interoperate with that of your SC partners to improve your resilience against risks and disruptions?
9. Do external stakeholders, such as governmental agencies and NGOs, play any role to complement the efforts of SC actors in relation to traceability systems? If yes, elaborate.

Interview Questions for Regulators

1. General respondent information (position, years in company, years in role)
2. General organization information (name, location(s), size, industries covered, responsibility in AFSC)
3. What does your role entail in the cocoa/fruit supply chain?
4. How do you ensure SC actors comply with agreements/regulations/standards?
5. Can you elaborate on the disruptions faced across the SC?
6. What strengths/structures do you have in place to identify and communicate breaches along the SC?
7. Does traceability facilitate the prevention, or expedite the response to, compromises along the SC?
8. How do you enhance inter-firm traceability systems to facilitate real-time tracking and monitoring to limit the delivery of unwholesome food products to consumers?

SUPPLEMENT 2 – Summary of the risks and SCRes strategies identified

Category of Risk	Risk/Threat/Disruption	Impact/ Outcome	SCRes Strategies
Risks Internal to the Supply Chain – *Risks caused by conditions within the boundaries of the SC*			
Production Risks – *Risks that cause a variation in the expected quality and/or volume of output.*	Inputs risk*, weeds, pests and disease outbreak, theft, high production costs, deforestation*	Crop losses – low productivity Poor quality raw materials Increased health and safety risks Price fluctuations of inputs High labor turnover Unenthusiastic employee behavior	Enhanced proximity, backward integration, supplier development, collaboration, coopetition, enhancing traceability, risk management culture, improving visibility, technology adoption, multiple sourcing, improving flexibility, improving velocity, contingency planning, quantity limits, redundancy, sustainability, stakeholder engagement,
Logistics Risks – *Risks that disrupt the flow of food materials and processed food products in the right quality and quantity across the SC.*	Poor road network, road traffic congestion, inadequate temperature-controlled compartments on cargo planes, high cost of transport and storage, limited warehouse/ storage space, wrong labelling, in-transit risks*	Product damages Product theft Delayed or wrong deliveries	Enhanced proximity, demand and supply planning, collaboration, stakeholder engagement, enhancing traceability, improving visibility, technology adoption, staff training & motivation, scheduling, outsourcing, product recall management, improving flexibility, improving velocity, redundancy, contingency planning
Processing Risks – *Risks associated with the series of activities that prepare and treat cocoa beans or fruits into products for consumption or further processing.*	Limited cold storages, concealment of product condition, machine and equipment breakdown, dishonest employees*	Inconsistency in quality of products Frequent need for machine and equipment repairs and replacements Low production volumes Increased risk of contamination Increased production costs	Demand and supply planning, collaboration, coopetition, enhancing traceability, risk management culture, improving visibility, technology adoption, staff motivation and training, scheduling, sustainability, supplier development, improving velocity, product recall management, redundancy, contingency planning
Risks External to the Supply Chain – *Risks that originate from events/conditions outside the boundaries of the SC that have a direct impact on the SC's performance*			
Geo-political Risks – *Risks associated with policy decisions and political factors that impact business activities that occur within a geographical location.*	Unfair competition*, geographical location*, smuggling*, power outages, corruption, policy and regulatory risk*, drought, floods, bushfires, weak legal system, COVID-19 directives	Bureaucratic procedures disincentivizes and limits expansion Negative perceptions of African firms Short tenure of policies	Supplier development, enhanced proximity, backward integration, demand and supply planning, advance contract agreements, collaboration, coopetition, stakeholder engagement, enhancing traceability, improving visibility, staff motivation and training, sustainability, multiple sourcing, product recall management, risk management culture, improving visibility, improving flexibility, redundancy
Economic/ Market Risks – *Risks associated with the uncertainties of changes in economic and market conditions that negatively affect global firms.*	Price volatility, demand and supply variability, contractual breaches*, fluctuating exchange rates, unstable interest rates and taxation	Reputational damage Low profitability Unable to compete internationally Cheaper imported substitutes in the local market	Supplier development, backward integration, demand and supply planning, quantity limits, advance contract agreement, collaboration, coopetition, stakeholder engagement, enhancing traceability, risk management culture, improving visibility, technology adoption, multiple sourcing, improving flexibility, improving velocity, redundancy, contingency planning
Socio-cultural Risks – *Risks that arise from the societal and cultural context in which the SC operates.*	Poverty, illiteracy, informal sector*, informal labor practices*, insecure land tenure system*, inadequate social infrastructure, customs and religious beliefs	Limited knowledge of international food standards Limited access to finance to expand Unable to afford certification to access global markets Inaccurate records Buying counterfeit inputs Loss of farmlands Traceability issues	Collectivism and solidarity, dispute resolution, financial inclusion

SUPPLEMENT 3 – Traceability as a direct and indirect enabler of supply chain resilience (SCRes)

SC Tier	Product(s) & Processes traced	Identifier	Benefits of Traceability	Impact on SCRes
Cocoa Case				
Farmers	Dried cocoa beans • Routine farming activities • Chemicals used (date, type, and quantity) • Geomatic records for yield estimation • Volume (quantity) of cocoa beans supplied	Passbook	Farm mapping helps provide information on the location and size of farms (CF3)	Traceability
			Providing evidence to the responsible regulatory bodies (CF1-3)	Collaboration
			Sharing information with other/new farmers to raise awareness on activities within the SC (CF1-3)	Coopetition
			Identifying collective interests when joining/forming farming societies/cooperatives (CF1-3)	
			Helps verify agro-chemicals to detect counterfeits (CF1-3)	Risk management culture
Licensed Buying Companies (LBCs)	Dried cocoa beans • Registered farmers' information (e.g., location, expected volumes) • Purchasing details (volume, quality, cost, etc.) • Organizing the haulage of cocoa to the designated take-over centers	Identity/Station Mark	Determining the originating farm/society of cocoa beans (CL1-4)	Traceability
			Generating and transferring information on provenance and ethical conformance (CL1-3)	
			Estimating the volume of cocoa beans for the period (CL1-4)	Demand and supply planning
			Setting up purchasing centers and assigning staff to oversee buying activities (CL1-4)	
			Allocating transport and warehouse space for estimated yield across purchasing centers (CL1-3)	
			Identifying the sources of "*not-too-dry*" cocoa beans (CL1-3)	
			Providing evidence fosters trust and confidence among SC partners (CL1-4)	Collaboration
			Supporting regulatory bodies to formulate informed regulations and policies (CL1-4)	
			Supporting other SC actors to detect product issues along the SC (CL1-3)	
			Guiding new entrants on the potential unethical activities within the SC (CL1-4)	Coopetition
			Forming alliances with competitors to organize warehouse space and transport services (CL1-4)	
			Analyzing farming practices to reduce impact on the environment and people (CL1-3)	Sustainability
			Identifying farming community needs when providing social amenities (CL1-3)	
			Allocating more purchasing clerks to busier purchasing centers (CL1-3)	Flexibility
			Providing updated product information as it moves along the SC (CL2-3)	
			Staying up-to-date with the activities of other SC partners (CL1-3)	
Marketers & Exporters	Dried cocoa beans • Receipt & storage of cocoa beans • Allocation of storage units to contract specifications	Marketing Number	Determining the originating farm/society of cocoa beans (CM1-3)	Traceability
			Linking SC activities to the responsible staff (CM1-3)	
			Providing access to farm mapping information to confirm farm information (CM1-3)	
			Estimating volume of cocoa beans for the period (CM1-3)	Demand and supply planning
			Identifying potential cases of illicit trade and putting control measures in place (CM1-3)	
			Convincing customers in pre-contracting to protect against price fluctuations (CM1-3)	
			Determining ideal order limits for customers per period (CM1-3)	
			Allocating appropriate transport and warehouse space for cocoa beans (CM1-3)	
			Supporting the formulation of more informed regulations and policies for the industry (CM1-3)	Collaboration
			Auditing and inspecting LBC activities to ensure conformance (CM1-3)	Risk management culture
			Coordinating deliveries to optimize warehouse space (CM1-3)	Scheduling
			Optimizing offloading time and movement in the warehouse (CM1-3)	

			Identifying community needs and supporting where necessary - e.g., scholarships for deserving children of farmers (CM1-3)	Sustainability
			Analyzing farming practices to reduce impact on the environment and people (CM1-3)	
			Tracking warehouse demarcation to expedite movement in the warehouse (CM1-3)	Flexibility
Processors	**Input:** Dried Cocoa Beans **Output:** Cocoa butter, cocoa liquor, cocoa cake, cocoa nibs • Reconciling received raw materials with associated documentation • Segregation into production lots	Stack Numbers Batch Numbers Lot Numbers	Generating and transferring requested information on provenance and conformance (CP1-4)	Traceability
			Fostering trust and confidence among SC partners (CP1-4)	Collaboration
			Combining efforts to detect product issues as products move across the SC (CP1-4)	
			Involvement in formulating regulations and policies for the industry (CP1-2)	
			Farming societies/cooperatives to enhance the collective bargaining right in transactions (CP1-4)	Coopetition
			Periodic human intervention during automated processing activities (CP1-3)	Risk management culture
			Auditing and inspecting supplier activities (CP1-3)	
			Sharing timely and reliable updates (including pictures) of any issues along the SC (CP1-3)	Improving visibility
			Providing social amenities in farming communities (CP1-3)	Sustainability
Regulatory Bodies	• Inspection & grading activities • Phytosanitary activities	Seal Number Certificate of Inspection	Identifying the officers responsible for clearing/approving SC activities (CR1)	Traceability
			Authenticating farm mapping information on location and size of farms (CR4)	
			Identifying and returning "*not-too-dry*" cocoa beans to the right LBCs (CR1, CR4)	Product recall management
			Facilitating the replacement of damaged cocoa beans when detected (CR1-2)	
			Overseeing the detection of product issues as products move across the SC (CR1)	Collaboration
			Providing cocoa health extension, pest and disease control services for farmers (CR4)	
			Awareness of the adherence of SC actors (CR1)	Improving visibility
			Ensuring farm locations don't encroach protected forests (CR4)	Sustainability
			Regulating the sale and use of agro-chemicals and other inputs (CR1)	
			Identifying unsustainable farming communities to engage chiefs and traditional leaders to support enforcement (CR1, CR4)	
			Collecting used agro-chemical containers (plastics) from farmers (CR3)	
Fruit Case				
Farmers	Fresh fruits (banana, pineapple, papaya, coconut, citrus etc.) • Routine farming activities • Chemicals used (date, type, and quantity) • Harvest details (plot, date, quantity, time elapsed from last chemical application) • Quantity and variety of fruits supplied	Unit Identification	Providing customers with evidence of adherence to agreed quality and safety specifications (FF1-3)	Traceability
			Updating regulatory bodies on any product changes (FF1-3)	Collaboration
			Identifying collective interests when joining/forming farmer societies/cooperatives (FF1-3)	Coopetition
			Enhancing the transparency and visibility of sustainability adherence (FF1-3)	Sustainability
			Phone-calling to keep SC partners updated on products in-transit (FF1-3)	Improving visibility
Packers & Exporters	**Input:** Fresh fruits (whole) **Output:** Packaged fruits • Inspection & grading activities • Disinfection procedure – chemicals used, date, etc. • Packaging to meet specific customer specifications	Traceability code	Tracking product distribution path and status along the SC with unique identity details (FE1-4)	Traceability
			Providing customers with evidence of adherence to agreed quality and safety specifications (FE1, FE3)	
			Identifying alternative sources of fruits locally and from neighboring countries (FE1)	Demand and supply planning
			Allocating stock equitably in times of shortages (FE1)	
			Expediting the identification of unsafe products, and swiftly tracing all affected batches (FE1-4)	Product recall management
			Determining the cause of product safety issues when reported by customers (FE1-3)	
			Identifying capacity building needs of SC partners to meet international market standards (FE1-3)	Collaboration

	• Maintaining suitable temperature in storage and during transportation • Scheduling haulage based on customer locations		Enhancing the transparency of SC transactions to foster trust and confidence (FE1-4)	
			Updating regulatory bodies on any product changes (FE1-4)	
			Providing tailored health extension/ agronomic services for farmers (FE1-4)	
			Supporting the formulation of more informed regulations and policies for the industry (FE1-4)	
			Supporting new entrants and competitors to meet international market requirements (FE1-3)	Coopetition
			Monitoring product status as it moves along the SC (FE1-4)	Risk management culture
			Scheduling human interventions during automated processing (FE1-3)	
			Expediting the identification and communication of risks across tiers (FE1-3)	
			Increased awareness of SC activities and outcomes (FE1-4)	Improving visibility
			Tracking products along the SC to receive feedback from consumers (FE1)	
			Updating product information as it moves along the SC (FE1-3)	
			Setting up machines and equipment ahead of fruit arrivals (FE2-4)	Scheduling
			Estimating processing times, transport and storge space required for products (FE1-3)	
			Accounting for the chemical residual levels in fruits (FE1-3)	Sustainability
			Facilitating the judicious distribution of relief items within farming communities (FE1-3)	
			Enhancing transparency and visibility of sustainability adherence (FE1-4)	
			Volume flexibility – Adjusting output levels in response to demand fluctuations (FE1-3)	Flexibility
			Managing sub-contracted processors in other countries during shortages (FE1)	
Processors	**Input:** Fresh fruits **Output:** Processed fruits (juiced, dried, frozen and canned fruits) • Inspection & grading activities • Disinfection procedure • Organizing customer orders • Processing activities – dehusking, peeling, cutting, churning, etc. • Packaging to meet customer specifications • Maintaining suitable temperature during processing, in storage and during transportation • Organizing haulage based on customer location	Traceability Code	Tracking product distribution path and status along the SC with unique identity details (FP1-4)	Traceability
			Providing customers with evidence of adherence to agreed quality and safety specifications (FP1-4)	
			Identifying alternative sources of fruits locally and from neighboring countries (FP1-2)	Demand and supply planning
			Allocating stock equitably in times of shortages (FP1-4)	
			Overseeing the activities of field officers (FP1-3)	
			Identifying the affected batches, and swiftly tracing to the source to ensure full recovery (FP1-3)	Product recall management
			Identifying the location and withdrawing all batches affected or marked unsafe (FP1-4)	
			Determining the cause of product safety issues and rectifying such issues (FP1-4)	
			Identifying capacity building needs of SC partners to meet international market requirements (FP1-4)	Collaboration
			Transparent SC transactions to foster trust and confidence (FP1-4)	
			Updating regulatory bodies on any product changes (FP1-3)	
			Providing tailored health extension/ agronomic services for farmers (FP1-2)	
			Supporting the formulation of more informed regulations and policies for the industry (FP1-4)	
			Sharing knowledge and resources with new entrants or competitors (FP2-3)	Coopetition
			Monitoring product status as it moves along the SC (FP1-4)	Risk management culture
			Scheduling human intervention during automated processing (FP1-3)	
			Positioning staff at high-risk points to ensure products are safe before final delivery (FP1-2)	
			Communicating risks across tiers (FP1-3)	
			Increased awareness of SC activities and outcomes (FP1-3)	Improving visibility
			Tracking products to receive feedback from consumers (FP1-2)	
			Updating product information as it moves along the SC (FP1-2)	
			Rerouting delivery vans to avoid road traffic congestions (FP1)	Scheduling
			Setting up machines and equipment ahead of fruit arrivals (FP1-3)	
			Optimizing storage space and time required to load and offload vehicles (FP1-3)	

			Computing food waste generated and accounting for its disposal (FP1)	Sustainability
			Identifying community needs and supporting them with appropriate social amenities (FP1-3)	
			Accounting for the chemical residual levels in fruits (FP1-4)	
			Enhancing transparency and visibility of sustainability adherence (FP1-4)	
			Volume flexibility – Adjusting output levels in response to demand fluctuations (FP1-4)	Flexibility
			Scheduling processing times, transport and storge space for products (FP1-4)	
			Managing sub-contracted processors in other countries during shortages (FP1-2)	
			Organizing customer orders to ensure products arrive in their right specifications (FP1-3)	
Regulatory Bodies	• Inspections of manufacturing, packhouse, retail and storage facilities • Periodic market surveillance for non-compliance products • Product verification inspections	Facility Licenses Pack-House Certificate Phytosanitary Certificate	Identifying and withdrawing all processed batches marked unsafe (FR1)	Product recall management
			Collating a database of foodborne diseases (FR1)	Risk management culture
			Monitoring agro-chemical sales to ensure only licensed chemicals are in supply (FR2)	
			Increased awareness of SC activities to ensure adherence (FR1-3)	Improving visibility
			Determining the causes of any high chemical residual value in fruits (FR1-2)	Sustainability
			Collecting used agro-chemical containers (plastics) from farmers (FR2)	

Notes:
Traceability – *Enhancing the ability to uniquely identify a product, trace and communicate its provenance, location, status, composition along the SC to inform all parties of any potential disruption and the source/ location of a disruption.*
Demand and Supply Planning – *Forecasting the expected output/ harvest ahead of the production period and setting it against the expected demand for the period*
Product recall management – *Retrieving/withdrawing potentially unsafe products to control the adverse effects of a disruption.*
Collaboration – *Coordinating efforts, information and resources with other SC actors to plan and execute actions to prevent or respond to a disruption.*
Coopetition – *Cooperating with competitors for mutual benefits such as sharing knowledge and other resources to enhance the reliability of the SC.*
Risk Management Culture – *Continuously monitoring risk-prone activities to prevent disruptions from occurring, ensure early identification and expedite responses to a disruption.*
Improving visibility – *Timely information on the status of processes and products at all stages of the SC to enhance the identification of potential threats and enhance the response to a disruption.*
Scheduling – *Allocating space and resources ahead of product arrivals to maximize space and resource utilization.*
Sustainability – *Ensuring SC operations adhere to the social and environmental requirements, including to prevent risks related to brand reputation.*
Flexibility – *Improving the ability to easily alter operations in response to any unexpected changes within minimum time.*