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Management practices to improve the cocoa bean value chain in Sierra Leone: Cocoa bean production in Sierra Leone

Alieu MOININA — Department of Agriculture, Government Technical Institute (GTI) Kailahun, Technical and Vocational Education and Training (TVET), Sierra Leone
Rachid LAHLALI — Department of Crop Protection, Phytopathology Unit, École Nationale d'Agriculture de Meknès, Morocco
Mohammed BOULIF — School of Agriculture, Fertilization and Environmental Sciences, Mohammed VI Polytechnic University, Ben Guerir, Morocco

The cocoa bean value chain creates the largest source of employment and livelihood in the agricultural sector of Eastern Sierra Leone. The present review spans solutions to poor management practices, thereby improving the quality of cocoa beans and, by extension, the income of cocoa farmers. The major problems leading to the low yield of cocoa are unimproved varieties, low soil fertility, inadequate phytosanitary practices, climate change, aging of some plantations, and poor postharvest handling practices. The Sierra Leonean cocoa farmers adopt cocoa agroforestry systems. However, the typology of plantation management practices (climate-smart agriculture, organic agriculture, and conventional agriculture) that influence the cocoa quality parameters remains little known. Fairtrade, UTZ certified (Rainforest Alliance), Ecocert, and USDA Organic are the external certification organizations regulating the phytosanitary requirements of dried cocoa beans in Sierra Leone. The certifications influence the prices of cocoa bean export which remain vague to the farmers. The concise review helps recommend the conceptual framework of the cocoa bean value chain to all actors. There is a need for specific certification skills training courses in the country for proper inspection and audit of cocoa phytosanitary practices.

Keywords: Cocoa production, postharvest handling practices, phytosanitary regulations, cocoa bean value chain, Sierra Leone

INTRODUCTION

Cocoa is one of the main cash crops in Sierra Leone. The country produces dried cocoa beans between 14,000 and 20,000 metric tons per year, with an average yield of 410 kg/ha. In 2017, the country was ranked 17th for both production and area harvested among all cocoa-producing countries because of its poor management practices (FAOSTAT, 2020). The World Bank Trade Statistics in 2017 records Sierra Leone's cocoa export earnings of US$ 14,461 million (EU, 2019) despite the low yield as compared to other West African countries. As a major cash crop, cocoa farming is the main source of livelihood of rural inhabitants of Eastern Sierra Leone.

However, cocoa production in Sierra Leone is confronted with problems along its value chain. Indisputably, the major problems of poor quality cocoa beans in the country are poor research on cocoa quality parameters, sub-standard inputs, climate change, farmer's knowledge and skills in managing cocoa plantation, and inconsistent transparency in marketing. The latter has huge impact

on a cocoa farmer's income as they only become more impoverished (MAF, 2019).

For any disruption along cocoa value chain, farmers become more vulnerable than any other actors in Sierra Leone. Lack of structured good management practices greatly affect the quality of dried cocoa beans from production unit to commercialization unit as a result of the entrance of inexperienced export participants (FAO, 2007). The quality parameters are often imposed on the produce of inexperienced farmers by the middlemen and cocoa export agencies. They provide the necessary quality parameter indicators to farmers in situ of transaction. Moreover, the naivety of most cocoa farmers in marketing of their produce is a source of gross wealth of the middlemen and their associates. Despite the annual inflation in dried cocoa prices, making cocoa agribusiness more lucrative (Oluyole, 2005), Sierra Leonean cocoa farmers incur drastic price discounts because of the little knowledge of grades of their cocoa beans. According to Levai et al. (2015), licensed middlemen companies hardly respect bean quality and buying operations set by farmers.

To avoid the stress from the companies operating on intermediary services, cocoa farmers could sell to anyone ready to buy dried cocoa beans. Appropriate actions are not considered regarding to the quality control of the produce. In Sierra Leone, the aforementioned quality parameters have not been officially reported and made known to farmers. As such, the quality is decided by the middlemen to the detriment of the cocoa farmers.

Another aspect that requires more transparency and technical skills are the cocoa certification schemes in Sierra Leone. Predominantly, organic cocoa farming is practiced with the knowledge to few farmers. Through contract farming between middlemen and farmers, the farmers are supported to produce cocoa beans based on the specifications. The certifications schemes regulating cocoa production in the country are Fairtrade, UTZ Certified (Rainforest Alliance), USDA Organic, and EU Organic (Ecocert). The specifications set by these are not clearly known to both the government authorities and the farmers. As a matter of fact, these certification courses are not introduced in the educational system in Sierra Leone. The certification is only known to the exporting agencies due to the auditing requirements. According to Uribe-Leitz and Ruf (2019), the certification challenges have impeded the improvement of cocoa value chain and farmers' income. Consequently, the hindrance extends to the contribution of cocoa sector to the agricultural GDP.

Through in-depth review of literature, the authors seek to make a conceptual framework of cocoa bean value chain adaptable to the context of both smallholder cocoa farmers and large scale cocoa producers in the world.

COCOA PRODUCTION IN SIERRA LEONE

Cocoa bean is predominantly produced in the Eastern region of Sierra Leone of which Kailahun District accounts for about 114,125 ha, followed by Kenema District (58,086 ha) and Kono District (43,232 ha). It is also commercially produced in Bo District with an area of 11,715 ha (Statistics Sierra Leone, 2017). For the past two decades, cocoa yield in Sierra Leone has been varying on average, between 300 kg/ha to 400 kg/ha (FAOSTAT, 2020) (Figure 1). However, calculated yield in 2019 was higher than 500 kg/ha. Among the major West African cocoa belt, the cocoa yield in Sierra is greater than that of Nigeria and Liberia but closely compared to that of Ghana. Surprisingly, the cocoa yield of Côte d'Ivoire which is the world largest cocoa producing country, has been linearly decreasing in the last decade.

Climate of cocoa-producing region in Sierra Leone

The country has a tropical climate with principally two seasons; the dry season, which lasts from October to March, and the rainy season lasts from May to October. Rainfall levels range between 1,500 mm in the interior areas of the country and 5,100 mm in the coastal areas. According to the interval of rainfall in the West Africa Cocoa belt, the rainfall in Sierra Leone is very favorable for

cocoa production (Schroth et al., 2016). The interior plateaus, mountains and inland valley swamps of the eastern region of the country are suitable for the cultivation cocoa.

Varieties of cocoa in Sierra Leone

Cocoa was introduced in Sierra Leone in the 16th century by the Portuguese sailors. Also, in the early 20th century, there were cocoa varieties from the present day Ghana. Today, Sierra Leone has over 49,000 cocoa farm families which are predominantly found in the Eastern region of the country. Moreover, there has not been any official report on the collection of the cocoa varieties (MAF, 2019). Due to the phenotypic characteristics of cocoa cultivars, Criollo and Forastero are grown in the country. The Amazon variety, which belongs to Forastero varieties, is widely grown in the cocoa-producing districts in Sierra Leone. Even though there is little information on Amazon cocoa in Sierra Leone, the Forastero variety is divided into the Lower and Upper Amazon. Amongst other characteristics, these varieties are known for their vigor growth, large beans, good yields and disease resistance in West Africa (Iwaro et al., 2000). Farmers prefer Forastero variety because of its bigger pods, double bearing per year and yields than the other locally available variety, the Amelonado (Lower Amazon Forastero) (MAF, 2019).

WAYS OF IMPROVING COCOA BEAN VALUE CHAIN

Improving cocoa farmers' knowledge and practices

The low technical skills of the majority of Sierra Leonean cocoa farmers hinder their crop productivity. Training in understanding and adopting good agronomic practices is essential (Figure 2). Plantation management skills, including soil conservation, shade management, pruning and spacing are essential pre-harvest activities which very few farmers can carry out properly (Diawo, 2022; MAF, 2019). Moinina et al. (2018) emphasized on the importance of improving the farmers' knowledge and practices in tree crop production and such practices should be adaptable to the measures against climate change.

Another skills training the farmers should have access to is cocoa certification. The cocoa farmers should know and apply the specification practices of a particular certifying body prior to farming. This opportunity underpins the sustainable income availability through their contract farming as cocoa is a permanent crop. Ruf et al.(2019) and Uribe-Leitz and Ruf (2019) mentioned the challenges that affect cocoa certification procedure and farmers' access to the knowledge and skills. Until the transparent transfer of information and technical skills expected of cocoa farmers are met, the cocoa value chain and its impact on the national economy remain unreliable. Farmers also fail to meet their standard operating procedures because of lack of knowledge and financial means. This has led to early degeneration and early death of cocoa trees which is now apparent in Côte d'Ivoire and Ghana (Wessel and Quist-Wessel, 2015).

The participatory approach training through farmer field school (FFS) should be transparently reinforced so that farmers acquire the desired training. The extension service providers need to convey the rightly information to the farmers with highest professionalism. Demonstration farms should adopt the best practices so that farmers will not hesitate to emulate cocoa production and postharvest management practices. More emphasis should be placed on improving farmers' knowledge on digital information sharing. Witteveen et al. (2017) reported on the usefulness of digital farmer field school (DFFS) in training for improving farmers' knowledge and skills along the cocoa value chain. This type of training is very useful in times of crisis, like the lockdown due to COVID-19 pandemic.

Choice of cocoa production systems

One of the fundamental challenges in Sierra Leonean cocoa industry is the knowledge and

application of a specific production system. The cocoa farmers in Sierra Leone adopt agroforestry system with incorporation of diverse crops in their plantation. However, the choice of cocoa agroforestry management practices such as climate smart agriculture (CSA), organic farming, and conventional farming affect the market value of dried cocoa beans (Akrofi-Atitianti et al., 2018). Massaquoi et al. (2022) highlighted the random use of synthetic agro-chemicals by cocoa farmers in Sierra Leone. Whether knowledgeable or not, an illiterate farmer can use any input at their disposal without considering the negative impacts.

For cocoa beans quality and environmental protection, the cocoa value chain stakeholders should make a consensus with farmers about best cocoa production options and create market for their produce. The production system often comes in consideration during the sales of dried cocoa beans. The classification of agricultural production systems based on agro-chemical input use are organic, conventional and integrated productions. The choice and skills in each of the production systems determine the market. However, because of unstructured productions, farmers could even market their organic cocoa beans at their own losses.

Climate change mitigation and adaptation strategies

Climate change is the major environmental factor that hinders cocoa farming in Sierra Leone. When farming is well structured, cocoa agroforestry will help sink carbon thereby mitigating the harsh impacts of extreme climatic events. Climate vulnerability is globally one of the main limiting factors to cocoa production. Climatic suitability is projected to decline markedly in line with the increase in maximum temperatures, while the more coastal parts of Liberia and Sierra Leone are projected to remain climatically highly suitable (Schroth et al., 2016).

In 2016, the 846,000 ha of the land in Sierra Leone was more that 50% of climate suitability for cocoa production. As projected for 2050, 48,000 ha of that area will be unsuitable for cocoa farming (Schroth et al., 2016) if appropriate climate adaptation and mitigation measures are not taken. Oyekale et al.(2009) emphasized that along the cocoa value chain, climatic variability is one of many factors affecting the growth of cocoa industry. The dry season and wet season do no longer have apparent duration as weather events occur abruptly.

Good mitigation and adaptation strategies will help curb the impediments of climate change to cocoa industry. The climate-smart agriculture in its entirety could substantiate a sustainable solution. In a conformed agroforestry management, incorporation of other crops will help not only reduce the impact of climate change but also diversify a farmer’s income (Amfo et al, 2020; Schroth et al., 2016). Farmers must be aware that the practices that increase climate variability exponentially reduce their income. Most Sierra Leonean cocoa farmers practice organic farming mainly because of their non-access to synthetic agro-chemicals. Therefore, there should be a reinforcement of extension services regarding climate change and farmers’ livelihood improvements.

Improved cocoa seeds for cultivation

Forastero cocoa is the main variety cultivated in Sierra Leone. Aside from the seed selection practiced by the farmers, improved seeds are always imported from other West African cocoa belts. “Amazon cocoa”, “Ghanaian cocoa” and “Ivorian cocoa” are the names coined by Sierra Leone farmers owing to their origin. There has been no official cocoa seed multiplication enterprise in the country. The use of planting material, especially the seeds, should be resistant to disease and adaptable to some climate variations. According to MAF (2019), the market for purchasing seeds is not regulated. As a result, the smallholder farmers receive non certified seeds. This hinders cocoa production in the country. Moreover, little research has been undertaken to develop the cocoa industry.

The agronomic and climatic requirements of the certified cocoa seeds from the other countries

could relatively differ from that of Sierra Leone. Victor et al. (2010) explain that farmers should also be knowledgeable of cocoa seed multiplication once they obtain the adaptable varieties from the sustainable point of view. Furthermore, there is a need for sale of certified cocoa seedlings to ease the production.

Adequate agronomic practices

Inadequate soil fertility in a cocoa orchard is one of the major causes of poor yield of cocoa pods in the tropics. In the early establishment of cocoa seedlings, the soil fertility might be high. With improper replenishment, the quality of the soil will degrade over the years (Ogunlade et al., 2009). Cocoa plant takes in large amount of plants nutrients. If the nutrients are not correctly replenished, this will result in poor growth as well as poor yield. In cocoa agroforestry system, the competition for nutrients is very high and management of soil nutrients has to be a difficult task especially for smallholder cocoa farmers.

The smallholder farmers in Sierra Leone barely apply agrochemical inputs to their plantation. The frequent use of compost and other forms of organic fertilizers will help improve soil fertility and boost cocoa production sustainably. According to Baah et al. (2011) and Ololade et al.(2010), rational application of organic fertilizer in a cocoa plantation will also help control disease and increase yield. The organic fertilizers such as compost manure, reuse of cocoa pod shells after breaking, green manure obtained during under-brushing, farmyard manure are at cocoa farmers' disposal. The reuse of by-product provides a mitigating solution to climate change and also reduce the cost of cocoa beans production.

Main cultural practices such as pruning, under-brushing and rehabilitation should be well scheduled to enhance cocoa plantation management. These practices will help optimize cocoa pod yield. Asare (2006) explicitly links rehabilitation to climate change adaptation and mitigation practices in a cocoa agroecosystem. The practices will guarantee a cocoa farmer's income due to substantive productivity. As the economic lifetime of cocoa trees is between 30 and 40 years, at least 25 year old farms may qualify for rehabilitation. Detailed field trials in ten cocoa districts in Côte d'Ivoire have shown that on sites with 25 to 30 year old cocoa trees, rehabilitation is feasible and profitable (Asare, 2006). It is paramount that the good cultural practices underpin pest control in the plantation.

Integrated pest management strategies

Cocoa production is affected by the infestation of a wide range of pests in the West Africa cocoa belt of which Sierra Leone is located. In Serra Leone, rodents, bats and monkeys are categories of vertebrate pests that attack mature cocoa pods. These pests are very difficult to control in cocoa plantation.

Insect pests have been reported to be devastating in West Africa cocoa belt. The key pests are mirids, mealy bugs, capsids and, moths, weevils and thrips (Wessel and Quist-Wessel, 2015). In Sierra Leone, farmers consider only stored insect pests and cocoa weevil as the pest commonly affecting dried cocoa bean production.

The black pod disease (Phytophthora spp.) is the most commonly identified disease in the cocoa orchards in Sierra Leone. Cocoa farmers are however able to recognize its presence due it the black coloration of pods. This disease is caused by two pathogen species, P. palmivora and P. megakarya (Marelli et al., 2019). The latter species is very endemic to West Africa. Despite its yield loss being unquantified in Sierra Leone, yield loss due to it is about 40 percent and even higher in the sub-region (N'Guessan et al., 2013). Akrofi (2015) highlighted P. megakarya infection on cacao as a threat to the economies of countries in West Africa. The disease can attack all the organs of a cocoa plant. The most destructive part of it is its impact on cocoa pod which will lead to the rotting of the fruit. Viral diseases are not easily reckoned with. However, they can cause great damage,

especially to the cocoa seedlings. A typical example of virus, Cocoa Swollen Shoot Virus Disease (CSSVD) is found in all the cocoa producing countries West Africa (Wessel and Quist-Wessel, 2015). Other phytosanitary problems like witches's broom (Moniliophthora perniciosa), vascular streak dieback (Ceratobasidium theobromae), and monilia pod rot (Moniliophthora roreri) affect cocoa farming (Marelli et al., 2019).

Understanding cocoa pest management along cocoa value chain is fundamental for quality production. The cocoa value chain actors (both public and private) should make concerted efforts in ensuring that farmers apply proper pest management practices. Cocoa certification schemes need to consider knowledge and technology transfer so that farmers should not only be aware of pest problems but also manage them in line with production specifications.

Knowledge of quality parameters of dried cocoa beans

The basic quality parameters of dried cocoa beans are major determinant factors influencing the price. Furthermore, the quality of cocoa products obtained from the manufacturing industries is influenced by cocoa beans (Afoakwa, 2014). Samaniego et al. (2021) and Vigneri (2010) explained the reasons why a cocoa exporting country receives a given price. Cocoa products manufacturing industries consider the good fat content, fine flavor, low moisture content and low impurities in cocoa beans. In addition, Aroyeun et al., (2009) precisely evaluated fungal development and its interest to estimate global quality of raw materials which may be useful to take decision on their potential use.

Guda et al. (2017) categorized dried cocoa beans into two principal grades. Grade I must contain at most 3% of each of the impurities (moldy beans, salty beans, slate beans, and any other impurities). Grade II must not exceed 4% of moldy beans, 6% of slate beans and 8% of any other impurities. Any cocoa beans which are not categorized into the two grades are considered substandard grades. The grading of dried cocoa beans should be done on phytosanitary regulations provided by the government and the exporting agencies.

Good fermentation practices

After cocoa harvesting and pod-breaking, fermentation technique of cocoa beans is the next activity that farmers undertake. A fermentation technique depends on a container at farmer's disposal. Cocoa beans are fermented in heaps, wooden boxes, woven baskets, and bags. Each of these containers and the quantity of the cocoa beans have influence on quality of fermented beans (De Vuyst and Weckx, 2015; Obinze et al., 2022). Cocoa beans need to be fermented adequately for 5 to 7 days before drying to improve the sensory qualities and prevent pest damage (Figueroa-Hernández et al., 2019).

In Sierra Leone, smallholder cocoa farmers often ferment cocoa beans in bags of small quantity in their dwelling places because of theft. It is important to know that small quantity often resulted in higher number of unfermented beans, and thus poor quality of dried cocoa beans (Tunjung-Sari et al., 2021). When fermented in large quantity the quality high temperature and microbial activities will be induced.

Suitable drying techniques

Fermented cocoa beans undergo drying by different methods: direct sun-drying, oven-drying or solar-drying. Cocoa drying process requires the spreading of fermented cocoa beans on tarpaulin, cemented ground (drying floor) or locally woven platform. Lasisi et al. (2014) explain the advantage of sun dried cocoa beans over the oven dried cocoa beans. The former method presents the better quality parameters that cocoa processing industries demand. Alasti et al. (2019), Banboye et al. (2019) and Kongor et al. (2016) add that a cocoa flavor depends on soil type, age of cocoa tree, fermentation, drying and industrial conditioning. Solar-drying method (greenhouse dryers) is more

effective than direct sun-drying because of shorter duration and grade quality. Greenhouse dryers are used by a few number of cocoa companies in Sierra Leone.

The duration of sun-drying process depends on the intensity of sun rays to dry cocoa to below the required threshold of moisture content. Cocoa drying is a crucial process as the beans should be mold-free (Fardkhales, 2014). However, sun-drying process is impeded in the peak of rainy season which can alter the quality of dried cocoa beans in Sierra Leone. Harvesting of cocoa pods occurs in both rainy and dry seasons. Better cocoa pod yield is often expected in the rainy season.

Improved packaging and storage

Storage of dried cocoa beans is another postharvest handling constraint in Sierra Leone. Because of limited storage facilities and other postharvest handling challenges, most smallholder cocoa farmers in Sierra Leone would prefer to sell their produce at the farm gate through contract farming. Sierra Leonean cocoa farmers store their dried cocoa beans in jute bags. Jonfia-Essien et al. (2008) emphasized that the achievement of a country's food security program depends on its capacity to safely store its agri-food products. Safety storage of cocoa beans will help thoroughly regulate prices and avoid some exporting cocoa companies from impoverishing the farmers. Moisture and stored pests should be well managed in a cocoa warehouse.

Transparency in grading and pricing

The cocoa sector requires independent entity for inspection and grading. There has been reports about pesticide use among Sierra Leonean cocoa farmers (Massaquoi et al., 2022) and this practice impacts the quality and pricing of their cocoa beans export. The companies involved in buy of dried cocoa beans from the farmers are aware that price varies according to the system of production and the qualities of dried cocoa beans.

There is a urgent need of structured market for dried cocoa beans so that the contribution of the sector to the agricultural GDP of Sierra Leone would improve. This involves the development of a stringent government policy encouraging the transparent investment in the sector. The cocoa value chain's expansion has started in the country where cocoa powder and cocoa butter are locally processed. Massaquoi et al. (2022) analyzed that there is a high turnover from sales of dried cocoa beans. However, the farmers received relatively half of what the immediate middlemen (cocoa cooperatives and contracted buyers) would benefit. The vague information and lack of transparency affect bluntly the vulnerable illiterate farmers.

Access to agricultural services

The likely approach to improve cocoa farmers' income is by making agricultural services available and accessible to them. The main agricultural services that cocoa farmers need can be specified as follows: skills training services, credit services, credible markets, and reliable information. Both public and private sectors regulating cocoa production and trade policies should create a common platform that support farmers. FAO (2007) precisely stressed on cocoa farmers' desire for skills training that improve the prices of produce and livelihoods.

Skills training in cocoa production and processing at both formal and non-formal level should be accessible to farmers and other cocoa value chain actors. At institutional level, there is no official cocoa certification courses at degree level in Sierra Leone. Those involved in cocoa auditing obtain their training courses elsewhere. According to Diawo (2022), less than 40% of cocoa farmers have access to training. Even as such, the training they undergo is often in the form of workshop which often lasts for less than three days. However, the Skills Development Fund (SDF) project in Sierra Leone has helped develop curricula on certificate and diploma courses in cocoa production and quality control since 2021. These courses have pioneered the skills upgrade of few cocoa farmers, cocoa field supervisors and other service providers in Kailahun District. The government should

make a sustainable platform for the accessibility of the aforesaid skills training to a large number of cocoa value chain actors.

Through the Ministry of Agriculture and Forestry in Sierra Leone, e-extension services were launched in late 2022 to facilitate delivery of agricultural services. The effectiveness of the e-extension services depends on how the stakeholders intend to provide technical and financial support to the innovation program. Elsewhere, Nyarko and Kozári (2020) express concerns that the illiteracy and low living standard of cocoa farmers hinder the use of e-extension services. The knowledge and experience of extension agents in providing technical solutions and transparently delivering inputs to the farmers should be monitored.

There is lack of access to reliable market information. Commercial deals and prices are at best shady, and commodity information including actual market prices is not transparently communicated to producers (MAF, 2019). The stakeholders should fairly ensure credits and improved inputs are at cocoa farmers' disposal.

CONCLUSIONS AND RECOMMENDATIONS

The present in-depth review of literature elucidates the current status and perspectives on cocoa production in Sierra Leone. The cocoa bean value chain in the country has remained unstructured because of related technical and socio-economic reasons. The market has become destabilised with incredible inspection and auditing. Consequently, the cocoa farmers feel vulnerable than any other actors along this cash crop value chain.

Along the cocoa bean value chain, the fundamental problem affecting quality cocoa yield is the technical skills of the farmers. The skills required to apply sequential cocoa production and primary processing practices is channelled through production level, fermentation and drying, and marketing. At the plantation level, the high quality cocoa pod productivity is hindered due to unsuitable planting materials, low knowledge of production system, poor agronomic practices, climate change issues, improper pest control techniques. Occurrence of any of the aforementioned production problems will have a negative impact on the primary processing, and market value of dried beans. At the postharvest handling stage, the problems to reckon with are cocoa quality parameters.

Incorrect fermentation and dying requirements for cocoa beans negatively impacts a cocoa farmer's income. Irrespective of the quality of the cocoa beans, it is worth knowing lack of transparency and insufficient technical services are impoverishing the farmers.

Succinctly, the cocoa value chain stakeholders (both public and private) should implement best management practices and cascade the services to the farmers and primary processors. To this, the cocoa bean value chain framework provides adaptable management practices encompassing cocoa crop. To ensure sustainable cocoa production in Sierra Leone, the country has to make stringent policies in favor of the cocoa farmers.

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