High-Value Markets and the Economic Viability of Agroforestry: A Case Study in Southwestern Antioquia, Colombia

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Degree project/Independent project • 30 credits
Swedish University of Agricultural Sciences, SLU
The Department of Biosystems and Technology
Agroecology - Master's Programme
Alnarp 2025

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Credits:	30 credits
Level:	Second cycle, A2E
Course title:	Independent Project in Agricultural science, A2E - Agroecology - Master´s Programme
Course code:	EX0848
Programme/education:	Agroecology - Master's Programme
Course coordinating dept:	Department of Biosystems and Technology
Place of publication:	Alnarp, Sweden
Year of publication:	2025
Keywords:	economic viability of agroforestry, high-value markets, TAPE framework, agroforestry case study, agroecology

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Abstract

Agroforestry, despite its well-documented environmental benefits, still holds significant potential for broader adoption. A critical factor for scaling agroforestry is ensuring its economic viability. There is a recognised need for more data on the socioeconomics of agroforestry and for research to move beyond biophysical indicators by placing greater emphasis on the analysis of socioeconomic dimensions. This study employed semi-structured interviews and the TAPE framework to investigate how participation in high-value markets influences the economic viability of agroforestry systems in Southwestern Antioquia, Colombia. The findings show that participation in high-value markets significantly increased farmers' incomes. A combination of high-value crops and value-added processing emerged as an effective strategy for improving profitability. Agro- and ecotourism also provided important supplementary income streams. Collaboration, primarily with associations, other farmers, extension services and cooperatives, supported access to high-value markets. Furthermore, participation in such markets created incentives for adopting agroecological practices. Beyond market incentives, farming decisions were influenced by values such as food sovereignty, tradition and environmental stewardship. This case study identifies strategies that small-scale agroforestry producers used to achieve profitability without compromising ecological benefits, such as soil conservation and biodiversity, or social values like food sovereignty. These strategies offer insights for designing and managing sustainable agroforestry production systems globally.

Keywords: economic viability of agroforestry, high-value markets, TAPE framework, agroforestry case study, agroecology

Foreword

As I came to understand that agriculture was a major driver of deforestation, the loss of biodiversity and ecosystems around the world, I began to have a powerful desire to do something about it. That desire has acted like an entity of its own: it would not be ignored, has never dissipated and certainly has had a big influence on my life decisions. It led me to a long and wonderful journey - from learning from peasants by working together, learning about how to take care of the living soil from literature, saving and sharing seeds, to studying agroecology at SLU. From growing zucchini seedlings on a windowsill in cut plastic bottles to producing thousands of kilograms of organic food on a large farm to feed people. From noticing how a wild apple tree, giving the most delicious apples I have ever tasted long into winter months, was so robust and abundant in contrast to a pest-ridden apple orchard nearby, to becoming completely restless about understanding, finding and scaling solutions: yet another form that this desire to "do something" has taken. The desire also brought me closer to the people of the countryside. I saw the grip that an industrialised and extractive model of agriculture had on their livelihoods, presenting agrochemicals, indebtedness, uncertainty and replacement of heirloom varieties all in one conventional package.

Somewhere down the road on this journey, I imagined a forest-like agroecosystem and as I could not find any information about it, nor did I know the word "agroforestry", I concluded that it must have been my invention. A sanctuary for all life. I became determined to find ways to create it. Should I try to buy a plot of land and establish it? And where do I even start to learn about what species do well together or how to design it? Or maybe it's better to work to make it more widespread, somehow? But how? My head was full of questions and it seemed like a quest impossible.

Now I know a little more about agroforestry. I know it's certainly not my invention. I was lucky to discover the agroecology programme at SLU and even luckier to study there, thanks to the Swedish Institute scholarship. I am deeply grateful for the chance to study agroecology and for the opportunity to carry out an independent project exploring pathways to scale up agroforestry. The experience taught me about systems thinking and turned me into a slightly more humble human being, which is yet another thing I am grateful for.

Agroecology, for me, is soulful farming. A holistic way forward. A practice and powerful movement for transformation. While I find myself full of questions yet again, I often think of a powerful slogan: "Food Sovereignty. Now!" (shoutout to La Vía Campesina) and I am looking forward to seeing where that initial desire "to do something" will lead me next.

Acknowledgements

I am deeply grateful to my supervisors, Marcos Lana and Harry Fischer, for their academic guidance, invaluable support in overcoming practical challenges during fieldwork and for helping me complete this thesis within the required timeframe.

I would also like to express my sincere gratitude to Teun Dekker for his support throughout this project and for helping me secure funding. His efforts to bridge the gap between science and practice have given the Agroecology programme the depth it deserves and made it possible for me to carry out this research in collaboration with Biosuroeste.

This research project would not have been possible without the generous financial support from SLU Global, which covered the travel expenses for my fieldwork in Southwestern Antioquia, Colombia.

I would like to thank Federico Botero Jaramillo and Esteban Gil Restrepo from Biosuroeste for introducing me to the local context and connecting me with agroforestry producers.

I would like to express my appreciation to Elaine Springgay, FAO's Agroforestry Officer, for the valuable time and insights shared during our conversations. Her perspectives significantly deepened my understanding of the socioeconomic dimensions of agroforestry and influenced the direction of this research.

Finally, I extend my heartfelt thanks to all *campesinos*, the agroforestry farmers, for their participation in this research.

To my dearest friend, Carolina da Fonseca Sampaio Barbosa, who deeply cared about the environment, believed that sustainability lies in diversity and nurtured connections everywhere she went. Your sudden absence changed the course of my thesis journey, eventually leading me to Colombia.

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Abbreviations

HVM	High-value market
HV	High-value
CSA	Community supported agriculture

1. Introduction

Agroforestry is increasingly recognised as a climate and biodiversity solution that can simultaneously build resilience and improve food security. However, despite its well-documented environmental benefits, agroforestry still has considerable potential for broader adoption and scaling. Much of the existing research has concentrated on environmental aspects, while socioeconomic factors remain underexplored. There is a recognised need for agroforestry research to move beyond biophysical indicators and place greater emphasis on studying socioeconomic dimensions, including markets, value chains, policy and institutional contexts (Agroforestry Network 2018).

Improving enabling conditions and strengthening the capacities of agroforestry producers is critical for scaling up the adoption of agroforestry systems. The findings from the FAO's Global Agroforestry Capacity Needs Assessment conducted in 2022 identify barriers to scaling up agroforestry and highlight priority action areas - including the transformation of agroforestry into an economically viable production system (Springgay & Pajel 2024). The assessment emphasised the need for more data on the socioeconomics of agroforestry, "including economic feasibility, sociocultural factors that influence adoption, and case studies and examples of systems that have worked and those that have not" to achieve these goals.

This study addresses this need by examining how participating in high-value markets (HVMs or HV markets) influences the economic viability of agroforestry systems and offers an empirical case study of strategies that small-scale agroforestry producers in Antioquia, Colombia use to access high-value markets to achieve economic viability. It aims to contribute to improving data on the socioeconomics of agroforestry, with a broader goal of supporting the scaling up of agroforestry practices. The following section outlines the research questions and objectives that guide this study.

1.1 Research questions and objectives

This research is centered around two core questions:

1. Can participation in high-value markets improve the economic viability of agroforestry production systems, and if so, to what extent?
2. Can it help to accelerate transition toward agroecological practices?

The objective of this study is to evaluate how participation in high-value markets affects the economic viability of agroforestry production systems and investigate related potential implications for agroecological transition.

Specific Objectives:

Assess the economic performance of farms as a result of their participation in high-value markets, focusing on income growth and financial stability.

Analyse the strategies small-scale agroforestry producers use to access high-value markets to achieve economic viability.

Identify enabling and limiting factors influencing economic viability based on farmers' perspectives on challenges and opportunities.

2. Literature review

2.1 Environmental benefits of agroforestry

The environmental benefits of agroforestry systems are well documented, including improvements in soil fertility, biodiversity and water regulation. Tobella et al. (2014) showed that trees can improve soil infiltration and contribute to deeper drainage and groundwater recharge. This effect is likely linked to better soil structure and improved porosity under trees, which are associated with higher concentrations of soil organic matter and intensified biological activity from soil fauna and roots. Trees also support ecosystem services such as enhancing water and nutrient cycling and regulating pests (Kuyah et al. 2016). In addition, agroforestry systems that incorporate trees to supply fuelwood and timber on farms contribute to reducing pressure on felling trees in natural woodlands and protected forests (Iiyama et al. 2014). Agroforestry systems help create habitats that support biodiversity. For instance, the adoption of sustainable practices such as shade and leaf litter management in coffee production can support biodiversity conservation and the preservation of ecosystem services, while simultaneously enhancing the economic viability of coffee production (Ríos-Orjuela et al. 2024).

There is also a growing recognition of the critical role of ecosystem services provided by trees within agricultural landscapes for food security. Realising these benefits requires appropriate management practices and the selection of species that are well-suited to the specific contexts (Agroforestry Network 2018). Agroforestry systems offer a wide range of ecosystem services, including pollination, protection from wind, nitrogen fixation and erosion control (FAO 2017). They provide proven approaches for carbon sequestration, enhancing soil quality, conserving biodiversity and improving air and water resources, delivering benefits to society as a whole (Jose 2009). The adoption of agroforestry has the potential to reverse both biodiversity loss and ecosystem degradation by creating multi-species systems that offer food, habitat, refuge and improved soil-plant-water dynamics (Udawatta et al. 2019).

2.2 Socioeconomic dimensions of agroforestry

In addition to environmental benefits, agroforestry systems offer important contributions to rural livelihoods. A study assessing agroforestry systems for livelihood improvement in northwest Vietnam (Hung Do et al. 2020) showed that agroforestry systems provided ecosystem services such as erosion control and soil fertility improvement and simultaneously were more profitable and productive than sole-crop systems. However, better value chains and stable markets for agroforestry products were key prerequisites for enabling the widespread adoption of

agroforestry in the region. Based on their study conducted in three communities in Campeche, Mexico, Yazzur et al. (2017) concluded that traditional agroforestry systems are a form of ecological farming that significantly contribute to local food security and serve as a fundamental livelihood strategy for peasant families. For example, incorporating fodder species can provide animal feed and increase smallholders' income (Franzel et al. 2003). Tobella et al. (2024) proposed integrated agroforestry-bioenergy systems that can increase agricultural productivity and produce sufficient biomass on-farm to cover the household's need for fuelwood. Agroforestry systems can enhance productivity and economic returns, diversifying farms' income by delivering multiple products with less external inputs (Lehmann et al. 2020). Diverse crops can provide income at different times throughout the year, act as a buffer against yield losses and compensate for price fluctuations in cash crops (Louman et al. 2024). Additionally, empirical evidence from two smallholder communities in Kenya suggest that agroforestry can enhance livelihood resilience, with agroforestry practitioners scoring, on average, 10% higher on resilience indicators (Quandt 2018).

Agroforestry systems also enhance resilience in the face of climate, economic and political shocks within food systems (Ickowitz et al. 2021). Similar resilience benefits also extend to non-food agroforestry products. For instance, Stroesser et al. (2018) found that diverse rubber-based agroforestry systems in southern Thailand were more resilient to price volatility, whereas monoculture systems were more vulnerable due to the over-reliance on rubber trees. Additionally, Mbow et al. (2014) argue that agroforestry holds significant potential to create synergies between food security and climate change mitigation, highlighting that climate change mitigation and carbon sequestration alone are rarely the primary drivers of farmers' decision-making.

Despite these advantages, the economic performance of agroforestry systems remains a subject of debate. The success of agroforestry is not solely dependent on environmental factors but also on the socioeconomic conditions in which these systems are implemented. The profitability of agroforestry systems can vary significantly depending on factors such as design, management and market connections. Value chains for agroforestry products and for connecting farmers to the market are underdeveloped and need to be promoted (Agroforestry Network 2018). Jezeer et al. (2017) argue that the perception of lower economic performance in agroforestry systems is often based on incomplete economic evaluations that fail to analyse all relevant indicators. Similarly, Jezeer et al. (2018) highlighted that while earlier studies linked lower coffee yield with increased shade, recent research has challenged this view. They showed in a case study in Peru that, contrary to common assumptions that agroforestry underperforms economically compared to intensive unshaded systems, there was no negative correlation between shade management and economic performance in smallholder coffee systems. Furthermore, the study demonstrated that coffee agroforestry systems can perform

economically as well as, or even outperform, sun-exposed plantations and systems reliant on higher input levels.

2.3 High-value markets for agroforestry

One of the primary barriers to agroforestry expansion is the lack of well-established markets for tree products (FAO 2013). Underdeveloped markets remain a challenge for the sustainability of agroforestry value chains. However, as consumer awareness of climate change and biodiversity grows, high-quality agroforestry products have significant market potential (Agroforestry Network 2020). For example, biodiversity benefits linked with cacao and coffee, species that are well suited to agroforestry landscapes, grown under shade trees are well documented (Jezeer et al. 2017). As global demand for sustainable, responsibly produced and higher-quality cacao continues to grow, new market opportunities have emerged for producers and exporters in developing countries (Villacis 2022).

High-value crops are defined as those that generate greater gross margins per hectare and per unit of labor input compared to conventional commodity crops. High value can be obtained by differentiating the quality of the final product. Markets are increasingly indicating a preference for differentiated products, prompting farmers and traders to seek higher-value alternatives as a means of enhancing their incomes (Niederhauser et al. 2008). Similarly, high-value markets offer greater returns for agricultural products than traditional markets (Huka et al. 2024). For example, specialty coffee represents a high-value market. Specialty coffee is associated with high quality and proper brewing methods (Urwin et al. 2019). Historically, coffee-producing countries have primarily exported unprocessed green beans to international markets for bulk coffee, while the economic value in the coffee industry generated from processing, branding and marketing has largely been captured by coffee roasters and companies in consuming nations (Inter-American Development Bank 2002). Under the first International Coffee Agreement (ICA), signed in 1962, export quotas were assigned to producer countries. However, the collapse of this regulatory system in 1989 led to a global decrease in coffee prices (Kilian et al. 2006). It also shifted the balance of power in the coffee value chain, with a greater share of profits remaining in consuming countries. This transition transferred power from producers and local traders in developing countries to operators based in consuming countries and introduced greater price volatility (Ponte 2002). An alternative to this commodity-driven model is coffee, sold in differentiated markets, that is produced in ways which address global socio-environmental concerns, such as biodiversity conservation. This segment of high-quality, specialty coffee is expected to continue growing. To participate in these higher-value markets, value-added strategies and effective marketing are necessary (Inter-American Development Bank 2002). Similarly, consumer preferences for differentiated cacao, based on flavor profile and darkness have increased over the years. Added value of such cocoa is expressed

by consumers' willingness to pay above standard commodity prices for the attributes such as health benefits that differentiate the product (Gockowski et al. 2011).

Adopting a market-driven approach that aligns with such consumer preferences has the potential to strengthen economic opportunities for farmers (Balatico et al. 2024). In a study on smallholder participation in higher-value markets, Donovan and Poole (2014) summarise that the literature presents differing perspectives on the profitability of specialty coffee for smallholder farmers, which highlights the complexity of assessing the economic benefits of participation in such markets. Nonetheless, an increasing number of consumers in developed countries are willing to pay higher prices to support more environmentally responsible production methods (Donald 2004). And more opportunities are created for farmers to participate in niche markets that are associated with sustainability goals (Olagunju et al. 2025).

2.4 Research gaps and study contribution

There is a need for agroforestry research to place greater emphasis on socioeconomic dimensions and long-term, large-scale impacts. This could be supported by landscape-level studies that connect biophysical variables with social and economic outcomes, identify potential synergies and strategies for managing trade-offs. Additionally, to facilitate the scaling of agroforestry initiatives and enhance the relevance of research findings, a more participatory research approach is necessary (Agroforestry Network 2018). While the environmental benefits of agroforestry are well documented, and some studies, though limited, highlight economic advantages, fewer have examined the broader sociocultural and economic conditions that make these systems viable for small-scale producers, or the synergies and trade-offs between these benefits. There is also a lack of empirical research on the strategies small-scale agroforestry producers use to achieve economic viability, or on how participation in high-value markets affects the environmental, social and economic sustainability of agroforestry systems. This study addresses these gap and provides a more integrated understanding of how market dynamics and farmer motivations and values interact within agroforestry systems. Furthermore, it investigates the relationship between high-value market participation and the adoption of agroecological practices, exploring how market-driven incentives may accelerate the agroecological transition.

2.5 Theoretical framework

2.5.1 Agroecology

Agroecology provides the conceptual foundation for this research, as understanding the interconnected environmental, social and economic dimensions of agroforestry production systems was essential for addressing the objectives of

this study. Agroecology provides a food systems lens to understand how all parts of the food system interact with one another. It is a transdisciplinary field that offers a holistic framework for both analysing food systems and guiding the transformation towards more sustainable and socially just models. It challenges the dominant industrial model of agriculture and promotes systemic change across all levels of the global food system. This includes advocating for food sovereignty, strengthening the resilience of peasant and Indigenous farmers and fostering consumer awareness of where and how food is produced - re-establishing more direct relationships between producers and consumers (Gliessman 2015). Agroecology encompasses more than crop production: it integrates the socio-economic, political and developmental dimensions of food systems. Initially emerging in the early 20th century as an application of ecological principles to agriculture, it combined agronomy with ecology and emphasised the importance of the natural complexity of agroecosystems as the basis for long-term productivity. From the 1980s onward, agroecology gradually evolved into a social movement and a set of practices (Wezel et al. 2009).

Today, agroecology is increasingly recognised in policy discourses as a pathway for transitioning toward more resilient food systems. Conceptualising and assessing agroecological transitions is therefore essential. For instance, Gliessman (2015) proposed five levels of conversion that describe a stepwise conversion process for transitioning toward sustainability in food systems. The Food and Agriculture Organization of the United Nations (FAO) developed the Tool for Agroecology Performance Evaluation (TAPE), which provides a structured, multi-dimensional approach to assessment of agroecological performance.

2.5.2 TAPE

TAPE is a global analytical framework that enables the collection of heterogeneous, harmonised data on the multidimensional performances of agroecology, which is essential to bridge knowledge gaps and inform policy decisions. It helps overcome the challenges of fragmented evidence demonstrating positive impacts of agroecology caused by varied methodologies, scales and timeframes (FAO 2019).

Step 1 of the TAPE was used to evaluate the current agroecological level of participating farms within the study area. TAPE consists of two main steps (1 and 2), preceded by an initial description of context and systems (step 0) and an optional typology (step 1bis). A final phase involves analysis and participatory interpretation of the results (Step 3). Step 1 is based on the 10 Elements of Agroecology as proposed by FAO. This step assesses the level of transition to agroecology based on the elements, using 37 semi-quantitative indices scored on a modified Likert-type scale (0–4). This stepwise approach was inspired by the Evaluation of Natural Resource Management Systems (Marco para Evaluación de Sistemas de Manejo de Recursos Naturales Incorporando Indicadores de Sustentabilidad or MESMIS - its

Spanish acronym). Mesmis consists of six-steps assessment cycles and is a flexible and adaptable approach aiming to capture the specific characteristics of the contexts being assessed (Cândido et al. 2015). A detailed description of the TAPE methodology, including the steps and guidelines, is available in the FAO's official document: Tool for Agroecology Performance Evaluation (TAPE) - Test version (FAO 2019). The questionnaire for Step 1 – characterisation of agroecological transitions, which was used in this study, is provided in Appendix 2.

2.5.3 Participatory approach

This research aimed to understand farmers' perspectives, motivations and values. Therefore, semi-structured interviews were conducted alongside TAPE. The TAPE was also adapted to better align with the local context of the study area. Previous studies have also combined TAPE in conjunction with other methods (Chabi et al. 2025; Clotuche et al. 2023).

Semi-structured interviews allow researchers to gather more in-depth information from interviewees for qualitative research compared to structured interviews. They offer flexibility, enabling researchers to adapt the questions as needed, while still staying focused on the main topics, unlike unstructured interviews, which can be less directed (Ruslin et al. 2022). Semi-structured interviews are also among the tools commonly used in Participatory Rural Appraisal (PRA), an effective approach widely applied in rural contexts. Developed in the early 1990s, it marked a shift from a top-down to a bottom-up approach, transitioning from extractive survey questionnaires to the experience sharing by local communities. This methodology allows to gain insights into rural life and their environment through the perspectives of local people (Cavestro 2003). Although this study did not fully implement the PRA framework, the use of semi-structured interviews is consistent with the participatory approach of PRA, and of agroecological research more broadly, which emphasises the inclusion of local knowledge and perspectives.

These theoretical and methodological choices provide a foundation for assessing how high value market participation influences the economic viability of agroforestry systems. They also help evaluate whether such participation supports agroecological transition. Together, they directly address the study's core research questions.

2.6 Study area

The Department of Antioquia is located in the tropical Andes, in the northwest of Colombia, with geographic coordinates ranging from approximately 5.4° N to 8.8° N latitude and 73.8° W to 77.5° W longitude, covering an area of approximately 63,612 km². The department is known for its agricultural activities, including coffee and banana production and cattle grazing (Gomez-Ossa et al. 2023). Antioquia experiences a precipitation regime similar to a unimodal pattern,

with one dry period and one wet season that includes at least one month of reduced rainfall, though not reaching typical dry season thresholds (World Bank 2023).

Antioquia is composed of 125 municipalities grouped into nine subregions and has a population of approximately 6.6 million people - 13.5% of the national population. Antioquia is a significant contributor to Colombia's GDP, ranking as the second most important regional economy after the capital, Bogotá. It contributes 14.5% to the country's GDP. In the southwest of Antioquia, where the local economy relies heavily on agriculture (primarily coffee and banana) and tourism, the bioeconomy accounts for up to half of the total value added. Bioeconomy provides important opportunities for local economies to foster sustainable development (Alviar et al. 2021; Dávila & Cogollo 2009).

Agriculture is a key source of export income in Colombia, with coffee being the country's most significant export commodity. Antioquia is one of the main coffee-producing departments. Antioquia, Huila and Tolima together produce about one-third of the national output.The coffee is cultivated by over half a million farmers, predominantly smallholder farmers with less than 20 hectares land area. Farmers commonly grow coffee for income, alongside subsistence crops such as plantain and maize (World Bank 2017).

Antioquia, which covers approximately 6% of Colombia's national territory (63,612 km²), is considered a region of exceptional biodiversity, supporting nearly half of the country's reported species. However, historic (70 percent of the department area has been deforested) and ongoing deforestation, estimated at over 25,000 hectares per year, has placed Antioquia among the departments with the highest number of threatened species in Colombia. At the same time, the coffee industry, a key economic sector in Antioquia, is highly vulnerable to the impacts of rising temperatures and hydrological events, which pose significant risks to production levels and the livelihoods of smallholder farmers in the region (World Bank, 2017).

In response to these challenges, agroforestry systems offer an effective adaptation strategy. Due to its mountainous topography and varied elevations, Antioquia provides an ideal environment for coffee and cacao agroforestry systems. Cacao has long been cultivated in Colombia and holds cultural significance within the national diet. It is predominantly grown by smallholder farmers within diversified agroforestry systems, which are adapted to local conditions such as climate, soil characteristics and the specific needs of farming households (Rodríguez et al. 2023). While coffee was also traditionally grown in agroforestry systems, intensive monocultures were strongly promoted by the National Coffee Growers Federation (FNC) for several decades during the 20th century (Guhl 2008).

2.7 Biosuroeste

This research was carried out in collaboration with Biosuroeste, whose market-driven approach aligns closely with the objectives of this study and provided a unique and relevant context for the research. Biosuroeste is an initiative that aims to catalyse regenerative rural development in Southwestern Antioquia. It acts as a living lab, fostering collaboration among businesses, communities and academic institutions, leveraging their complementary strengths. A part of their strategy is promoting the development of regenerative agribusinesses that integrate into high-value markets to strengthen rural farming family economies and generate formal employment in the bioregion (here understood as a geographical area defined by natural features such as ecosystems, climate and topography). This includes crops such as coffee and cacao, which are well-suited for agroforestry systems. For that purpose, Biosuroeste works with "development-driving organisations" in the region, which can be companies, cooperatives, government entities, nonprofit associations or other profitable organisations that are participating in high-value national or global markets or established market sectors relevant to the Southwestern Antiouqian economy. Biosuroeste (2024) describes these organisations as crucial actors within their territories: "What makes these organisations special is their close relationship with the population and the environment in which they operate. They not only engage in productive and/or commercial activities in the area but also invest resources and efforts to improve the economic, social and environmental conditions of the territory". Biosuroeste works to foster business connections among such organisations and other stakeholders, including small-scale farmers, aiming to enhance small-scale farmers' access to high-value markets. In addition, Biosuroeste manages three demonstration agroforestry plots (2,000 m² in total) that serve as hubs for capacity building and knowledge exchange.

Collaboration between small-scale farmers and connective businesses can create mutual benefits for all involved, with small-scale farmers capturing significantly more value than in traditional markets. Borrella et al. (2015) describe connective businesses that function by fostering shared value creation, linking farmers with specialty coffee roasters who would otherwise lack the opportunity to establish direct trade relationships. Fees for their services are paid by the roasters. Connective businesses facilitate small-scale farmers' access to higher-value-added and less volatile market segments.

3. Methodology

3.1 Data collection methods

The research questions and objectives were refined during the first month of the research. The preliminary exploratory phase was critical in developing the research design, methodology and data collection tools. Engagement with stakeholders through informal discussions with key informants, farm visits and interviews was essential to gain familiarity with the local context. During this background research, three farm tours were attended and two in-depth interviews were conducted with the assistance of a hired interpreter. This more in-depth investigation during farm visits helped identify some of the most important factors relevant to the overall research aims. Simultaneously, representatives from Biosuroeste provided insights into the broader bioregional context, such as common agroforestry systems, main cash crops and emerging market opportunities.

This study employed the TAPE (Tool for Agroecology Performance Evaluation) framework alongside semi-structured interviews. This initial engagement informed the choice of both tools, guided the design of the questionnaire for the semi-structured interviews and ultimately led to focusing on Step 1 of the TAPE framework, deemed most useful for the research objectives, while omitting Step 2 due to difficulties in obtaining certain information and time constraints. As a result, the TAPE was adapted to align with the study objectives and the local context and an additional set of questions designed to explore farms' economic performance in more detail were incorporated.

Combining TAPE with semi-structured interviews proved particularly valuable as it provided insights that neither method alone could fully capture. This mixed-methods approach allowed for a more holistic understanding of the complex dynamics within agroforestry systems, integrating quantitative indicators across farms with qualitative insights into farmers' strategies, values and motivations. The TAPE also enabled data triangulation with qualitative findings and complemented the insights gathered from semi-structured farmer interviews. The TAPE framework proved useful in identifying key strengths and weaknesses, helping to determine which of the 10 agroecological elements require priority interventions to advance the transition. The alignment between TAPE results and farmer insights strengthens the framework's credibility and demonstrates its potential for data triangulation.

Subsequently, all further interviews were conducted individually. For the interviews involving an interpreter, the participants were revisited with a refined questionnaire to ensure clarity and the consistent application of a standardised set of questions across all interviews. A total of 19 interviews were conducted for this study, comprising 16 interviews with farmers and 3 additional stakeholder interviews. Of the farmer interviews, 6 were conducted online using WhatsApp

video calls, while the remaining 10 were conducted in person. All stakeholder interviews were also conducted in person. All documents (TAPE Step 1 and questionnaire) were translated in Spanish. Finally, multiple field visits were conducted, including two visits to local farmers meetings. The following sections describe and justify the methods used in the study.

3.2 Semi-structured interviews

The questionnaire that guided the interviews was carefully designed to respond to the research question and align with the specific objectives of the study (see Appendix 1 for the full questionnaire). It systematically addressed key aspects related to farmers' production systems and market integration, ensuring that each question contributed directly to obtaining insights relevant to the research questions. The questionnaire primarily consisted of semi-closed questions, providing predefined answer choices while including an "Other - please specify" option that allowed respondents to elaborate beyond the given choices if none of the options fully captured their answer. It included questions about the most profitable crops and activities on farms, the influence of high-value market incentives on production decisions, such as the adoption of “environmentally friendly practices” (the term “environmentally friendly practices” was used instead of “agroecology”, as it was reported during preliminary fieldwork that the latter was sometimes perceived as politically charged or associated with leftist movements), as well as questions about integration into high-value markets, value addition and income increases. Additionally, it explored collaboration with other entities and challenges in accessing high-value markets. The interviews were conducted in a conversational format, using the interview guide to structure interviews which often lasted between 1 and 2 hours. This approach allowed for in-depth conversations and follow-up questions based on participants' responses. This approach was chosen to ensure structured responses while balancing quantitative data collection with qualitative insights, as understanding farmers’ perspectives and experiences was crucial for the study’s objectives.

All interviews were audio-recorded and transcribed. Spanish-language interviews were transcribed and translated using a combination of online tools, including Speechmatics.com, Turboscribe.ai, Otter.ai, Sonix.ai and Google Translate. All participants provided informed consent prior to their involvement in the study.

3.3 TAPE

The TAPE assessment was conducted during field visits, with all farmers participating by responding to the full set of TAPE questions to ensure accuracy. However, due to logistical constraints, 6 farmers were interviewed online and provided self-reported data on their farming practices. To maintain data accuracy, all questions were thoroughly explained during the online TAPE assessments. In

cases where interviews were conducted in person, field observations largely aligned with the farmers' descriptions of their agroecological practices. Although some interviews were held online and did not allow for direct observation, the consistency observed across interviews suggests a reliable account of the current on-farm practices. In four cases, due to time limitations, only 4 elements of agroecology were evaluated.

3.4 Additional Interviews

Based on recurring themes identified in the farmer interviews, threee additional stakeholder interviews were conducted to cross-check findings and provide further context. First interview was conducted with a cacao producer involved in a local cacao association to gain insights into local value chain dynamics and producers' access to markets. Additionally, as several farmers expressed concerns about the threat of large-scale mining, the second interview was carried out with a representative from a grassroots organisation. Initially formed as a communication collective to support local farmers and environmental defenders, the organisation played a key role in social mobilisation and helped halt a major mining project in 2021. Finally, a representative from Biosuroeste was also interviewed.

3.5 Sampling and interview process

The participants included 16 farmers from 12 villages, one representative of a farmers' association and two representatives from active organisations in Southwest Antioquia. The sample size of farmers was determined to be 16 agroforestry producers based on the available time for data collection and the feasibility of conducting in-depth interviews. For the purposes of this study the target group was determined to be small agroforestry producers, primarily cultivating cash crops such as cacao and coffee.

The selection of representative samples of farms was guided by Biosuroeste's network and recommendations from initial farmer participants. While these recommendations facilitated access to relevant participants, they may have been influenced by the referrers' interpretation of the research questions, leading them to suggest farmers who they believed aligned with the study's focus - specifically, small agroforestry producers participating in or interested in accessing high-value markets, agroecological transition or environmental sustainability. All data were collected between February 9 and March 10. Contact with participants was established by explaining how their information had been obtained, introducing the research through a text message and asking if they were interested in participating. In some cases, representatives from Biosuroeste or a hired translator who also knew the farmers introduced the researcher to the participants. The involvement of someone they already knew helped build trust. Once contact was made, farm visits and online meetings were arranged.

For Spanish-speaking farmers, a short but detailed text in Spanish describing the research, its motivations and the interest in farmers' perspectives was prepared, which participants were asked to read during the meetings. The TAPE was introduced, the purpose of the interview was explained, permission to record was requested and it was ensured that participants understood the recordings would aid in accurate translation and prevent missing any important details. To support communication, online translator tools were used to prompt follow-up questions when needed. Transparency was maintained regarding the research objectives, emphasising that there were no right or wrong answers and expressing genuine interest in participants' experiences. It was also shared that the researcher had farmed for several years before beginning academic studies.

Finally, as the researcher was a foreigner student with very limited Spanish skills, it needs to be acknowledged that the outsider position could have influenced interview dynamics. Conducting interviews in Spanish may have limited the understanding of certain nuances or reduced the depth of follow-up questions. Additionally, unfamiliarity with some agricultural and socio-cultural specifics of the region may have affected the ability to fully grasp certain expressions or cultural references by the researcher. However, researcher's background in farming helped establish common ground and build trust, which likely encouraged more open conversations and fostered a sense of shared understanding.

3.6 Data analysis

The semi-structured interviews yielded both quantitative and qualitative data due to the mix of closed-ended and open-ended questions. Quantitative data were analysed using simple quantitative analysis methods. All collected data from interviews were entered in Google Sheets, where frequencies of responses (predefined answer options) were counted. For multiple-choice questions, where respondents could select more than one option, each selected response was counted individually to assess their relative distribution. Descriptive statistics, such as response counts and proportions, were used to identify trends and patterns in the data.

Qualitative data were systematically organised in spreadsheets and documents for analysis, with thematic coding applied following Braun & Clarke's (2006) six-step framework. All interviews were transcribed and all Spanish interviews were translated using multiple online tools to conduct thematic analysis. Different online tools were used for transcription and the transcripts were carefully checked against the audio recordings for accuracy. Farmers' responses were read and reviewed multiple times to familiarise with the data and identify possible patterns. Initial codes were generated from data by manual coding and organising data into meaningful groups. Particular attention was given to capturing variations within the data to ensure a comprehensive representation of farmers' perspectives. These

codes were then categorised into potential broader themes, which were later reviewed and refined to ensure they accurately represented the data. Each theme was then clearly defined and named (e.g. “food sovereignty” or “value addition”) and considered both in relation to each other and to the research question. Some themes contained sub-themes, for instance the theme “challenges” included “price negotiation”, “price fluctuation”, “market access”, etc. Finally, data were analysed within themes and the most representative quotes and vivid examples were selected to illustrate the findings and demonstrate the prevalence of the themes. Additionally, to ensure a coherent account of the data, the results are presented in close alignment with the questionnaire structure, with thematic findings integrated throughout the report. Qualitative content analysis was also applied to open-ended responses under "Other (please specify)”, which was one of the predefined answer option for several questions, as well as to follow-up questions requesting explanations in semi-closed questions (e.g. “Explain briefly"). The responses were reviewed to identify recurring themes and their frequency was recorded where applicable. This combined approach allowed for a structured numerical analysis while also capturing additional insights beyond the predefined response options. Finally, to visualise some of the key findings, data were presented using tables, a bar chart, a pie chart and TAPE radar charts.

For each farm, responses related to the 10 elements in TAPE were assigned scores based on predefined descriptive scales. The scores for indices under each element were summed and standardised to a 0–100% scale to obtain a general score for each element, following the guidelines by FAO. The standardised scores were then visualised using radar charts, enabling a comparative representation of agroecological elements. Additionally, the element scores were averaged across all farms to identify which agroecological elements scored highest and lowest. This approach was taken because preliminary observations during the TAPE assessment indicated that certain elements consistently exhibited higher or lower scores across farms.

4. Results

4.1 Description of production systems

The land area under production ranged from less than one hectare to 14 hectares, with an average of 5.98 hectares. Fifteen farmers reported hiring workers, most for seasonal work and fewer on a permanent basis. All farmers cultivated a variety of crops for both subsistence and sale. The majority (15 out of 16) relied primarily on a single crop as their main source of income. The main cash crop varied among farmers: 10 cultivated coffee, four grew cacao, one produced various fruits and one grew tangerines. The most common crops were bananas, cassava and plantains, followed by citrus fruits such as tangerines, oranges and limes, and avocados. Some also grew sugarcane, pineapple, mango, beans and maize, along with a variety of vegetables, including lettuce, tomatoes, onions and carrots, as well as aromatic herbs. Beekeeping was common and some raised livestock, including cows, chickens, pigs and horses. Regarding the most profitable crops or activities, 10 farmers identified coffee as their primary source of income, while four reported cacao. One farmer adopted a Community Supported Agriculture (CSA) model, in which customers paid an annual subscription fee upfront in exchange for regular deliveries of fresh produce throughout the year. Another reported tangerines, noting that they were also developing agrotourism. In addition, five farmers cited agro- or ecotourism as key income-generating activities. Although not explicitly asked about it, 11 farmers mentioned engaging in tourism in some form. As one farmer explained: “Ecotourism is another very interesting economic activity because it brings in additional income beyond just land use, though we are using the land for birdwatching and nature walks as part of the tours.”

4.2 Crop decision-making: market opportunities and other influences

Market opportunities influenced farmers’ crop decisions to varying degrees. Six farmers stated that market opportunities had a significant impact on their choices and another six reported a moderate influence. As one farmer explained: “Entirely [on the market influence], because the crops I grow must generate some profitability to sustain the farm and the entire family”. The remaining four said market factors had no influence on their decisions. Although, among those four, two explained that they would continue growing coffee because it was reliable and in stable demand. The other two prioritised food sovereignty over market potential when selecting crops

Food sovereignty, or food autonomy (a term farmers often used), was brought up by many as an important factor in their crop decisions, even though it was not a direct interview question. It emerged frequently in discussions, particularly in response to questions about market influence on their crop choices. All farmers

grew crops for household consumption and some explicitly emphasised its importance during interviews. As one farmer shared: “I think we are really autonomous when we are growing food. I think in my case it's not about how much we are going to earn”. Intercropping coffee and cacao plants with fruit trees and staple crops to diversify the “household food basket” was common and many also grew vegetables. One farmer stressed that self-sufficiency was the foundation of sustainable production, explaining that growing diverse crops to ensure food security helped stabilise the household economy by reducing expenses. And surplus production could be sold or used to feed livestock, generating income over time. Another farmer described his approach:

> We have bee hives here on the farm. The fruits, cassava, plantains, avocado… a vegetable garden, so all that is entirely for self-consumption. Well, obviously, we need an economic activity to sustain ourselves, which is transforming coffee. And for coffee, I am already transforming the entire farm's production and selling it with added value. The other part [growing food] gives us food sovereignty.

Tradition also shaped crop choices, as some farmers continued cultivating specific crops due to long-standing practices within their families and communities. As one farmer explained: “I want us to preserve this land and preserve these traditions. I am the fourth generation of cacao farmers. Cacao is a tradition of approximately one hundred years in the family.” Some emphasised the cultural and economic value of these traditions, which had historically been part of local farming systems but were later displaced by industrial agriculture. One farmer highlighted the importance of maintaining these traditional, culturally appropriate practices:

> Practices such as growing guadua [bamboo] and beekeeping… The key is to improve processes, organise ourselves and find markets for these products, as they are truly easy, culturally acceptable, we have always had them, but they have typically been made invisible by technological packages that involve specific varieties of seeds, inputs and techniques imposed by a market and we neglect traditional knowledge.

These findings align with the highest-scoring elements in the TAPE assessment. Farmers’ emphasis on tradition corresponds with the element of Culture and Food Traditions, which had an average score of 75.00% and includes the assessment of local or traditional (peasant/indigenous) identity and awareness. Many farmers cultivated a diverse range of crops to meet household food needs, which reflected a strong alignment with both the Diversity element (72.27%), including crop, animal, tree and activity diversity, and the Efficiency element (74.22%), measuring household-level productivity and reliance on external inputs. Efficiency represents “an emergent property of agroecological systems that carefully plan and manage diversity to create synergies between different system components.” (FAO 2018.) Figure 1 shows the average results of TAPE Step 1 across all assessed farms. Culture and Food Tradition, Efficiency and Diversity were the highest scoring

elements, while Responsible Governance, Recycling and Co-creation and Sharing of Knowledge were the lowest scoring elements.

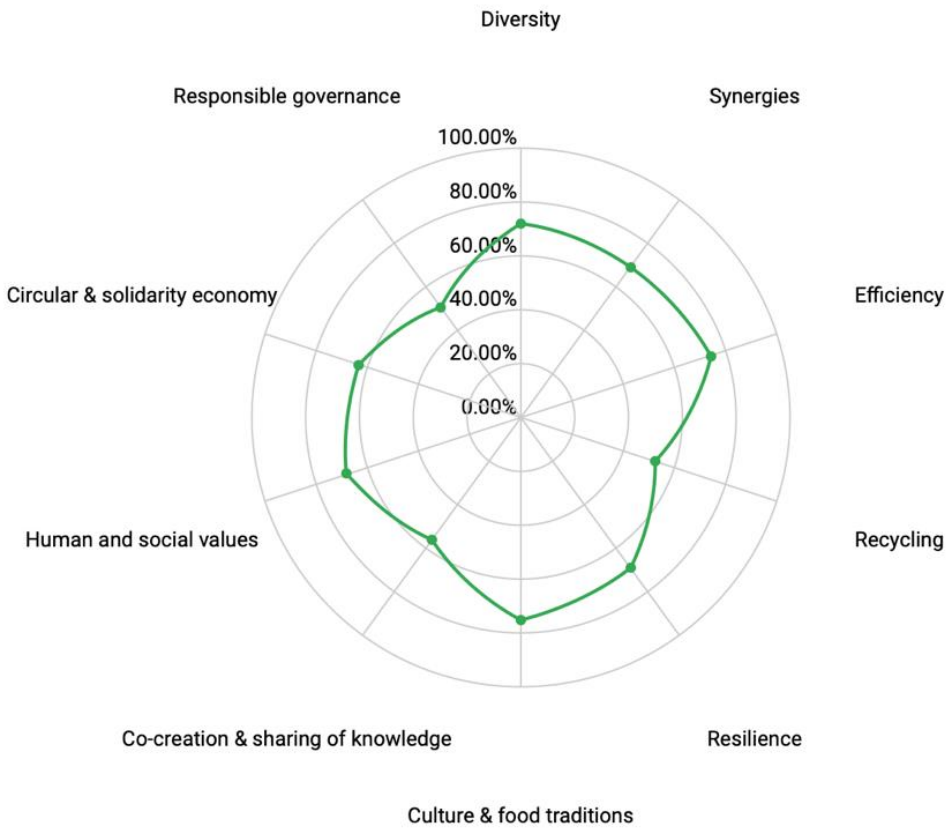


Figure 1. Radar chart of the average scores for each of the 10 elements of agroecology from TAPE Step 1 (characterisation of agroecological transitions) across all assessed farms.

4.3 Agroecological practices and the role of high-value markets

When asked to what extent high-value market opportunities had encouraged them to adopt more environmentally friendly practices, the majority (13 out of 16) described some level of market influence. As one farmer put it: "If the market tells us to move away from chemicals or pesticide substances, then we [farmers in general] will work accordingly." Another farmer explained:

> "Significantly [about high-value market incentives], really, because, obviously, when one wants to reach those markets, you have to change agricultural practices no matter what. So, we now talk about a much more artisanal coffee… about good practices that are environmentally friendly, especially because we offer coffee here along with birdwatching. For birds to be here, they need to find a habitat... We have fruit trees and native trees among the coffee plants. These trees provide food for bees, different bird

species and mammals. Here, we associate the farm with a forest and everything related to food sovereignty."

Three farmers said that high-value markets had no impact on their decisions. Two of these farmers explained that their farming practices were motivated by their commitment to environmental stewardship rather than market incentives. However, all three acknowledged the role of customer demand. One of them highlighted that their customers remained loyal not only because of the food, but also because they valued the farms' environmental principles. Another suggested that HVMs have the potential to motivate more farmers to adopt similar practices. The third farmer explained that HVMs had not influenced them because they had not been integrated into such markets yet. Figure 2 illustrates the varying degrees of market influence on farmers' practices.

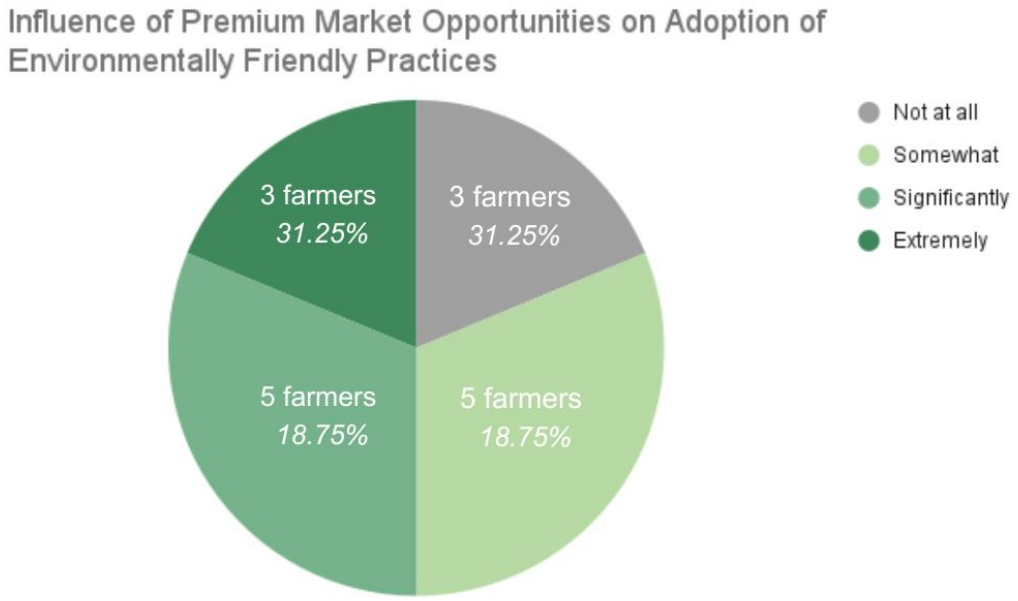


Figure 2. Farmers' perceptions of market influence on the adoption of "environmentally friendly" practices, based on interview responses.

In a follow-up question, however, although farmers were specifically asked which environmentally friendly practices they had adopted or would consider adopting to meet market requirements, most did not frame their answers in relation to the market. Instead, they described the practices they already carried out on their farms. Some of these practices aligned with both market requirements and environmental benefits. For example, one noted: "To produce premium coffee we need to have diverse shade, trees that protect them from the sun, like guamo and chachafruto." Another farmer shared: "Our customers are people who want to drink

organic coffee, people who want to think that - I buy coffee that takes care of the forest." As a result, it was not always possible to distinguish whether these practices were market-driven, motivated by other factors or a combination of both. As one farmer explained:

> For example, our experience here shows that the added value of our coffee comes from the way it's produced. People want to drink it because those with sensitivity, who appreciate the way we work, are drawn to it. So now, people want to buy from us and support us simply because we're doing something for the environment. And that generates something more - it's sentimental, it's also about love.

Picture 1. Agroforestry system integrating coffee, banana, plantain, sugarcane, nitrogen fixing plants, shade and fruit trees and other species that aid in nutrient and water cycling.

Farmers implemented a wide range of practices to improve soil health, enhance ecological interactions on farm, support biodiversity and reduce external inputs. One farmer explained while chopping banana leaves and spreading them on the ground: "Bananas for eating, the main stalk for cows, leaves and branches back to soil to return the nutrients. And then cow manure as well - back to soil!"All farmers used shade trees or intercropped with trees (Pictures 1 and 2). Farmers described multiple functions of the fruit and native trees integrated with coffee and cacao plants. These functions included providing shade, fixing nitrogen, attracting pollinators, providing food and shelter for birds, as well as food for household

consumption. Promoting pollination, intercropping with nitrogen-fixing species and organic pest control were common. Beekeeping was particularly important for coffee farmers, with some reporting increased production after adopting it. On the other hand, maintaining soil cover was critical for cacao farmers, since midges, the primary pollinators of cacao, required leaf litter cover for reproduction. Many farmers highlighted their efforts to connect fragmented landscapes and maintained wildlife corridors on their land. Other practices included making biofertilisers, enriching soil with microorganisms and biochar, intercropping with food crops and implementing rotational grazing with cattle. Three farmers used septic systems to prevent water contamination and one farmer installed a biodigester to process organic waste into biogas for cooking and slurry for fertilisation. Table 1 summarises some of the practices. (The participants were also asked about practices they would consider adopting; however, the responses reflect only those practices they already implemented). Other practices to improve soil health and reduce dependence on external inputs included planting leguminous cover crops, composting manure, maintaining soil cover and reducing or eliminating agrochemical use. Several farmers also experimented with native trees for soil improvement. Other reported strategies included no-till farming, manual weeding, growing animal feed on-farm and saving their own seeds. One farmer shared:

> …it's essential to plant a variety of species that interact and support each other through their diversity. When the soil is rich in bacteria, fungi and other microorganisms, the key is to nourish them so that balance is maintained…With poisons and insecticides, you kill the insects that attack the plant. But at the same time, you kill insects that are very good for the soil... Then, "oh, why is the land so barren?" Because you're killing it.

Table 1. "Environmentally friendly" farming practices adopted by farmers.

Practices adopted	**Farmers (n)**
Using shade trees or intercropping with trees	16
Promoting pollination	15
Intercropping with nitrogen-fixing species	14
Using organic or natural pest control methods	12
Maintaining soil cover with cover crops & mulch	11
Other (specify)	6

The specific examples of species were observed during field visits and discussed during interviews. Many of these trees fit into different categories, as they may serve multiple purposes. For example, some trees function both as shade trees and nitrogen-fixing species, while also producing fruits. Shade tree species commonly used included *Inga edulis* (guama), *Cedrela odorata* (cedro), *Albizia carbonaria* (carbonero) and *Handroanthus chrysanthus* (guayacán amarillo). Coffee and cacao plants were often intercropped with species such as *Manihot esculenta* (mandioca), *Musa* × *paradisiaca* (plátano) and *Tithonia diversifolia*, with the latter used for its

ability to absorb nutrients from deep soil layers. Fruit trees were a significant part of the agroforestry systems, including *Mangifera indica* (mangos), *Persea americana* (aguacate), *Citrus reticulata* (mandarina), *Citrus sinensis* (naranja), *Litchi chinensis* (lychee), *Artocarpus heterophyllus* (jaca), *Nephelium lappaceum* (rambutan), *Tamarindus indica* (tamarindo), *Bixa orellana* (achiote), *Eugenia uniflora* (pitanga) and *Psidium spp*. (guayaba) among others. Nitrogen-fixing species such as *Gliricidia sepium* (matarratón), *Albizia carbonaria* (carbonero), *Inga edulis* (guama), *Cajanus cajan* (guandul), *Acacia spp.*, *Mucuna pruriens* (frijol vitabosa) and *Canavalia spp.* (canabalia) were frequently mentioned. Additionally, pollinator plants like *Spondias purpurea* (ciruela de monte), *Gliricidia sepium* (matarratón) and *Cestrum nocturnum* (jazmín de noche) were used. Farmers also practiced natural pest control methods, such as pruning and removing diseased leaves, using organic fungicides and using locally adapted and native plant varieties and animal breeds.

Picture 2. Multi-layered agroforestry system with cash crops like coffee, subsistence crops like plantain and supporting species that enhance soil fertility and nutrient cycling.

Interviews revealed a broader set of motivations shaping farmers' decisions and practices beyond market incentives alone. As one farmer mentioned: "Here, we associate the farm with a forest and everything related to food sovereignty." While high-value market opportunities significantly influenced both farmers' crop decisions and adoption of agroecological practices, farmers also emphasised values such as food sovereignty and self-sufficiency, care for the environment and a sense

of tradition and dignity. One farmer explained: “The agroecological farming allows other species to coexist harmoniously… Agroecology is about respecting and caring for the environment and protecting peoples’ health. This truly dignifies the work we do as farmers.” Another shared: “Look what can be achieved... with little, you can have quality of life. Our goal has been to show small-scale coffee growers that with a small piece of land, they can live with dignity.”

Several farmers emphasised the importance of working with local ecosystems and moving away from monocultures to ensure long-term sustainability. As one farmer put it: “I have to work with the ecosystem I've got here, not chase after models from somewhere else. Because that's exactly what the industry wants, to keep us locked into their way of doing things.” Another farmer shared their experience of moving away from certain agricultural practices introduced in the past:

> In the 1980s, the Green Revolution led to forests being wiped out to plant smaller coffee plants. My father wasn’t someone who deforested too much. Because there were many people who cut down forests, and well, it caused a lot of damage. Thankfully, my father didn’t clear the forest… The Federation [Colombian Coffee Growers Federation] developed new, shorter Arabica varieties, but in the past, taller ones like Bourbon and Pajarito were common. I want to recover these older genetic lines in one plot because their quality is exceptional…We no longer use herbicides. There was also a very bad practice taught by the Federation, which was the use of herbicides. So now, as much as possible, we use machetes. And that [biomass] also turns into organic cover. That covers the soil.

4.4 Income improvements and economic outcomes

Integration into HV markets contributed to varying levels of income growth. Most farmers reported an increase in income compared to three years ago, which they directly linked to their access to HV markets. Fifteen farmers experienced higher income, while one stated that their income had remained the same. The only farmer whose income stayed the same was the one that used a CSA model. When asked about how much their income had increased as a result of participating in high-value markets, seven farmers reported an increase of more than 50%, five farmers experienced increases between 20–50% and one reported a 10–20% increase. Another farmer noted a smaller increase of 0–10%, explaining that they had only recently started accessing HV markets. One farmer was participating in HV markets from the beginning and could not provide a comparison. Another farmer had not yet entered these markets due to a lack of certification. Farmers identified different sources of their farms’ profitability. Most attributed their increased income and profitability to value addition, such as processing coffee or cacao, followed by agrotourism. And three farmers pointed to diverse production as the main factor.

Value addition emerged as a key strategy for securing economic viability of agroforestry production systems. All farmers reported processing at least one

product on-farm to increase its value and receive higher prices. They emphasised the critical role of value addition in improving profitability and financial stability. Coffee producers described several stages of on-farm processing. They used honey, washed and natural processing methods, followed by fermentation, drying, husk removal, roasting, grinding and packaging for direct sales. Cacao producers also processed their harvests through fermentation, drying and roasting and transformed the beans into a variety of products, including chocolate, crushed cacao nibs and chocolate liquor. Some farmers highlighted the use of traditional cacao varieties such as Criollo, which they valued for its rich flavour and potential for producing fine-flavour cacao (see Picture 3). This further increased the market value of their products. Two farmers explained:

> So, the process of transforming [processing] cacao and adding value is what brings in good income - because I set the price. Otherwise, I'd be at the mercy of the market… It's because the cacao, due to its price and because what is sold here is a transformed product, is the key to sustainability. In reality, the income comes from a transformed product. We are not selling raw material; it's the transformation that helps us. Everything we grow, we transform. In products that we sell.

> To ensure sustainability and long-term stability…it's important to produce a high-quality product. We [referring to a coffee farmers' organisation] need to engage in constant training, especially in processing. Because we are seeing that the added value of coffee and cacao lies in processing. Once we learn how to process, we can add value to our product. And if we add value to our product, we can achieve long-term sustainability. That is always the goal in the specialty coffee or specialty cacao sector - to be sustainable, to generate good income and for that income to be reflected in the well-being of our families. And for our children to see a great opportunity in this work.

Through processing, farmers created value-added goods that they sold at significantly higher prices than raw coffee or cacao beans. In addition, one farmer produced tangerine juice without additives and dried herbs; another dried fruits; a third made fruit marmalades; two produced panela from sugarcane and one made pineapple-based beverages. In one case, a farmer achieved economic stability through a Community Supported Agriculture (CSA) model, securing a stable customer base and predictable income through direct relationships with consumers. Farmers consistently emphasised the importance of value addition not only as a way to increase income, but also as a strategy for resilience against price fluctuations, climate uncertainty and dependency on intermediaries. As one farmer explained: "Transforming [products through value addition] and achieving a balance that ensures stable sales due to transformation is a success for us. Once you reach that balance, you are no longer at the mercy of the market. You have achieved self-sufficiency. It's one of the biggest achievements for our family." Another shared:

> …Although climate change sometimes greatly affects crops - for example, there are years when there is no coffee production, which is very difficult. If there was a particularly harsh winter, it becomes really hard to maintain stable coffee production. So, coffee production drops significantly, but we can recover through roasted coffee, tourism and other activities that help mitigate those challenges.

Picture 3. Different varieties of cacao displayed during a farm tour that showcased the key post-harvest stages of cacao – fermenting, drying and processing and final product tasting.

Picture 4. Different value-added products derived from cacao, as presented during a farm visit.

Nearly all farmers reported making changes to their production practices to access HV markets. The most commonly reported change was acquiring new knowledge and skills, followed by land-use modifications. Table 2 shows an overview of the reported changes, including an "Other" category. It presents the types of changes reported by farmers in response to a structured questionnaire (see Appendix 1). Specific examples of these changes were identified through field observations and interviews. For instance, farmers described acquiring new knowledge and skills related to post-harvest processing techniques such as fermenting, drying and roasting cacao, or improving coffee drying methods. Land-use modifications included transitions from monocultures to agroforestry systems or expanding production due to market demand. Agricultural inputs mentioned included organic fungicides, while financial investments often involved purchasing processing machinery or planting materials. Additional adjustments included improving hygiene and sanitation in processing facilities, establishing collaborative partnerships and implementing systems to ensure traceability of their products.

Table 2. Changes in production practices made by farmers to access HV markets, with the frequency of each change reported, including an "Other" category.

Changes made	**Farmers (n)**
New knowledge & skills	15
Land-use modification	10
Agricultural inputs	8
Financial investments	6
Technology	5
Additional labour	3
Other (specify)	3
No changes made	1

4.5 Collaborations

Most farmers (13 out of 16) collaborated in some way to access HV markets. The most common collaborations were with associations, followed by forming alliances with other farmers, extension services and cooperatives (Table 3). For example, one farmer, who achieved profitability through value addition and integration within the HV market, collaborated with other farmers through cacao association because: "Demand is so high that we are expanding cacao plantations and also buying dried cacao nibs from others". Another farmer explained that they aggregated larger quantities of their production with other farmers to meet volume requirements for efficient transportation and market access. A third farmer worked in a local farmer-led entrepreneurial organisation focused on specialty coffee production, sustainability and community well-being. With 150 member families

(80% women), the organisation supported quality improvements, value-added processing and traceability. It reinvested profits in farmer support and community initiatives. They explained:

> It is a great opportunity because we know that coffee already has a secured market, right? And when we talk about specialty coffee, the price increases, right? It is also linked to agrotourism - bringing people to the farm so they can learn about the process, from harvesting to fermentation, drying and finally, transformation and preparation of the beverages.

Table 3. Types of collaboration reported by farmers to access HV markets, including the frequency of each collaboration selected.

Collaboration type	Farmers (n)
Associations	8
Other farmers	4
Extension Services	3
No collaboration	3
Cooperatives	3
Other (specify)	2

Figure 3 compares the support farmers received from various collaborations with the additional support they identified as beneficial. Reported collaborations mainly provided capacity building and knowledge sharing, followed by technical assistance and support for market access, while financial support was the least common. However, farmers expressed a need for stronger market connections, more capacity building opportunities and greater access to financial resources. Additionally, several farmers emphasised the lack of farmers associations, partnerships and platforms for knowledge-sharing. They noted that while some initiatives existed, they were not widespread in rural areas. Two farmers highlighted that the lack of trust was prevalent, especially between social classes. As one put it: “Like, it's in both ways. It's not just, like, the rich people are against the poor people. Like, the poor people are against the rich too. It's really complex.” Another farmer, who purchased an abandoned monoculture coffee farm and established a diverse agroforestry system explained:

> We have to change our coffee culture. We have to do a lot of educational effort to change that. I think capacity building is very important because we have a long history with the National Coffee Federation and this was like the language on coffee. And now we have to work in another kind of narrative around that. So we are sharing knowledge, but one thing that is very important in Colombia and to mention is building trust. It's difficult because we were at war and we had armed conflict for many years. And I think it's still here. And trust is something that we have to work to win because it's not like, at the first moment, we all believe and trust anybody. We have to build that trust.

A few farmers explained that although some programmes had provided support with infrastructure or business initiatives, people did not participate and take advantage of them. For example, one farmer shared:

> Yes, there are organisations that help out with projects, but what happens is that it's always the same people [participating]. It's not that the networks aren't open or social, but… sometimes, projects focus on people who already have some production, but what about those who have land and yet nothing is produced?… The question is how can we make space so that people get open to the opportunities. How to inspire. Because I think the problem is that the people don't see they have a future.

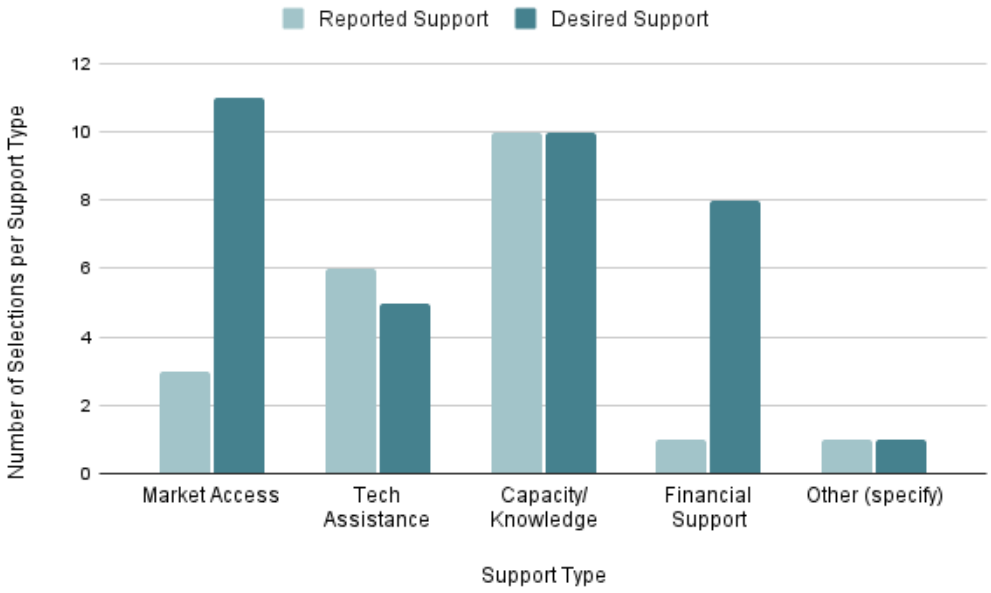


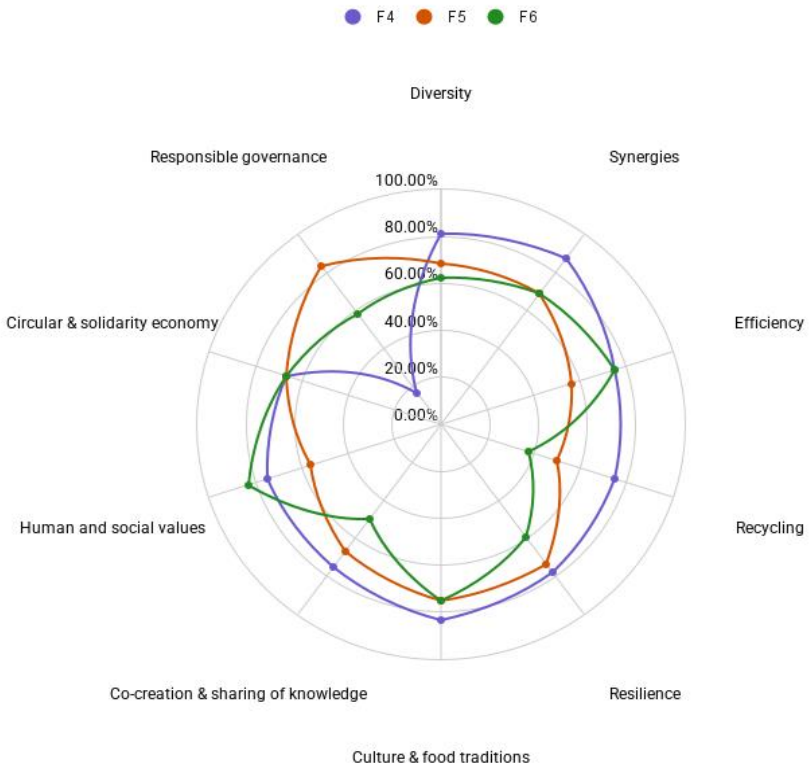
Figure 3. Comparison of support received by farmers from various collaborations and the additional support they wished for.

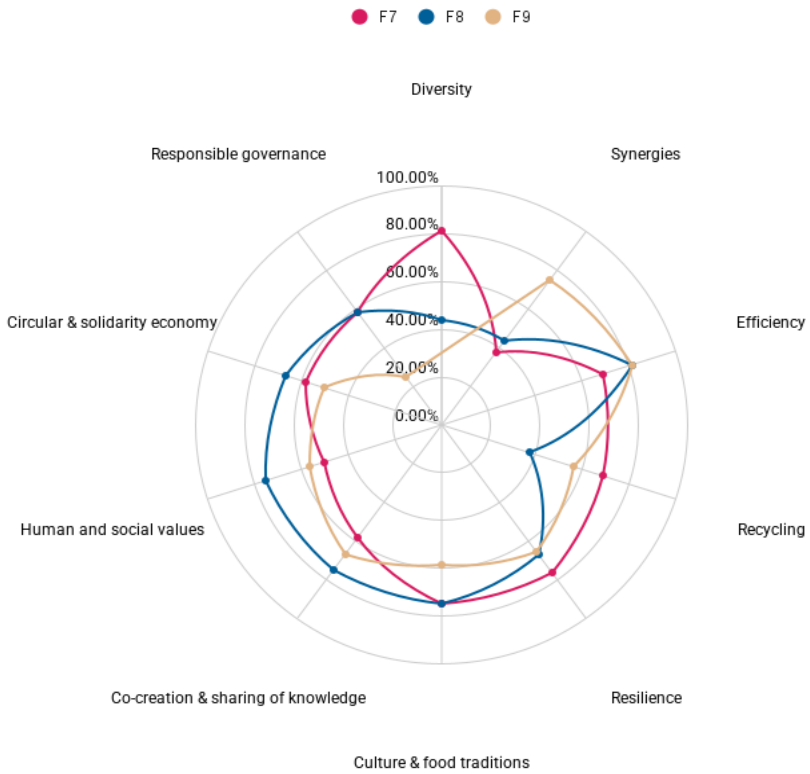
The interviews revealed a strong need for more collaborations, especially for those that foster market access and knowledge sharing to improve agricultural practices. As two farmers noted: "It's a matter of culture and education." These insights align with the TAPE assessment results, which showed particularly low scores in Co-creation and Sharing of Knowledge (average 56.06%). This element includes indicators such as the presence of platforms for horizontal creation and transfer of knowledge and good practices, access to agroecological knowledge and participation of producers in networks and grassroots organisations. Similarly, Responsible Governance also scored low (average 50.69%), reflecting the limited presence of producer organisations and associations. Figure 4 shows the results of TAPE step 1 for each farm. One farmer highlighted the importance of such farmers' associations:

> Yes, in the year 2000, we were part of an associative process that, following a coffee crisis, allowed us to explore market opportunities. We found an allied peasant community nearby… along with Indigenous communities, who had an organic production market line to sell as Fairtrade in the Netherlands. … we received a bonus of 1,050 more per kilo. This was based on a certification we obtained after three years of stopping the use of synthetic chemical products and improving production. To achieve increased income, associativity is fundamental. This is because, in most cases, we do not initially have sufficient financial resources to invest in a full production

system or expand cultivation on a larger scale and the availability of labor in rural areas is decreasing. Therefore, associative processes are what will allow us to generate a sufficient quantity to access the market.

To complement the interview findings, the radar charts in Figure 4 provide a visual summary of each farm's characterisation of agroecological transitions, based on the 10 Elements of Agroecology. Each farm is labeled F1 to F16 (e.g., F1=Farm 1). Farms (F1 - F16) are presented in four separate charts. The first three charts group farms based on their overall level of agroecological transition, from highest to lowest scoring: farms F1 - F3, F4 - F6, and F7 - F9, respectively. The fourth chart includes farms F12 - F16, which were assessed using a simplified version of the TAPE tool due to time limitations, with only four elements evaluated for these farms. In addition, Figure 5 presents a combined radar chart showing all 16 farms together to provide an overall comparison across the full sample. These visualisations show the TAPE results and enrich the qualitative insights presented throughout the report. Across all farms, the elements scoring highest were Culture and Food Traditions, Efficiency and Diversity. In contrast, the elements with the lowest scores were Responsible Governance, Recycling and Co-creation and Sharing of Knowledge. These trends align with key themes from the interviews.


F4
F5
F6
Diversity
Responsible governance
Synergies
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
Circular & solidarity economy
Efficiency
Human and social values
Recycling
Co-creation & sharing of knowledge
Resilience
Culture & food traditions


F7
F8
F9
Diversity
Responsible governance
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100.00%
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Human and social values
Recycling
Co-creation & sharing of knowledge
Resilience
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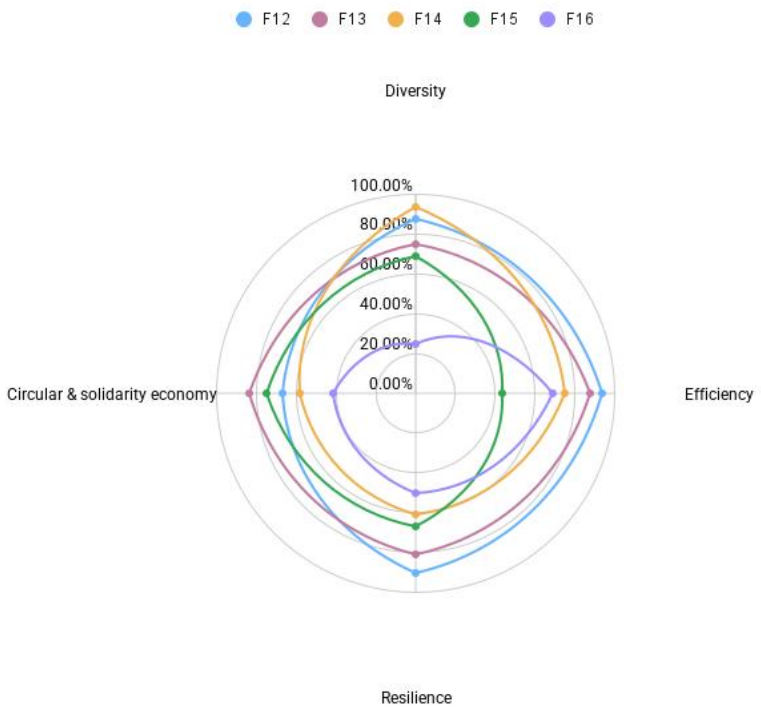

Figure 4. Radar charts showing the results of TAPE Step 1 (characterisation of agroecological transitions) for all assessed farms.[1]

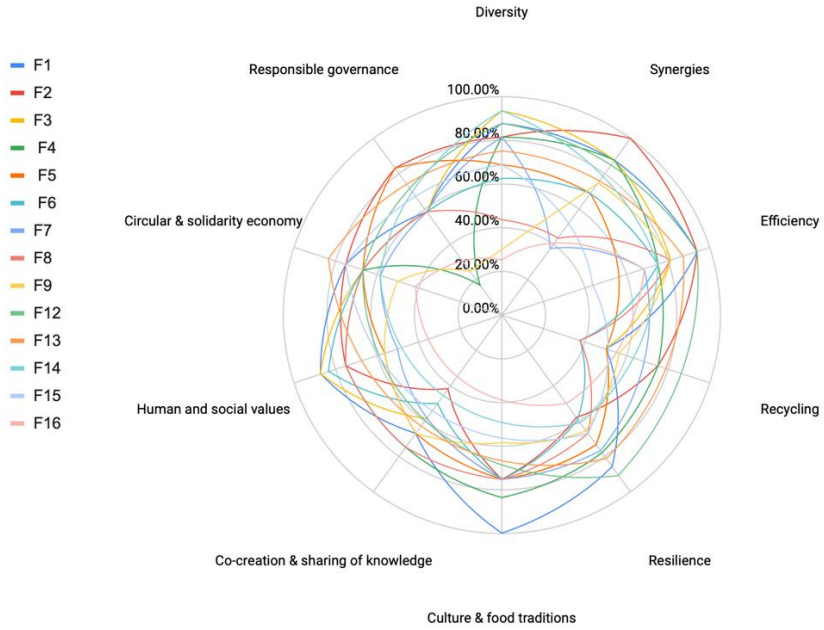

Figure 5. Aggregated radar chart of all assessed farms (F1 - F16) showing comparative agroecological transition scores of TAPE Step 1.

[1] One of the elements shown, Circular and Solidarity economy, refers to inclusive, circular models that reconnect producers and consumers through fair, local markets, supporting sustainability and social equity (FAO 2018).

4.6 Challenges in selling products at higher prices

4.6.1 Price fluctuations

Coffee farmers described global market volatility as one of the biggest barriers to selling coffee at a stable high price. They explained that coffee prices are unpredictable because they are influenced by global supply and demand dynamics. One farmer discussed that prices were ultimately influenced by large international actors. Farmers noted that pricing can be affected by climate-related events too. For instance, Colombian coffee prices were high this year, because Brazil, the world's largest coffee producer, suffered crop losses due to extreme weather events. A similar situation occurred 3-4 years ago when a combination of frost and drought reduced Brazilian coffee yields, leading to a price increase benefiting Colombian farmers. However, the opposite can also occur - when there is an oversupply in the global market, coffee prices in Colombia can drop. As two farmers reflected on market dynamics:

> It's just that at times… since coffee is a commodity that is traded on the New York Stock Exchange and it depends on supply and demand, we are experiencing price fluctuations. So, right now, what is happening? There is no supply. Brazil lost a harvest, so now Colombia is at the top. Prices like this have never been seen before. So, at this moment, it is selling well. Right now, there is money for everyone. We are doing well. But sometimes, it's the opposite. Then there are too many offers… and the price in Colombia drops to levels where farmers actually lose money.

> Because our coffee was of very good quality… there was a pact that we as Colombians, as the National Coffee Federation, signed ... And because of that, it was very good to produce coffee… But then this pact, I don't know what happened, it failed and everything was a mess. Because after that, coffee has been on the C market, but with New York. This is a commodity and the price is regulated by the C prices. So, the market is supposed to work based on supply and demand. So, if there's a lot of demand, the price is better. If there's low demand, the price is lower.

4.6.2 Market access and bargaining power

Several farmers said they struggled to reach HV markets. One farmer explained: "The current markets do not value origin or high-quality products; they are predatory markets. We have to create a culture of consumption." Farmers described a lack of bargaining power in local markets. They described how local buyers offered low prices for "normal" coffee and cacao. Most farmers said that intermediaries often dictated prices, which limited their ability to negotiate. As two farmer explained:

> At the local level, the entire market is managed by middlemen, people who buy, negotiate and manage the products, so you don't have the opportunity to manage your prices, but prices are imposed by people from outside, not based on what you do. And most people don't sell to the final consumer.

> But the problem in the countryside is that you produce, and you don't have a distribution system or anything that guarantees the purchase of your product. Coffee is profitable and has endured because the Federation ensures the purchase. They buy in large quantities, of course, at a fixed price or at whatever the market price is. But with all other products, you're practically at the mercy of intermediaries and policies on this are very weak in Colombia.

Producing specialty coffee, for example, required extra time and labor. However, not all buyers were willing to pay appropriately for this added value. As a result, one farmer chose to return to selling in bulk to a cooperative that paid a uniform price. Similarly, a farmer who sold tangerines explained that large buyers, such as restaurant chains and supermarkets, expected low prices. These buyers assumed that direct purchases from farmers should cost less than purchases made through intermediaries. However, the farmer pointed out that they managed the logistics typically handled by intermediaries, making further price reductions unsustainable. Finally, a few farmers highlighted the need to educate consumers about the benefits of "regenerative" and "ecological" products. One farmer explained:

> ...educating the consumer to make them aware of the benefits of a regenerative product that truly contributes to people's health and helping them understand that they are consuming something that comes directly from the hands of farmers. The challenge is educating consumers. That is why we have implemented the agrotourism system, where consumers can see firsthand how our entire process works. This way, we educate people to make healthier consumption choices.

Additionally, the competition in the specialty coffee sector remained intense, making differentiation a significant challenge. As one farmer explained, "I had to go through the certification process just to be competitive." One farmer said that after a natural product store they used to supply closed down, they stopped paying for certification because there was no guarantee of a better price for their organic tangerines. Another shared that they maintained certification for nearly two years but had to stop, as they could not meet volume requirements and struggled with high transportation costs. A third farmer said their cacao was organic and high-quality, but it could not enter HV markets due to the lack of certification. Some farmers also faced transport-related barriers. Poor rural roads limited their ability to move products efficiently and restricted access to markets. Beyond infrastructure, farmers struggled to connect with buyers, especially in distant cities. One described the challenge:

> Transportation is one of the challenges, but also it's finding them [customers] through technologies [digitally]... It's really a big challenge for all the producers because we are really far away from the final clients… So, we have to explore, we have to make that connection… Buyers are not here. Buyers are in other places. So, finding them is kind of hard.

4.6.3 Value chains

As described above, one farmer reverted to bulk sales through a cooperative. Although this system did not offer the highest prices, it provided predictable payments. Similarly, a cacao producer who also directed an agricultural consulting firm and worked with a cacao association described how the association supported small producers. The association operated gathering points where farmers delivered their harvests. These centers acted as intermediaries, collecting cacao and selling it to large buyers. This system ensured a steady flow of income for producers, who might otherwise have struggled with transportation costs to reach buyers. The association purchased all the cacao that producers brought to the gathering points, but paid by weight and did not assess cacao quality. While this guaranteed timely payments, which were important for farmers to reinvest in the next production cycle, the price stayed the same regardless of quality.

The association lacked the tools and knowledge to evaluate and differentiate cacao quality. They also lacked connections with buyers interested in purchasing cacao of different quality levels. As a result, they sold all the produce in bulk to one or two buyers, including the national chocolate company, at fixed prices. The consultant added that smaller buyers, such as themselves, demanded higher quality and were willing to pay more, but purchased in lower volumes. To shift toward price differentiation, the association would need to secure diverse buyers who valued and paid for quality.

Strengthening the cacao value chain required investment at multiple levels. Cacao quality depended on both farm practices, such as shade management, soil cover and post-harvest processing, including fermentation and drying. Farmers needed to improve these practices to deliver higher-quality cacao to the gathering centers. The centers needed to implement structured systems for quality evaluation, classification and separation. This would allow them to sell different grades of cacao to different buyers at varying prices and, in turn, pay producers according to the quality of their products. However, to make this model viable, the association needed to secure several buyers, each interested in a different quality grade and willing to pay accordingly. Moreover, sorting cacao by quality required physical and sensorial assessments. The process was labor-intensive and demanded investment in infrastructure and trained personnel. Finally, the consultant noted that while small-scale producers often struggled to access financial support, membership in an association made it much easier to apply for and secure funding.

Table 4 summarises the enabling and limiting factors influencing the economic viability of agroforestry production systems, based on farmers' perspectives on challenges and opportunities. The table highlights key factors identified through interviews.

Table 4. Summary of the enabling and limiting factors influencing economic viability based on farmers' perspectives on challenges and opportunities.

Enabling factors	Limiting factors
Value addition	Price fluctuations
Growing high-value crops	Limited market access
Environmentally responsible production	Lack of bargaining power
Collaborative partnerships	Underdeveloped value chains
Integration of tourism	
Changes in production practices to access HVMs	

4.6.4 Other challenges

Farmers also mentioned other challenges beyond selling at high prices. These included environmental concerns and social issues, which several farmers raised during the interviews.

Several farmers expressed a desire to improve recycling and have technologies to generate renewable energy. They maintained forest cover along water sources on their land and emphasised the importance of protecting water. As described earlier, three farmers installed septic systems to prevent water contamination. As one farmer explained: "One of the main issues we face in rural communities is the management of wastewater." A few saw potential in using crop residues or animal manure to create biogas. Some already processed agricultural byproducts. For example, they produced beverages from coffee husks or cacao juice. These concerns were reflected in the low scores for the Recycling element in TAPE (average - 52.27%), which assesses renewable energy use and production, as well as recycling of biomass and nutrients. One farmer shared their plan to transition to renewable energy:

> There are some inputs we don't produce, so we have to buy them. Energy is a big part of this question because one of my projects is to transition to renewable energy: solar energy and through hydraulic rams. The hydraulic ram propels water without needing an external source. Because what has happened now with all the issues with the aqueduct? We don't want to be too dependent on one system. We want to start being more autonomous, more sustainable.

Several farmers raised concerns about a mining threat in the region and described how social movements in villages of Támesis and Jericó had mobilised to oppose a potential mining project. The project aimed to extract minerals from the mountains near Jericó and could threaten underground water supplies, agricultural production and local ecosystems in both Jericó and Támesis. Farmers explained that while the national government had considered declaring southwestern Antioquia an "agroecological district", the regional government in Antioquia viewed mining as an economic opportunity. Farmers also discussed a new national law that

established Food Production Protection Areas (Áreas de Protección para la Producción de Alimentos, APPAs). While some farmers supported the intention of this law, some worried that it excluded the protection of subsoil. They expressed concern that if mining activities were approved (as mining companies can apply for new licenses in the future), their land could be expropriated for exploration or exploitation. One farmer described the risk: "They can come and buy your land, but also they can come and put a platform for exploration in your land. But they have the right. To come and to explore your land." Another farmer shared their concerns:

> There is no land sovereignty. They just go over everything… And those of us who have a little bit of information are very few… Even if the land is in your name, they override that. That is exactly what's happening here with this project…They come and they just go ahead with their plans… If they need to go through, they go through. Even if the land belongs to someone else.

One farmer emphasised that change had only recently begun:

> Only now and under this government, are rural producers invited to participate, farmers are considered as subjects of rights and agroecological reserve zones and food protection areas are being promoted. For the first time, farmers are being called upon to plan their own development.

These concerns aligned with the low scores on the TAPE element Responsible Governance (50.69%). This element includes both Participation of Producers in Governance of Land and Natural Resources and Producers' Empowerment. A representative from a local organisation echoed these concerns. They emphasised the importance of protecting water security and agricultural activity in the tropical Andes, a global biodiversity hotspot. In response to the mining threat, their organisation promoted an alternative development model for the bioregion based on regenerative economies, agroecology and sustainable tourism. The organisation identified and connected 68 local initiatives, including farms, tourism agencies and cultural projects, that preserved cultural values and worked to "transition toward taking care of nature and the land". They promoted these projects, fostered networking among these actors and facilitated knowledge exchange.

Finally, farmers also highlighted a growing concern: the migration of young people from rural areas to cities. They observed that rural youth often felt they had no viable future in agriculture. As one farmer explained:

> We need to create opportunities for young people and children to stay… Where roots are created... because the current education system does not offer many opportunities related to the land. It is part of the culture to leave the rural area to find a job. So now, young people think that agriculture is too difficult and they want to emigrate. Or maybe they don't want to emigrate, but they probably feel they have to.

Picture 5. A community meeting between politicians, farmers and other stakeholders. The banner in the centre reads: "The threat to peace in the southwest of Antioquia is mining".

5. Discussion

5.1 Economic performance of agroforestry systems

Participation in high-value markets significantly increased farmers' incomes. While crop diversification was a common practice among these farms, profitability concentrated around a few high-value crops, predominantly coffee and cacao, followed by tourism as a complementary activity. This aligns with findings by Wollni and Zeller (2007), who found that participation in the specialty coffee segment increased farmers' incomes and Huka et al. (2023), who reported similar outcomes for smallholder farmers participating in high-value markets. Charry et al. (2025) further confirmed that price premiums in specialty markets can significantly influence farm profitability. Their study showed that cacao production systems can be financially viable, highlighting that economic performance is influenced by factors such as yields, price levels, land size and low land costs. Moreover, income diversification through associated crops, especially in the early years of establishment, and a low reliance on hired labor can further improve profitability. This study demonstrates that a combination of high-value crops and value-added processing is an effective strategy for accessing high-value markets and enhancing the economic viability of agroforestry production systems. Farmers achieved higher profitability not solely by cultivating high-value crops but also by processing them into value-added products. Beyond increasing income, value addition emerged as an important strategy for strengthening farmers' resilience in the face of volatile markets and climate uncertainty and reducing dependency on intermediaries. These findings suggest that such approaches could improve the profitability of agroforestry systems in broader contexts and that more attention should be given to designing agroforestry systems around crops and value chains that enable farmers to capture higher prices. Furthermore, the potential of tourism as a complementary income source in agroforestry systems deserves further investigation, as it appears to offer additional opportunities for increasing revenue and contributing to the economic success of agroforestry.

An important factor for scaling up agroforestry is the development of value chains that connect producers to markets that fairly compensate them for their products, valuing the environmental benefits provided by agroforestry systems. As Louman et al. (2024) highlighted, niche markets that demand lower environmental footprints, such as those for coffee or cacao, often offer higher prices. This study demonstrates that integration into such markets can significantly improve the economic outcomes of agroforestry systems. Furthermore, the findings indicate that participation in such markets can contribute to the broader goal of agroecological transformation, as the incentives these markets provide acted as important catalysts for the adoption of agroecological practices among most of the farmers. However,

while these incentives encouraged the adoption of such practices, they were far from being the sole factor influencing farmers' decisions.

Addressing barriers to adopting sustainable agroforestry practices requires ensuring the economic viability of agroforestry systems and strengthening key enabling environments. This includes developing sustainable value chains and markets for agroforestry products, as well as improving access to markets and financing (Springgay & Pajel 2024). The findings from this study underscore that market integration is central to the economic sustainability of agroforestry systems. Furthermore, results highlight that the biggest gaps between the support farmers have received and the additional support they wished for were improved access to markets and financing. This reveals a critical limitation in the current enabling environments, reaffirming the argument that improving market and financial access is essential for the success of sustainable agroforestry systems.

Collaborations were a key support mechanism for accessing high-value markets. Farmers expressed a strong need for more inclusive and accessible networks, such as producer associations, organisations, knowledge sharing platforms and other forms of collaboration. The lack of such networks was evident in the particularly low TAPE scores for Co-creation and Sharing of Knowledge (average - 56.06%) and Responsible Governance (average - 50.69%). Farmers also noted that current support often reaches only a small group of individuals, highlighting the need for greater inclusion and trust-building. Special attention should be given to understanding farmers' diverse needs and conditions, as it's critical in ensuring long-term participation. Such collaborations could address some of the challenges farmers faced. Strengthening smallholder farmer organisations and cooperatives can enhance their negotiating power and improve access to advisory service and finance (Agroforestry Network 2020).

The institutional strengthening of farmer associations and cooperatives is essential for facilitating smallholder participation in high-value markets (Inter-American Development Bank 2002). For example, Wollni and Zeller (2007) found that cooperatives play a critical role in helping farmers meet specialty coffee market demands and that participation in cooperatives led to increased prices for producers. They suggest that promoting participation in cooperatives and specialty coffee segments could help alleviate some of the economic pressures faced by farmers in conventional coffee sectors. A recent study in Ecuador (Villacis et al. 2022) demonstrated that associativity plays an important role in developing high-value cacao value chains, particularly for fine and flavour organic cacao. Associations facilitate market access, helping farmers overcome challenges such as lack of market channels, high transportation costs and price negotiations. They also provide training and certification support and can help farmers gain a competitive advantage by promoting the production as environmentally friendly and socially responsible. Through such collaborations, agroforestry farmers can strengthen their position within the value chain. Well-organised farmer cooperatives can offer extension services to their members and facilitate their access to markets (Agroforestry

Network 2018). The importance of establishing farmers' cooperatives to enhance production stability and improve product quality to better meet market requirements was also emphasised by farmer interviewees in Hung Do et al. (2020), which aligns closely with the findings of this study.

Moreover, for producers with limited expertise or access to appropriate post-harvest infrastructure, associations or cooperatives can take on the processing role, buying raw produce and ensuring a uniform high quality of final product. For example, in Colombia, farmers are often not adequately compensated for the additional labor and costs involved in producing high-quality cacao. In such contexts, it may be more viable for farmers to sell cacao in its mucilage stage to a centralised fermentation and drying facility managed by a producer organisation, which can better guarantee quality and facilitate access to HV markets (Benjamin et al. 2018).

Value-added processing emerged as a key strategy for small-scale agroforestry farmers to access HVMs and improve profitability. Rather than focusing on volume, farmers processed their products, such as different coffee processing methods or chocolate production from cacao and developed their own brands. Post-harvest processes such as fermentation and drying are essential for ensuring cacao bean quality (Benjamin et al. 2018). For example, instead of selling raw cacao beans, processing them into differentiated products can increase producers' incomes (IICA 2021). From a broader food systems perspective, value addition through processing and brand creation can help farmers capture a greater share of profits in coffee- and cacao-producing countries and contribute to fairer food systems.

In addition, agro- and ecotourism were significant supplementary revenue streams. Participants benefited from integrating shade-grown coffee and cacao with ecotourism, as their farms attracted birds and wildlife. This highlights the synergies between the ecological and economic benefits of agroforestry. Shade-grown coffee systems provide important habitats for biodiversity (Manson et al. 2024). This is particularly relevant in tropical South America, one of the most vulnerable regions to potential irreversible biodiversity loss in the coming decades. The replacement of native forests with crops such as coffee and cacao disrupts sensitive bird communities, negatively impacting species abundance and diversity (Bohada-Murillo et al. 2019). Harvey and González Villalobos (2007) suggested diversifying agroforestry systems with native trees and other plants that provided fruits and resources to support wildlife. Similarly, farmers in this study demonstrated an awareness of and efforts to achieve these ecological benefits, planting native and fruit trees to attract pollinators, birds and mammals and maintaining wildlife corridors. Their practices contributed to biodiversity conservation at the landscape level. Eco-tourism initiatives have been shown to support conservation efforts (Samantaray 2024) and have been proposed as valuable supplementary income sources in regions where biodiversity enhances tourism potential (Inter-American Development Bank 2002).

Additionally, birds contribute to natural pest management in agroforestry systems. The combination of pest control services and premium prices for shade-grown coffee can offset the lower yields often associated with agroforestry (Hernandez-Aguilera et al. 2019). Optimal shade conditions created by shade trees can facilitate coffee pest control and support beneficial microorganisms (Staver et al. 2001). Shade trees in agroforestry serve multiple functions. For example, they provide food, timber and firewood, support higher biodiversity, stimulate nutrient cycling, protect the soil from erosion, facilitate biological pest control and mitigate extreme weather events (Tscharntke et al. 2011). In the case of coffee and cacao, the production of high-value final products often requires shade-grown systems. Producers in this study were moving away from monocultures and were cultivating these crops within agroforestry systems. This trend contrasts with the historical shift from diverse agroforests to high-yielding monocultures reliant on agrochemical inputs.

The specialty coffee and cacao markets, driven by consumer demand for both quality and sustainability, encouraged farmers to adopt more environmentally sustainable practices. Research has shown that the quality of Arabica coffee is significantly enhanced when grown under shade (Muschler 2001; Bote & Struik 2011). In this context, the incorporation of shade trees offers an opportunity to align economic incentives with environmental benefits, further highlighting the synergies between the ecological and economic benefits of agroforestry. Moreover, avoiding the further conversion of the traditional coffee and cacao agroforestry systems into monoculture plantations is important for biodiversity and ecosystem services conservation (Beenhouwer et al. 2013).

5.2 High-value markets and agroecological transition

The findings show that farmers responded to HV market incentives when making crop choices. However, food sovereignty, or “food autonomy”, also played a significant role, as many farmers aimed to balance market opportunities with self-sufficiency and household food security. Moreover, beyond economic motivations, environmental stewardship and traditional practices also influenced some farmers' crop decisions, reflecting a broader set of values. These results suggest that while market incentives are a powerful driver, socio-cultural and ecological considerations also play a significant role in farmers decision-making and should not be overlooked.

The findings indicate that HV market opportunities act as incentives for adopting environmentally sustainable practices. Most of the farmers reported adjusting their practices to access HV markets and in response to consumer demand for high-quality and environmentally responsible products. For farmers who prioritised environmental stewardship over market incentives, these incentives served as reinforcement rather than a primary motivator. However, while market-driven

incentives played a key role, often they were not the sole drivers of agroecological practices but rather complemented farmers' existing values. Similar to the factors influencing crop decisions, food sovereignty, along with environmental stewardship and a sense of dignity, was an important motivator for farmers. Farmers' acknowledgement of HV markets as an incentive to adopt good practices and the alignment between such market incentives and environmental benefits highlights the potential of HV markets to act as a catalyst for agroecological transition. However, the degree to which such incentives can drive broader transitions remains uncertain. The sample in this study was primarily composed of farmers already practicing or transitioning to agroecology, making it unclear whether similar motivations would be effective for more conventional producers. Figure 6 synthesises how participation in high-value markets can accelerate agroecological transition by reinforcing ecological, economic and socio-cultural dimensions.

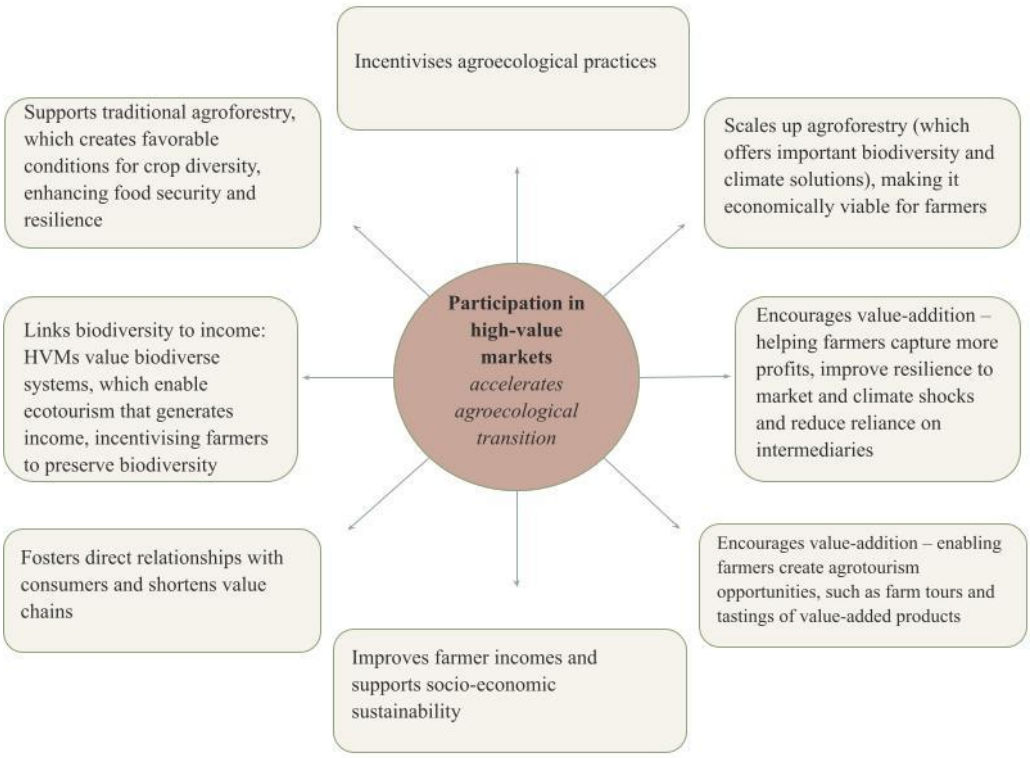

Figure 6. Visual synthesis of how participation in high-value markets can help accelerate agroecological transition.

HV markets are not a silver bullet. While they offer important financial incentives, the findings also suggest that relying solely on HV markets or a single high-value cash crop, such as specialty coffee, would expose farmers to serious risks. Such risks include price volatility, limited market access and bargaining power. One of the key challenges farmers highlighted was price volatility. Even products that command price premiums are subject to fluctuations driven by external factors, including shifting global market trends and climate-related events.

For instance, extreme weather in Brazil has often led to spikes in global coffee prices (Ponte 2002). Farmers shared that Brazil's reduced harvest caused price increases that benefited Colombian farmers. However, while price spikes can offer short-term financial benefits, they are unpredictable, leaving farmers in both countries vulnerable to fluctuations in global markets. Another primary barrier is accessing these markets, since it is not only the quality of production but also the broader structural conditions that shape the market landscape. Farmers in this study pointed to barriers such as intense competition in specialty coffee and organic cacao markets, the logistical constraints, including poor rural infrastructure, as well as certification requirements. While certifications can facilitate market access, their costs were risky investments without guaranteed returns. Beyond barriers to market access, power imbalances in value chains further constrain farmers' ability to benefit from high-value markets. Moreover, participation in these markets requires specific skills, resources, infrastructure and business connections that not all farmers possess. Additionally, the limited scale of such markets may constrain how many producers can realistically benefit from them.

The necessity for farmers to orient their production toward high-value, niche markets to achieve economic viability can also lead to critical trade-offs and points to a broader systemic issue within conventional food systems. Conventional food markets often fail to provide fair compensation for producing diverse food for local communities, compelling small-scale farmers to target premium segments that cater to more affluent consumers or export markets. This raises a broader concern about food sovereignty: relying on niche markets for economic viability may disconnect food production from the nutritional and social needs of local populations. For example, a study on the agrarian transition in the Scottish Highlands (Wach 2021) highlighted that continued market dependency can divert resources away from producing foods that align with the dietary needs of the local population, thereby conflicting with agroecological principles. Low-cost food imports create economic pressure on local producers, who often must orient their businesses toward niche, high-value markets to sustain their livelihoods.

As Stoian et al. (2012) pointed out, focusing solely on developing single value chains without considering how participation in these chains affects the overall livelihood resilience of the rural population is insufficient. They emphasised the need for a more comprehensive approach to rural development, that considers diverse livelihood strategies, along with the associated risks and trade-offs. While value chain development interventions may lead to increased farmers' income from commercialised crop production, they can also involve important trade-offs, such as reduced food security, that should not be overlooked.

These limitations point to the need for caution in how participation in high-value markets or markets in general are positioned within agroecological transitions. Agroecology must not be regarded as a mere branding strategy for higher-priced food produced within a "greener" version of input-dependent agricultural systems, as this risks reinforcing, rather than transforming, current food systems. As Rosset

and Altieri (2017) observe: “Agroecology is at a crossroads, facing a major struggle over its possible co-optation by the mainstream”. Giraldo and Rosset (2017) argue that greenwashed discourses serve as powerful legitimising tools, attempting to obscure the growing body of evidence that capitalist agricultural technologies are eroding the very economic and ecological foundations they rely on. They also describe how civil society actors, including La Vía Campesina, have raised concerns about the risk of agroecology being co-opted and reduced to “a set of eco-techniques in the toolkit” of the industrialised food system, stripped of the political and transformative aims of grassroots agroecology. Indeed, agroecological practices have been adopted within the dominant agro-food regime, which is contrary to agroecology’s transformative aims (Levidow et al. 2014).

Therefore, value chain development for agroforestry products should be pursued within a broader framework that prioritises food sovereignty and the resilience of rural livelihoods. Rather than relying solely on high-value markets, promoting diverse agroforestry systems that integrate high-value crops with those for household consumption, as well as other culturally appropriate species (e.g., bamboo for construction, as noted by one farmer), offers a more resilient strategy. This approach provides a buffer against market and climate shocks and enhances food sovereignty. Additionally, promoting direct-to-consumer and short-chain markets, such as Community Supported Agriculture, can address barriers related to market access, price fluctuations and bargaining power. Moreover, this approach can advance the agroecological transition by reconnecting food producers and consumers (Gliessman 2015), thereby strengthening food sovereignty. One of the six pillars of food sovereignty, as outlined in the 2007 Nyéléni Declaration for Food Sovereignty emphasises the importance of localising food systems: “Food sovereignty brings food providers and consumers closer together; puts providers and consumers at the centre of decision-making on food issues” (European Coordination Via Campesina 2018).

This research illustrates that participation in HV markets does not necessarily undermine food sovereignty or agroecological way of farming. The findings demonstrate that it is possible to increase farmers’ income and farm profitability without compromising ecological benefits such as soil conservation and biodiversity, or social values like food sovereignty. The TAPE assessment showed that farms involved in HV markets can be agroecologically advanced. TAPE provided a data-driven framework to assess the agroecological level of these farms. Farmers consistently emphasised values such as food sovereignty, self-sufficiency, tradition, dignity and environmental stewardship in their agricultural practices. These values align closely with the TAPE results. Particularly high scores were recorded in Culture and Food Traditions (75.00%), Efficiency (74.22%), and Diversity (72.27%), reflecting a strong alignment between the quantitative results and the qualitative insights gathered through interviews and farm visits.

Across nearly all farms assessed, farmers highlighted the importance of producing a diverse range of crops for household consumption, emphasising the

goal to achieve “food autonomy.” This directly aligns with the high score in the Diversity element, which underscores the socio-economic and environmental significance of diversified systems for food security and natural resource protection (FAO 2018). Many farmers also expressed a deep sense of identity tied to culturally rooted, traditional practices. Themes of dignity and tradition emerged during interviews, reflecting the cultural dimension of farming and connecting to the other highest scoring element, Culture & Food Traditions. This element highlights the importance of "Cultural identity and sense of place" in supporting culturally appropriate and healthy diets. Furthermore, a strong commitment to environmental care was evident in the farmers’ practices, particularly those related to soil regeneration, minimising agrochemical use and focusing on nutrient recycling through ground cover and composting, water protection and biodiversity preservation. These practices align with high TAPE scores for the Efficiency element, which reflect farmers' efforts to create synergies within diverse system components, optimise natural resource use and reduce reliance on external inputs.

The results of the FAO’s Global Agroforestry Capacity Needs Assessment (CNA) confirmed persistent barriers that have hindered the scaling up of agroforestry over the decades. Balancing profitability, biodiversity and agroecological principles in agroforestry systems remains a core challenge. Strengthening economic capacities, including the development of market-driven strategies and value chains and creating effective policies and incentives are key factors in addressing the challenge (Springgay & Pajel 2024). Economic factors are central to farmers’ decision-making and the strategies identified in this study have the potential to make agroforestry systems economically attractive to farmers globally.

5.3 Knowledge translation

Further research is needed to identify which crop species suitable for agroforestry systems offer significant commercial potential across various climatic regions. For instance, for European temperate regions, nut crops with high nutritional value and high calorie content, such as walnuts and chestnuts, may hold significant commercial potential. Research on establishing walnut orchards has highlighted their high economic returns (Popa et al. 2023; Žalac et al. 2023; Mercan 2025), but there remains a lack of studies assessing the commercial potential of such crops within agroforestry systems. Research should explore how to design market-oriented and economically resilient agroforestry systems. This includes focusing on the selection of ecologically compatible crop combinations, the integration of cash crops with supporting species and studying existing market demand, value chains and sales channels. For example, high-value crops in temperate climates such as walnuts could be intercropped with nitrogen-fixing species like Autumn olive (*Elaeagnus umbellata)*. It is well established in the silvicultural field that walnuts benefit greatly when planted with nitrogen fixing

species such as *Elaeagnus umbellata* (Clark et al. 2008). Another economically promising species could be Sea Buckthorn (*Hippophae rhamnoides*). It is a hardy plant with high nutritional and medicinal value which can also support biodiversity by providing habitat and food for birds (Dubey et al. 2024). The Swedish Infrastructure for Ecosystem Science (SITES) Agroecological Field Experiment (SAFE) has incorporated sea buckthorn in their agroforestry experiment to improve soil fertility by nitrogen fixation (Barreiro & Albertsson 2022). These species not only improve nitrogen availability for the crop trees and the overall soil fertility, but also produce berries that can be transformed into and sold as value-added products like jams or drinks.

6. Conclusions

This research aimed to evaluate the impact of high-value market participation on the economic viability of agroforestry production systems and explore its implications for agroecological transition. By analysing semi-structured interviews and results of TAPE Step 1, the study shows that participation in high-value markets can significantly enhance the economic viability of agroforestry systems and create incentives for adopting agroecological practices. Cultivating high-value crops and engaging in value-added processing to access high-value markets enables farmers to capture a greater share of the generated value and substantially improve their profitability.

Additionally, the decisions made by farmers in this study regarding crop selection and farming practices are influenced by market incentives, as well as by values such as food sovereignty, environmental stewardship and tradition. This study suggests that promoting diverse agroforestry systems that integrate both high-value and culturally appropriate subsistence crops, alongside value addition, offers a promising approach to make agroforestry economically viable and improve rural livelihoods.

Agroforestry offers solutions amid the biodiversity and climate crisis. Making agroforestry economically attractive to farmers is central to successfully scaling it up (Springgay & Pajel 2024). This case study provides a real-world example of how agroforestry systems can be economically viable and highlights concrete strategies that farmers have used to achieve this. Although this research was conducted in a tropical context, primarily among coffee and cacao producers (crops with high global demand and often integrated into agroforestry systems), the insights gained are applicable to other regions and contexts as well. By bridging environmental goals with economic realities, this research contributes to the understanding of how agroforestry systems can improve livelihoods and create synergies between ecological and economic benefits. Future research could explore how to optimise agroforestry design and management to create and leverage these synergies further, as well as assess the long-term performance and economic viability of the strategies identified in this study.

7. Recommendations

The following recommendations are intended for Biosuroeste, other organisations and agricultural/agroforestry extension and advisory services working in Southwest Antioquia that aim to promote agroecological transitions, connect farmers to markets and improve the overall socio-economic sustainability of local farming systems. These recommendations build on the findings from this study.

Organisations and extension services can offer targeted training to help farmers improve processing techniques, develop branding and create value-added products, while also promoting diversification strategies. For instance, supporting coffee quality improvement should be accompanied by promoting practices that create synergies between high-quality coffee production, environmental sustainability and food security from diversified crops. Farmers can gain premium prices for environmentally responsible production, improve coffee and cacao quality under shade and access additional income through eco- and agrotourism opportunities like birdwatching. Promoting diversified agroforestry systems with multifunctional trees that support food production, preserve local agrobiodiversity and cultural heritage and improve soil fertility and biodiversity can help farmers secure food, diversify income and strengthen resilience to market and climate shocks. Many farmers in this study demonstrated the skills and experience needed to implement such systems.

Another important strategy can be fostering business collaborations between producers and market-connected actors. Not all farmers will have the capacity, interest or resources to take on the full scope of value addition themselves and participate in higher-value markets independently. In such cases, it is strategic to support collaborative models - linking farmers with market-connected enterprises or producers who already have established market access and can manage processing and branding.

Finally, it’s essential to focus on improving farmers’ access to markets, as this remains a critical need. Collaborative initiatives should also offer training programs and opportunities that strengthen farmers’ knowledge and skills, particularly those required to meet the demands of high-value markets.

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Popular science summary

Agroforestry allows us to produce food while preserving nature. It offers solutions to big global problems like biodiversity loss and climate change. But to make agroforestry widespread, farmers also need to be able to make a good living from it. While there has been a lot of research on the environmental benefits of agroforestry, less attention has been paid to its social and economic aspects.

In this study, I worked with agroforestry farmers in Southwestern Antioquia, Colombia, to explore how agroforestry can be both environmentally and economically sustainable. I investigated whether selling agroforestry products in markets that pay better and fairer prices than regular markets made their agroforests more profitable. Because such markets often expect environmentally friendly products, I also looked into whether they encouraged farmers to take better care of nature.

The research found that farmers improved their incomes by selling in such markets. They achieved this not only by growing crops with strong market demand, but also ensuring high product quality. This was done by creating good growing conditions, but more importantly, by adding value to their products. For example, instead of selling raw and unprocessed coffee or cacao beans at low prices, farmers processed them: roasted and packaged coffee, or turned cacao into chocolate. This way, they could sell their products at higher prices.

Farmers also knew that these higher-paying markets expected environmentally friendly practices, which gave them extra motivation to care for soil, water and biodiversity. Working together with associations, other farmers and cooperatives helped them reach these markets. But profitability wasn’t the only factor in their decisions about what crops to grow or how to grow them. Farmers also wanted to grow healthy food for their families, protect their land and keep traditional ways of farming alive. Many farmers also earned extra income through tourism, such as birdwatching, because the trees in their agroforests attracted so many birds, it was like walking through a bird sanctuary.

This case study shows that agroforestry can support both nature and livelihoods. With the right support and market opportunities, more farmers may be able to choose this path and similar strategies could work in other regions far beyond Colombia.

Appendix 1

Interview guide questionnaire in Spanish and English

1. ¿Cuánta tierra tiene en producción?

2. ¿Contrata trabajadores?

A) Sí

B) No

3. ¿Cuáles son los principales cultivos y/o productos que produce?

4. ¿Cuáles son los cultivos y/o actividades más rentables en su finca?

5. ¿En qué medida las oportunidades de mercado influyen en su decisión sobre qué cultivos producir?

A) Nada

B) Un poco

C) Significativamente

6. Si se ha integrado en mercados premium (café especial, cacao de alta calidad, limón, agro-/ecoturismo), ¿en cuánto ha aumentado su ingreso como resultado?

A) 0-10%

B) 10-20%

C) 20-50%

D) Más del 50%

E) No me he integrado

7. ¿Procesa algún producto para agregar valor y recibir mejores precios?

A) Sí

B) No

• Si su respuesta es sí, ¿qué productos y cómo?

8. ¿Ha realizado cambios en sus prácticas de producción para poder vender sus productos en mercados premium?

A) Sí

B) No

• Si su respuesta es sí, seleccione los cambios que ha realizado (o que serían necesarios) (puede elegir más de una opción):

A) Inversiones financieras

B) Mano de obra adicional

C) Nuevos conocimientos y habilidades

D) Tecnología

E) Modificación del uso de la tierra

F) Insumos agrícolas

G) Otro (especifique):

9. ¿Ha enfrentado desafíos al intentar vender sus productos a precios más altos?

A) Sí

B) No

• Explique brevemente:

• …Pocas oportunides, canales de comercilizacion

10. ¿Ha colaborado con otras fincas, organizaciones o empresas para acceder a mercados premium?

• A) No he colaborado

• B) Sí, con: (puede elegir más de una opción)

o 1) Cooperativas

o 2) Servicios de extensión

o 3) Asociaciones

o 4) Otros agricultores

o 5) Otro (especifique):

• ¿Cómo le han apoyado? (puede elegir más de una opción)

o A) Acceso a mercados

o B) Asistencia técnica

o C) Capacitación/Intercambio de conocimientos (por ejemplo, formación, desarrollo de habilidades y compartir buenas prácticas)

o D) Apoyo financiero

o E) Otro (especifique):

• ¿Qué apoyo adicional haría más beneficiosa esta colaboración? (puede elegir más de una opción)

o A) Conexiones más fuertes con el mercado

o B) Asistencia técnica

o C) Capacitación/Intercambio de conocimientos

o D) Apoyo financiero

o E) Otro (especifique):

11. ¿En qué medida las oportunidades de mercados premium (por ejemplo, café especial, cacao de alta calidad, turismo) le han incentivado a adoptar prácticas agrícolas más amigables con el medio ambiente?

A) Nada

B) Un poco

C) Significativamente

D) Extremadamente

12. ¿Cuáles de las siguientes prácticas agrícolas sostenibles ha adoptado—o consideraría adoptar—para cumplir con los requisitos del mercado? (puede elegir más de una opción)

A) Uso de árboles de sombra o cultivos intercalados con árboles

B) Mantenimiento de cobertura del suelo con cultivos de cobertura o mulch

C) Promoción de la polinización (por ejemplo, conservación o creación de hábitats para polinizadores, incluyendo apicultura)

D) Uso de métodos de control de plagas orgánicos o naturales

E) Cultivo intercalado con especies fijadoras de nitrógeno

F) Otro (especifique):

13. ¿Cómo compara sus ingresos con los de hace tres años?

A) Más ingresos

B) Mismos ingresos

C) Menos ingresos

1. How much land do you have under production?

2. Do you hire workers?

A) Yes

B) No

3. What are the main crops and/or products you produce?

4. What are the most profitable crops and/or activities on your farm?

5. To what extent do market opportunities influence your decision on which crops to grow?

A) Not at all

B) Somewhat

C) Significantly

6. If you have integrated into premium markets (specialty coffee, high-quality cacao, lime, agro-/ecotourism), how much has your income increased as a result?

A) 0-10%

B) 10-20%

C) 20-50%

D) More than 50%

E) Haven't integrated

7. Do you process any products to add value and receive higher prices?

A) Yes

B) No

• If yes, which products and how?

8. Have you made changes in your production practices to be able to sell your products on premium markets?

A) Yes

B) No

- If yes, please select which changes have been (or would be) required (choose all that apply):

A) Financial investments
B) Additional labour
C) New knowledge and skills
D) Technology
E) Land-use modification
F) Agricultural inputs
G) Other (please specify):

9. Have you faced any challenges when trying to sell your products at higher prices?

A) Yes
B) No

Explain briefly:

10. Have you collaborated with other farms, organizations, or businesses to reach premium markets?

- A) No collaboration
- B) Yes, with: (Choose all that apply)
  - 1) Cooperatives
  - 2) Extension services
  - 3) Associations
  - 4) Other farmers
  - 5) Other (please specify):

- How do they support you? (Choose all that apply)
  - A) Market access
  - B) Technical assistance
  - C) Capacity building/Knowledge sharing (e.g., training, skill development, and sharing best practices)
  - D) Financial support
  - E) Other (please specify)

- What additional support would make these collaborations more beneficial? (Choose all that apply)
  - A) Stronger market connections
  - B) Technical assistance
  - C) Capacity building/Knowledge sharing
  - D) Financial support
  - E) Other (please specify)

11. To what extent have premium market opportunities (e.g., specialty coffee, high-quality cacao, tourism) encouraged you to adopt more environmentally friendly farming practices?

A) Not at all

B) Somewhat

C) Significantly

D) Extremely

12. Which of the following environmentally friendly farming practices have you adopted—or would consider adopting—to meet market requirements? (Choose all that apply)

A) Using shade trees or intercropping with trees

B) Maintaining soil cover with cover crops or mulch

C) Promoting pollination (e.g., preserving or creating habitats for pollinators, including beekeeping)

D) Using organic or natural pest control methods

E) Intercropping with nitrogen-fixing species

F) Other (please specify)

13. How do you compare your income compared to three years ago?

A) More income

B) Same income

C) Less income

Appendix 2

Step 1 - Characterisation of agroecological transitions
(Step 1 of TAPE - Tool for Agroecology Performance Evaluation)

1. DIVERSITY

CROPS

> 0 - Monoculture (or no crops cultivated).

> 1 - One crop covering more than 80 percent of cultivated area.

> 2 – Two or three crops with significant cultivated area.

> 3 - More than 3 crops with significant cultivated area adapted to local and changing climatic conditions.

> 4 - More than 3 crops of different varieties adapted to local conditions and spatially diversified farm with multi-, poly- or inter-cropping.

ANIMALS (INCLUDING FISH AND INSECTS)

> 0 - No animals raised.

> 1 - One species only.

> 2 - Two or three species, with few animals.

> 3 – More than three species with significant number of animals.

> 4 – More than three species with different breeds well adapted to local and changing climatic conditions.

TREES (AND OTHER PERENNIALS)

> 0 - No trees (nor other perennials).

> 1 - Few trees (and/or other perennials) of one species only.

> 2 - Some trees (and/or other perennials) of more than one species.

> 3 - Significant number of trees (and/or other perennials) of different species.

> 4 - High number of trees (and/or other perennials) of different species integrated within the farm land.

DIVERSITY OF ACTIVITIES, PRODUCTS AND SERVICES

> 0 - One productive activity only (e.g. selling one crop only).

> 1 - Two or three productive activities (e.g. selling 2 crops or one crop and one type of animals).

> 2 - More than 3 productive activities.

> 3 - More than 3 productive activities and one service (e.g. processing products on the farm, ecotourism, transport of agricultural goods, training etc.).

> 4 - More than 3 productive activities, and several services.

2. SYNERGIES

CROP-LIVESTOCK-AQUACULTURE INTEGRATION

The enumerator needs to consider the resources shared at community level. In the case of communal pastures for example, the corresponding feed inputs for animals are not considered as external. Are considered external only the feed purchased from the market.

> 0 - No integration: animals, including fish, are fed with purchased feed and their manure is not used for soil fertility; or no animal in the agroecosystem.

> 1 - Low integration: animals are mostly fed with purchased feed, their manure is used as fertilizer.

> 2 - Medium integration: animals are mostly fed with feed produced on the farm and/or grazing, their manure is used as fertilizer.

> 3 - High integration: animals are mostly fed with feed produced on the farm, crop residues and by-products and/or grazing, their manure is used as fertilizer and they provide traction.

> 4 - Complete integration: animals are exclusively fed with feed produced on the farm, crop residues and by-products and/or grazing, all their manure is recycled as fertilizer and they provide more than one service (food, products, traction, etc.).

SOIL-PLANTS SYSTEM MANAGEMENT

> 0 - Soil is bare after harvest. No intercropping. No crop rotations (or rotational grazing systems).

Heavy soil disturbance (biological, chemical or mechanical).

> 1 - Less than 20 percent of the arable land is covered with residues or cover crops. More than 80 percent of the crops are produced in mono and continuous cropping (or no rotational grazing).

> 2 - 50 percent of soil is covered with residues or cover crops. Some crops are rotated or intercropped (or some rotational grazing is carried out).

> 3 - More than 80 percent of soil is covered with residues or cover crops. Crops are rotated regularly or intercropped (or rotational grazing is systematic). Soil disturbance is minimized.

> 4 - All the soil is covered with residues or cover crops. Crops are rotated regularly and intercropping is common (or rotational grazing is systematic). Little or no soil disturbance.

INTEGRATION WITH TREES (AGROFORESTRY, SILVOPASTORALISM, AGROSILVOPASTORALISM)

Consider also communal forest areas.

> 0 - No integration: trees (and other perennials) don't have a role for humans or in crop or animal production.

> 1 - Low integration: small number of trees (and other perennials) only provide one product (e.g. fruits, timber, forage, medicinal or biopesticides substances…) or service (e.g. shade for animals, increased soil fertility, water retention, barrier to soil erosion…) for humans crops and/or animals.

> 2 - Medium integration: significant number of trees (and other perennials) provide at least one product or service.

> 3 - High integration: significant number of trees (and other perennials) provide several products and services.

> 4 - Complete integration: many trees (and other perennials) provide several products and services.

CONNECTIVITY BETWEEN ELEMENTS OF THE AGROECOSYSTEM AND THE LANDSCAPE

Consider the surrounding areas, the semi-natural environments and the potential zones of ecological compensation

> 0 - No connectivity: high uniformity within and outside the agroecosystem, no semi-natural environments, no zones of ecological compensation.

> 1 - Low connectivity: a few isolated elements can be found in the agroecosystem, such as trees, shrubs, natural fences, a pond or a small zone of ecological compensation.

> 2 - Medium connectivity: several elements are adjacent to crops and/or pastures or a large zone of ecological compensation.

> 3 - Significant connectivity: several elements can be found in between plots of crops and/ or pastures or several zones of ecological compensation (trees, shrubs, natural vegetation, pastures, hedges, channels, etc.).

> 4 - High connectivity: the agroecosystem presents a mosaic and diversified landscape, many elements such as trees, shrubs, fences or ponds can be found in between each plot of cropland or pasture, or several zones of ecological compensation.

3. EFFICIENCY

USE OF EXTERNAL INPUTS

Take into account all inputs needed for production, including energy, fuel, fertilizers, seeds, young animals, straw for artificial insemination, workforce, phytosanitary substances etc.

> 0 - All inputs are purchased from the market.

> 1 - The majority of the inputs is purchased from the market.

> 2 - Some inputs are produced on farm/within the agroecosystem or exchanged with other members of the community.

> 3 - The majority of the inputs is produced on farm/within the agroecosystem or exchanged with other members of the community.

> 4 - All inputs are produced on farm/within the agroecosystem or exchanged with other members of the community.

MANAGEMENT OF SOIL FERTILITY

> 0 - Synthetic fertilisers are used regularly on all crops and/or grasslands (or no fertilizers are used for lack of access, but no other management system is used).

> 1 - Synthetic fertilizers are used regularly on most crops and some organic practices (e.g. manure or compost) are applied to some crops and/or grasslands.

> 2 - Synthetic fertilisers are used on a few specific crop only. Organic practices are applied to the other crops and/or grasslands.

> 3 - Synthetic fertilisers are only used exceptionally. A variety of organic practices are the norm.

> 4 - No synthetic fertilisers are used, soil fertility is managed only through a variety of organic practices.

MANAGEMENT OF PESTS & DISEASES

> 0 - Chemical pesticides and drugs are used regularly for pest and diseases management. No other management is used.

> 1 - Chemical pesticides and drugs are used for a specific crop/animal only. Some biological substances and organic practices are applied sporadically.

> 2 – Pests and diseases are managed through organic practices but chemical pesticides are used only in specific and very limited cases.

> 3 – No chemical pesticides and drugs are used. Biological substances are the norm.

> 4 - No chemical pesticides and drugs are used. Pests and diseases are managed through a variety of biological substances and prevention measures.

PRODUCTIVITY AND HOUSEHOLD'S NEEDS

Consider all types of assets, including animals, perennial tress etc.

> 0 - Household's needs are not met for food nor for other essentials.

> 1 - Production covers only household's needs for food. No surplus to generate income.

> 2 - Production covers household's needs for food and surplus generates cash to buy essentials but doesn't allow savings.

> 3 - Production covers household's needs for food and surplus generates cash to buy essentials and to have sporadic savings.

> 4 - All household's needs are met both for food and for cash to buy all essentials needed and to have regular savings.

4. RECYCLING

RECYCLING OF BIOMASS AND NUTRIENTS

> 0 – Residues and by-products are not recycled (e.g. left for decomposition or burnt). Large amounts of waste are discharged or burnt.

> 1 - A small part of the residues and by-products is recycled (e.g. crop residues as animal feed, use of manure as fertilizer, production of compost from manure and household waste, green manure). Waste is discharged or burnt.

> 2 - More than half of the residues and by-products is recycled. Some waste is discharged or burnt.

> 3 - Most of the residues and by-products are recycled. Only a little waste is discharged or burnt.

> 4 - All of the residues and by-products are recycled. No waste is discharged or burnt.

WATER SAVING

> 0 - No equipment nor techniques for water harvesting or saving.

> 1 - One type of equipment for water harvesting or saving (e.g. drip irrigation, tank).

> 2 - One type of equipment for water harvesting or saving and use of one practice to limit water use (e.g. timing irrigation, cover crops).

> 3 - One type of equipment for water harvesting or saving and various practices to limit water use.

> 4 - Several types of equipment for water harvesting or saving and various practices to limit water use.

MANAGEMENT OF SEEDS AND BREEDS

> 0 - All seeds and/or animal genetic resources (e.g. chicks, young animals, semen) are purchased from the market.

> 1 - More than 80 percent of seeds/animal genetic resources are purchased from the market.

> 2 - About half of the seeds are self-produced or exchanged, the other half is purchased from the market. About half of the breeding is done with neighbouring farms.

> 3 - The majority of seeds/animal genetic resources are self-produced or exchanged. Some specific seeds are purchased from the market.

> 4 - All seeds/animal genetic resources are self-produced, exchanged with other farmers or managed collectively, ensuring enough renewal and diversity.

RENEWABLE ENERGY USE AND PRODUCTION

> 0 - No renewable energy is used nor produced.

> 1 - The majority of the energy is purchased from the market. A small amount is self-produced (animal traction, wind, turbine, hydraulic, biogas, wood…).

> 2 - Half of the energy used is self-produced, the other half is purchased.

> 3 - Significant production of renewable energy, negligible use of fuel and other non-renewable sources

> 4 - All of the energy used is renewable and/or self-produced. Household is self-sufficient for energy supply, which is guaranteed at every time. Use of fossil fuel is negligible.

5. RESILIENCE

STABILITY OF INCOME/PRODUCTION AND CAPACITY TO RECOVER FROM PERTURBATIONS

> 0 - Income is decreasing year after year, production is highly variable despite constant level of input and there is no capacity to recover after shocks/perturbations.

> 1 - Income is on decreasing trend, production is variable from year to year (with constant inputs) and there is little capacity to recover after shocks/perturbations.

> 2 - Income is overall stable, but production is variable from year to year (with constant inputs).

Income and production mostly recover after shocks/perturbations.

> 3 - Income is stable and production varies little from year to year (with constant inputs).

Income and production mostly recover after shocks/perturbations.

> 4 - Income and production are stable and increasing over time. They fully and quickly recover after shocks/perturbations.

MECHANISMS TO REDUCE VULNERABILITY

With gender perspective

> 0 - No access to credit, no insurance, no community support mechanisms.

> 1 - Community is not very supportive and its capacity to help after shocks is very limited. And/ or access to credit and insurance is limited.

> 2 - Community is supportive but its capacity to help after shocks is limited. And/or access to credit is available but hard to obtain in practice. Insurance is rare and does not allow for complete coverage from risks.

> 3 - Community is very supportive for both men and women but its capacity to help after shocks is limited. And/or access to credit is available and insurance covers only specific products/risks.

> 4 - Community is highly supportive for both men and women and can significantly help after shocks. And/or access to credit is almost systematic and insurance covers most of production.

INDEBTEDNESS

> 0 - Debt is higher than income.

> 1 - Debt is more than half of the income. Capacity to reimburse is limited.

> 2 - Debt is approximately half of the income.

> 3 - Debt is limited and capacity to reimburse is total.

> 4 - No debt.

DIVERSITY OF ACTIVITIES, PRODUCTS AND SERVICES

This index is the average score for the element of diversity already assessed

6. CULTURE & FOOD TRADITION

APPROPRIATE DIET AND NUTRITION AWARENESS

> 0 - Systematic insufficient food to meet nutritional needs and lack of awareness of good nutritional practices.

> 1 - Periodic insufficient food to meet nutritional needs and/or diet is based on a limited number of food groups. Lack of awareness of good nutritional practices.

> 2 - Overall food security over time, but insufficient diversity in food groups. Good nutritional practices are known but not always enforced.

> 3 - Food is sufficient and diverse. Good nutritional practices are known but not always enforced.

> 4 - Healthy, nutritious, diversified diet. Good nutritional practices are well known and enforced.

LOCAL OR TRADITIONAL (PEASANT / INDIGENOUS) IDENTITY AND AWARENESS

> 0 - No local or traditional (peasant / indigenous) identity felt.

> 1 - Little awareness of local or traditional identity.

> 2 - Local or traditional identity felt in part, or that concerns only part of the household.

> 3 - Good awareness of local or traditional identity and respect of traditions or rituals overall.

> 4 - Local or traditional identity strongly felt and protected, high respect for traditions and/ or rituals.

USE OF LOCAL VARIETIES/BREEDS AND TRADITIONAL (PEASANT & INDIGENOUS) KNOWLEDGE FOR FOOD PREPARATION

> 0 - No use of local varieties/breeds nor traditional knowledge for food preparation.

> 1 – A majority of exotic/introduced varieties/breeds are consumed, or there is little use of traditional knowledge and practices for food preparation.

> 2 - Both local and exotic/introduced varieties/breeds are produced and consumed. Local or traditional knowledge and practices for food preparation are identified but not always applied.

> 3 – The majority of the food consumed comes from local varieties/breeds and traditional knowledge and practices for food preparation are implemented.

> 4 – A number of local varieties/breeds are produced and consumed. Traditional knowledge and practices for food preparation are identified, applied and recognised in official frameworks and/ or specific events.

7. CO-CREATION & SHARING OF KNOWLEDGE

PLATFORMS FOR THE HORIZONTAL CREATION AND TRANSFER OF KNOWLEDGE AND GOOD PRACTICES

With gender perspective. Platforms can be formal or informal organizations, farmer field schools, regular meetings, trainings, etc.

> 0 - No platforms for co-creation and transfer of knowledge are available to producers.

> 1 - At least one platform for the co-creation and transfer of knowledge exists but does not function well and/or is not used in practices.

> 2 - At least one platform for the co-creation and transfer of knowledge exists and is functioning but is not used to share knowledge on agroecology specifically.

> 3 – One or several platforms for the co-creation and transfer of knowledge exist, are functioning and are used to share knowledge on agroecology, including women.

> 4 – Several well established and functioning platforms for the co-creation and transfer of knowledge are available and widespread within the community, including women.

ACCESS TO AGROECOLOGICAL KNOWLEDGE AND INTEREST OF PRODUCERS IN AGROECOLOGY

With gender perspective. Agroecological knowledge and practices may also be called in some other ways, and producers may know and apply them without knowing the word “agroecology”. Focus on the actual practices and knowledge for the evaluation, and not on the formal knowledge of “agroecology” as a science.

> 0 - Lack of access to agroecological knowledge: principles of agroecology are unknown to producers.

> 1 - Principles of agroecology are mostly unknown to producers and/or there is little trust in them.

> 2 - Some agroecological principles are known to producers and there is interest in spreading the innovation, facilitating knowledge sharing within and between communities and involving younger generations.

> 3 – Agroecology is well known and producers are willing to implement innovations, facilitating knowledge sharing within and between communities and involving younger generations, including women and younger generations.

> 4 - Widespread access to agroecological knowledge of both men and women: producers are well aware of the principles of agroecology and eager to apply them, facilitating knowledge sharing within and between communities and involving younger generations.

PARTICIPATION OF PRODUCERS IN NETWORKS AND GRASSROOT ORGANIZATIONS

With gender perspective.

> 0 - Producers are isolated, have almost no relations with their local community and do not participate in meetings and grass-root organisations.

> 1 - Producers have sporadic relations with their local community and rarely participate in meetings and grass-root organisations.

> 2 - Producers have regular relations with their local community and sometimes participate in the events of their grass-root organisations but not as much for women.

> 3 - Producers are well interconnected with their local community and often participate in the events of their grass-root organisations, including women.

> 4 - Producers (with equal participation of men and women) are highly interconnected and supportive and show a very high engagement and participation in all the events of their local community and grass-root organisations.

8. HUMAN & SOCIAL VALUES

WOMEN'S EMPOWERMENT

> 0 - Women do not normally have a voice in decision making, not in the household nor in the community. No organisation for women empowerment exists.

> 1 - Women may have a voice in their household but not in the community. And/or one form of women association exist but is not fully functional.

> 2 - Women can influence decision making, both at household and community level, but are not decision makers. They don't have access to

resources. And/or some forms of women associations exist but are not fully functional.

> 3 - Women take fully part in decision making processes but still don't have full access to resources. And/or women organisations exist and are used.

> 4 - Women are completely empowered in terms of decision making and access to resources.

And/or women organisations exist, are functional and operational.

LABOUR (PRODUCTIVE CONDITIONS, SOCIAL INEQUALITIES)

> 0 – Agricultural supply chains are integrated and managed by agribusiness. Social and economic distance between landowners and workers. And/or workers don't have decent working conditions, make low wages and are highly exposed to risks.

> 1 – Working conditions are hard, workers have average wages for the local context and may be exposed to risks.

> 2 - Agriculture is mostly based on family farming but producers have limited access to capital and decision-making processes. Workers have the minimum decent labour conditions.

> 3 - Agriculture is mostly based on family farming and producers (both men and women) have access to capital and decision-making processes. Workers have decent labour conditions.

> 4 - Agriculture is based on family farmers which have full access to capital and decision-making processes in gender equity. Social and economic proximity between farmers and employees.

YOUTH EMPOWERMENT AND EMIGRATION

> 0 - Young people see no future in agriculture and are eager to emigrate.

> 1 - Most young people think that agriculture is too hard and many wish to emigrate.

> 2 - Most young people do not want to emigrate, despite hard working conditions, and wish to improve their livelihoods and living conditions within their community.

> 3 - Most young people (both boys and girls) are satisfied with working conditions and do not want to emigrate.

> 4 - Young people (both boys and girls) see their future in agriculture and are eager to continue and improve the activity of their parents.

ANIMAL WELFARE [IF APPLICABLE]

> 0 - Animals suffer from hunger and thirst, stress and diseases all year long, and are slaughtered without avoiding unnecessary pain.

> 1 - Animals suffer periodically/seasonally from hunger and thirst, stress or diseases, and are slaughtered without avoiding unnecessary pain.

> 2 - Animals do not suffer from hunger or thirst, but suffer from stress, may be prone to diseases and can suffer from pain at slaughter.

> 3 - Animals do not suffer from hunger, thirst or diseases but can experience stress, especially at slaughter.

> 4 - Animals do not suffer from stress, hunger, thirst, pain, or diseases, and are slaughtered in a way to avoid unnecessary pain.

9. CIRCULAR & SOLIDARIT Y ECONOMY

PRODUCTS AND SERVICES MARKETED LOCALLY

> 0 - No product/service is marketed locally (or not enough surplus produced), or no local market exist.

> 1 - Local markets exist but hardly any of the products/services are marketed locally.

> 2 - Local markets exist. Some products/services are marketed locally.

> 3 - Most products/services are marketed locally.

> 4 - All products and services are marketed locally.

NETWORKS OF PRODUCERS, RELATIONSHIP WITH CONSUMERS AND PRESENCE OF INTERMEDIARIES

With gender perspective

> 0 - No networks of producers for marketing agricultural production exist. No relationship with consumers. Intermediaries manage the whole marketing process.

> 1 - Networks exist but do not work properly. Little relationship with consumers. Intermediaries manage most of the marketing process.

> 2 - Networks exist and are operational, but don’t include women. Direct relationship with consumers exist. Intermediaries manage part of the marketing process.

> 3 - Networks exist and are operational, including women. Direct relationship with consumers exist. Intermediaries manage part of the marketing process.

> 4 - Well established and operational networks exist with equal women participation. Strong and stable relationship with consumers. No intermediaries.

LOCAL FOOD SYSTEM

> 0 - Community is totally dependent from outside for purchasing food supply and agricultural inputs and for the marketing and processing of products.

> 1 - The majority of food supply and agricultural inputs are purchased from outside and products are processed and marketed outside the local community. Very few goods and services are exchanged/sold between local producers.

> 2 – Food supply and inputs are purchased from outside the community and/or products are processed locally. Some goods and services are exchanged/sold between local producers.

> 3 – Equal shares of food supply and inputs are locally available and purchased from outside the community and products are processed locally. Exchanges/trade between producers are regular.

> 4 - Community is almost completely self-sufficient for agricultural and food production. High level of exchange/trade of products and services between producers.

10. RESPONSIBLE GOVERNANCE

PRODUCERS' EMPOWERMENT

With gender perspective

> 0 - Producers' rights are not respected. They have no bargaining power and lack the means to improve their livelihoods and develop their skills.

> 1 - Producers' rights are recognised but not always respected. They have small bargaining power and little means to improve their livelihoods and/or to develop their skills.

> 2 - Producers' rights are recognised and respected for both men and women. They have small bargaining power but are not stimulated to improve their livelihoods and/or to develop their skills.

> 3 - Producers' rights are recognised and respected for both men and women. They have the capacity and the means to improve their livelihoods and are sometimes stimulated to develop their skills.

> 4 - Producers' rights are recognised and respected for both men and women. They have the capacity and the means to improve their livelihoods and to develop their skills.

PRODUCERS' ORGANIZATIONS AND ASSOCIATIONS

With gender perspective

> 0 - Cooperation among producers is non-transparent, corrupted or non-existent. No existing organisation or they do not to distribute profits transparently and/or equally nor do they support producers.

> 1 – One organisation of producers exists but its role is marginal and support to producers limited to market access.

> 2 - One organisation of producers exists and provides support to producers for market access and other services (e.g. information, capacity development, incentives…), but women don't have access.

> 3 - One organisation of producers exists and provides support to producers for market access and other services with equal access to men and women.

> 4 – More than one organisation exist. They provide market access and other services, with equal access to men and women.

PARTICIPATION OF PRODUCERS IN GOVERNANCE OF LAND AND NATURAL RESOURCES

With gender perspective

> 0 - Producers are completely excluded from the governance of land and natural resources. There is no gender equity in the governance of land and natural resources.

> 1 - Producers participate in the governance of land and natural resources but their influence on decisions is limited. Gender equity is not always respected.

> 2 - Mechanisms allowing producers to participate in the governance of land and natural resources exist but are not fully operational. Their influence on decisions is limited. Gender equity is not always respected.

> 3 - Mechanisms allowing producers to participate in the governance of land and natural resources exist and are fully operational. They can influence decisions. Gender equity is not always respected.

> 4 - Mechanisms allowing producers to participate in the governance of land and natural resources exist and are fully operational. Both women and men can influence decisions.

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High-Value Markets for Agroforestry: Practical Steps to Increase Profitability

For small-scale farmers interested in making agroforestry more profitable and sustainable

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- Selling to high-value markets helped farmers earn more money.
- Processing their own products (like roasting coffee or making chocolate) helped farmers keep more of the profit and improve their income.
- Offering tourism on the farm (like birdwatching or tours) brought in extra income.
- Working together in cooperatives and joining associations made it easier to reach better markets.
- High-value markets gave farmers extra motivation to adopt eco-friendly practices.
- High-value markets boost income, but shouldn't be the only strategy due to risks like price fluctuations.

Study purpose

This research investigated if participating in high-value markets can improve the income of agroforestry producers. It also explored if it rewards farmers who adopt more eco-friendly practices.

Agroforestry is gaining recognition as a way to fight climate change and protect biodiversity while improving farmer livelihoods. Agroforestry can make farms more resilient to challenges like climate change and market shifts (Ickowitz et al. 2021). One major barrier to expanding agroforestry is that markets for tree products are still limited (FAO 2013). But as more consumers care about climate and biodiversity, high-quality agroforestry products are gaining market potential (Agroforestry Network 2020). High-value markets pay more than traditional ones (Huka et al. 2024). For example, specialty coffee or organic cacao can be sold on high-value markets. Farmers in this study cultivated high-value crops and processed them into value-added products to reach such markets.

Methods

This research took place in Southwestern Antioquia, Colombia and involved 16 small-scale agroforestry farmers from 12 villages. I interviewed the farmers and analysed their farms using TAPE, which stands for *Tool for Agroecology Performance Evaluation*.

Practical recommendations:

Learn value-adding techniques: Process your products on-farm and create a unique brand to increase income.

Diversify crops and income: Combine cash crops, food crops and tourism to reduce risks from price fluctuations and unpredictable climate events.

Join producers' groups: Associations and cooperative can help you gain knowledge, skills and access better markets.

Sell directly: Selling directly to customers can secure better prices and give you more control over your sales.

Conclusion

This case study offers real-world examples of profitable agroforestry and highlights concrete strategies farmers have used to achieve improved income without compromising biodiversity or food security. These strategies provide valuable insights for designing and managing sustainable agroforestry production systems globally. A combination of high-value crops and value-added processing is an effective strategy for improving profitability. Agro- and ecotourism also provided important supplementary income streams.

However, while these strategies can help, there are some challenges that need to be addressed to make sure these solutions work well in the long run.

Challenges

Price fluctuations - The price of products like specialty coffee can change quickly due to global market trends, making income unpredictable.

Limited market access - Many farmers struggle to connect with reliable buyers who pay premium prices. They face challenges like poor roads, transportation issues and difficulty reaching high-value markets. On top of that, certification requirements and strong competition in sectors like specialty coffee make it harder to stand out and get better prices for their products.

Low bargaining power - Individual farmers often have little control over pricing, as local buyers and intermediaries set prices, limiting their ability to negotiate based on the quality of their products

Weak or inefficient value chains - Many farmers sell in bulk at uniform prices, regardless of product quality. A lack of quality assessment, limited buyer options and missing infrastructure reduce opportunities to earn more for better products.

Picture 1. Agroforestry system integrating a cash crop (coffee), subsistence crops (banana, cassava, etc.), nitrogen fixing plants, shade and fruit trees and other species that aid in nutrient and water cycling.

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