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Comparative economic and environmental analysis of cocoa and bush mango cultivation in Bomboko, Cameroon: Implications for agroforestry integration and livelihood enhancement

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ABSTRACT

Cocoa (*Theobroma cacao*) is a major cash crop in Cameroon, while bush mango (*Irvingia gabonensis*) is a valuable non-timber forest product with growing commercial potential. However, limited understanding of their comparative economic returns and environmental interactions hinders informed decision-making regarding agroforestry integration. This study examined the comparative economic and environmental contributions of cocoa and bush mango cultivation in the Bomboko area of Cameroon's South West Region, with focus on agroforestry integration and livelihood enhancement. Data were collected through semi-structured questionnaires administered to 105 farmers, 10 key informant interviews, 06 focus group discussions and field observations. Quantitative data were analysed using descriptive statistics, while qualitative responses were synthesised thematically. Results showed that farmers earn average annual incomes of 2,060,500 FCFA from cocoa and 1,015,000 FCFA from bush mango, with cocoa contributing 67% of household income and bush mango 33%. Production costs represented 9.4% of cocoa income and 5.5% of bush mango income. Seventy-five percent of farmers practice cocoa-bush mango agroforestry, reporting benefits including year-round income (90%), soil preservation (32%), improved moisture retention, and enhanced biodiversity. Major challenges included pest outbreaks (86%), cocoa rotting (40%), limited knowledge of agroforestry practices (56%), and space constraints (28%). The study concludes that cocoa-bush mango agroforestry systems offer a viable pathway for enhancing livelihoods, environmental resilience, and sustainable land use. Recommendations include targeted farmer training, improved market access, strengthening of farmer cooperatives, and policy support for agroforestry adoption.

Key words: *Theobroma cacao*, *Irvingia gabonensis*, Agroforestry, Livelihood enhancement, Economic analysis, Bomboko Cameroon

INTRODUCTION

Cocoa (*Theobroma cacao* L.) and bush mango (*Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill.) are two significant agricultural commodities in Cameroon, each playing a vital role in the country's economy and the livelihoods of its rural communities (Ingram *et al.*, 2017; Jagoret *et al.*, 2011). Cocoa cultivation has a long-standing history in Cameroon, serving as a primary cash crop for a large portion of the rural population. Between 1963 and 1993, annual cocoa production averaged around 110,000 tons, but recent reforms and increased local processing have seen production rise considerably (MINADER, 2022).

Cameroon now ranks among the top five cocoa producers in Africa and among the top ten globally (ICCO, 2021). Despite its economic importance, cocoa producers in Cameroon, predominantly smallholder farmers, face numerous challenges including limited access to resources, fluctuating market prices, and diseases such as black pod disease caused by *Phytophthora* species (Aneani *et al.*, 2012). Cocoa production has also been associated with environmental challenges including deforestation, soil degradation, and biodiversity loss when managed as monoculture (Gockowski and Sonwa, 2011). These concerns have prompted increased interest in agroforestry systems that integrate cocoa with other tree species.

Bush mango, also known as wild mango or ndo'o, is a non-timber forest product (NTFP) widely used across Central Africa (Leakey *et al.*, 2005). The tree has multiple uses: it produces hard wood, the kernels are a nutritional source of protein and fat used as a soup thickener, and the bark and kernel have medicinal uses (Ayuk *et al.*, 1999). Bush mango provides incomes for actors along the market chain from harvester to consumer and is increasingly used in the United States of America and Europe as a weight-loss aid and health supplement, with its rich oil used in cosmetics (Ngondi *et al.*, 2009). In the South West Region of Cameroon, studies have shown that a majority of interviewed collectors have begun cultivating both Irvingia species, indicating a shift from solely wild harvesting to domestication efforts (Ofundem *et al.*, 2017).

Agroforestry, the intentional integration of trees with crops or livestock on the same land, is increasingly recognised as a sustainable land-use practice that can address both environmental and economic objectives (Garrity, 2004; Leakey, 2012). In the humid forest zone of Cameroon, traditional cocoa agroforests have been shown to harbour high levels of biodiversity while providing economic benefits to farmers (Sonwa *et al.*, 2007). The integration of indigenous fruit trees such as bush mango into cocoa farms may offer additional benefits including income diversification, improved soil fertility, and enhanced ecosystem services (Atangana *et al.*, 2006).

However, despite the potential benefits of cocoa-bush mango agroforestry systems, there is limited understanding of their comparative economic returns and environmental impacts in the Bomboko area of Cameroon's Southwest Region. This knowledge gap hampers informed decision-making by farmers, extension agents, and policymakers regarding the promotion and adoption of such systems (FAO, 2013). As a result, farmers may not optimise their land use, leading to diminished livelihoods and environmental degradation.

This study therefore aimed to evaluate the economic and environmental contributions of cocoa and bush mango cultivation and the implications of agroforestry integration for rural livelihoods in Bomboko. The specific objectives were: (1) to assess and compare the economic benefits of cocoa and bush mango farming; (2) to analyse the environmental impact of cocoa monoculture versus cocoa-bush mango integration; (3) to evaluate the feasibility and challenges of integrating bush mango into cocoa farms; and (4) to provide recommendations for sustainable agroforestry practices.

MATERIALS AND METHODS

Study area

The study was conducted in the Bomboko area, located in Mbonge Sub Division, Meme Division, South West Region of Cameroon. Bomboko is situated between longitude 9° to 9°13' East of the Greenwich Meridian and latitude 4°12' to 4°29' North of the Equator. The area lies on the north-western slopes of Mount Cameroon, bounded in the West by the Atlantic Ocean, in the East by Mount Cameroon, in the

South by parts of Muyuka and Mbonge sub divisions, and in the Southeast by the forests of Ndian Division.

The vegetation is thick evergreen equatorial rainforest rich in flora and fauna, with an equatorial climate characterised by high rainfall and high temperatures. The area experiences two seasons: a dry season from November to March and a rainy season from April to October, with rainfall reaching approximately 2300 mm per year (Longonje and Ndrozem, 2017). The soils are rich in humus and in some areas mixed with clay. The volcanic soils favour the cultivation of multiple crops and other farm activities.

The Bomboko area comprises nineteen rural communities located along the slopes of Mount Cameroon (Longonje and Ndrozem, 2017). Farming remains the main income-generating activity in the area. Crops cultivated include coco-yams, yams, egusi, beans, maize, oranges, and other fruit trees. Banana, plantain, pepper, and oil palm cultivation are on the increase, but cocoa cultivation is widespread.

Research design and sampling

This study adopted a descriptive comparative cross-sectional design combining quantitative and qualitative approaches. The target population comprised active cocoa and bush mango farmers in the Bomboko area who had lived permanently in the area for at least five years and owned cocoa or bush mango farms.

A total of 105 farmers were sampled from three villages: Bomana (37 farmers, 35%), Kotto 1 (58 farmers, 55%), and Kotto 2 (10 farmers, 10%). The sample was drawn using purposive sampling, targeting farmers with at least five years of experience in cocoa or bush mango cultivation.

Data collection

Primary data were collected through semi-structured questionnaires administered to sampled farmers. The questionnaires captured data on farm size, yield, production costs, market prices, labour input, income from cocoa and bush mango, environmental practices, perceptions of soil quality, and agroforestry integration. Ten key informant interviews were conducted with agricultural extension officers and community leaders to provide contextual insights. Six focus group discussions were held with cocoa and bush mango farmers (two focus groups per village) to capture group perspectives on cultivation challenges, climate variability, environmental concerns, and livelihood contributions. Secondary data were obtained from agricultural reports, scientific literature, project documents from non-governmental organisations, and records from local cooperatives.

Data analysis

Quantitative data were analysed using descriptive statistics (frequencies, percentages, means, medians, minimum and maximum values) with IBM SPSS version 26 and Microsoft Excel.

Net profit (income) was calculated as revenue (total sales) minus total costs (cost of goods, transport, taxes, labour, and other expenses). Qualitative data from interviews and focus group discussions were analysed using thematic analysis.

RESULTS

Comparative economic returns

Farmers earn significantly more income from cocoa than from bush mango (Table 1). The mean annual income from cocoa was 2,060,500 FCFA, contributing an average of 67% of household income. Mean annual income from bush mango was 1,015,000 FCFA, contributing 33% of household income. Minimum annual incomes were 600,000 FCFA for cocoa and 300,000 FCFA for bush mango. Maximum annual incomes reached 6,300,000 FCFA for cocoa and 3,500,000 FCFA for bush mango. Seventy-five percent of farmers reported that cocoa generates more income per hectare of land compared to bush mango.

Production costs represented a smaller proportion of income for bush mango than for cocoa (Table 2). Mean annual production cost for cocoa was 193,000 FCFA, representing 9.4% of cocoa income. Mean annual production cost for bush mango was 55,722 FCFA, representing 5.5% of bush mango income. Costs included fertilisers, labour, and harvesting and processing tools. Farmers had greater experience in cocoa production than in bush mango production. Thirty percent of farmers had over 21 years of experience in cocoa production, whereas no farmer had comparable experience in bush mango production.

Table 1. Comparison of annual income from cocoa and bush mango

Parameter	Cocoa (FCFA)	Bush mango (FCFA)
Minimum	600,000	300,000
Maximum	6,300,000	3,500,000
Median	1,400,000	700,000
Mean	2,060,500	1,015,000
Mean % household income	67.0%	33.0%

Table 2. Comparison of annual production costs for cocoa and bush mango (n=20)

Parameter	Cocoa (FCFA)	Bush mango (FCFA)
Minimum cost	80,000	30,000
Maximum cost	1,000,000	100,000
Median cost	135,000	50,000
Mean cost	193,000	55,722
Mean cost as % of income	9.4%	5.5%

Table 3. Main challenges in cocoa-bush mango agroforestry

Challenge	Grounding (%)	Representative quote
Pest outbreaks	86	"Too many insects damages cocoa"
Cocoa rotting	40	"When the mango trees become too big, it disturbs cocoa production (rots)"
Lack of knowledge	56	"Lack of technical knowledge on agroforestry and spacing"
Space constraints	28	"Integrating requires good spacing but my farm is not very big"
Insufficient labour/tools	18	"Labour for harvesting bush mango is expensive"

Table 4. Main benefits of cocoa-bush mango agroforestry

Benefit	Grounding (%)	Representative quote
Increased/diversified income	90	"Make income throughout the year. Extra income from bush mango during cocoa off season"
Soil preservation	32	"No soil drying. Less erosion"
Shade and microclimate improvement	Reported qualitatively	"The tree cover helps the cocoa to do well (high yields)"

Environmental impact and agroforestry integration

Seventy-five percent of farmers practice some form of agroforestry, integrating cocoa and bush mango on the same plot. The majority use intercropping and boundary planting techniques. Over 78% of farmers reported observing environmental changes when integrating bush mango into cocoa farms, including improved soil fertility, enhanced water retention, shade provision from bush mango trees, and increased biodiversity. Farmers with greater knowledge of agroforestry noted that bush mango trees provide shade, improve microclimates, and help retain soil moisture during dry periods. These practices align with ecological benefits of agroforestry documented in the literature.

Challenges in cocoa-bush mango agroforestry

Farmers identified several challenges associated with integrating bush mango into cocoa farms (Table 3). The most common challenge was pest outbreaks (reported by 86% of farmers), with bush mango fruits attracting insects that damage cocoa pods. Farmers reported needing to invest more in pest management as a result. Cocoa rotting was reported by 40% of farmers, attributed to limited sunlight reaching cocoa when mango trees become too large.

Lack of knowledge on agroforestry practices, including appropriate spacing and pruning, was reported by 56% of farmers. Space constraints due to small farm sizes were reported by 28% of farmers. Insufficient labour and tools for agroforestry management were reported by 18% of farmers.

Benefits of cocoa-bush mango agroforestry

Farmers reported multiple benefits from integrating bush mango into cocoa farms (Table 4). The most frequently reported benefit was increased and diversified income (90% of farmers). Farmers noted that the farm generates income throughout the year, even during the cocoa off-

season, providing extra income from bush mango. Soil preservation was reported by 32% of farmers, who noted reduced erosion and improved soil moisture retention. Farmers also noted that bush mango trees provide shade to cocoa plants, preventing damage from harsh sunlight and contributing to higher cocoa yields.

Table 5. Importance of cocoa and bush mango farming to household livelihood

Importance level	Frequency	Percent
Very important	84	80.0
Important	21	20.0
Total	105	100.0

Livelihood contributions

Eighty percent of farmers rated cocoa and bush mango farming as "very important" to their household livelihood, while 20% rated it as "important" (Table 5). Income from both crops is used primarily for education, household needs, healthcare, food, and clothing. Farmers noted that having both crops allows them to maintain more stable livelihoods, especially in the face of market fluctuations and climate uncertainties.

DISCUSSION

Comparative economic returns

The findings demonstrate that both cocoa and bush mango contribute substantially to household incomes in Bomboko, with cocoa providing the larger share. The mean annual cocoa income of 2,060,500 FCFA is consistent with Gockowski and Sonwa (2011), who reported that cocoa-based agroforestry in the Mount Cameroon region generates significant household incomes. The mean bush mango income of 1,015,000 FCFA supports Ndoye *et al.* (1997), who reported that NTFPs like bush mango contribute substantially to household income in forest-edge communities of Cameroon's Southwest Region. The finding that 75% of farmers earn more from cocoa per hectare than from bush mango reflects the more developed market infrastructure and established value chains for cocoa compared to bush mango (Ingram *et al.*, 2017). However, the lower production costs for bush mango (5.5% of income versus 9.4% for cocoa) suggest that bush mango may offer a more favourable cost-benefit ratio, consistent with observations that NTFPs often require fewer external inputs than cash crops (Shackleton *et al.*, 2011). The higher production costs for cocoa reflect expenditures on fertilisers, fungicides for black pod disease control, and labour for frequent harvesting (Aneani *et al.*, 2012). The greater farmer experience with cocoa compared to bush mango reflects cocoa's longer history as a cultivated cash crop in Cameroon, while bush mango has traditionally been wild-harvested (Leakey *et al.*, 2005). The shift toward bush mango cultivation observed in this study (75% practicing agroforestry) aligns with Ofundem *et al.* (2017), who reported that collectors in the Southwest Region have begun cultivating Irvingia species in response to increasing demand.

Environmental benefits of agroforestry integration

The finding that 78% of farmers observed environmental improvements when integrating bush mango into cocoa farms supports previous studies demonstrating that agroforestry enhances soil fertility, moisture retention, microclimate regulation, and biodiversity conservation (Garrity, 2004; Leakey, 2012). Farmers' observations of improved soil moisture and shade benefits are consistent with findings from cocoa agroforests in Cameroon (Sonwa *et al.*, 2007). However, reports of cocoa rotting associated with excessive shading indicate the need for proper canopy management through regular pruning to maintain optimal light conditions and reduce disease incidence (Jagoret *et al.*, 2011).

Challenges and adoption barriers

The high prevalence of pest outbreaks (86%) associated with bush mango integration represents a significant challenge. Bush mango fruits may attract insects that also affect cocoa pods, requiring increased pest management. This finding has not been widely documented in previous literature and warrants further investigation. The lack of knowledge on agroforestry practices reported by 56% of farmers is consistent with broader observations that extension services in Cameroon have traditionally focused on monoculture cash crops rather than integrated systems (FAO, 2013). The space constraints

reported by 28% of farmers reflect the smallholder nature of cocoa production in Cameroon, where average farm sizes are limited (Jagoret *et al.*, 2011). On small farms, farmers face difficult trade-offs between maintaining cocoa density and integrating additional tree species. The labour constraints reported reflect the labour-intensive nature of both cocoa and bush mango production. Cocoa requires frequent harvesting during the season, while bush mango requires labour for fruit collection, de-pulping, kernel extraction, and drying (Ingram *et al.*, 2017). When both crops mature in close succession, labour demands may exceed household capacity, particularly for smaller families.

Livelihood and resilience contributions

The finding that 80% of farmers rated cocoa and bush mango farming as "very important" to their livelihood underscores the central role of these crops in rural economies. The income diversification provided by bush mango is particularly valuable given the seasonal nature of cocoa income (October to January). Bush mango, harvested from April to July, provides income during the cocoa off-season, helping households avoid "lean months" and maintain year-round cash flow. This finding aligns with the sustainable livelihoods framework (Ellis, 2000), which emphasises that diversification of income sources reduces vulnerability and increases household resilience to economic and environmental shocks. The complementary seasonal patterns of cocoa and bush mango represent a form of "natural insurance" for farming households (Shackleton *et al.*, 2011). The gendered dimension of bush mango production (women dominating collection and sale) is consistent with broader patterns in NTFP value chains across Cameroon (Ingram *et al.*, 2017). Promoting bush mango cultivation may have positive implications for women's economic empowerment, as has been documented elsewhere in sub-Saharan Africa (Schreckenberg *et al.*, 2006).

Comparison with other agroforestry systems

The economic and environmental outcomes observed in Bomboko are broadly consistent with studies of cocoa agroforestry systems elsewhere in Cameroon and West Africa. In Southern Cameroon, Jagoret *et al.* (2011) documented that cocoa agroforests maintain high levels of tree diversity while providing comparable cocoa yields to monoculture systems.

Sonwa *et al.* (2007) reported that cocoa agroforests in the humid forest zone harbour significant biodiversity. The specific integration of bush mango into cocoa farms represents a locally adapted agroforestry practice that builds on traditional knowledge while responding to market opportunities for NTFP. The challenges identified in this study, pest outbreaks, shading conflicts, knowledge gaps, and labour constraints, suggest that successful promotion of cocoa-bush mango agroforestry requires context-specific technical support.

CONCLUSION

This study examined the comparative economic and environmental contributions of cocoa and bush mango cultivation in the Bomboko area of Cameroon's South West Region, with a particular focus on agroforestry integration and livelihood enhancement. The findings demonstrate that both crops contribute substantially to household incomes, with cocoa providing the larger share but bush mango offering a more favourable cost-benefit ratio and complementary seasonal income. Seventy-five percent of farmers practice cocoa-bush mango agroforestry, reporting benefits including year-round income, soil preservation, improved moisture retention, and enhanced biodiversity. However, significant challenges constrain adoption, including pest outbreaks, cocoa rotting from excessive shade, limited knowledge of agroforestry practices, space constraints, and labour shortages. The study concludes that cocoa-bush mango agroforestry systems offer a viable pathway for enhancing livelihoods, environmental resilience, and sustainable land use in the Bomboko area, but successful promotion requires context-specific technical support, improved market access, and enabling policies.

RECOMMENDATIONS

For extension services and training: Provide targeted training on agroforestry management practices including appropriate spacing, pruning, pest management, and soil fertility enhancement. Government and NGOs should support community-based agroforestry extension officers familiar with local realities.

Training programmes should address the specific challenges identified by farmers, including canopy management to prevent excessive shade and integrated pest management strategies for cocoa-bush mango systems.

For infrastructure and market access: Improve farm-to-market roads to ease transportation of perishable products like bush mango during peak seasons. Establish collection and storage centres for bush mango and other NTFPs to reduce post-harvest losses. Support value addition through processing equipment for bush mango kernel drying, grinding, and packaging.

For farmer organisation and finance: Encourage the formation of farmer cooperatives to enhance bargaining power, marketing, and knowledge sharing. Facilitate access to affordable credit and input subsidies to help farmers manage costs and invest in agroforestry systems. Cooperatives could also help with storage and transportation, reducing individual farmer burdens.

For policy and institutional support: Incorporate cocoa-bush mango agroforestry into national climate-smart agriculture and rural development policies. Recognise and support indigenous agroforestry practices through formal land tenure and tree ownership rights. Ensure that policies address the specific needs of women, who play a dominant role in bush mango collection and processing.

For research and development: Conduct participatory research on optimal agroforestry models suited to Bomboko's microclimates, including trials on spacing regimes, pruning frequencies, and pest management strategies. Support innovation in value addition for bush mango, including improved drying technologies, packaging, and quality standards for export-grade processing. Investigate the specific pest interactions between bush mango and cocoa to develop evidence-based management recommendations.

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