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## **The impact of the informal sector on supply chains in Africa**

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### **Abstract:**

The informal sector adds a systemic layer of uncertainty and risk for the performance of Food Supply Chains in Sub-Saharan Africa. Based on interviews conducted among all the agents directly involved in the FSCs and international statistics, we analyzed how the informal sector affects five mango FSCs in Burkina Faso in their economic, social and environmental performance. The informal sector accounts for about 30% of the total FSCs value, 67% of the total production, and 99% of the workforce. The lack of statistics, lack of legal compliance, lack of public infrastructure, increases the probability and severity of any given risk and therefore hinders investments. Firms internalize the risks with horizontal and vertical integration, the support of subsidies, or by avoiding the costs of international standards compliance. As a result, we distinguish subsidized resilience from informal resilience. FSCs resilience' in Sub-Saharan Africa will depend on how the level of State intervention, legal compliance and law enforcement will affect the informal sector.

**Keywords:** Informal sector; Risk; Resilience; Food supply chain; Sustainability; Agriculture; Burkina Faso.

### **1. Introduction**

The socio-economic development level of a country is positively related with the informal sector and related challenges (ILO, 2018). This sector also affects the well-being of people (Krishna, 2007). Worldwide, countries are concerned in a gradient depending on its prevalence and intensity (Ohnsorge and Yu, 2021; Schneider, 2005). Most of the world's workforce is in the informal sector: 2 billion workers, or about 61% of all workers, including agriculture, and 50% outside agriculture

(OECD, 2019). The informal sector involves about 4 out of 5 self-employed workers, 1 out of 2 managers, 2 out of 5 employees, and all family workers (ILO, 2014; OECD, 2019).

While the informal economy accounts for one-fifth of GDP and 16% of employment in advanced economies, it accounts for one-third of GDP and 70% of employment in emerging market and developing economies (Ohnsorge and Yu, 2021). The vast majority of employment in Africa (85.8 per cent) is informal (ILO, 2018). Sub-Saharan Africa (SSA) has the highest prevalence of the informal sector in the world, i.e., 60% of total employment and 60% of GDP (Ohnsorge and Yu, 2021, p. 32). As a result: *“Regardless of the nature and causes of informality, countries with larger informal sectors tend to have less access to finance for the private sector, lower labor productivity, slower physical and human capital accumulation, and smaller fiscal resources”* (Ohnsorge and Yu, 2021, p. 31).

In some economies in Sub-Saharan Africa (SSA), informal employment accounts for more than 90% of total employment. Since 2000, both output and employment informality have fallen somewhat, by five and six percentage points, respectively (Ohnsorge and Yu, 2021). In Burkina Faso, in 2015, 95.5% of the workers had their main activity in the informal sector, and virtually all of them (99.3%) in rural areas (ENESI, 2015). Most often they work in Food Supply Chains (FSC). The risks for these FSCs are low as long as they, or FSC segments that employ these workers or managers, remain below the radar of formal rules and regulations (Schneider, 2005).

The informal sector affects the implementation of international standards for sustainable FSCs (GLOBALGAP, 2019; The Council of the European Union, 2007). FSCs dedicated to exports in SSA operate in a context of both a competitive market with the necessity to comply with stringent norms and standard; and the burden of the informal sector. FSCs increasingly need to comply with economic, social and environmental indicators in order to be able to access the international trade system. For example, GLOBALGAP requirements aim to ensure that FSCs are sustainable, safe, and socially responsible, meeting the expectations of consumers, retailers, and regulatory bodies (GLOBALGAP, 2019). The informal sector hinders risk assessment and risk mitigation: the lack of data, the lack of safety nets for employees, or the lack of law enforcement, add uncertainty and risks for the managers to decide to invest or not.

There is a need to assess the informal sector among FSCs because evidence-based policies and investments require a minimum level of information. From an empirical perspective, this sector also adds a systemic layer of uncertainty and risk to the performance of FSCs (Yao and Fabbe-Costes, 2018), which is particularly crucial in SSA. Risk covers strategic uncertainties, operational catastrophes and operational accidents (Franck, 2007). These systemic risks and uncertainties, inherent to the informal sector, affect permanently the overall societal environment in which a FSC operates.

This paper is a contribution to the theory of resilience (Holling, 1973; Walker et al., 2012; Yao and Fabbe-Costes, 2018), in which we add risk-management techniques (Franck, 2007; Ravulakollu et al., 2018). We differentiate “subsidized resilience” concerning firms which benefit directly or indirectly from public or donor support and comply with stringent norms and standards; from “informal resilience” concerning firms operating outside stringent norms and standards. The systemic risk layer, added to the FSCs from the informal sector, contributes to the Risk Based Resilience Assessment (RBRA) Framework (Ravulakollu et al., 2018).

We assess the impact of the informal sector on five mango FSCs in Burkina Faso to illustrate the challenges posed by the informal sector (Rey et al., 2007; Vanni re et al., 2013; Vayssieres et al., 2015). These five mango FSCs were subject to an economic, social and environmental analyses of all their operations in the country (Parrot et al., 2022). To our knowledge, this study is the first of its kind to simultaneously compare five FSCs competing for the same primary product; and to simultaneously consider an economic, social and environmental assessment.

In section 2, we define the informal sector, its causes and consequences, and how it affects resilience. In section 3, we present the methodology for the economic, social and environmental assessments of the mango FSCs. In section 4, we present a product-level, process-level and systemic-level risk assessment applied to the mango FSC. In section 5, we discuss how FSCs cope with systemic risks with “subsidized resilience” and “informal resilience” strategies.

## **2. Conceptual framework**

Export oriented FSCs are subject to international norms and standards. There are also subject to the prevalence of the informal sector which affects their performance.

### **2.1. Stringent norms and standards**

The general requirements of GLOBALGAP for food supply chains cover a wide range of topics (GLOBALGAP, 2019): (1) Legal compliance: all production and supply chain activities must comply with relevant national and international laws and regulations such as certification; (2) Food safety management: the management system must identify and control potential hazards throughout the supply chain, from production to processing and distribution; (3) Environmental protection: the production and supply chain activities must comply with environmental regulations and protect the environment from any harmful practices; (4) Worker health and safety: the production and supply chain activities must prioritize worker health and safety, including adequate training, protective equipment, and hygiene practices; (5) Traceability and transparency: the supply chain must have a documented traceability system that allows for the identification and recall of products if necessary, as well as transparency in communication and reporting; (6) Quality management: the supply chain must implement a management system that ensures the consistent quality of products and services, including appropriate testing and monitoring; (7) Integrated farm assurance: for agricultural products,

the supply chain must follow the Integrated Farm Assurance standard, which covers production aspects such as crop management, animal welfare, and soil management. These requirements aim to ensure that food supply chains are sustainable, safe, and socially responsible, meeting the expectations of consumers, retailers, and regulatory bodies.

By definition, international norms do not impact or interact with the informal sector and consequently FSCs evolving in the informal sector. However, as soon as a segment or more of a FSC steps into the formal sector, it is affected by international certification norms, explaining our attention on Certified and Non-Certified FSCs, especially for organic production and manufacture. For example, in the export-oriented mango FSCs of Burkina Faso, the fruit fly involves stringent international norms and standards when it comes to the exports to the EU.

## **2.2. The informal sector**

The informal sector is known by many names: the underground economy, the shadow economy, or the unobservable economy. Subsistence farming and criminal activities are generally not included in the estimation of the informal sector. We define the informal sector as the production of goods and services by the market that escapes detection in official GDP estimates to avoid (Schneider, 2005, p. 600): (1) paying income, value added or other taxes, (2) paying social security contributions, (3) complying with certain legal labor market norms, such as minimum wage, maximum working hours, safety standards, etc., and (4) complying with certain administrative procedures, such as filling out statistical questionnaires or other administrative forms.

The informal sector provides income and employment opportunities for people who may otherwise be excluded from the formal economy (ILO, 2018). This can be particularly important in developing countries, where formal employment opportunities may be limited. In many cases, the informal sector provides a vital source of income for households and communities, enabling them to access basic needs such as food, housing, and healthcare. Furthermore, this sector can also contribute to the local economy by providing goods and services to the community. This can include informal markets and street vendors, who may offer affordable and accessible products to low-income consumers. These reasons explain why the informal sector prevails in some form or the other, in all countries in the world (Ohnsorge and Yu, 2021).

The informal sector is closely linked to the role of the State, its policy instruments and decision-making for investment. It influences State interventions both ways, weakening State capacity to intervene, thus affecting FSCs; and poor public intervention or corruption strengthening informal behavior.

### **2.3. Risk and resilience**

The international standard ISO 31000 defines risks as the effect of uncertainty to the organizational objectives (Ravulakollu et al., 2018). Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist (Holling, 1973, p. 17). Supply network resilience can be defined as a complex, collective, adaptive capability of organizations to maintain a dynamic equilibrium, to react to and recover from a disruptive event, and to regain performance by absorbing negative impacts, responding to unexpected changes, and capitalizing on the knowledge of success or failure (Yao and Fabbe-Costes, 2018, p. 260).

Resilience differs from the concept of “stability”, which is the capacity of a system to return to an equilibrium after a temporary disturbance (Holling, 1973). Stability refers to a static, and therefore predictable world, in which unlimited natural resources bring minimal fluctuations.

Resilience and stability resonate, on the one side, with norms and standards codified in stable, predictive, contractual frameworks such as GLOBALGAP; and, on the other side, with tacit, informal knowledge which is uncoded and therefore more flexible and responsive to disruptive events (Morgan and Murdoch, 2000). Yet, the more a so-called “stabilized system” is optimized by its users to meet their own objectives, the less resilient the system is in general (Walker et al., 2012). This is particularly true for the agricultural sector in which standardized, conventional knowledge can replace tacit farming knowledge (Morgan and Murdoch, 2000).

Standardized knowledge stabilizes a system, but makes it more vulnerable to disruptive events. In farming systems, it establishes uniform practices, techniques, and technologies, enhancing stability and predictability in agricultural production (Walker et al., 2012). It provides farmers with proven methods and guidelines for cultivation, pest control, irrigation, and harvesting, leading to increased efficiency and yield consistency. However, this standardization also heightens the vulnerability of farming systems to disruptive events.

In standardized farming, reliance on uniform practices creates a monoculture environment, where crops are genetically similar and cultivated using identical methods. While this approach optimizes production and resource management, it increases susceptibility to pests, diseases, and adverse weather conditions (Altieri, 2002). A single disruptive event, such as an outbreak of a new pest or an extreme weather event, can devastate entire crops or agricultural regions due to the lack of diversity and resilience inherent in standardized farming practices.

Farming systems that integrate diversity, adaptive management, and local knowledge are often more resilient to disruptions (Altieri, 2002). Embracing agroecological principles, diversifying crops, and promoting indigenous farming practices can enhance the resilience of farming systems, enabling them to withstand and recover from unforeseen challenges while promoting long-term sustainability.

### **3. Methodology used for the mango FSC in Burkina Faso**

This case study is based on the Value Chain for Development (VCA4D) initiative of the Capacity4Dev EU initiative. This initiative conducts value chain analyses across a range of agricultural commodities and countries in order to appraise their contribution to growth and job creation, considering the sustainability and inclusiveness of these value chains. Regular updates can help creating quantitative baselines, capturing changes linked to investments over time, or understanding the real issues at stake in order to better target policies, strategies, policy dialogue and projects. Each VCA4D study is carried out by an economic, a social and environmental expert from European Universities or Research Centers and a national expert. A standardized methodological framework is provided as a tool for diagnosis, comparison, and monitoring through the valorization of quantitative data and evidence-based information. The framework has a potential bias inherent to the methodologies imposed (financial audits, social scoring and life cycle analysis), which was reduced by the use of complementary methods in Burkina Faso (rapid rural appraisal, cross-cutting interviews, consultation of literature and agronomic analysis). Furthermore, high sample rates were obtained to the extent possible.

This case study covers mango in Burkina Faso. Mango is the fifth most widely produced fruit in the world, reaching around 54.27 million tons in 2021 (FAOSTAT). Most mangoes are traded in domestic or regional markets. Production and world trade for mangoes are not geographically correlated. Latin America accounts for about 45% of world trade despite its relatively small production. Mangoes are predominantly consumed in the production countries and export trade is marginal: exports in the world represent less than five percent of the world production. Africa accounts for 11% of the world production. Concerning West Africa, the share of exports to the European Union (EU) is around 10%, i.e., 30,000 tons a year (Parrot et al., 2022). Despite the relatively small volumes of exports to the EU, the African mango industry has been an example for decades of the successful international integration of thousands of African smallholders and exporters in international and increasingly competitive FSCs (Rey et al., 2007).

The mango tree was introduced in Africa in the 18th century and has been present in Burkina Faso since 1920 (Rey et al., 2006). The favorable environment has allowed its gradual spread, particularly throughout the Sudano-Sahelian zone that includes western Burkina Faso, northern Ivory Coast and Benin, southern Mali and northeastern Guinea. A collective learning process (among colonial institutes, producing countries, farmers, developers, importers, etc.) made it possible to monitor its production (period of the 1940s and 1960s) and then its marketing (1970s) (Tourte, 2013). The commercial take-off was boosted by the improvement of road and rail networks. The arrival of sea freight in the 1980s and the devaluation of the FCFA on 13 January 1994 also increased the exports. Domestic fresh or dried mangoes FSCs not only provide income to farmers and traders, they also provide vital micronutrients to the population.

Burkina Faso is one of the ten poorest countries in the world (United Nations, 2015). It is a landlocked country with no direct access to marketing channels outside Africa. The country is therefore vulnerable to disruptive events. For example, in 2015, the country's main road and railway line was disrupted by the derailment of a train linking Bobo-Dioulasso (Burkina Faso) and Abidjan (Côte d'Ivoire).

The prevalence of the informal sector is particularly high in Burkina Faso. In 2015, 95.5% of employed persons were not declared, 99.3% in rural areas and 81.2% in urban areas. The legal minimum wage has been set by decree since 1986 at 30,684 CFA francs per month (about US\$51) and has not evolved since. The legal minimum wage is actually below the international poverty line (US\$2 per day, 1,215 CFA francs).

Marketing channels that supply continental markets (Morocco via Mauritania, and Algeria via Niger; and Ghana) are located close to or inside areas at high military and political risk. Continental marketing channels are therefore unreliable. To overcome the problem of storage, Burkina Faso pioneered a dried mango FSC in the early 1980s.

In our study, we limit our analyses of FSCs to the last transaction concerning a product and by-product involving a Burkinabe agent (organization or individual) in Burkina Faso. As a result, only the FSC concerning fresh mangoes for the domestic market benefited from a full frame analysis, i.e., from producers to consumers.

Both the formal and informal sector were analyzed, assessing FSCs that comply at least partially with norms and standards and those that do not comply, in spite of existing norms and standards. For example, FSCs that export to the EU must comply with norms and standards. The FSC of fresh mangoes consumed locally in Burkina Faso is mostly informal, and national standards and certification processes exist in the food sector, however their enforcement is not common (Carrico et al., 2021). This implies de facto that no official data and information are available for these informal FSCs. In this study, we distinguish between certified FSCs and non-certified FSCs. Certified mangoes (dried or fresh) exported to the EU comply with norms and standards. Non-certified FSCs (such as the continental and local FSC) do not.

Data were collected in 2017 and covered fiscal year 2016. A total of 86 interviews were conducted among all agents directly involved in the FSCs (farmers, coaxers, trackers, traders, exporters, processors, etc.); those indirectly involved such as 1) advisory services and auditors, 2) policy makers and regulators, 3) health centers and primary schools facing potential health or educational issues, 4) researchers and international organizations supporting the sector. The survey rates among the firms ranged from five percent (farmers) to 100 % (all nine export firms). We examined databases where available.



For the dried mango FSCs, we combined data from the processor's national association and firms' financial audits. For 2016, we listed 57 affiliated operators instead of the 76 generally mentioned in the records.

No reliable information is available to estimate production and local consumption of non-certified fresh mangoes in Burkina Faso. For example, the surface area of mango orchards derived from satellite imagery varies between 33,0701 hectares in 2011 to 80,000 in 2015. Average yields range from two to seven tons per hectare, with a maximum national average of 10 tons per hectare (Diakite et al., 2008; Sanou and Tougma, 2008). For these reasons, we set the total production to be at least similar to that of certified FSCs, i.e., 50,000 tons, for which data are more easily available from official sources (customs, firms, etc.). This approach eases extrapolations for a crop, which, in any case, usually reveals high variations in yield within and between years. We set the total marketed production at a realistic 100,000 tons in Burkina Faso in 2016, divided equally between certified (exports to the EU) and uncertified FSCs (domestic consumption and sales to continental Africa).

#### **4. Results**

In 2016, the total value added of all sub-sectors was estimated at 51 million USD in end-products. Their direct and indirect contributions to Burkina Faso's GDP are 0.5% in current value and 2.9% of the agricultural sector. The contribution of direct and indirect taxes amounts to 2.7 million USD. The export for fresh, dried, or puree exports contribute to 0.6% of the total exports of goods FOB to the European Union.

We studied five mango FSCs in Burkina Faso: 1) the fresh mangoes exported (by boat or by plane) to the EU, 2) the fresh mangoes exported to continental Africa, 3) the dried mangoes exported to EU, 4) the mangoes transformed into of juice and puree and 5), the fresh mangoes consumed locally.

The primary product is fresh mango. There are three main by-products: dried mango, pureed mango, and mango juice. The puree is the raw material used to make mango juice or mixed fruit cocktails. Different mango varieties ensure that fresh mangoes, of competitive quality for exports, are available throughout the harvest season.

Trackers are self-employed middlemen. They ensure that the harvest is properly conducted (harvest techniques, storage on trucks). Packaging stations aim to limit their dependency on trackers through the acquisition of modern orchards or through securing their supplies through contract farming.

Exporters of fresh mangoes target either European markets or continental Africa. Some exporters include sorting, grading, and packaging in their business model, while others outsource this service. During sorting, 60% of mangoes are discarded or rerouted to the other local, and regional FSCs, which are less regarding for fruit quality.

Most drying units benefit from subsidized butane gas and from the systematic purchase of dried mango by NGOs. Dried mango can be “*organic*” (certified) or “*conventional*” (non-certified). Two distinct drying technologies (low or high tech) can be used for processing. The first consists of a traditional low technology package running on butane gas and associated with small production units with low fixed and operating costs. However, the competitiveness of these traditional production units depends on government subsidies for butane gas in Burkina Faso (a 2:1 price ratio vis-à-vis competitors in neighboring countries) and on technical assistance and donor support throughout the FSC. The newly introduced drying tunnels are ten times more expensive in terms of investments but they facilitate the use of sulphites and consequently the marketing of “*visually attractive*” dried mangoes. Sulphiting preserves the color of the fruit, the taste, the nutritional value, and the homogeneity of the slices (shape and dimensions), which is a major attractiveness factor for potential customers. For organic mangoes, sulphiting the mango slices before drying is prohibited.

The only mango juice firm in Burkina Faso was established in 2003. Because the local demand for juice is higher than the company can supply, most of the juice produced is sold on the local market. In 2016, the company employed 130 permanent and 250 seasonal workers. Most of the permanent and seasonal workers are declared with formal contracts.

Wholesalers, semi-wholesalers, and retailers sell mangoes on both local and regional markets. About 30 wholesalers are directly or indirectly involved in the mango FSCs aimed at the local market and continental Africa. Most retailers are women who employ part-time sorters. Generally, and definitely in urban areas, retailers buy mangoes from semi-wholesalers in 60 - 70 kg bags (depending on losses), and sell them in the cities. In rural areas, retailers buy or collect mangoes from trackers and coaxers or directly from farmers.

#### **4.1. The informal sector in the mango FSCs**

The informal sector expresses itself through heterogeneous quality procedures among exporters to detect infected mangoes, the heterogeneous quality controls from dedicated laboratories located in Burkina Faso, and lack of control agents all along the FSCs. A major challenge for the EU export mango FSCs is to comply with stringent norms and standards concerning the fruit fly *Bactrocera invadens*, a quarantine pest in Europe. All the mango FSCs are challenged by the lack of statistics (unknown total production, losses), lack of legal compliance (labor, land access, etc.), lack of public infrastructure (non-paved roads), which in consequence increases the probability and severity of any given risk and therefore hinders investments. In the fiscal year 2016, the total added value of the five FSCs reached around 50 million USD in end products, net of foreign aid (Parrot et al., 2022). They contribute with direct and indirect taxes to the economy (2.7 million USD). Most revenues from the export conditioning and storage firms are declared. The local fresh mango FSC is totally informal. It

accounts for only 30% of the total value of the five FSCs but up to 67% of the total mango trade in volume (Figure 1).

[Please insert Figure 1 about here]

Non-declared workers represent 99% of the five FSCs' total workforce estimated around 28,000 workers, with about 10,000 farmers and 10,000 female retailers. About three-quarters of the workforce is self-employed or working in similar roles such as farming, tracking, or retail. The remaining quarter comprises indirect salaried jobs, of which only about 350 (1% of total employment) are declared and permanent contractors linked to the export of fresh mangoes. Seasonal labor for fresh mango exports to the EU involves approximately 4,000 workers, predominantly women, who are employed for three to four months and paid 1,000 CFA francs per day (about 1.64 USD), just above the poverty line. The retailers may also hire sorters, resulting in further employment opportunities, albeit often undeclared. All of the 10,000 farmers are non-declared farmers. The other specific challenges faced by the mango FSCs in Burkina Faso caused by the informal sector are

#### **4.2. Product-risk**

Mango is a risk in itself. Mango production is unpredictable unless very high-tech and classified techniques are used, as in Brazilian orchards. Orchards only start yielding after several years and annual yields are erratic (Rey et al., 2007; Vannièrè et al., 2013). With proper irrigation techniques, mango trees are most productive between their 7<sup>th</sup> and 12<sup>th</sup> year (with an *off* year occurring every two or three years), followed by a gradual decline in yield.

[Please insert Table 1 about here]

Mangoes have several crop characteristics urge FSC agents to react with risk-mitigation and countermeasure strategies (Table 1). Firstly, perishable mangoes pose logistic constraints for exports and storage problems for sale on the retail market. Processing fresh mangoes into dry mangoes mitigates this issue. Secondly, mangoes are harvested from March to late June in Burkina Faso, making economic and social activity seasonal. Consequently, product diversification is necessary to ensure that machinery operates all year: for example, some firms or local cooperatives producing dried mangoes also add value to FSCs on coconut, cashew nuts, and hibiscus.

Thirdly, sorting mangoes according to their quality and the corresponding markets is another strategy adopted to reduce crop losses and waste: premium class mangoes intended for the EU markets by plane and the rest being dispatched in other FSCs - local market or dried mango.

Fourthly, mango trees are a long-term investment as they only reach their potential production capacity after ten years. In the early stages of tree growth, intercropping with vegetables mitigates investments costs. Mango yield forecasts are also variable and unreliable, making it difficult for

farmers to plan their investments and sales. Product diversification stabilizes farm income (Altieri, 2002).

And lastly, another challenge for mango production in Burkina Faso is the vulnerability to at least 18 fruit fly species, leading to harvest and post-harvest losses that can range from 0% in the early stages of the harvest period to as high as 70% at the end of the season (Vayssieres et al., 2015). The fruit fly *Batrocera invadens* is also a quarantine pest in Europe, highlighting the importance of stringent quality control at packaging stations. Therefore, focusing on early mango varieties can help farmers avoid fruit fly infestations and ensure the quality of their products (Vannièrè et al., 2013).

Mango production in Burkina Faso faces challenges related to perishability, seasonal economic activity, long-term investment, unreliable yield forecasts, and vulnerability to fruit flies. Farmers and other FSC agents mitigate these risks by processing fresh mangoes into dry mangoes, purchasing fresh mangoes from neighboring countries, sorting and dispatching mangoes to other FSCs, intercropping with vegetables, diversifying their product line, and focusing on early mango varieties. Stringent quality control at packaging stations is also crucial to ensure compliance with international trade regulations.

#### **4.3. Process-risk**

Process-risk refers to the process itself, process continuity, and retroactive processes following risk realization (Franck, 2007). In our case, quality control at all levels of the sub-sectors is essential for the FSCs integrated into a competitive regulatory system. For companies integrated in a more social, less competitive model, the guarantee of being able to sell their goods whatever the quality of the product does not encourage the adoption of a quality process.

The rating of some of the risks that directly or indirectly concern the agents is summarized in Table 2.

[Please insert Table 2 about here]

The process risk matrix corresponds to the standard risk matrix in a RBRA framework in which the firms and the FSC can implement corrective countermeasures and mitigation strategies (Ravulakollu et al., 2018).

As stated earlier, the fruit fly *Batrocera invadens* a quarantine organism in the EU, representing the only and most critical threat to the export FSCs, concerning both a product and process risk management. If a single infected mango in a container is detected by EU customs the entire whole content and container are destroyed at the exporter's expense. Beyond the loss of earnings, fruit-fly detection from a single exporter greatly affects the reputation of the entire FSC. Ultimately, recurring fruit-fly contamination of fresh mango exports may result in a ban imposed by the EU. A risk avoidance strategy consists in selecting early mango varieties, biocontrol measures, and early harvests

before the fruit flies affects the economic threshold of the farms. Risk reduction consists in visual quality controls for mango before shipping.

The process risk is also affected by downstream and upstream factors. Mango FSCs face downstream dependencies and need to comply with international norms and standards to access international markets. For example, paragraph 1 of Article 113a of the European Council Regulation states that: *“The products of the fruit and vegetables sector which are intended to be sold fresh to the consumer, may only be marketed if they are sound, fair and of marketable quality and if the country of origin is indicated”* (The Council of the European Union, 2007).

Mango FSCs also face upstream dependencies, such as the seasonal availability of mangoes, which varies from one year to another (due to the erratic annual yield levels). Middlemen also compete for access to mangoes when demand exceeds actual supplies. The traders in the mango FSCs also depend on suppliers (trackers) of fresh mangoes and on farmers, who in the absence of contract farming, are not locked-in with a single buyer. Export oriented FSCs also depend on energy subsidies by the government and technical assistance, and auditing costs paid for by donors.

#### **4.4. Systemic risk**

All the above-mentioned product and process-risk can be aggravated by the prevalence of the informal sector. A first implication is by definition the absence of or access to data, and therefore the absence of information. This constitutes a loss of decision power for FSCs managers.

A second implication is precisely the opposite of GLOBALGAP and certification requirements: the informal sector has no requirements on legal compliance, food safety management, environmental protection, worker health and safety, traceability and transparency, quality management; and on insurance.

A third implications of the informal sector is the lack of public infrastructure (roads, access to energy) and public services (water, energy, ...) (Sumberg, 2005). For example, the installation of cold rooms for the storage of perishable goods requires not only a constant source of energy, but also an available and qualified maintenance service. This results in poor quality equipment and services for the transport, equipment and service sectors. We identified that two factors mainly affect the environmental impacts of value chains: distance and technology. In Burkina Faso, mango FSCs mainly use obsolete and poorly maintained trucks over long distances. The absence or the weakness of government support for technology, and the absence or weakness of quality control, affect the environmental impacts of all value chains (Parrot et al., 2022).

A fourth implication of the informal sector is that, in the absence of social safety nets or insurance, the probability and severity of a given disruption or risk increases. Studies in India, Kenya, and Uganda, countries where the informal sector is largely entrenched, found that the illness (HIV, malaria) of the

head of the household, often the main provider of resources, is likely to drag his or her entire family into poverty (Krishna, 2007). Workers without social safety nets or insurance poses a social threat to the sustainability of a FSC.

## **5. Risk-mitigation and resilience strategies**

Most firms in the FSC respond to risk and disruption with absorbing, responding, and capitalizing capabilities (Yao and Fabbe-Costes, 2018). We identified three resilience strategies in which these capabilities operate.

### **5.1. Vertical and horizontal integration**

Vertical integration strategies refer to the process by which a company integrates a particular function or process into its own operations, rather than outsourcing it to a third party. In the case of mango, foreign investment is compensating for the informal sector by “internalizing” the functions of all links in the chain, from production by so-called modern orchards (irrigation, maintenance, pruning, inputs) to processing and marketing. In Burkina Faso, one or two international firms in the mango industry are securing their supply chain by combining orchards of their own, and all the manufacturing processes for exports.

Horizontal integration strategies refer to a diversification or merger strategy in a specific stage of the FSC. Because mango is a seasonal fruit in Burkina Faso, dry mango manufacturers incorporate other crops (such as coco) to take the maximum advantage of their machinery all-year long. This is true for the manufacturers who are not totally subsidized. The manufacturers who are totally subsidized are not encouraged to operate their machinery off-season.

Vertical and horizontal integration reduces risk-exposure for the firms in a FSC. It illustrates complex, collective, adaptive capability of organizations in the supply network to maintain a dynamic equilibrium (Yao and Fabbe-Costes, 2018). This integration can also expand beyond the boundaries of a FSC and the firms’ processes, in particular when public services and State intervention are insufficient. Firms then need to invest and compensate for deficient public services. FSC private sector agents adopt vertical and horizontal strategies in order to obtain better access to finance, higher labor productivity, faster physical and human capital accumulation, and larger fiscal resources.

### **5.2. Subsidized resilience**

Subsidized resilience can be defined as a concept where financial support or incentives are provided by governments, organizations, or institutions to encourage the development and implementation of measures that enhance resilience against various challenges or risks. In Burkina Faso, between 2014 and 2017, USD 40 million were granted to the formal FSCs by the International Development Association of the World Bank alone (World Bank, 2017).

Subsidies in agriculture provide resilience by supporting FSCs with financial support, particularly in times of economic hardship or when they face challenges such as natural disasters or low market prices. Subsidized resilience highlights the role of formal institutions and rent seeking strategies in economic theory: boosting production by making it financially viable for farmers to invest in their operations, such as purchasing new equipment, improving infrastructure, or adopting new technologies. Government subsidies, such as in the EU or in the USA, help to keep FSCs in business and maintain a stable food supply.

Subsidized resilience also highlights rent seeking strategies. The FSC for dry mangoes was profitable in 2016, only because it is subsidized and dependent on the purchasing strategies of Non-Governmental Organizations (NGOs) and donors. In Burkina Faso, 3 NGOs and donors alone purchased 71% of the volume of dried mangoes produced in 2016, with almost no regards concerning product-quality. In consequence, part of the dry mangoes prepared for export had to be unpacked, checked for quality, and then re-packed. Also, most drying units benefit from subsidized butane gas and they depend on these subsidies to remain competitive on the West-African market. (a 2:1 price ratio vs competitors in neighboring countries). Subsidies can also have negative impacts, such as distorting trade and market prices, and can sometimes lead to overproduction and environmental degradation.

Subsidies, public and donor supports provide stability in the FSC, with minimal fluctuations to disruptive events. Formal rules, codified knowledge, norms and standards also provide stability and predictability in the system (Morgan and Murdoch, 2000). But the observed resilience is dependent on external factors: if subsidies stop and changes in formal rules evolve drastically, then the overall system is in jeopardy.

Such stability, dependent on external factors, stabilizes and optimizes the system by its users to meet their own objectives, but the system is therefore less resilient (Walker et al., 2012). Such stability may therefore weaken its capability to learn from the experience of disruptions.

### **5.3. Informal resilience**

We define informal resilience as the ability of individuals, households, FSCs, and communities to cope with and adapt to adversity and change without relying on formal systems or external support. It encompasses the informal networks, relationships, and practices that people use to manage risk and uncertainty in their daily lives and operations. By relying on informal systems, FSCs find creative and effective ways to cope with risks and disruption and maintain their well-being, even in the face of significant uncertainty.

From an economic perspective, informal resilience highlights the marginalization of formal institutions in economic theory as it seeks to avoid paying income, value added or other taxes, (2) to avoid paying social security contributions, (3) to avoid complying with certain legal labor market

norms, such as minimum wage, maximum working hours, safety standards, etc., and (4) to avoid complying with certain administrative procedures. It reduces the costs of a FSC to comply with norms and standards as in GLOBALGAP: legal compliance costs; food safety management costs; environmental protection costs; worker health and safety costs; traceability and transparency costs; quality management costs; and integrated farm assurance costs. Informal resilience is important when formal systems such as public services, social safety nets, or formal financial institutions are not sufficiently available or accessible. Public infrastructure can also be insufficient or inadequate, such as unpaved roads and energy providers. Informal resilience also reduces to costs of social security contributions and the costs of complying with administrative procedures.

From a social perspective, it is challenging for young people, women, and migrants to acquire land for establishing their orchards. Although a Land Law has been passed to ensure fair access to rural land, it is not effectively implemented, and State services are not available to assist with the process. Most land transactions occur outside the scope of statutory law, which is unfavorable both to women, youth and migrants, and to the Land Law. Consequently, land conflicts have been on the rise.

Child labor illustrates the tension between international standards and traditional values. In Burkina Faso, although primary and secondary school attendance is mandatory, the International Labor Organization estimates that in 2006 nearly one-third of children between the ages of 5 and 14 were working - in most cases with their families - in rural areas (ILO, 2014). During our study, child labor was mentioned in a few villages during the mango harvest, up to 10% of primary school children missing school to harvest mangoes. During this period, girls become street vendors of mangoes to help their mothers. But these data remain unclear. Controversy continues to surround children's extracurricular activities, which are considered by some as a family and cultural event, and by others as hidden labor. Interestingly, several testimonies among women in export FSC revealed that, despite formal paychecks just above the poverty lines, they were proud to be recognized as salaried workers and "part of the formal system".

From an environmental perspective, two factors affect significantly the environmental impact of FSCs: distance and technology. The distance for the flow of goods and the corresponding technology of transportation used affects greenhouse emissions. Most flows in the FSCs in Burkina Faso and in SSA involve long distances and old trucks. The lack of public transport infrastructure (paved roads), public service (technical and safety inspection) aggravates the environmental impact of FSCs but improves the resilience of the local FSCs. Similarly, the use of subsidized butane gaz reduces the costs of energy for the low-tech driers in Burkina Faso, but it has more negative environmental impacts compared to the electric technology.

As well as for vertical and horizontal integration, most agents of the FSC, mostly farmers and low qualified workers, display an adaptive capability, an agility, to maintain a dynamic equilibrium from



disruptive events (Ravulakollu et al., 2018; Yao and Fabbe-Costes, 2018). On the other hand, the informal sector comes along with a high societal cost: in an economic (absence of income, value added or other tax contribution), social (absence legal labor market norms), and environmental (long distances and poor technologies) perspective.

In conclusion to this result section, certified and non-certified FSCs illustrate the interactions between formal and informal strategies to international norms and standards. Informal and subsidized resilience display different challenges to the agents of the FSCs and to the regulatory role of the State in their economic social and environmental perspective.

## **6. Conclusion**

Credit should be given to African FSCs as they operate in a very challenging environment. The sustainable practices applied in these FSCs will largely depend on the future of the informal sector. Recognizing and assessing the magnitude and impact of the informal sector on any given FSC is a first step towards reducing its negative impacts.

The mainly informal mango sector is an issue of concern in Burkina Faso: at least a third of its added value is not declared and 99% of their 28,000 work-force does not benefit from a formal and declared contract. Large segments of the FSCs escape from international and national norms and standards. The informal sector accounts for about 30% of the total FSCs value, 67% of the total production, and 99% of the workforce.

The main limitation of this study is the difficulty to rigorously quantify risk, risk mitigation, and concepts such as resilience in a RBRA framework considering the strong prevalence of the informal sector. However, this case study is a first step to investigate, quantify, and analyze a set of five FSCs competing for the same primary commodity in such a context. It also managed to analyze their respective economic, social and environmental risks and performance in a comparative approach. As a result, it provides a first valuable “sustainability” quantitative assessment of the impact of the informal sector on resilience.

The implications of this study are three-fold. First, it brought to light informal FSCs with quantitative data and treated informal FSCs as equal with more formal FSCs. Second, as a result, this study is a contribution to the theory of resilience and the supply network resilience approach, with the different forms, styles, and types that resilience can adopt through integration strategies, subsidized strategies and informal strategies. Third, the simultaneous economic, social and environmental assessments provide grounds for future panel surveys and a “sustainability” approach to the resilience assessments of FSCs.

The informal sector affects a society and the FSCs in which they operate. The challenges posed by the informal sector are those of responsibility: the citizens, the State, the firms, the managers, the

employees, and the consumers. An explicit policy recommendation would be to both apply and comply with the existing laws. Questioning the future trends of FSCs is questioning those of economic development in Africa, that is, the commonly accepted definition of economic development - which is the transition from a ‘traditional’ society to a ‘modern’ society. Therefore, a reflection on FSCs that takes into account different individual and collective contexts also requires a reflection on the individual and collective responsibilities in FSCs.

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Table 1. Mango risk assessment, consequences and potential risk-mitigation strategies for mango food supply chains (FSCs) in Burkina Faso.

<b>Crop characteristics</b>	<b>Consequences for the FSCs</b>	<b>Risk-mitigation by the FSCs</b>
Mangoes are perishable.	Mangoes involve logistic constraints (costs and energy consumption) in the cold chain for exports, and storage problems for sale on the retail market.	Processing fresh mangoes into dry mangoes can resolve the problem of perishability Or purchasing fresh mangoes from neighboring countries (Mali, Ivory Coast)
Mangoes are harvested only from March to late June.	The economic and social activity is also seasonal, which raises the question of economic and social activity outside this period.	Product diversification to ensure the machinery for the transformation of other products operates all year round.
Mangoes have different qualities	Not all fresh mangoes arriving at the packaging stations in charge of sorting and grading for export to the EU do qualify.	Mangoes not qualifying are being dispatched to other FSCs
Mango trees are a long-term investment as they only reach their potential production capacity when the trees are 10 years old.	Mango production is not profitable in the first years after planting.	Intercropping with vegetables in the early stages of tree growth
Mango yields forecasts are variable and unreliable.	Forecasts for investments are also variable and unreliable.	Product diversification to ensure a more stable income
Mangoes are vulnerable to at least 18 fruit fly species identified in Burkina Faso.	Harvest and post-harvest losses vary from 0% in the early stages of the harvest period to as high as 70% at the end of the season. The fruit fly <i>Batrocera invadens</i> is a quarantine pest in Europe.	Stringent quality control at the packaging stations Focus on early mangoes varieties

Source: authors.

Table 2. Process risk-matrix of the mango FSCs in Burkina Faso.

Agent	Risk	Probability	Severity
Farmers	Quality of the trees (aging of the orchards) (note that a tree cannot be torn out)	5	3
	Quality of agricultural practices (pruning, irrigation, plant protection);	5	3
	Quality of the fruits (according to the variety, the sizes, the ripening, the rotting)	3	4
Trackers	Quality of the harvest (cutting, collection, storage in the orchard);	3	5
	Quality of the means of transport (trucks, vans)	3	3
Juice Manufacturers	Quality of transformation processes (machine maintenance, spare parts, electrical standards, following technical instructions)	3	3
Dry mango manufacturers	Quality of handling (loading and unloading of bulk trucks at some processors, washing)	3	3
	Quality of transformation processes (machine maintenance, spare parts, electrical standards, following technical instructions)	3	3
		3	3
	Quality of the contractual relations of the employees?		
Exporters & Packaging stations	Quality of the contractual relations of the employees.	3	3
	Quality of fruit control (according to variety, size, ripening, rotting and especially the <b>fruit fly</b> )	3	<b>5</b>
Wholesalers / Importers	Quality of storage (full sun, on the ground)	3	2
Retailers / Traders	Quality of storage (full sun, on the ground)	3	2
Consumers	Risk of diversion of the national production of the best mangoes to supply other African countries	5	2
State	Quality of public goods: roads, tracks, water, electricity;	5	4
	National and continental logistics (e.g., port of Abidjan)	5	4
	Transaction costs (hassles)	5	4
Input suppliers	Quality of the packaging (damaged boxes) and their supply	4	4

	Quality of the plants (healthy plants for example)	3	4
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Likelihood Rating: Almost certain (5), probable (4), possible (3), unlikely (2), rare (1). Impact: Critical (5), severe/severe (4), moderate (3), lesser (2), negligible (1).

*Source:* Authors.

Figure 1. The share of the local informal mango FSC in Burkina Faso, in volume (2016). *Source:* authors.

