Rubber faming is increasingly becoming common Ghana
Photo credit: CIFOR

CHAPTER 29

Sustainable green economies with tree commodities: the dominant narratives in Africa

Lalisa A Duguma, Peter A Minang, Meine van Noordwijk, Esther Kamwilu, Kennedy Muthee, Dieudonne Alemagi, Serge Mandiefe Piabuo

Highlights

Achieving sustainability depends on reconciling and synergizing several narratives:

- The **diversification** narrative focuses on a risk aversion strategy at the plot, farm and landscape/livelihoods level, at supply chains, processing and marketing stages;
- The **efficiency** narrative focuses on how to maximize the many types of efficiency at farm level, in the landscape and along the supply chain processes;
- The **ecosystem services** narrative looks at strategies to maintain ecosystem services (such as water, biodiversity and climate-related ones) by appropriate incentives that acknowledge farm and landscape level trade-offs;
- The **certification** narrative tries to enforce farm-level compliance to socially and environmentally acceptable standards to match consumer footprint concerns in exchange for a (small) price premium;
- The **political economy** narrative entails that the mentioned problems in commodities have their roots in colonial history and the unequal power relations in commodity value chains between producing and consuming countries that dominate the sectors till today;
- The **governance** (and **policy**) narrative emphasizes the need for policy and regulatory instruments to enforce compliance and also promote sustainable practices that benefit people, businesses, and the environment, based on Sustainable Development Goals.

Duguma LA, Minang PA, van Noordwijk M, Kamwilu E, Muthee K, Alemagi D, Piabuo SM. 2021. Sustainable green economies with tree commodities: the dominant narratives in Africa. In: Minang PA, Duguma LA, van Noordwijk M, eds. 2021. Tree commodities and resilient green economies in Africa. Nairobi, Kenya: World Agroforestry (ICRAF).

1. Introduction

Green economy policies that are meant to stimulate tree crop commodity production in ways that support farmer wellbeing, environmental quality, employment and a national economy would typically consist of regulations, incentives/investment, and a 'narrative'. The narratives rationalize the choices made and are meant to motivate societal parties to all play their part. Tree crop commodities are an important part of the discussion on 'greening' the economy of African countries, as they are an important part of the agriculture-based economy, and they face challenges in matching current environmental and social norms and standards in global trade. Greening the economy is at the centre of a network of 'narratives' that link various contrasting views on tree crops (Minang et al 2022 *chapter 1*) to the economic, ecological, social, and governance aspects of the innovation challenge (van Noordwijk et al 2022 *chapter 3*) of market-based growth, as part of achieving Sustainable Development Goals (see Minang et al 2022 *chapter 2*), as this chapter explores (Figure 29.1).

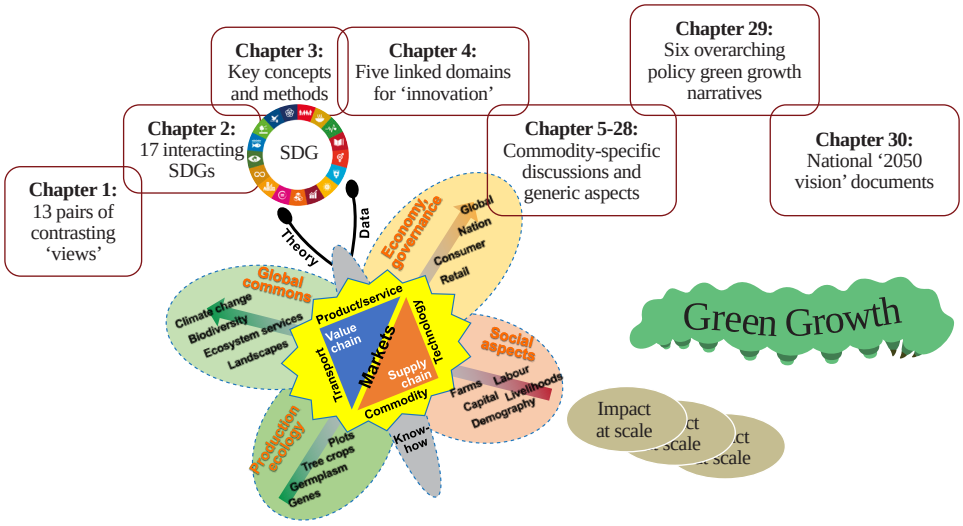

Figure 29.1: *Logical flow and connections across the chapters in the introductory and the concluding sections*

Noting the actions and policies already implemented, this chapter explores narratives and concepts that underlie the pathways to sustainability at various scales and process stages in the tree commodities sector in Africa. Insights into these narratives and deliberate efforts in creating complementarity among them would give a stronger base for the path to sustainability in the tree commodities sector.

1.1. Economic aspects

While Africa's total export value across the commodities considered in this book was 24.8 billion USD/year in the 2016-2020 period (and 46 % of total agricultural exports), the import of these commodities reached 11.6 and the trade balance was 13.1 billion USD (Table 29.1). The imports were, by value, only 13% of agricultural imports. The main imports were oil palm, fruits, coffee, tea and chocolate products, while the trade balance was negative for oil palm and coconut as vegetable oils.

Table 29.1: *FAOSTAT data (averaged over 2016-2020) for Africa for the tree crop commodities discussed in this book and other agricultural products listed in FAOSTAT (2022)*

in '000 USD	Export	Import	Trade balance
Cocoa	9,265,598	783,697	8,481,901
Fruits	7,567,477	2,236,972	5,330,505
Cashew	2,519,116	51,870	2,467,247
Coffee	1,903,274	1,064,518	838,756
Rubber	1,166,977	333,379	833,598
Tea	1,574,469	929,417	645,052
Shea	62,614	7,457	55,157
Coconut	30,320	87,138	-56,818
Oil palm	701,862	6,133,731	-5,431,869
Tree crop commodities	24,791,707	11,628,178	13,163,529
Other agriculture	28,575,245	76,901,921	-48,326,675

While Africa dominated the global export value for cocoa beans, cashew nuts with shell and karite nuts, it contributed around 10% of the global export value for rubber, only 3% for tropical fruits, and only 6% across all commodities combined (FAOSTAT 2022). Yet, tree crop commodities are a major source of government revenue in many African countries. The continent also dominates world production of gum Arabic (reported as a forest rather than an agricultural product). Smallholder farmers in different agroecological zones of the continent are engaged in the cultivation of these tree commodities. In West Africa, for example, cocoa plantations owned by smallholder farmers are responsible for 57% of annual expansion, and in 2013, 6.3 Mha was used for cocoa cultivation in the region (Ordway et al 2017).

1.2. Ecological aspects

West Africa has lost 90% of its original moist forest and what remains is heavily fragmented and degraded (Salzmann and Hoelzmann 2005), due to the expansion of tree crops, as well as annual crop-based agriculture. Contrary to the common deforestation narrative, Leach and

Fairhead (2000) found that in the savanna-forest transition zone, high tree cover tends to be associated with villages and active human management of agroforests, at least in Guinea. This pattern, however, is not the dominant one. Cocoa plantations, among other plantations such as oil palm, rubber and coconut, are the main drivers of deforestation in Ghana and Côte d'Ivoire (Barima et al 2016; Smith Dumont et al 2014). Ghana, in West Africa, has lost more than 2.5 million hectares (Mha) (33.7%) of its forest since the early 1990s (Osei et al 2019, Oduro et al 2015) mostly as a result of the cocoa expansion. The statistics for Côte d'Ivoire are even more alarming, as the country has experienced rapid deforestation since the mid-1950s as a result of tree crop cultivation like cocoa (Leach and Fairhead 2000).

1.3. Social aspects

On the social side, the production of tree commodities in Africa has been associated with child labour. For example, child labour has been reported on cocoa farms in Cameroon, Guinea, Nigeria, and Sierra Leone (Food Empowerment Project 2022). Most cocoa farmers in West and Central Africa earn less than $1 per day, which is an income below the poverty line (Douglas 2018). To this end, they oftentimes resort to the use of child labour to keep their prices competitive (Nestlé USA 2021). The International Labour Organization (ILO) has referred to this as "the worst form of child labour" because it has the propensity to inflict harm on the health of children. Indeed, about 2.1 million children in the Ivory Coast and Ghana work on cocoa farms, most of whom are likely exposed to the worst forms of child labour (ILO nd, Antonie and Friedel 2020). In parallel with the child labour concern, and expressing shared responsibility for the status quo, the discussions on 'living wage' for employed persons and 'living income' for family farmers expressed the relevance of income levels that allow food, health and education to be provided, without a need for child labour (van Vliet et al 2021). It represents a responsibility that consumers should pay a fair price if they don't want to be co-responsible for child labour and exploitation.

1.4. Governance aspects

In response to concerns and issues over the environmental and social consequences of tree crop production, policies and other initiatives (like certification schemes and standards) have been developed to create markets for goods that are sustainably produced under environmentally and socially responsible conditions (Potts et al 2014). Third-party production standards and certification schemes, as well as relevant policies and initiatives, provide a means for companies and producers to demonstrate to brand manufacturers and consumers that commodities have been produced with sustainable practices (Kissinger et al 2015). Classical examples of standards and certification schemes applied to tree commodities include the Roundtables on Sustainable Palm Oil, Soy, and Biofuels; the Sustainable Agriculture Network (SAN)/ Rainforest Alliance

Certification; Fairtrade, UTZ, among others. As Kissinger et al (2015) further opined, certification schemes and standards tend to focus on best practices related to social issues, land use, and agricultural production practices within the production unit (e.g., farm, concession and/or mill). However, they note that some certification schemes and standards incorporate principles or criteria that go beyond the production unit to include biodiversity, livelihood, and/or ecosystem service considerations.

Beyond incorporating certification, further improvements to the current systems are necessary to enhance environmental and societal sustainability. One of these ways is by improving the production stage in the supply chain through the proper choice of techniques that manage environmental impacts. To manage the land, approaches such as intercropping and double cropping have been used to combine export crops and subsistence crops for food provision. Often these combined systems achieve Land Equivalence Ratio's above 1 and as such contribute to 'land sparing' (van Noordwijk et al 2018), even when yields for the tree crop commodities are below the monoculture potential under intensified management. If the tree crop classifies as a tree, such systems can be described as agroforestry. Often, however, the presence of other trees, providing shade, managing microclimate, recycling nutrients and providing fruits, firewood and/or timber, is involved in agroforestry. Such systems are, for example, commonly used in coffee farms, supporting nutritional security for the farmer households. Further increase in total value of these systems can derive from an improved choice of seedlings through research and technology integration, with methods such as vegetative propagation being used to improve the production of existing stands as an alternative to replanting (Muchugi et al 2022, *chapter 13).*

Many of the 'narratives' link across these economic, ecological, social and governance aspects, as the real world cannot be easily compartmentalized. The chapter presents six major clusters in the sustainability discourse and then highlights the entry points that could be facilitated at various scales. It finishes by highlighting the pertinent challenges that need to be addressed by various actors in policy and practice.

2. Sustainability discourse narratives

2.1. The diversification narrative

A commonly used term, agricultural intensification, is surprisingly poorly defined. Where the output (harvestable yield) is used as its primary metric, desirability of intensification may not be contested, but the ways to achieve this are. While popular metrics for 'intensification' refer to 'closing yield gaps '(that means: approximating the potential yield for a given crop in a given climate), it appears to imply that monocultures are efficient 'by definition', rather

than based on empirical data that apply to mixed, diversified systems. The terms 'ecological intensification' and 'sustainable intensification' have emerged in this debate and bring back the focus on 'means' rather than 'targets'. A key ingredient in many ecological intensification debates is 'diversification'.

Diversification as counterpoint to specialization has within the tree commodity space implications for increasing income stability and reducing risks to farmers (Vandermeer et al 1998, Cramer 1999, Barret et al 2001, Sonwa et al 2007, Kassie 2018, Ruf and Schroth 2015, Khasanah et al 2020; Figure 29.2). Specialization is typically associated with a specific perspective on efficiency (see next narrative), retaining or rediscovering diversity with risk management. The diversity paradox, as formulated by Swift et al (2004) points to hugely increased diversity at the level of (affluent) consumers, based on products that derive from less diverse, specialized farms. The current narrative of diversification is mostly focused on field-level diversity (α), farm (β) and landscape/livelihood (γ) levels. However, the diversification agenda is also relevant for steps beyond the farmgate and local markets, along the supply chain to retail and consumers. As depicted in Figure 29.2, diversification can be along 1) field activities where production takes place, 2) households that meet part of their needs from their farm and surrounding landscape, part from further away through markets, 3) market diversification, which embeds options of various markets for the commodities that provide better and fair prices, 4) production mode diversification, i.e., commodities could be grown in various types of farming methods, e.g., forest coffee, garden coffee, full-sun coffee, etc., 5) processing diversification, which may involve various different energy-efficient processing techniques, from hydro-powered ones to solar energy-based technologies.

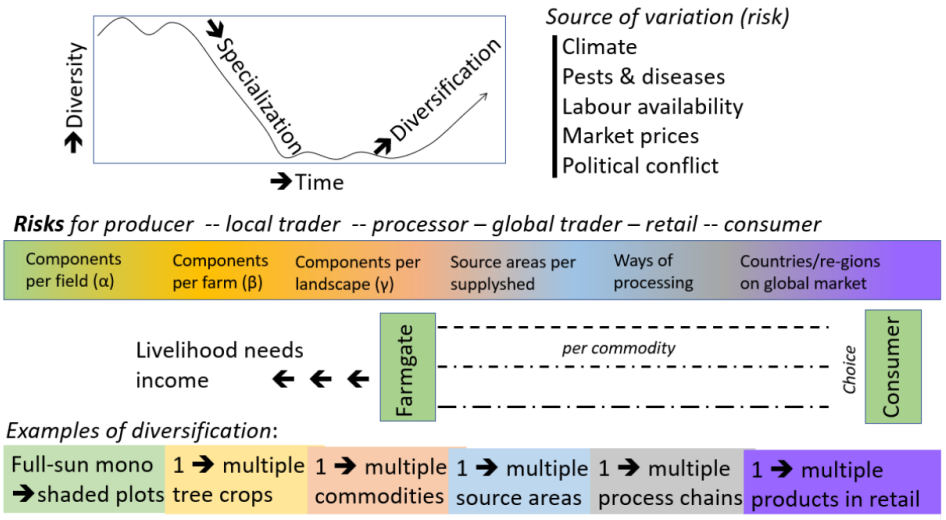

Figure 29.2: *Balance between specialization and portfolio diversification across tree commodity value chains*

Tree-based diversification (Ordonez et al 2014) is seen as a pathway to increase the income stability of smallholder households (Waarts et al 2021), based on the old advise 'don't put all your eggs in one basket'. Risk aversion among the producer communities whose livelihoods are directly dependent on tree commodities can lead them to miss out on profitable intensification opportunities. Market-based insurance schemes can only partially substitute for farm-level diversity, while the profitability of insurance companies suggests part of the benefits accumulate outside the farm. Where diversity may have some costs in favourable years, it provides benefits at landscape and community scale, rather than in capital city markets. Yet, once agronomy is not seen through a single-commodity lens, diversification can help on overspecialized, even-aged monoculture farms. For example, the increasing pressure of 'swollen shoot disease' has increased the need for diversification of trees in cocoa plots to minimize the risks to producer households. Diversification can also help in moving away from techniques and technologies that come with significant social or environmental externalities. For many, the transition from the status quo to a more sustainable and environment-friendly production scheme needs time and it has to be a gradual and scale-based process of integrating those proven to have a positive outcome for people and the environment. That is why the portfolios presented in Figure 29.2 go beyond the usual diversification discourse that is happening at the farm level only.

On another note, diversification of farming systems can also be another way of reducing pressure on the forest, thereby advancing REDD+. For example, it has been established that households with more diverse farms (rice fields and other mixed gardens) in the Kerinci Seblat National Park area in Sumatra, Indonesia, depended less on adjacent national park resources compared to those that farmed exclusively rice (Murniati et al 2001). This and other studies point to diversification through agroforestry as a robust strategy for mitigating climate change by reducing increasing pressure on forested ecosystems (Alemagi and Feudjio 2012). A study in Ethiopia confirmed that food security is highest for households that combine coffee agroforestry, home gardens and mixed food crop systems (Jemal et al 2021).

2.2. The efficiency narrative

Linked to the diversification narrative, but also to the following one on ecosystem services and disservices, there is also a call for enhancing efficiency in the tree commodity sector broadly. Efficiency refers to the ratio of output to inputs and can be applied at many scales. Considerable confusion in the literature derives from the idea that all types of efficiency are linked, and increasing one specific type (for example, closing yield gaps) will have positive effects on all. In fact, 'closing efficiency gaps' in agriculture through more circular agricultural systems is more challenging than 'closing yield gaps' (van Noordwijk and Brussaard 2014).

The emphasis in the efficiency narrative often is to reduce the energy inputs required in production, processing, transporting, and trading, and to minimize wastage at the consumption level, which normally happens at the household or individual level. Such a holistic, footprint-based look at the efficiency along the value chain is less popular but highly important to understand the resources required to deliver a kg of coffee or cacao to the final consumer located thousands of kilometres away (van Noordwijk et al 2022). Table 29.2 describes the classes of efficiency along with some relevant scales at which they are defined.

Table 29.2: *Typologies of efficiencies relevant to various tree commodities*

Efficiency typology	Definition	Relevant scale	Relevant actors	Implications for elements of natural capital
Total factor production efficiency	Farm income per unit cost (land + labour + inputs)	Farms	Farmers, smallholders, commodity farm managers, credit providers	Water, land, biodiversity
Land use efficiency	Harvested yield per unit land area	Farm	Off takers, supply-shed managers, land use planners	Water, land, biodiversity
Land equivalent ratio	Equivalent land area needed to produce all products derived from a mixed system	Landscape	Landscape managers, land use planners	Water, land, biodiversity
Labour use efficiency	Farm result per unit labour	Farm	Farmers, farmhands, trade unions	Deflection of forest use
Processing efficiency	Marketable product per unit raw material harvested	Farm level, association levels, cooperative levels	Farmers, smallholders, plantation farms, associations, cooperatives	Water, land, biodiversity
Trading efficiency	Products sold to retailers per products bought	Company levels, cooperatives	Aggregators, wholesalers, exporters, shipping companies, transport sector, etc.	Energy, water, etc.
Distribution (retail) efficiency	Products sold to consumers per products bought	Retail shops, supermarkets,	Supermarket managers and operators, retail shop operators, transport companies	Energy, water, etc.
Consumption efficiency	Products consumed per products bought	Individuals, households, and other end-users	Individuals, households, and other end-users	Water, biodiversity, energy, etc.
Footprint efficiency	Attributable emissions along the whole chain per unit consumption	Consumer-level products, consumption portfolio's	All of the above	Carbon (greenhouse gas emissions)

Figure 29.3 illustrates the supply chain for coffee, marking points at which efficiency discourses or narratives are crucial. One may even look at the finer scales in between the marked points to reflect on efficiency issues.

Figure 29.3: *The process chain for coffee from the farms to the final processed product delivered to the consumer.*

To further discuss the efficiency narrative, we explore the loss and waste perspective of tree commodities across the value chain. The three distinct levels of loss and waste that emerge are: pre-harvest loss at the production level, post-harvest loss from production to distribution, and food waste at the consumption level. Figure 29.4 illustrates the efficiency narrative in the representation of loss and waste, introducing points of interventions that can be used to reduce the impact of various activities across the value chain.

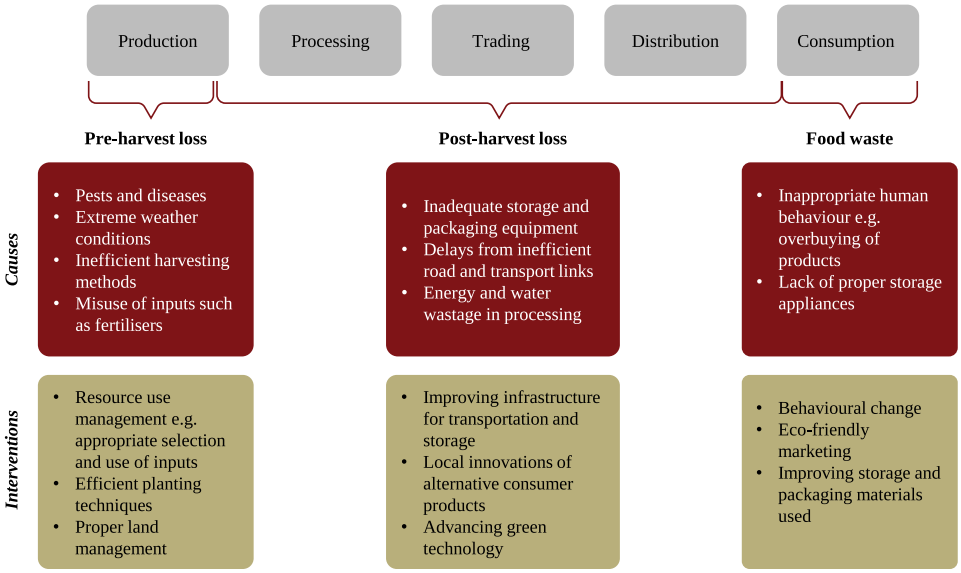

Figure 29.4: *An illustration of the loss and waste in the tree commodities value chain*

Pre-harvest loss is majorly caused by poor production conditions such as soil infertility, extreme weather conditions such as drought and floods, unknown mature indices, pests and diseases, and poor harvesting techniques (Kirigia et al 2017). The pre-harvest, commonly referred to as the production stage of the supply chain, affects the yield (both the number and volume of harvested entities matter) and also contributes to the quality of produce. The average yield of commodities has been low in Africa and negatively impacted the average income that can be earned by smallholder farmers. For example, average cocoa yields in Ghana are estimated at 423 kg/ha and 352 kg/ha in Cote d'Ivoire in 2016 (Bymolt et al 2018). Therefore, efficiency is required to ensure that the productivity within farms is operational at the optimum level; thus, reducing loss of resources and minimizing the cost of inputs. In oil palm, the theoretical maximum number of Fresh Fruit Bunches that could be harvested in one year is around 17, but when more than 11 fruit bunches per tree actually develop, the maximum yield is already achieved (Monzon et al 2022): more bunches means smaller ones (and more labour to harvest them), as internal plant resources become limited and developing fruit bunches compete.

To achieve the efficiency that ensures that maximum benefits are gained on farms, it is important that farmers are aware of techniques that reduce losses and maximize the output of available resources. Therefore, resource use management, such as the appropriate selection and use of inputs, e.g., water, fertilizers, labour, farming machinery, and equipment, is properly incorporated. Practices such as proper irrigation will ensure that the crop and soil health are well maintained. Additionally, efficiency in labour through the incorporation of appropriate equipment could reduce the use of child labour within tree commodity farms. Planting techniques that save water and fertilizers are also essential to reduce the costs incurred by farmers and achieve maximum yields. Furthermore, proper land management will aid in ensuring the conservation of soil and biodiversity within farms. It will also ensure that land degradation is prevented, thereby, reducing the need for deforestation to acquire additional land for cultivation.

Post-harvest loss is a crucial challenge in the global agricultural industry for both cash and food crops. In the 2021 African Agricultural Technology Foundation (AAFT) webinar, it was indicated that Africa loses 100 million metric tons of food each year, amounting to $4 billion (AATF 2021). With the variability of the causes of post-harvest loss dependent on the location, type of crop, infrastructure, and market, among others, pre-harvest loss can occur at all the supply chain stages, except at the consumption level (as shown in the processing chain, figures 29.5 and 29.6). However, the availability of information is limited in the case of cash crops. Post-harvest losses are majorly linked to food production and the effect on food insecurity globally. Additionally, research on post-harvest loss is limited due to the diversity in system activities (Ndaka et al 2012), such as storage, transportation, marketing, and processing. Generally, harvest loss translates into the loss of resources from land, water, energy, and inputs.

Therefore, post-harvest loss is not only a key contributor to food insecurity and loss of income but also bears a considerable debt to the environment. The loss found on the farms reduces the benefits that can be accrued by the farmers, thus, less income for the farmer. Therefore, it is essential that local innovations in recovery are created to allow farmers and processors to reduce losses and gain economic and environmental values.

In 2011, the cocoa sector in Sierra Leone experienced about 20-25% of post-harvest loss (FAO, 2011). Assuming a similar percentage in the 2020 production of 193,156 tonnes (Knoema n.d.), this would show a loss of about 38,631-48,289 tonnes. Furthermore, a study in Kogi state in Nigeria shows the loss of 467 kg of cashew apple per hectare (Oluyole 2016). Despite having limited current data on the figures, it is evident that the post-harvest loss of coffee is affected by the unpredictability of weather, with most of the drying process relying on weather conditions, poor storage conditions, and the reabsorption of moisture and condensation during transport and shipment (Grainpro). Additionally, Wessel and Quist-Wessel (2015) note that high rainfall seasons cause the post-harvest loss of cocoa in West Africa due to insufficient drying and storage facilities. Commodities in Africa are majorly produced for the export market, and in cases where the quality is low-grade, these commodities could be sold in local markets or discarded. Evidence of this can be found in the horticulture industry, where appearance is directly translated to the quality of the products, e.g., fruits with tarnished skins can be considered lower quality. In the case of tree commodities, attributes such as colour are used to determine the quality of the produce, such as coffee beans.

Hence, the concept of efficiency concerning post-harvest loss is crucial to reducing the revenue that can be earned by farmers and countries through intervening to resolve the causes of post-harvest loss and the innovation of local products that utilize the unavoidable losses. To implement this, it is important that knowledge of post-harvest management is extended to actors throughout the supply chain. For example, farmers can be trained in efficient methods of storage and packaging of commodities that are transported to markets. Additionally, the equipment that can facilitate proper storage is crucial to reducing the losses after harvesting and during transportation. Improving the local infrastructure, such as roads and transport links, of communities where commodities are produced is important to reduce delays and losses from the transportation sector. Local innovation is also significant in using unavoidable losses, such as using the rejected produce for exports to make local products that can be utilized in the producing countries. Furthermore, commodity losses can be used in energy generation, such as using coffee pulp from processing to make briquettes, with Kenya as an example (Mugo and Gathui 2010).

With Africa having low consumption rates of tree commodity products such as coffee and chocolates, data is limited on the amount of waste produced at the consumption level. However, it is essential to advocate for the adoption of efficiency understanding among households that consume these commodities. As consumption rates continue to increase, with more targets set for this in the continent, a change in behaviour such as the overbuying of products can be communicated on various awareness platforms, e.g., social media. It is also essential that eco-friendly marketing of products that follow environmental regulations and are healthy for consumers be developed. Furthermore, proper storage and packaging materials that are not only eco-friendly but also protect the shelf-life of the products should be enhanced. The behavioural aspect is what demands intense consideration, noting that the planet is experiencing a large volume of food and commodity products being wasted either on the farms or at the consumption table once processed. Stuart (2009) revealed that consumers in rich countries waste close to 222 million tons of food equivalent to the net annual food production in sub-Saharan countries. Each ton of crop product comes at the cost of inputs, labour, mineral extraction from soil and water, and environmental externalities. Though there is a growing awareness, consumers still barely understand what it takes to get the food on their plates as they tend to feel 'I have paid for it.'

2.3. The ecosystem services narrative

A recently reported experiment with cacao in Peru showed that excluding birds and bats from productive cacao plants reduced the yield by 50% or more ("potentially due to increased abundances of arthropods preying on pollinators or flower herbivores," Vansynghel et al 2022), while exclusion of insects had mixed effects, as it affected pollinators, pests, as well as natural enemies of pests. Part of the 'ecosystem services' provided by functioning agro-ecosystems lead to direct benefits to the farmer, even when they are not recognized as such and are at risk of disappearing if the surrounding landscape changes and/or when the use of pesticides effectively increases pest pressure. Many of the ecosystem services operate at landscape, rather than farm scale, such as the buffering of water flows, maintenance of water quality and function agrobiodiversity, and these are at risk of becoming 'externalities' in farm-level decision making.

Managing the (apparent and real) trade-offs between production and regulating services has been the central discussion for decades among academia, practitioners, and policymakers. Specifically, the discussion on how to minimize the carbon and environmental trade-offs of commodity production has not yielded much fruit to date due to the limited understanding of the mechanisms to design and implement the transformative actions that could change the way production takes place. This is besides the lack of policy level actions that did not help to regulate how commodity production takes place with minimal environmental externalities.

The arguments around coining appropriate incentives to offset such effects have gained more interest, though the understanding of how much incentives could compensate for the losses incurred on the production side due to choices of environmentally friendly production techniques is limited. There is a need to have an in-depth practice level accounting of the services and disservices associated with a given production system. That would effectively help in ensuring what level of incentives could convince producers to change their ways of doing things on the ground. Figure 29.5A (for coffee) and Figure 29.5B (for cocoa) show schematically what the incentive structure looks like when comparing the dominant production systems for the two commodities in Africa. The framing is more focused on the incentives required to avoid conversions of high-value ecosystems to low-value ecosystems with high production benefits.

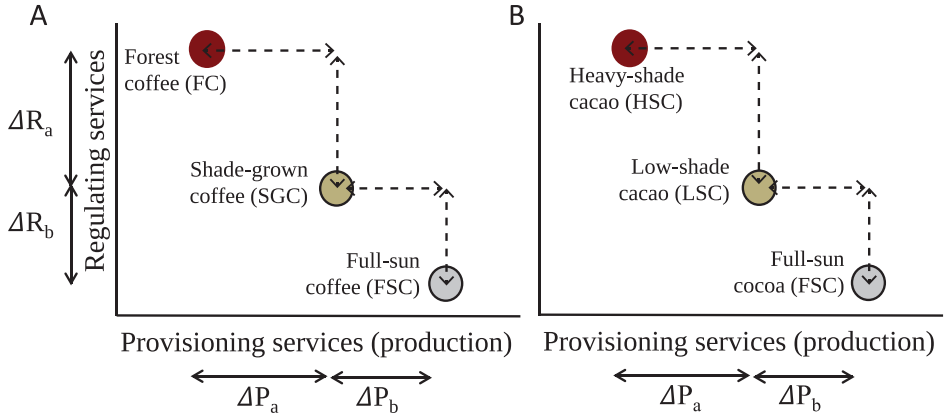

Figure 29.5: *Managing the trade-offs between production and regulating services in A. coffee and B. cocoa systems through properly designed incentives for regulating services at field level*

For a break-even point in economic decision making the explicit loss of value in regulating services R_a R_b) should match the explicit value of (positive) change in production P_a, P_b). Part of the concerns over the loss of regulating services may be expressed locally, let's say with a 'shadow price' s_R. This means a required ratio of the market prices per unit production and regulating services, (m_p and m_R, respectively):

$m_R/m_P > P_a/R_a - s_R/m_p)$ for intensification step 1,

$m_R/m_P > P_b/R_b - s_R/m_p)$ for intensification step 2, and

$m_R/m_P > P_a P_b)/R_{a\ b}) - s_R/m_p)$ for the two steps taken at once.

If, for example, P_a P_b are around 0.5 Mg coffee beans ha^{-1} y^{-1}, and $R_{a\ b}$ a time-averaged C stock of 20 and 10 Mg C ha^{-1}, that is achieved in a ten year period, the break-even carbon price (in the absence of local benefits as reflected in S_R, and ignoring transaction costs) would be four or one times the farmgate price of coffee beans, both expressed per Mg).

The required economic incentive can be achieved by a combination of increased prices for environmentally friendly production systems and direct incentives related to evidence for changes in service level. Price premiums per unit product require certification systems that can be and are trusted along the value chain. Direct incentives require close monitoring of actual changes in regulating services. Neither of these is easily achieved.

In the public debate, the 'baseline' of expectations may be shifting faster than the use of effective policy instruments to achieve them. Early concepts of the relevance of premium prices for environment-friendly production accepted that open-sun monocultures are the default, and as such, are acceptable. Increasingly, however, being 'deforestation-free' no longer qualifies for premium prices but is a requirement for access to markets, such as those in the European Union. Exclusion from these markets serves as a penalty, as less-demanding market segments pay less.

Another aspect to consider is the level of employment that is provided for in the various levels of intensification. As the character of work may change (e.g., increased use of agrochemicals for intensification versus work in pruning shade trees), it may require different wage rates. There may also be consequences along the value chain in jobs related to transport and processing.

Interacting with the ecosystem services narrative is one way of minimizing vulnerability (or active adaptation) to climate change. In many parts of the tropics, a key aspect of climate change is increased uncertainty about and variability of rainfall, which makes the 'buffering' of moisture in soil profiles and at landscape scale (natural or manmade reservoirs and water harvesting structures) a key 'ecosystem service'. Maintaining or enhancing such services is a generic way of avoiding damage by climate change.

2.4. The certification narrative

Mithöfer et al (2017) defined certification as "…the provision by an independent body of written assurance (a certificate) that the product, service, or system in question meets specific requirements". Globally, the need for certification arose as consumers wanted to have some guarantee that the product they consume is not produced at the expense of other people's livelihoods or at the expense of the environment. There were also concerns from the other actors involved in the tree commodity value chains about the backlash they receive due to the negative environmental and social externalities they cause at the source due to a lack of proper regulatory frameworks and or structures. Deforestation, chemical pollution, and loss of native biodiversity and their habitats were among the few environmental concerns voiced by groups advocating for the environment. Low pay, child labour, indigenous communities' rights, and land grabbing were among the few social externalities many advocates have been highlighting for a long time. Third-party certification was then seen as a way of assuring consumers about the good practice embedded in the production process (Ansah et al 2020).

Interesting differences have emerged in the certification patterns for cocoa and coffee (early start, many current privately managed schemes; Arifin et al 2021 chapter 25), palm oil (initially a single effort, currently competing producer-country schemes and many deforestation-related commitments and targets) and rubber (hardly any). As discussed by Leimona et al (2018) these differences don't match the actual difference between the best and worst modes of production (which may, for biodiversity, be highest in rubber), but do reflect the history of public debate, and possibly the way consumers relate to the end-products.

Certification will only be sustainable if there are at least some net benefits for all involved – compared to a baseline of eroding trust, consumer boycotts and conflict, as analysed in Arifin et al 2022. The benefits can consist of any combination of shared knowledge, improved skill, fewer social conflicts, better networking, premium process for increased product quality, less-degrading or rehabilitating ecosystem services, reduced threats to global biodiversity, and a reduced sense of 'consumer guilt'; while the costs include those of registration, compliance monitoring, conflict resolution, opportunity costs of foregone intensification options, and/or a premium price paid. To illustrate, Sanial et al (2019) found that the Rainforest Alliance certification had a positive impact on the yield and income of smallholder farmers in Africa. With certification, there also comes technical and financial support to the farmers, thereby assisting them to adopt a more sustainable production pathway. Fenger et al (2017) and Brako et al (2021) also found a positive influence of certification on Ghanaian cocoa farmers' livelihoods. In fact, Sanial et al (2019) argued that with the expansion of the certification requirements, doors for legal cocoa are increasingly opening allowing for the wider adoption of sustainable production techniques.

For certification to be effective and minimize the associated externalities, acceptable standards are crucial. Standards, as defined by Mithöfer et al (2017), provide requirements, specifications, guidelines, or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose. Though many may not oppose the idea of certification, in general, the biggest challenge remains certification against which standards. For companies, standards that do not restrict their production and profitability schemes are often selected. However, such standards may not be able to lead to a sustainable commodity-based economy for the locals as well as the companies, if seen critically. On the other hand, local producers and communities, including indigenous ones, want standards that ensure their benefits and rights to a larger extent.

Evidence from the past few decades shows that it is challenging to enforce the minimum standards that products ought to have met. It has remained a relative comparison of *product a* versus *product b* rather than an acceptable minimum requirement that *product a* and *product b* should meet in their own contexts. Hence, the definitions of the standards that products

ought to have met remained, in some cases, less relevant. That made the standards remain more general than specific and based on the system level interdependence between the various elements affected and how their interdependence leads to the bigger system collapse. Tayleur et al (2018) emphasized the need for more in-depth details to be collected for the standards to make a valid case for benefiting the people and the environment. Sanial et al (2019) pose a similar sentiment arguing in the case of the cocoa sector in Cameroon, where they ask what the standard for legal cocoa is and who defines those minimum sets of criteria and thresholds which justify legality. The tree commodity sector needs a governance structure and mechanisms that guarantee the agreed minimum requirements are acceptable and do not come at the expense of the local communities.

According to Tayleur et al (2018), most agricultural commodity certifications focus on biodiversity conservation rather than improving the livelihoods of the communities dependent on the ecosystems. In principle, the two objectives should have been accommodated. The comprehensive assessment by Tayleur and colleagues thus proves that the emphasis of the certification was rather the global importance than local relevance to the people affected by the activities. Brako et al (2021) also found that certified smallholder cocoa farmers in Ghana had limited diversification options and are therefore highly vulnerable to production and or economic shocks.

The cost of certification is also another aspect that needs some consideration. For example, Tayleur et al (2018) found that most certifications for agricultural commodities were from areas that are closer to the market and hence export. Potts et al (2016) also noted that most certifications are in advanced and export-oriented economies. Processors and producers targeting domestic or local markets may therefore be reluctant to invest. An important case in this regard is the growing number of oil palm farms in Cameroon, which are expanding because of investment by local urban elites. For commodities with significant local demand, the certification requirements may not make much economic sense since the consumption happens at local levels. This is among the key drawbacks of certification as a key pathway to sustainability since the requirement is largely voluntary, except for export cases. Some are, in fact, using farmer-level certification as a way of gaining recognition for their own companies both domestically and internationally.

2.5. The political economy narrative

Many commodities and their associated problems have their roots in colonial history, and in either the allocation of land to European-operated commercial plantations and/or forms of forced cultivation by local farming communities, with monopolized trade that allowed benefits to accrue elsewhere (Kröger 2014). At independence, many of the private plantations were

nationalized or taken over by local elites, while marketing boards that monopolized global market access were vulnerable to corruption and low performance standards. A political economy narrative begins with this historical perspective and describes the persistence of unequal power relations in value chains between producing and consuming countries that dominate the sectors till today, as well as between farmers, the local private sector and/or national marketing boards. Examples of such narrative are found in the analysis by Odijie (2016, 2018) of cocoa in Côte d'Ivoire and Ghana.

2.6. The governance narrative

The policy narratives around sustainable green economies with tree commodities in Africa are largely coined around enhancing the productivity of the commodities, social equity, and improved human well-being, with minimal environmental risks and ecological scarcities (de Oliveira 2012). However, the prevailing policies at national and regional levels have inadequately addressed externalities associated with the production of various tree commodities in Africa. To illustrate, oil palm production is associated with deforestation and forest degradation across Africa, with countries such as Cameroon, Nigeria, and Côte d'Ivoire reporting high deforestation rates due to oil palm expansion (Duguma et al 2021). From a socioeconomic perspective, existing policy structures have numerous gaps that have exposed children to exploitation through offering free or poorly paid labour. Busquet et al (2021) linked child labour in cocoa farming in Ghana and Côte d'Ivoire to inadequate capital access and protection by the existing policy and governance structures. Furthermore, most African nations have more policy and governance priorities on economic growth through tree commodities than promoting sustainable green economies.

There are several policies and governance pathways to enhance sustainable green economies with tree commodities across Africa. These may include ratification and domestication of international treaties, regulations, and agreements designed for environmental and ecological protection, including REDD+ and Aichi targets, among others. Integrating the international process with domestic and local laws is crucial to ensure that sustainability goals are met locally and aligned with international goals. The certification process is also crucial in ensuring compliance with national and global regulations. To illustrate, palm oil producing countries in Africa can be guided by RSPO in setting their national standards to ensure compliance with global standards (for example, deforestation-free production) while Rainforest Alliance Certificates set standards for coffee (Markne 2016). However, global international standards should consider what is acceptable at local levels as standards, so that the definition and application of standards is a participatory process, taking into account the varied contexts while ensuring coherent aggregation for monitoring purposes. Developing and following national environmental impact assessments and audits is also critical in tree commodities development

to ensure environmental integrity is followed in the production process. Additionally, encompassing research and development as part of national policy and governance is an ideal pathway toward promoting a sustainable green economy with tree commodities. Research and development across the tree commodity value chain ensures maximized productivity and profitability without incurring any externality.

A relevant version of the governance narrative points to the need for a scale between an individual plantation or farming community, and the national scale of policy formulation and international accountability. At this scale, a voluntary multi-stakeholder panel of a 'landscape approach' can interact with the formal power of the lowest levels of local governance with 'jurisdictional' authority (that means: capacity to make and enforce rules). Having first emerged in the context of climate policy and REDD+ debates, there are expectations that at this scale, issues of 'leakage' (e.g. uncontrolled displacement of deforestation pressure) and 'additionality' (agreed reference baseline to judge changes) are more easily handled. The discussion, however, continues.

3. Discussion: Towards connected actors and actions to achieve sustainability in the tree commodity sector

For sustainability to be deeply rooted in the tree commodities sector, there is a need for cross-sectoral collaboration. The lack of sectoral coordination has led to the allocation of thousands of hectares of virgin forest lands, home to indigenous communities and precious biodiversity, for commodity farm expansion by companies. Communities have been displaced in the name of commodity crop investment schemes. Duguma et al (2021) (*chapter 9*) demonstrated the rampant land grab happening in Africa for the sake of expanding commodity plantations. Such challenges of losses of high biodiversity value ecosystems could have been avoided if the ministries responsible for investments and those responsible for the environment had collaborated. Among the notable examples tackling such issues is the One Map Initiative (The One Map Initiative - A Single Land Database for Indonesia - SIG (sig-gis.com)) by the Government of Indonesia, where a single map, maintained across the various agencies with a say in what happens, guides the assignation of a given land for a given purpose and serves as authoritative 'registry'. Such experiences could be brought to Africa and adopted to minimize the risks to native people and ecosystems resulting from the Siloed approach of granting permits and striving to save the environmental and ecological integrity of the ecosystems. However, it is also important to recognize the emerging efforts in the continent too. For example, on climate-smart cocoa in central African countries, forestry and agriculture people began working together to minimize the impact of cocoa expansion on forests (Nasser et al 2020). It is such

cross-sectoral approaches that are bringing to light the strong need for landscape approaches to avert the trade-offs associated with commodity production systems in the continent. Minang et al (2014) argue as a growing platform and pathway towards achieving multi-functionality for the benefit of the people, planet, and climate. All actions and processes associated with the tree commodities in the continent should encapsulate the key features of landscape approaches (e.g., synergies, trade-offs, complementarity and collaboration) to minimize social, environmental and biodiversity damages as well as emissions of greenhouse gases.

Table 29.3 provides the wider schemes of interventions to promote sustainable green economies through tree commodities in Africa. The actions span from individuals to governments, from local governance to international mechanisms of commodity marketing, and from local processing to international consumption behaviours.

Table 29.3: *Potential key entry points for enhancing sustainability in tree commodities for a holistic benefit to people, businesses, and the environment*

Intervention Options	Specific details	Actors	Relevant examples	Some potential policy and regulatory tools
Practice choice	Environment-friendly interventions	Farmers, Commercial plantation crop managers	• Shaded cocoa and coffee rather than full sun cocoa and coffee • IPM adoption than the use of chemical pesticides and herbicides • Composting and mulching, less chemical fertilizers: circularity	• Environmental Impact Assessment (EIA) • Certifications (e.g., FSC, Rainforest, ISCC (International Sustainability and Carbon Certification), etc.)
	Climate-smart interventions	Same as above	• Intensification rather than expansion into forests • Less-mechanised options (reducing emissions from equipment)	• REDD+, FSC certification, ISCC
	Biodiversity friendly interventions	Above actors and conservation agencies	• Practice designs that allow corridors for animal movements • Pollinator and insect-friendly options	Convention on Biodiversity, Rainforest Alliance Certification, Aichi target

Intervention Options	Specific details	Actors	Relevant examples	Some potential policy and regulatory tools
Resource use efficiency	Choice of lands with less competition	Producers, consumers, policy actors	Use of marginal and degraded lands for tree crops than clearing forests	National or local land use policy
	Using 'Good Agricultural Practices' (GAP) guidelines	Producers	Minimizing pesticide use, utilizing biological control options	Localizing GAP guidelines in evolving field practice
	Efficient resource utilisation	All actors	Use of biodigester and solar power for energy	Energy saving certificates
Processing	Waste management	Processors	• Coffee waste for energy generation and biofertilizer • Wastewater treatment in rubber and palm oil processing	Enforcing water quality standards
	Renewable energy	All actors	• Processing plants using renewable energy; • Use of biodigester and solar power for energy	Energy saving certificates, Renewable energy certificates
	Reuse, Reduce, Recycle	All actors	Biodegradable packaging, reusable bottling, etc.	
Marketing	Unfair pricing dominating current market mechanisms at local level	Traders, policymakers	Improved bargaining power through cooperatives and other local institutionalization processes.	Price floors and price ceilings.
Overall Governance	Transparency and corruption free, Child labour eradication, Gender balance, Humane working area	All actors particularly policymakers and managers	• Health benefits to employees • Corporate social responsibility (CSR) by major tree crop producers; • Institutional setup	ILO Minimum Age Convention, 1973 (No. 138), Labour laws, Taxation compliance, Carbon neutrality
Consumption behaviour	Food waste management, Ecological consequences through certification, etc.	Consumers	Tree commodity certification schemes	

4. Steps forward: dealing with persistent challenges to transition to sustainability pathways

Since the first Rio Earth Summit, the agenda of moving towards sustainable production schemes has been the central discussion point in the commodity supply chains – from the farms to the exporters, to processors and final consumers. Despite the gradual increase in awareness of the sustainability challenges that our planet is facing, the adoption of sustainable production systems still faces numerous hurdles, especially in the tree commodities sector. The sector often interacts with climate (GHG emissions), biodiversity, rights, and livelihood issues. The endorsement of the Millennium Development Goals (MDGs) which were gradually replaced by the Sustainable Development Goals (SDGs) has brought much more clarity on what needs to be achieved if our planet's functionality must continue as expected. Nonetheless, the progress is not that promising (Kroll et al 2019). In fact, it is in Agenda 2030 (SDGs) that countries have managed to go beyond the economic growth narrative and embraced a more holistic set of policy goals that cover the economy, society, and the environment in one frame. This came after a lapse of almost two and a half decades since the Rio summit. Relative to this delay, it is not surprising that the move to more sustainable pathways in the commodity supply chain did not take off as expected. Below, we summarized some of the key hurdles in the transition.

1. **Policy bias**: Still, many developing countries and developed countries prioritize economic growth over the whole sustainability achievement across the various frontiers of social, economic, and environmental benefits. Existing policies are thus biased toward the economic attributes of commodities production rather than the broader sustainability targets. Such a bias was not only at the national level but also at the global level. For example, Hulme and Scott (2010) noted that despite the endorsement of the targets, state actions were largely defined by the state interest rather than holistic objectives that were to advance the move towards sustainability.

2. **Weak (or absence of) policy instruments to enforce actions**: Besides global consumers, it is also the responsibility of the public sector to put in place measures that enforce the sustainability standard in commodity production schemes. Many developing countries usually suffer from a lack of capacity to enforce the existing policy instruments. Such countries also do not have strong policies that provide clear strategic guidance and enforcement mechanisms. Such loopholes have been used in some instances. For example, when the production requirements in Asian countries got strict, oil palm companies began migrating to Africa where the regulatory requirements and enforcement are weak or non-existent.

3. Commitment and willingness but lack of action: Many countries and companies are already signatories to many treaties that advocate for poverty eradication and environmental sustainability promotion. However, the activities on the ground do not often reflect the aspirations made in commitments made. For instance, Waarts et al (2021) reported that the various efforts by different organizations have largely failed to achieve poverty reduction among smallholder tree commodity farmers. Furthermore, the ongoing loss of natural forests around the globe has seen so many treaties and commitments, but even now, forest loss is not abated. Among the major causes of this is commodity crop expansion. Hulme and Scott (2010) even noted that the main reason behind the failure of the MDGs in many aspects was the broad rhetoric without clear actions. The same is true with the diverse commitments by companies and countries without substantive concrete actions. Gardner et al (2019) also emphasize the tokenistic problem with no clear action that substantively justifies the adoption of a transformative path to sustainability. For example, many companies and countries committed to minimizing natural forest loss by 50% by 2020 through the New York Forest Declaration. However, that target has not been met as there was no tangible and clear implementation strategy (UN 2014).

4. Data: Companies and producers lack organized, robust data collection to support the comprehensive accounting of ecosystem services that are either promoted or negatively affected by tree commodity production. Getting the in-depth data needed to compute proper compensation is also very costly. As a result, the information used in compliance assessments is of lower quality or incomplete. Kroll et al (2019) noted that the average number of criteria used for standards is declining as companies mainly target mainstream markets where compliance is somehow compromised. Monitoring of the data supporting the sustainability arguments should be done consistently and should be accessible for transparency purposes. Such requirements should be obligatory for accountability and should not be left as a voluntary choice by companies and or producer groups.

5. Knowledge: Limited understanding of the system-level connectivity between production and enabling environmental factors for production. Many companies and commodity supply chain actors may not be knowledgeable about the system-level interdependence of the production aspect, the regulating services that enable the production of commodity crops, and the livelihood of the local communities. If forests disappear from the landscape, the hydrology of the landscape will be disturbed, which subsequently affects the overall commodity crop production. The same is true with the pollinator issue. Many have argued the use of chemicals to control diseases and pests affects the pollinators that are crucial for the production of commodity crops like cocoa and coffee, which rely on insect pollinators.

6. Weak transparency: The current state of supply chain governance in tree commodities lacks transparency, as argued by Gardner et al (2019). Unless mechanisms for improving transparency are appropriately built into the whole supply chain process, those taking dubious approaches to commodity production can never transition to sustainable production pathways.

7. Skewed political economy: Although tree commodities contribute significantly to export share and employment amongst African economies, their contribution to GDP remains minimal. However, these countries are on a trajectory of maximizing efforts in sectors that contribute significantly to economic growth, thus making the sustainability of tree commodity value chains second order. It has been argued that sustainability is more important for processing and distribution companies that capture a large share of the market value. Therefore, to incentivize the national political set-up for prioritizing the sustainability of tree crop commodities like in Indonesia, there is a need to shift market value from overseas markets to national markets through domestic processing and distribution of finished products.

8. Limited funding for tree crop production innovation: For widespread engagement in sustainability programs, the interests of different parties must be met. Governments expect more tax revenue, companies more profits, and farmers more production and profits. Currently, investment in research that leads to innovation on a large scale is limited, making it difficult to test and scale-up production. This is critical because processing companies are operating on a large scale, and current levels of production of certified tree commodities are not up to their scale of production. Thus, they cannot fully engage in this for fear of making losses. Additionally, governments do not want to lose tax revenue from reduced production. Therefore, there is a need for widespread change in production processes, but this must not be at the farmer's expense. It must permit increased productivity per unit area and can go further to exploit crop varieties that can grow on other landscapes, such as degraded savannah.

References

[AATF] African Agricultural Technology Foundation. 2021. Africa cannot afford post-harvest losses; needs policies and technologies to strengthen food security. AATF Website. https://www.aatf-africa.org/africa-cannot-afford-post-harvest-losses-needs-policies-and-technologies-to-strengthen-food-security/. (Accessed on 15 October 2021).

Alemagi D, Feudjo M. 2012. Agroforestry in climate change: Major challenges in the Efoulan municipality of South Cameroon and the way forward. *Annual Report, 2012-2013* of the World Agroforestry Centre, Yaoundé, Cameroun. 32pp.

Ansah EO, Kaplowitz MD, Lupi F, Kerr J. 2020. Smallholder participation and procedural compliance with sustainable cocoa certification programs. *Agroecology and Sustainable Food Systems* 44(1):54–87.

Antonie FC, Huetz-Adams F. 2020. *Cocoa Barometer 2020.* VOICE Network, 2020, Available online at: https://www.voicenetwork.eu/cocoa-barometer/.

Arifin B, van Noordwijk M, Glasbergen P, Ibnu M, Astuti A. 2021. Eco-certified coffee agroforestry in Indonesia: reconciling conflicting goals? In: Minang PA, Duguma LA, van Noordwijk M, eds. 2021. *Tree commodities and resilient green economies in Africa*. Nairobi, Kenya: World Agroforestry (ICRAF).

Barima YS, Kouakou AT, Bamba I, Sangne YC, Godron M, Andrieu J, Bogaert J. 2016. Cocoa crops are destroying the forest reserves of the classified forest of Haut-Sassandra (Ivory Coast). *Glob Ecol Conserv* 8:85–98.

Barrett CB, Reardon T, Webb P. 2001. Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food policy* 26(4):315–331.

Brako DE, Richard A, Alexandros G. 2021. Do voluntary certification standards improve yields and wellbeing? Evidence from oil palm and cocoa smallholders in Ghana. *International Journal of Agricultural Sustainability* 19(1):16–39.

Busquet M, Bosma N, Hummels H. 2021. A multidimensional perspective on child labour in the value chain: the case of the cocoa value chain in West Africa. *World Development* 146:105601. DOI: https://doi.org/10.1016/j.worlddev.2021.105601.

Bymolt R, Laven A, Tyzler M. 2018. *Demystifying the cocoa sector in Ghana and Côte d'Ivoire*. The Royal Tropical Institute (KIT): Amsterdam, The Netherlands.

Cramer C. 1999. Can Africa industrialize by processing primary commodities? The case of Mozambican cashew nuts. *World Development* 27(7):1247–1266.

de Oliveira JAP. 2012. *Green economy and good governance for sustainable development: opportunities, promises and concerns.* Shibuya-KU, Tokyo: United Nations University Press.

Douglas Y. 2018. West African cocoa farmers yet to earn a living income despite sales growth of fairtrade certified cocoa beans. *Confectionary News*. https://www.confectionerynews.com/Article/2018/10/19/West-African-cocoa-farmers-yet-to-earn-a-living-income-says-Fairtrade

Duguma LA, Muthee K, Minang PA, van Noordwijk M, Duba D, Bah A, Piabuo SM, Wainaina P. 2021. The palm oil sector in Africa: the dynamics, challenges and pathways to sustainability. In: Minang PA, Duguma LA, van Noordwijk M, eds. 2021. *Tree commodities and resilient green economies in Africa.* Nairobi, Kenya: World Agroforestry (ICRAF).

[FAO] Food and Agriculture Organization. 2011. *Continental programme on post-harvest losses (PHLs) reduction. Rapid country needs assessment – Sierra Leone.* Rome: FAO. https://www.fao.org/3/au874e/au874e.pdf

[FAOSTAT] Food and Agriculture Organization Corporate Statistical Database. 2022. *Food and agriculture data.* Rome: FAO. https://www.fao.org/faostat/en/#home

Fenger NA, Skovmand Bosselmann A, Asare R, de Neergaard A. 2017. The impact of certification on the natural and financial capitals of Ghanaian cocoa farmers. *Agroecology and Sustainable Food Systems* 41(2):143–166.

Food Empowerment Project. 2022. Child Labour and slavery in the chocolate industry. https://foodispower.org/human-labor-slavery/slavery-chocolate/

Grainpro. *Three post-harvest challenges that affect green coffee beans.* https://news.grainpro.com/3-post-harvest-challenges-that-affect-green-coffee-beans Accessed on 30th May 2022.

Gardner TA, Benzie M, Börner J, Dawkins E, Fick S, Garrett R, Godar J, Grimard A, Lake S, Larsen RK, Mardas N. 2019. Transparency and sustainability in global commodity supply chains. *World Development* 121:163–177.

Hulme D, Scott J. 2010. The political economy of the MDGs: retrospect and prospect for the world's biggest promise. *New Political Economy* 15(2):293–306.

[ILO] International Labour Organization. (nd). *The worst forms of child labour.* https://www.ilo.org/ipec/Campaignandadvocacy/Youthinaction/C182-Youth-orientated/worstforms/lang--en/index.htm

Jemal O, Callo-Concha D, van Noordwijk M. 2021. Coffee agroforestry and the food and nutrition security of small farmers of South-Western Ethiopia. *Front. Sustain. Food Syst.* 5:608868. https://doi.org/10.3389/fsufs.2021.608868

Kassie GW. 2018. Agroforestry and farm income diversification: synergy or trade-off? The case of Ethiopia. *Environmental Systems Research* 6(1):1–14.

Khasanah N, van Noordwijk M, Slingerland M, Sofiyuddin M, Stomph D, Migeon AF, Hairiah K. 2020. Diversification as strategy for smallholder oil palm production: multifunctional land equivalent ratios in agroforestry landscapes. *Frontiers in Sustainable Food Production* 3:122. https://www.frontiersin.org/articles/10.3389/fsufs.2019.00122/full

Kirigia D, Kasili R, Mibus H. 2017. African leafy vegetables pre-harvest and post-harvest constrains and technologies for losses reduction along the field to consumer chain. *African Journal of Horticultural Science* 12:51–60.

Kissinger G, Moroge M, Noponen M. 2015. Private sector investment in landscape approaches: the role of production standards and certification. In: Minang PA, van Noordwijk M, Freeman OE, Mbow C, de Leeuw J, Catacutan D, eds. *Climate-smart landscapes: multifunctionality in practice.* Nairobi, Kenya: World Agroforestry Centre (ICRAF).

Knoema. (nd). *The production of cocoa beans in Sierra Leone.* https://knoema.com/data/agriculture-indicators-production+cocoa-beans+sierra-leone

Kröger M. 2014. The political economy of global tree plantation expansion: a review. *Journal of Peasant Studies* 41(2):235–261.

Kroll C, Warchold A, Pradhan P. 2019. Sustainable Development Goals (SDGs): are we successful in turning trade-offs into synergies? *Palgrave Communications* 5(1):1–11.

Leach M, Fairhead J. 2000. Challenging neo-Malthusian deforestation analyses in West Africa's dynamic forest landscapes. *Popul. Dev. Rev.* 26 (1):17–43.

Leimona B, van Noordwijk M, Mithöfer D, Cerutti PO. 2018. Environmentally and socially responsible global production and trade of timber and tree crop commodities: certification as a transient issue-attention cycle response to ecological and social issues. *International Journal of Biodiversity Science, Ecosystem Services & Management* 13(1):497–502.

Markne M. 2016. *Certifying sustainability: independent oil palm smallholders' experiences of the RSPO certification process in the Riau province, Indonesia*. Available from: http://www.divaportal.org/smash/get/diva2: 898810/FULLTEXT01.pdf. (Accessed 26-05-2022).

Minang PA, van Noordwijk M, Freeman OE, Mbow C, de Leeuw J, Catacutan DC, eds. 2014. *Climate-smart landscapes: multifunctionality in practice*. ASB Partnership for The Tropical Forest margins. World Agroforestry Centre.

Minang et al., 2022 *chapter 1*

Minang et al., 2022 *chapter 2*

Mithöfer D, van Noordwijk M, Leimona B, Cerutti PO. 2017. Certify and shift blame, or resolve issues? Environmentally and socially responsible global trade and production of timber and tree crops. *International Journal of Biodiversity Science, Ecosystem Services & Management* 13(1):72–85. DOI: 10.1080/21513732.2016.1238848

Monzon JP, Jabloun M, Cock J, Caliman JP, Couëdel A, Donough CR, Vui PHV, Lim YL, Mathews J, Oberthür T, Prabowo NE. 2022. Influence of weather and endogenous cycles on spatiotemporal yield variation in oil palm. *Agricultural and Forest Meteorology* 314:108789. https://www.sciencedirect.com/science/article/pii/S0168192321004755

Mugo F, Gathui T. 2010. Biomass energy use in Kenya. *International ESPA workshop on biomass energy.* Parliament House Hotel, Edinburgh, 19-21 October 2010.

Murniati, Garrity DP, Gintings A. 2001. The contribution of agroforestry systems to reducing farmers dependence on resources of adjacent national parks: a case study from Sumatra, Indonesia. *Agroforestry Systems* 52:171–184.

Muchugi A, Kalinganire A, Chege J, Nyoka I. 2021. Commodity tree crop planting material infrastructures in Africa. In: Minang PA, Duguma LA, van Noordwijk M, eds. 2021. *Tree commodities and resilient green economies in Africa*. Nairobi, Kenya: World Agroforestry (ICRAF).

Nasser F, Maguire-Rajpaul VA, Dumenu WK, Wong GY. 2020. Climate-smart cocoa in Ghana: How ecological modernisation discourse risks side-lining cocoa smallholders. *Frontiers in Sustainable Food Systems* 4:73.

Ndaka D, Macharia I, Mutungi C, Affognon H. 2012. *Postharvest losses in Africa–analytical review and synthesis: the case of Kenya.* Nairobi, Keny: International Center for Insect Physiology and Ecology.

Nestlé USA. 2021. Available online at https://static1.squarespace.com/static/5810dda3e3df28ce37b58357/t/5f90b737ac064c0924860232/1603319607525/Cocoa+Amicus+Main+Document+E+FILE++Oct+21+2020.pdf.

Odijie EM. 2016. Diminishing returns and agricultural involution in Côte d'Ivoire's cocoa sector. *Rev. Afr. Polit. Econ.* 43:504–517. doi: 10.1080/03056244.2015.1085381

Odijie EM. 2018. Sustainability winners and losers in business-biased cocoa sustainability programmes in West Africa. *Int. J. Agric. Sustain.* 16:214–227. doi: 10.1080/14735903.2018.1445408

Oduro KA, Mohren GMJ, Peña-Claros M, Kyereh B, Arts B. 2015. Tracing forest resource development in Ghana through forest transition pathways. *Land Use Policy* 48:63–72.

Oluyole KA, Orisasona TM, Agbebaku EE, Williams OA, Abdul-Karim IF. 2016. Evaluation of the post-harvest loss of cashew apple among cashew farmers in Nigeria. *International Journal of Applied Research and Technology* 5(2):71–77.

Ordonez JC, Luedeling E, Kindt R, Tata HL, Harja D, Jamnadass R, van Noordwijk M. 2014. Constraints and opportunities for tree diversity management along the forest transition curve to achieve multifunctional agriculture. *Curr Opin Environ Sustain* 6:54–60.

Ordway EM, Asner GP, Lambin EF. 2017. Deforestation risk due to commodity crop expansion in sub-Saharan Africa. *Environ. Res. Lett.* 12(4):044015,

Osei JD, Andam-Akorful SA, Jnr EMO. 2019. *Long term monitoring of Ghana's forest reserves using Google Earth Engine*. https://doi.org/10.20944/preprints201909.0016.v1.

Potts J, Lynch M, Wilkings A, Huppe G, Cunningham M, Voora V. 2014. *The state of sustainability initiatives reviews 2014: standards and the green economy.* Winnipeg, MB: International Institute for Sustainable Development. [Google Scholar]

Potts J, Lynch M, Wilkings A, MacFatridge S. 2016. *State of sustainability initiatives review.* DesLibris.

Ruf F, Schroth G. 2015. Introduction—Economic and ecological aspects of diversification of tropical tree crops. In: *Economics and ecology of diversification*. Dordrecht: Springer, pp.1–40.

Salzmann U, Hoelzmann P. 2005. The Dahomey gap: an abrupt climatically induced rain forest fragmentation in West Africa during the late Holocene. *Holocene* 15(2) :190–199.

Sanial E, Lescuyer G, Ruf F, Tsanga R. 2019. *Relevance of a FLEGT-like approach for West and Central African cocoa sustainability*. Bogor, Indonesia: CIFOR.

Smith Dumont E, Gnahoua GM, Ohouo L, Sinclair FL, Vaast P. 2014. Farmers in Côte d'Ivoire value integrating tree diversity in cocoa for the provision of ecosystem services. *Agroforestry systems* 88(6):1047–1066.

Sonwa DJ, Nkongmeneck BA, Weise SF, Tchatat M, Adesina AA, Janssens MJ. 2007. Diversity of plants in cocoa agroforests in the humid forest zone of Southern Cameroon. *Biodiversity and Conservation* 16(8):2385–2400.

Stuart T. 2009. *Waste: uncovering the global food scandal*. WW Norton & Company.

Swift MJ, Izac AMN, van Noordwijk M. 2004. Biodiversity and ecosystem services in agricultural landscapes: Are we asking the right questions? *Agriculture, Ecosystems and Environment* 104:113–134.

Tayleur C, Balmford A, Buchanan GM, Butchart SH, Walker CC, Ducharme H, Phalan B. 2018. Where are commodity crops certified, and what does it mean for conservation and poverty alleviation? *Biological Conservation* 217:36–46.

[UN] United Nations. *New York Declaration on Forests*, New York, NY (US), 23 Sept. 2014, available at: https://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/Forests/New%20York%20Declaration%20on%20Forests_DAA.pdf

Vandermeer J, van Noordwijk M, Ong CK, Anderson JM, Perfecto Y. 1998. Global change and multi-species agroecosystems: concepts and issues. *Agriculture, Ecosystems and Environment* 67:1–22

van Noordwijk M, Brussaard L. 2014. Minimizing the ecological footprint of food: closing yield and efficiency gaps simultaneously? *Curr Opin Environ Sustain* 8:62–70.

van Noordwijk M, Duguma LA, Dewi S, Leimona B, Catacutan D, Lusiana B, Öborn I, Hairiah K, Minang PA. 2018. SDG synergy between agriculture and forestry in the food, energy, water and income nexus: reinventing agroforestry? *Curr Opin Environ Sustain* 34:33–42.

van Noordwijk M, Leimona B, Pham TT, Duguma LA, Dewi S, Minang PA. 2022. Carbon footprints, informed consumer decisions and shifts towards responsible agriculture, forestry and other land uses? *Carbon footprints* 1:4 https://dx.doi.org/10.20517/cf.2022.02.

van Noordwijk et al., 2022 *chapter 3*

van Vliet JA, Slingerland MA, Waarts YR, Giller KE. 2021. A living income for cocoa producers in Côte d'Ivoire and Ghana? *Frontiers in Sustainable Food Systems 5*:732831.

Vansynghel J, Ocampo-Ariza C, Maas B, Martin EA, Thomas E, Hanf-Dressler T, Schumacher NC, Ulloque-Samatelo C, Yovera FF, Tscharntke T, Steffan-Dewenter I. 2022. Quantifying services and disservices provided by insects and vertebrates in cacao agroforestry landscapes. *Proceedings of the Royal Society B* 289(1982):20221309.

Waarts YR, Janssen V, Aryeetey R, Onduru D, Heriyanto D, Aprillya ST, N'Guessan A, Courbois L, Ingram VJ. 2021. Multiple pathways towards achieving a living income for different types of smallholder tree-crop commodity farmers. *Food Security* 13(6):1467–1496.

Wessel M, Quist-Wessel PF, 2015. Cocoa production in West Africa, a review and analysis of recent developments. *NJAS-Wageningen Journal of Life Sciences* 74:1–7.