

Enriching coffee agroforestry systems in Bolivia: the role of CIAPEC



Agroforestry case studies 2. Bolivia

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Forest and Farm Facility



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FFF surveys of knowledge needs in areas of land and natural resources from 41 forest and farm producer organisations (FFPOs) in six countries carried out in 2018 identified two top priority research needs: climate resilience information and options; and diversified climate-smart agroforestry options. By 2022 the FFF programme had assembled case studies and guidance on the first of these priorities, climate resilience, spread in a peer-to-peer learning event in Vietnam (see www.iied.org/20311iied and www.iied.org/21211g). In 2023 further work was commissioned resulting in guidance on how FFPOs can advance agrobiodiversity for climate resilience, with another peer-to-peer learning event in Nepal (see www.iied.org/22251iied and www.iied.org/22451g). Agroforestry systems are the central land use system that allows integration of trees, crops and livestock to advance agrobiodiversity and climate resilience. Now in 2025, the FFF is focusing on the second identified priority knowledge need: how to increase adoption of 'diversified climate-smart agroforestry'. The coproduction process used by FFF draws insights from across the world of the most innovative FFPOs that have encouraged the adoption of agroforestry systems – which are then blended with an academic review of agroforestry adoption – to provide FFPOs with the latest thinking and best practice in promoting agroforestry. This case study is part of that process.

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Abbreviations

AECAR	Asociacion Ecológico de Caficultores el Rosario (Ecological Association of Coffee Growers of El Rosario)
AFS	Agroforestry system
APROCAFE	Asociacion de Productores de Cafe Ecologico (Association of Organic Coffee Producers)
CLAC	Latin American and Caribbean Network of Fair Trade Small Producers and Workers
CIAPEC	Cooperativa Integral Agrícola de Productores Ecológicos (Comprehensive Agricultural Cooperative of Organic Producers)
EMAPA	Empresa de Apoyo a la Producción de Alimentos (Food Production Support Company)
FAO	Food and Agriculture Organization of the United Nations
FFF	Forest and Farm Facility
FFPOs	Forest and farm producer organisations
IIED	International Institute for Environment and Development
IPM	Integrated pest management
ITC	Instituto Tecnológico Caranavi (Caranavi Technological Institute)
PES	Payments for environmental services
UPEA	Sede Académica Desconcentrada Caranavi (Caranavi Decentralised Academic Headquarters)

Summary

The Cooperativa Integral Agrícola de Productores Ecológicos (CIAPEC – the Comprehensive Agricultural Cooperative of Organic Producers) was created to foster sustainable development. It operates in the Yungas region of La Paz, Bolivia, with its warm-temperate climate, with temperatures ranging between 17° and 26° degrees Celsius, depending on the time of year. The altitude varies between 1,000 and 1,700 metres above sea level. The region is characterised by its biodiversity, mountains and cloud forests, where producers, many of them Aymara migrants from the Andean regions, grow high-quality coffee.

CIAPEC was founded on 4 April 2003, initially with 32 members, and has evolved to include products other than coffee (*Coffea arabica*). It now has 200 members and more than 1,000 families. CIAPEC's vision is that future generations of producers will strengthen their capacities, promote the integral development of their communities and contribute to global sustainability through responsible farming.

In terms of productive characteristics, CIAPEC implements an agroforestry system that is aligned with a model of growing cash crops under shade, mainly focused on the cultivation of coffee, but also integrating other products such as citrus (*Citrus* sp), walusa (*Xanthosoma sagittifolium*) and avocado (*Persea americana*). The agroforestry system is characterised by a stratification in different levels. The upper canopy includes large and tall trees such as cedar (*Cedrela odorata*), toco (*Enterolobium contortisiliquum*) and laurel (*Laurus nobilis*). The middle canopy of timber trees include smaller species such as siquili (*Inga edulis*), avocado (*Persea americana*), ceibo (*Erythrina poeppigiana*) and various citrus species (*Citrus* sp). The lower canopy includes dwarf trees and shrubs such as bananas (*Musa paradisiaca*) and coca (*Erythroxylum coca* var. *coca*). The main shade-tolerant crop is coffee (*Coffea arabica*) and additional subsistence crops include corn (*Zea mays*) and beans (*Phaseolus vulgaris*), as well as spices such as achiote (*Bixa orellana*) and root crops including walusa (*Xanthosoma sagittifolium*) and turmeric (*Curcuma longa*).

CIAPEC members have plots of land of approximately 10 hectares, with an average of two hectares dedicated to coffee plantations in production. Currently, CIAPEC has 636.8ha of land, 208 hectares of which is coffee grown under agroforestry; 140 hectares are certified as organic, and in 2025 an additional 60 hectares of agroforestry is being developed with the support of a CIAPEC direct beneficiary grant from the Forest and Farm Facility (FFF) hosted by the Food and Agriculture Organization of the United Nations (FAO).

CIAPEC has implemented several key strategies to facilitate the adoption of more diverse agroforestry systems among its smallholder members, ranging from training and practical workshops to the provision of seeds and technical knowledge. CIAPEC members face several important challenges such as management complexity, start-up and maintenance costs, and the need to diversify incomes. To drive wider adoption of agroforestry, it is essential to implement a number of strategic changes, ideally with the support of external partners, such as establishing public policies that support agroforestry.

The main conclusions highlight the fact that agroforestry offers multiple benefits: improving soil quality; increasing biodiversity; mitigating climate change impacts; strengthening the local economy; and broadening of food sources, which contributes to improved food security and nutrition for their families. It is recommended to establish public policies to support agroforestry, create economic incentives and promote the certification of agroforestry products to improve their market position.

1. Introduction to CIAPEC

1.1 Names and vision

The Cooperativa Integral Agrícola de Productores Ecológicos (CIAPEC – the Comprehensive Agricultural Cooperative of Organic Producers) has the vision that future generations of producers will strengthen their capacities, promote the integral development of their communities and contribute to global sustainability through responsible farming.

CIAPEC was created to promote sustainable development in the Yungas region of La Paz in Bolivia, working together with committed producers. It has the following objectives:

- Increasing coffee productivity and quality through agroforestry systems (AFS)
- Environmental conservation, highlighting the importance of protecting natural resources such as soil and water through the implementation of sustainable practices
- Improving the family economy with the direct impact of the project on the economic wellbeing of coffee-growing families
- Strengthening markets, considering the need to develop effective commercial strategies to access new markets and obtain better prices, and
- Sustainability aligned with the principles of sustainable agriculture and the conservation of natural resources.

1.2 Foundation

CIAPEC was founded on 4 April 2003. Initially, the cooperative had 32 members in the north of the department of La Paz in the municipality of Caranavi. CIAPEC has undergone a remarkable evolution over time. Initially focused on coffee production, the cooperative has expanded its scope to include producers of achiote, palillo (turmeric), citrus, coca and other products. This expansion has allowed it to consolidate itself as a fundamental pillar in the economy of the Yungas region of La Paz. Throughout its trajectory, CIAPEC has achieved several important milestones:

- **Legal recognition and expanding membership:** CIAPEC was officially incorporated in the National Institute of Cooperatives of Bolivia (INALCO), obtaining the Legal Personality N° 1086. Since its inception, it has worked to integrate more than 300 producer members.
- **Product diversification:** Initially focused on coffee, CIAPEC has diversified its production to include commercial sale of achiote, palillo, citrus and coca, adapting to market needs and the capacities of its members.
- **Adoption of Fairtrade practices:** CIAPEC complies with basic Fairtrade standards, respecting the environment, guaranteeing decent prices for producers and ensuring fair working conditions.
- **Organic certification:** CIAPEC currently has 140 hectares of coffee certified as organic, which positions it as a benchmark in the production of high-quality organic coffee.
- **Participation in key organisations:** CIAPEC is a member of the Federación de Caficultores Exportadores de Bolivia (FECAFEB – the Federation of Bolivian Coffee Growers and Exporters), the Asociación de Organizaciones de Productores Ecológicos de Bolivia (AOPEB – Association of Organizations of Ecological Producers of Bolivia), the Asociación de Cafés Especiales de Bolivia (ACEB – the Association of Specialty Coffees of Bolivia) and the Cámara Nacional de Exportadores De Bolivia (CANEB – the National Chamber of Exporters of Bolivia).
- **Commercial alliances:** CIAPEC has established marketing agreements with Empresa de Apoyo a la Producción de Alimentos (EMAPA – Food Production Support Company) and Ketal supermarkets for the sale of organic coffee under CIAPEC's Bolcafé brand.
- **Focus on sustainability:** The cooperative has implemented agroforestry systems on 208 hectares, with an additional 60 hectares in process, promoting responsible agricultural practices and the conservation of natural resources.
- **Development projects:** CIAPEC participates in projects such as the Forest and Farm Facility (FFF), a partnership between FAO, the International Union for Conservation of Nature (IUCN), the International Institute for Environment and Development (IIED) and AgriCord, which aims to support climate-resilient landscapes and improve livelihoods.

CIAPEC's evolution reflects an ongoing commitment to sustainable development, social justice and the wellbeing of its members. Through diversification, adoption of sustainable practices and participation in key networks and organisations, CIAPEC has established itself as a model of a successful cooperative in the Yungas region de La Paz.

1.3 Location

CIAPEC members are mainly Aymara migrants from the Andean regions of the Altiplano La Paz, located in the Yungas region of La Paz. This geographical location is characterised by its natural biodiversity, mountainous terrain and cloud forests that provide an ideal environment for the production of high-quality coffee. The altitude of the growing areas ranges between 1,400 and 1,700 metres above sea level. This altitude range provides a moderate climate and nutrient-rich soils which benefit the development of coffee beans with more complex flavours and intense aromas.

The region is surrounded by cloud forests, crystal clear rivers and a rich variety of flora and fauna. These ecosystems contribute to the environmental balance and provide natural shade for the coffee plantations. The region's biodiversity includes species such as toucans, quetzals and monarch butterflies, as well as a vast diversity of native plants, some of which are retained in coffee-growing areas.

CIAPEC's geographical location not only favours the production of high-quality coffee but also requires a commitment to sustainable and environmentally friendly agricultural practices. The cooperative implements reforestation programmes, conservation of water sources and support for local wildlife to maintain a balance between agricultural production and environmental protection.



Figure 1. Location of the CIAPEC case-study site in Bolivia

1.4 Membership

CIAPEC has extended its impact to 300 members and more than 1,000 families, organised in 12 settlements (U. Camacho, E. Ríos, Alto Alianza, Magallanes, Huatahata, Waldo, Kantutani, Villamontes, Rosas Pampa, Villa Camacho, Villa Exaltación and Trinidad) in the municipality of Caranavi in the north of the department of La Paz. CIAPEC members' properties have an average size of 10 hectares, although this can vary. Within these properties, the average size of coffee production is two hectares. Some members have up to four hectares of coffee in production.

CIAPEC was established around the production and marketing of agricultural products, with a special focus on organic coffee. Throughout its evolution, it has expanded its offer to include other products such as achiote, pallilo, citrus and coca. CIAPEC members grow both cash crops (for external sale) and subsistence crops (for domestic consumption), although the main focus is on cash crops, particularly coffee, which is the cooperative's flagship product. In summary CIAPEC has become known for:

- **Coffee as the main cash crop:** CIAPEC specialises in the production of organic coffee, which is marketed both nationally and internationally. The cooperative exports green coffee beans to markets such as the European Union, Asia and the USA, and sells roasted coffee in the domestic market under the Bolcafé brand.
- **Diversification into other cash crops:** In addition to coffee, CIAPEC's partners work with other products such as achiote, pallilo, citrus and coca. These products are also grown for commercial purposes and are governed by Fairtrade principles.
- **Diversification of subsistence agriculture:** Some CIAPEC members also grow crops for household consumption, such as corn, beans, walusa, bananas, citrus fruit and avocados. These crops supplement the income generated by cash crops and contribute to household food security.

2. CIAPEC's agroforestry system

2.1 Type of agroforestry

CIAPEC is implementing an agroforestry system that is aligned with the model of growing cash crops under shade, mainly focused on the cultivation of coffee. There are 208 hectares of coffee under agroforestry with 140 hectares of organic certification. Currently in 2025, management is expanding 60 hectares under agroforestry with the support of a direct beneficiary grant from the FFF, but also integrating other products such as citrus, walusa, mandarins and avocados. This approach seeks a balance between commercial production and environmental sustainability, taking advantage of the benefits that shade provides to crops and the ecosystem. The characteristics of CIAPEC's agroforestry system are based on:

- **Shade trees** that help regulate temperature, protect crops from direct sunlight and improve soil quality through leaf decomposition.
- **Sustainable practices:** CIAPEC promotes sustainable agricultural practices, such as agroforestry that can be certified as organic, rotational agriculture and the use of organic fertilisers. These practices help to protect natural resources and maintain the health of the ecosystem.
- **Incorporation of timber and fruit:** Timber trees such as cedar are also part of the agroforestry system, as are a range of different fruit tree species.

This approach seeks a balance between commercial production and environmental sustainability, generating economic and environmental benefits for CIAPEC families.

2.2 Main species

Coffee is the most important cash crop for CIAPEC members, but other crops, such as citrus, walrus, mandarins and avocados, play an important role in both income diversification and food security for members. Coffee is exported as both organic and Fairtrade coffee, which allows them to obtain better prices for their products and improve the living conditions of their members. Figure 2 is a hand-drawn diagram by Alfredo Espinosa Cárdenas, a CIAPEC member from Hernando Magallanes community, detailing the upper, middle and lower strata of his coffee agroforestry system in cross-section.

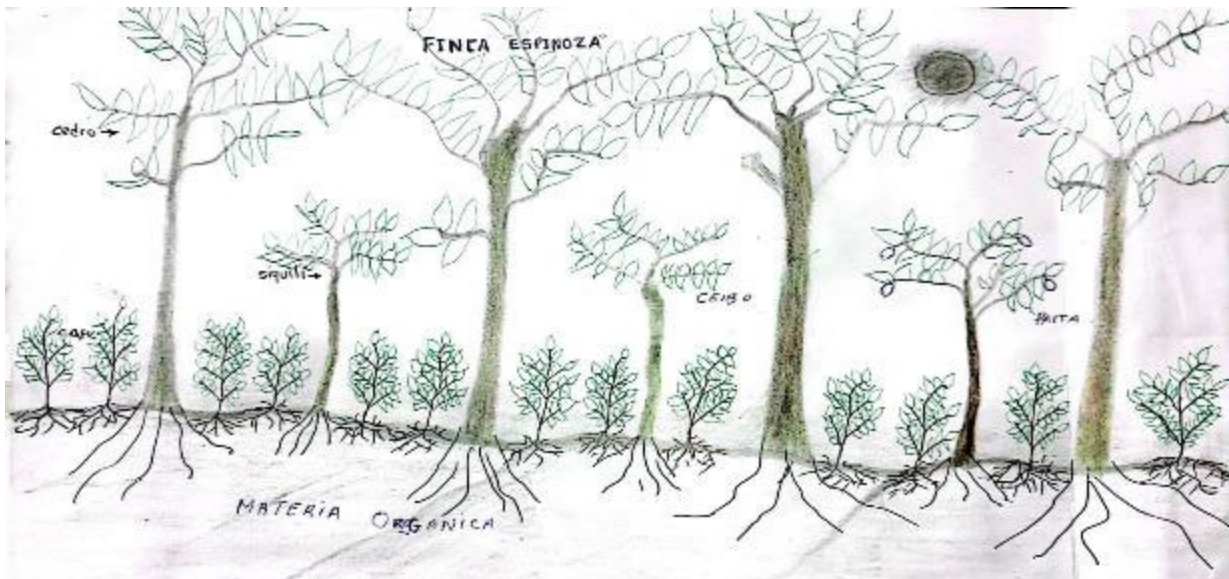


Figure 2. Diagram of a coffee agroforestry system by Alfredo Espinosa Cárdenas



Figure 3. Typical agroforestry system in the CIAPEC area © CIAPEC

The main species grown under each strata of the agroforestry system include:

Upper-canopy timber trees: This stratum plays a crucial role in the agroforestry system due to its height and ability to intercept sunlight. These trees, occupying the upper level, create a canopy that regulates the amount of light reaching the lower strata, which in turn influences the growth and development of the coffee and other species or crops below. The species found in this stratum include:

- **Cedar (*Cedrela odorata*):** This tree is consistently found in the upper stratum and reaches a great height.

- **Toco (*Enterolobium contortisiliquum*):** Located in the upper stratum, varieties such as toco blanco and toco colorado are mentioned.
- **Laurel (*Laurus nobilis*):** Like toco, laurel is found in the upper stratum, but in lower frequency than cedar.

Middle-canopy trees: These play a fundamental role by acting as a link between the upper and lower stratas. They contribute to the structural diversification of the system, generating multiple ecological niches. These species are especially important for their contribution to soil fertility through the litter they generate, and can play an important role in water conservation and soil protection against erosion. The species found in this stratum are listed below:

- **Siquili (*Inga edulis*):** Consistently found in the middle stratum, with variations such as siquili coroiqueño, siquili colorado and siquili nativo o cola de mono. The scientific name is not provided in the documents.
- **Avocado (*Persea americana*):** This species also appears in the middle stratum and is grown for sale and for household consumption.
- **Ceibo (*Erythrina poeppigiana*):** Like avocados, ceibo is grown for sale and for household consumption.

The lower stratum includes:

- **Dwarf trees and shrubs:** These are scattered infrequently among the main cropping components and include bananas (*Musa paradisiaca*) and coca (*Erythroxylum coca* var. *coca*).
- **Shade-tolerant crops:** This component focuses mainly on the cultivation of coffee (*Coffea arabica*). Prominent varieties include caturra, catuai rojo, mondo novo and castilla, among others.
- **Basic crops:** These are mainly agricultural crops for subsistence use but also form part of the productivity and sustainability of the agroforestry system. Staple crops such as corn (*Zea mays*) and beans (*Phaseolus vulgaris*) are commonly grown alongside other crops such as achiote (derived from *Bixa orellana*). Other important local crop root crops are also prevalent including walusa (*Xanthosoma sagittifolium*) and turmeric (*Curcuma longa*).

Based on research visits to the plots of multiple farmers for this case study, the research team has identified a common system design for CIAPEC's diversified coffee agroforestry system. This considers the different species of tree and shrub found in the upper, middle, and lower strata, to provide a more complex and diverse shade, alongside areas of cultivation of subsistence crops. These systems not only promote greater biodiversity, but also improve carbon sequestration and microclimate regulation including temperature. They are considered the most sustainable in the long term, as they combine coffee production with the provision of multiple ecosystem services. Table 1 shows the layering and key components of the agroforestry system design.

Table 1. CIAPEC's agroforestry system components and strata

Strata	Features
Emergent timber trees	Not present in this system.
Upper-canopy trees	This stratum includes large and tall trees, such as cedar (<i>Cedrela odorata</i>), verdolago (<i>Portulaca oleracea</i>), toco (<i>Enterolobium contortisiliquum</i>) and laurel (<i>Laurus nobilis</i>). These trees provide shade for coffee cultivation and may also have other uses, such as timber production.
Middle-canopy trees	In this stratum, smaller trees can be included, such as siquili (<i>Inga edulis</i> , with variations such as siquili coroqueño, siquili colorado and siquili nativo or cola de mono), avocado (<i>Persea americana</i>) and ceibo (<i>Erythrina poeppigiana</i>). These trees provide additional shade and can also be leguminous plants that help to improve soil fertility.
Dwarf trees and shrubs	Bananas (<i>Musa paradisiaca</i>) and coca (<i>Erythroxylum coca</i> var. <i>coca</i>) are sometimes incorporated in this stratum for family consumption.
Shade-grown cash crops	This is the main coffee cultivation stratum: <i>Coffea arabica</i> , with varieties such as catuai rojo and caturra.
Other basic crops	Beans (<i>Phaseolus vulgaris</i>) and corn (<i>Zea mays</i>) and achiote (<i>Bixa Orellana</i>).
Root crops	Walusa (<i>Xanthosoma sagittifolium</i>) and turmeric (<i>Curcuma longa</i>).

Timber trees, fruit trees and crops are integrated into the same plot, seeking to maximise production and environmental benefits. Members of CIAPEC have noticed that coffee needs shade to ripen well. Agroforestry systems allow the land to be maintained and the coffee soil to improve. The leaves that fall from the forest trees contribute to the organic matter in the soil, maintaining moisture and feeding the coffee plants naturally. Some producers use *chaqueo sin quema* (land clearance without burning) where felled trees are turned into fertiliser for the plot. *Inga edulis* is known for its ability to fix nitrogen through a symbiotic relationship with nitrogen-fixing bacteria, and leaves decompose easily to become a beneficial compost, as well as protecting against weeds and providing shade. The main components of the system are shown in Figure 4.


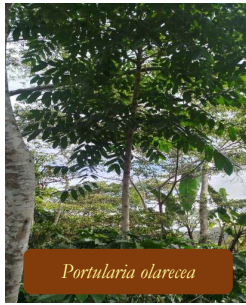
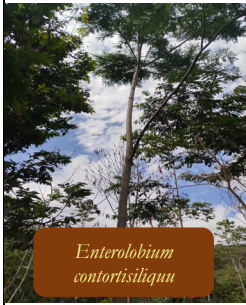
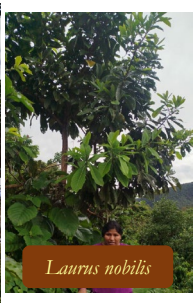

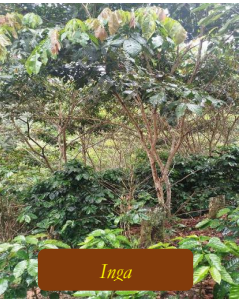
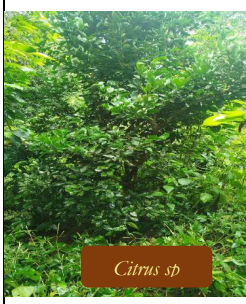
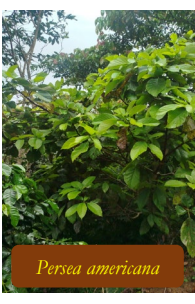




Upper canopy timber	 <p><i>Cedrela odorata</i></p>	 <p><i>Portularia olarecea</i></p>	 <p><i>Enterolobium contortisiliquum</i></p>	 <p><i>Laurus nobilis</i></p>
Middle canopy trees	 <p><i>Erythrina poeppigiana</i></p>	 <p><i>Inga</i></p>	 <p><i>Citrus sp.</i></p>	 <p><i>Persea americana</i></p>
Shade tolerant crop	 <p><i>Coffea arabica</i></p>		 <p><i>Efficient organisms and micro-organisms (MM)</i></p>	
Root crops	 <p><i>Phaseolus vulgaris</i></p>	Cultivation within SAF	 <p><i>Musa paradisiaca</i></p>	

Figure 4. Common species in the CIAPEC agroforestry system © CIAPEC

2.3 Other farming activities

Analysis of the balance between the agroforestry system and other subsistence land uses by CIAPEC would require more detailed study beyond the scope of this report, and there are no exact percentages on the distribution of land use. Nevertheless, agroforestry is the main focus of CIAPEC.

2.4 Scale

The agroforestry areas are managed by approximately 60 members of CIAPEC and cover 208 hectares of coffee under organic certification. The area of agroforestry is planned to expand by 60 hectares in 2025. Looking specifically at the agroforestry portion of the farming system, the following features stand out:

- **Small size of properties:** CIAPEC members have plots of land of approximately 10 hectares.
- **Predominant agroforestry system** (shade coffee and other integrated components) makes up 80–90% of this area and reflects CIAPEC’s main focus on shade coffee production, which includes the integration of timber and fruit trees.

- **Basic subsistence crops and root crops:** These are limited to 10% of the area in agroforestry farms.
- **Nurseries and land in conversion:** 5% of the area is devoted either to family nurseries or land in transition to organic or agroforestry practices.

Most of the land is privately owned, where each member has a title deed issued by the Instituto Nacional de Reforma Agraria (INRA – National Institute of Agrarian Reform). Land management and agroforestry activities are carried out at the family level, which reinforces the idea of individual or family land tenure. The members do belong both to an agrarian cooperative and to other community organisational structures that influence their agricultural decisions and practices.

3. Motivation to establish agroforestry

3.1 Origin and promotion of agroforestry

According to the research for this case study, the use of the agroforestry system was promoted by several entities and through different processes including technical assistance, exchanges of experiences, and conversations with neighbours and technical specialists. The promotion of agroforestry has been an evolutionary process that involves several actors and strategies over time. The key actors in the promotion of the agroforestry system include:

- **CIAPEC's predecessor organisations:** Before the foundation of CIAPEC, other organisations played a crucial role in the introduction of agroforestry practices, such as AECAR Cooperative (Asociación Ecológica de Caficultores el Rosario or Ecological Association of Coffee Growers of El Rosario). Although AECAR became defunct 10 years ago, it sowed the first seeds of agroforestry knowledge among farmers who would later join CIAPEC.
- **CIAPEC:** After its foundation in 2003, CIAPEC continued and expanded the promotion of agroforestry systems, encouraging sustainable development in the cultivation of coffee, achote, pallilo, citrus and coca.
- **Supporting institutions:** Coffee plantations have been developed with support from the Instituto Tecnológico Caranavi (ITC – Caranavi Technological Institute) and the Sede Académica Desconcentrada Caranavi (UPEA – Caranavi Decentralised Academic Headquarters). These institutions provided technical support and resources to establish agroforestry plots. Additionally, the National Coffee Investment Programme of the Ministry of Rural Development and Lands, and the Ministry of Coffee also provided coffee seedlings mainly of the cuatai rojo and castilla varieties.
- **Pioneer farmers and neighbours:** The importance of observation and learning among neighbours is highlighted.
- **Technicians and trainers:** The workshops conducted by CIAPEC provided knowledge on the design and management of agroforestry components.
- **Projects and certifications:** CIAPEC has participated in projects to improve the quality of production and obtain both Fairtrade and organic certifications, which has strengthened the production chain and improved family incomes.
- **External expertise:** CIAPEC has provided linkages to external expertise to facilitate the establishment of the agroforestry system.

As can be seen, the promotion of agroforestry systems within CIAPEC has been an ongoing and multifaceted effort, driven by organisations, institutions, pioneer partners and the cooperative itself. The combination of training, economic incentives and observation of results has been key to persuading farmers of the benefits of these systems.

3.2 Nutritional benefits

The members of CIAPEC perceive various benefits in terms of the quantity and diversity of food and other useful household products as a result of the implementation of agroforestry systems. These benefits are manifested both in the availability of food for household consumption and in the generation of additional income through the sale of surpluses.

Agroforestry has allowed members to diversify their food sources, which contributes to improving food security and nutrition for their families. In addition, agroforestry systems allow farmers to generate additional income through the sale of surplus crops. However, it is important to note that some of the planted forest trees are still developing and have not generated significant economic benefits for some members. Further research into gender differences in the perception of benefits is crucial, as is continuous monitoring of agroforestry systems to ensure their long-term sustainability and nutritional benefits.

3.3 Economic benefits

Agroforestry systems are a viable economic alternative to monocultures, offering diversified economic benefits. CIAPEC members perceive economic benefits through the sale of new or additional crops that are integrated into their agroforestry systems. This supplementary income from crop diversification is crucial for the economic sustainability of their families. The commercialisation of walusa, mandarins and avocados has been particularly important, with mandarins fetching high prices that rank alongside coffee. Bananas are also primarily sold locally, although it is considered a temporary crop and of lower economic value. The main perceptions of economic benefits included:

- **Income diversification:** In addition to improving coffee production, a well-managed canopy can provide other valuable products such as fruit, timber and firewood.
- **Cost reduction:** Recycling nutrients from pruning agroforestry components reduces dependence on external inputs and improves soil fertility.
- **Market access:** CIAPEC specialises in the commercialisation of organic coffee, with two main market offers: green coffee beans and roasted coffee, targeting both national and international markets. Green coffee beans are appreciated for their certified organic quality and unique flavour profile.

3.4 Ecological benefits

Partners see benefits in the overall productivity and health of their farming systems through practices such as the production of green manure or mulch. Agroforestry plays a crucial role in restoring and improving soil health and quality. These systems favour microbial life, promote nutrient recycling and organic matter addition and the shade provided by trees contributes to regulate soil temperature, protect soil from erosion and control weed growth. Key benefits to members were listed as:

- **Green manure and mulch:** Decomposing leaves and other organic materials provide essential nutrients to the soil.
- **Erosion control:** Shade cover and proper soil management in agroforestry systems help reduce erosion by improving soil structure and increasing organic matter.
- **Wind protection:** Trees act as natural windbreaks, protecting crops and reducing wind erosion.
- **Water management:** Agroforestry systems facilitate infiltration of rainwater into the soil, maintaining the productivity and health of the ecosystem.
- **Microclimate improvement:** Trees in agroforestry act as natural barriers against direct solar radiation, protecting coffee plants from water stress and radiation damage. This is crucial for maintaining coffee productivity. Shade trees play a crucial role in regulating soil temperature, which is essential for the health of coffee plants.
- **Biodiversity:** Agroforestry systems promote biodiversity by incorporating a wide variety of plant and animal species, creating habitats for beneficial insects, pollinators, birds and microorganisms. Better biodiversity helps to control pests and diseases, improve soil structure and increase resilience to extreme climatic changes.
- **Pest and disease control:** Trees with small, flexible leaves allow for uniform shade and reduce sudden fluctuations in temperature, which can stress the plants. Maintaining good air circulation within the plantation reduces humidity, making it more difficult for pathogens to proliferate.
- **Climate change mitigation and adaptation:** Agroforestry systems play an essential role in storing more carbon, regulating temperature and providing shade, facilitating adaptation to climate change.

Farmers use traditional knowledge to improve soil health and agricultural productivity. Diversified tree planting not only helps to mitigate the effects of climate change, but also regulate temperature and solar radiation, contributing to environmental conservation.

3.5 Social benefits

Agroforestry systems offer some benefits in terms of preserving community cultural traditions and also including individual women, youth and marginalised people in the production system. However, the main perceptions of communal-level involvement are limited. It was noted that non-members within the community do observe the coffee plots, and some then become members, but not all comment or actively participate. They think that the agroforestry system can be beneficial, but community collaboration is still limited. At community meetings, sometimes the experiences of agroforestry are shared and sometimes new agroforestry-related projects arrive, such as last year's project on drought, where seedlings were distributed and planted. Nevertheless, neighbours do not show much interest in participating, even though some do produce coffee.

CIAPEC has families within its membership, men and women, located in several communities of the municipality of Caranavi. It considers young people (both women and men) of the family units as direct beneficiaries in their projects. However, there is still a lack of interest and participation by some members of the community in the activities of the organisations and in the adoption of agroforestry systems. The general consensus was that it is essential to try harder to involve youth, women and marginalised groups more in agroforestry production systems, considering their needs and knowledge. Prioritising local resources and valuing traditional knowledge can increase the acceptance and sustainability of agroforestry systems. Agroforestry, with its principles of sustainability and respect for local knowledge, can play a crucial role in revitalising cultural traditions and promoting social inclusion in farming communities.

3.6 Disadvantages

Agroforestry systems offer multiple benefits as described above, but they also have disadvantages that are crucial for CIAPEC and its partners to consider. These disadvantages are explored below:

- **Management complexity:** One of the main challenges of agroforestry systems is their complexity compared to monocultures. Maintaining an agroforestry system requires detailed knowledge of the interactions between the different components (trees, crops and, in some cases, animals) and adaptive management to optimise production and ecosystem services. This complexity can be a barrier for some farmers, especially those with less technical experience.
- **Labour intensity:** Although agroforestry can reduce dependence on external inputs such as chemical fertilisers, they often require more labour, especially for weeding and pruning, which can be arduous work. There is the difficulty of finding time to work on the plot and the need to hire staff for weeding, paying between US\$58–87 (400–600 bolivianos) per field depending on the amount of grass. The need to hire labour can increase operating costs, especially for smallholders with limited resources.
- **Time delay before harvest:** Some components of agroforestry systems, such as timber trees, take several years to reach maturity and generate income. This waiting period can be a challenge for farmers who need short-term income.
- **Excessive shade:** Shade management is a critical aspect in agroforestry systems. Finding the right balance is essential to optimise production of coffee and other crops.
- **Pest and diseases:** Pest and disease management is a constant challenge that requires integrated management strategies.
- **Need for fertiliser:** There is concern about the future need to fertilise plants, anticipating that the weather will not be as it is now and that fertiliser will be essential to maintain production.
- **Climate risks and resource availability:** Drought has affected the availability of young *Inga edulis* trees, making reforestation and diversification of agroforestry systems difficult. Climate risks, such as droughts and changes in rainfall patterns, can affect the availability of essential resources for the maintenance of agroforestry systems.

4. Design and installation of the agroforestry system

4.1 Guidance on agroforestry installation

Within CIAPEC, various entities and strategies have facilitated training in agroforestry systems design and the adoption of sustainable practices by its members. It is mentioned that AECAR (a former CIAPEC organisation) provided training on agroforestry systems. It is also important to note that CIAPEC not only focuses on theoretical training, but also supports partners in the practical implementation of the agroforestry system.

CIAPEC runs courses and workshops where the partners learn about coffee and forest tree pruning, which they have to apply directly on their plots. In addition to formal training, knowledge sharing among the partners also plays an important role. Farmers mention that they learnt about agroforestry systems by observing the practices of their neighbours who integrated forest trees and siquili trees on their plots.

4.2 Seed sources

Coffee seeds are obtained from member farmers own plots or farms, from plants between 10 and 15 years old, from technicians who have collected seeds from neighbouring farms, or more recently from the FFF direct beneficiary grant support to CIPAEC. In addition, members also exchange seed and knowledge sharing.

4.3 Management issues

Implementing partners face a number of management challenges, and CIAPEC plays a crucial role in helping them overcome these obstacles. CIAPEC tries to find solutions to each problem. For example, CIAPEC helps its members to address:

- **System complexity:** CIAPEC provides training in agroforestry system establishment.
- **Labour:** CIAPEC shows how the need for labour reduces over time as well-established agroforestry system can reduce the need for weeding due to shade. CIAPEC also helps to provide workshops and trainings that teach efficient and sustainable ways of pruning coffee and forest trees.
- **Time delays until harvest:** CIAPEC offers some project support to offset upfront costs that can be a disincentive for the establishment of agroforestry systems.
- **Excessive shade:** CIAPEC addresses this problem by providing training on pruning and canopy management, allowing farmers to balance the amount of sunlight reaching their crops.
- **Pests and diseases:** CIAPEC facilitates access to technical knowledge on integrated pest management (IPM).
- **Need for fertiliser:** CIAPEC provides training in how to generate and use green manure and mulch to reduce the need for external fertilisers.
- **Climate change resilience:** CIAPEC, through the promotion of agroforestry, helps to spread economic options, reduce crop stress, improve soil nutrition, thereby strengthening the resilience of farms to adverse climatic conditions.

In this sense, CIAPEC plays a key role in helping farmers overcome the management challenges of implementing agroforestry systems, facilitating access to external expertise and promoting sustainable practices that improve production and protect the environment.

5. Aggregation and sale of agroforestry products

5.1 Markets for products

Final markets for agroforestry products, both locally and internationally, are a fundamental component for the economic viability of agroforestry systems. The following are some of the markets accessed by CIAPEC members, as well as some strategies to strengthen their presence in these markets:

- **Market diversification:** CIAPEC has managed to establish marketing agreements with EMAPA and Ketal for the sale of 2 tonnes of organic coffee under the Bolcafé brand. These agreements represent an important first step of establishing the product in the national market and have allowed the organisation to consolidate relationships with key actors in the value chain.
- **Marketing limitations:** Despite the success in marketing, current strategies have limitations that prevent a greater valorisation of the product and a significant increase in producers' incomes.
- **Untapped potential of the national market:** The Bolcafé brand does not have an active presence in local and departmental fairs, limiting its reach in the national market.
- **Quality standards:** CIAPEC's premium-quality coffee meets strict European standards, allowing it to reach international markets. The coffee is recognised by the highest standards in international markets, endorsing not only its quality, but also its fair and sustainable origin.

Improvement strategies: For the national market, CIAPEC has a coffee brand called Bolcafé, which does not yet have an active presence in local and departmental fairs. This absence represents a weakness, as Bolcafé is not yet known by the wider public. It is important to generate greater awareness of the brand and its products, allowing direct interaction with consumers to understand their preferences and needs to generate brand loyalty. CIAPEC also needs to establish contacts with potential distributors and retailers at the local level and reinforce the image of Bolcafé as a brand committed to local development and sustainability. Table 2 shows CIAPEC's main local, national and export markets.

Table 2. CIAPEC's main markets for its products

Market	Products	Description
Local	Mandarin, avocado, walusa, corn and banana	Mainly for domestic consumption and local sale of surplus.
National	Organic coffee	CIAPEC has its own brand of coffee called Bolcafé for the national market, although its presence in local fairs is limited. CIAPEC's has contracts with EMAPA and Ketal for Bolcafé. CIAPEC's roasted coffee is mainly aimed at the domestic market, valued by local consumers seeking a premium product.
Export	Green coffee beans	CIAPEC has marketed green gold coffee to markets in the European Union, Asia and the USA. In 2024, CIAPEC marketed approximately two containers of organic green coffee (38.5 tonnes) to Germany (Benecke Coffee) and the Netherlands (A van Weely BV Amstelveen). The coffee is appreciated for its certified organic quality and unique flavour profile, standards that meet European norms.

5.2 Changes over time

CIAPEC was originally founded with the objective of producing coffee, but over the years, the organisation has expanded its product range to include achiote, pallilo, citrus and coca. This reflects the fact that CIAPEC has helped to diversify producers' sources of income and respond to market demands. CIAPEC has played a crucial role in promoting and changing commercial production through various initiatives and strategies:

- **Integration of producers:** CIAPEC has integrated more than 60 active and 140 passive members, mainly migrants of Aymara origin, promoting sustainable development in the cultivation of coffee and other products.
- **Promotion of sustainable practices:** The organisation has implemented sustainable practices that protect natural resources and meet basic Fairtrade criteria. This includes shade cultivation, efficient use of natural resources and constant training of producers.
- **Organic certification:** CIAPEC has obtained organic and Fairtrade certification that allows it to access international markets with premium-quality coffee. The cooperative has 208 hectares certified organic, demonstrating a commitment to sustainable practices.
- **Marketing and market access:** CIAPEC facilitates the marketing of its products through agreements with local companies such as EMAPA and Ketal, and by exporting coffee to markets in Europe (Germany and Holland).
- **Capacity building:** CIAPEC offers workshops and training to producers on topics such as agroforestry systems management, coffee pruning and quality control.

5.3 Future plans

CIAPEC, as an organisation focused on sustainable development and improving the conditions of its producers, has several future strategies to develop its agroforestry system, seeking both to improve the system itself and to increase commercial income. These CIAPEC strategies for the development and change of the agroforestry system are:

- **Expanding organic certification:** CIAPEC plans to continue with organic certification in the future. This certification is crucial because it allows access to markets that value sustainable products and are willing to pay higher prices, which directly improves producers' incomes.
- **Coffee improvement through agroforestry:** The plan is to improve its coffee by using forest and leguminous species such as siquili (*Inga edulis*) to optimise the crop. Siquili in agroforestry systems can improve soil quality, provide shade and regulate humidity, which in turn can increase productivity and coffee quality.
- **Crop diversification with avocado:** The intention is to plant more avocado, as this crop performs well in the agroforestry system. Diversification with crops such as avocado not only provides an additional source of income, but also increases the resilience of the agroforestry system to possible fluctuations in coffee prices.
- **Using social media for marketing:** CIAPEC recognises the potential of social media to improve the marketing of its products. Several young people are already making a living from this, which can help a lot. Social media can make it easier to connect with wider markets, promote products effectively and build a strong brand.

CIAPEC is well positioned to improve its agroforestry system and increase the incomes of its producers through a combination of organic certification, crop diversification, use of social networks, practical training and institutional collaboration. By addressing challenges related to shade, fertilisation and weed control, CIAPEC can ensure the long-term sustainability of its agroforestry systems and contribute to the wellbeing of local communities.

6. Financing agroforestry plots

6.1 Start-up and running costs

The main costs involved in implementing and maintaining an agroforestry system encompass a variety of factors that directly influence the economic viability of these systems. These costs can be classified into initial and ongoing costs, and vary according to the region, the type of agroforestry system and the management practices implemented (see Table 3).

Table 3. Main costs of managing agroforestry systems

Detail	Description
Labour to clear the land	Involves initial site preparation, including the removal of existing vegetation, clearing land and preparing holes for planting trees and crops.
Purchase/cultivation of seedlings	Includes the purchase or production of tree seedlings and crops. This can represent a significant investment, especially if high-value species or improved varieties are used. CIAPEC supports with coffee seedlings.
Organic fertilisers	Although agroforestry systems aim to reduce dependence on chemical fertilisers, in some cases it may be necessary to supplement soil nutrition with organic or chemical fertilisers, especially during the early stages of growth. The use of bio-inputs replaces synthetic fertilisers and pesticides, improving soil health and controlling pests naturally.
Labour for weeding	Weed control is an ongoing activity that requires labour and can represent a significant cost. Alfredo Espinosa spends 500 bolivianos for weeding, but spends between 35,000 and 40,000 Bolivianos per hectare. Celia Condori hires people to weed her coffee plantation and pays between 400 to 600 bolivianos per cato (equivalent to about a third of an acre), depending on the amount of grass.
General labour	Includes hiring staff for various tasks, such as planting, weeding, pruning, harvesting and processing of produce.

6.2 External finance

Several external sources of funds are available to cover the costs associated with the implementation and maintenance of the agroforestry system, including projects, training and bank loans:

- **FFF project:** CIAPEC are currently working with FFF for the development of coffee and forestry nurseries. These types of projects usually provide technical and financial resources to boost the adoption of agroforestry practices.
- **Latin American and Caribbean Network of Fair Trade Small Producers and Workers (CLAC):** Trainings received through CLAC can help partners to improve their practices and access better markets.
- **Rabobank:** This bank has been approached for loans. Bank loans can be an option to finance the initial investment and operational costs of agroforestry systems.
- **Support from CIAPEC:** CIAPEC supports members by providing coffee seedlings, which reduces the initial costs of establishing agroforestry plots.

6.3 Future plans

CIAPEC has identified several expansion plans that may require further funding. These plans are aimed at improving production, sustainability and access to markets, both nationally and internationally. To develop these plans, CIAPEC is seeking funding through projects, training and loans. The cooperative seeks to integrate more producers and promote sustainable development in the cultivation of coffee, achote, pallilo, citrus and coca. CIAPEC's expansion plans are shown in Table 4.

Table 4. CIAPEC's expansion plans

Expansion plan	Description	Funding required
Expansion of agroforestry systems (AFS)	Increase the area of AFS beyond the current 140 hectares, optimising its management and diversifying products. There is an opportunity to expand this practice and optimise its management.	Funds for the purchase of seedlings, technical assistance for the design and implementation of PES, and training in sustainable management.
Improving coffee quality and production	Implement climate-smart agriculture (CSA) practices, improve post-harvest protocols and diversify coffee varieties.	Investment in coffee-processing equipment and technology, training in International Coffee Association techniques, and access to genetic improvement programmes.
Bolcafé brand development	Increase the presence of the brand in national and international markets, participating in fairs and events, and establishing alliances with distributors and retailers. This requires establishing contacts with potential distributors and retailers at the local level and reinforcing the image of Bolcafé as a brand committed to local development and sustainability.	Funding for marketing and promotion campaigns, participation in fairs and events, and development of a distribution network.
Obtaining organic and origin certification	Maintain and expand organic certification, ensuring compliance with international standards and achieving the Denomination of Origin for its coffee. It is necessary to expand the training offer to address more specific issues of the coffee value chain and strengthen the capacities of producers.	Costs associated with certification, audits and compliance.
Training and technical assistance	Expand the training offer to address more specific topics of the coffee value chain and strengthen producers' capacities.	Funds for the recruitment of experts, development of educational materials, and organisation of workshops and seminars.
Nursery modernisation	Improve the infrastructure and management of nurseries, ensuring the production of high-quality seedlings adapted to local conditions.	Investment in infrastructure, equipment and training in propagation techniques and nursery management.

7. Conclusions and recommendations

7.1 Key innovations

CIAPEC has implemented several key strategies to facilitate the adoption of more diverse agroforestry systems among its small member partners. Training and practical workshops are one of the decisive ways in which CIAPEC drives the adoption of agroforestry systems: the organisation offers workshops that require the implementation of what has been learnt directly on the plots, has contracted CIAPEC staff to give workshops on how to select seeds, determining the right distance between branches to optimise the quality of the forest, and about ecological thinning and the planting of forest trees in agroforestry systems. CIAPEC has also facilitated access to seeds and technical knowledge necessary for the implementation of agroforestry systems. In addition, CIAPEC has supported partners with coffee seedlings, which are essential for establishing plots under agroforestry systems.

To complement the above, it is important to note that a landscape approach can optimise synergies between different land uses, balancing food production with natural resource conservation. In addition, supportive policies, such as simplifying regulations and creating economic incentives, can significantly increase the adoption of agroforestry systems. Importantly, CIAPEC offers a comprehensive support structure that focuses not only on production, but also on the sustainability and wellbeing of communities. Table 5 shows the key innovations for each of these areas.

Table 5. Key CIAPEC innovations to help incentivise agroforestry uptake

Key area	Innovations implemented by CIAPEC
Motivating members	<ul style="list-style-type: none"> • Participatory workshops and field demonstrations: CIAPEC organises workshops where members have to apply what they have learnt directly on their plots. This allows partners to experience first-hand the benefits of agroforestry systems and overcome initial doubts. • Inspiration by example: Members have been inspired by observing their neighbours' AFS, suggesting that CIAPEC fosters a community network where individual successes serve as motivation for others.
Access to resources	<ul style="list-style-type: none"> • Support with coffee seedlings: CIAPEC provides coffee seedlings to members, facilitating the establishment of new plots under agroforestry systems. • Specialised technical training: CIAPEC hired experts to conduct workshops on seed selection and grain-quality optimisation. These workshops teach members how to determine the right distance between branches, which is crucial for the management of the agroforestry system. • Seed exchange networks: Coffee and forestry tree seeds are exchanged between neighbours, indicating that CIAPEC facilitates a community network for resource exchange.
Technological innovation	<ul style="list-style-type: none"> • Promoting <i>chaqueo ecológico</i> (ecological thinning): CIAPEC teaches its members about <i>chaqueo ecológico</i> and the planting of forestry trees in agroforestry systems. This practice helps to maintain soil health and reduce the need for traditional burning to clear the land.
Financial support	<ul style="list-style-type: none"> • Access to fair markets: CIAPEC ensures producers receive a fair payment for their products, sufficient for a dignified life, complying with basic fairtrade criteria. • Trade agreements: CIAPEC has established marketing agreements with EMAPA and Ketal for the sale of organic coffee under the Bolcafé brand. These agreements facilitate the insertion of the product in the national market. • Quality improvement projects: CIAPEC beneficiaries have participated in projects to improve production quality and strengthen organic certification.

7.2 Remaining challenges

CIAPEC members face a number of important challenges, and to help CIAPEC overcome these challenges, targeted external support would be useful. Table 6 is a detailed summary of the challenges, possible CIAPEC actions and the external support needed to achieve the desired changes.

Table 6. Challenges faced by CIAPEC and suggested external support

Challenge	Actions required	Suggested external support
Complexity and manpower for the maintenance of the agroforestry system	Simplify agroforestry management practices through continuous training and the development of more efficient techniques. Encourage knowledge sharing among farmers to learn from best practices.	Technical and financial support for research and development of labour-saving tools and technologies. Funding for agricultural training and extension programmes that focus on efficient and sustainable agroforestry management techniques.
Initial and maintenance costs of the agroforestry system	Seek external funding sources through projects and bank loans. Optimise the use of local resources and traditional knowledge to reduce dependence on external inputs.	Subsidies and soft loans to cover the initial costs of establishing and maintaining AFS. Support for the creation of credit cooperatives and revolving funds to facilitate access to finance for farmers.
Difficulty in maintaining the balance between shade and coffee production	Implement strategic pruning and shade-management practices to optimise coffee production. Regularly monitor shade conditions and adjust management practices as necessary.	Technical assistance for the design and management of shade canopies that maximise productivity and sustainability. Research on the best tree species to provide shade and improve soil quality. Digital tools such as ShadeMotion to facilitate the planning and design of AFS.
Lack of state support	Advocate for public policies that support AFS and sustainable agriculture. Participate in government initiatives and programmes that promote environmental sustainability and conservation.	Fiscal incentives and subsidies for farmers adopting AFS and sustainable practices. Technical and financial support programmes for organic certification and implementation of climate-smart agriculture practices. Regulatory frameworks that support the restoration of degraded landscapes and encourage the adoption of AFS.
Impact of climate change	Adopt climate change adaptation strategies, such as the use of resistant varieties and intensification of coffee management. Implement soil and water conservation practices to increase crop resilience.	Support for research and development of coffee and cocoa varieties resistant to climate change and diseases. Funding for climate change adaptation projects that include the implementation of AFS and sustainable agricultural practices. Early warning systems and climate-monitoring tools to help farmers make informed decisions.
Need to diversify income	Integrate other products and activities into AFS, such as the production of timber, fruits, honey and medicinal products. Develop marketing strategies for these diversified products and access new markets.	Technical and financial support for the diversification of AFS and to develop value chains for non-traditional products. Business management and marketing training to help farmers access new markets and obtain better prices. Support programmes for the certification of organic

		and Fairtrade products, enabling access to niche markets and higher prices.
Threat of pests and diseases	Implement IPM strategies that combine biological and cultural methods. Constantly monitor crops for early detection and control of pests and diseases. Use pest and disease resistant varieties of coffee and cocoa.	Support for research and development of biological and cultural pest and disease control methods. Early warning and monitoring systems for pests and diseases to help farmers make informed decisions. Training in IPM and crop-management practices that reduce the incidence of pests and diseases.

7.3 Policy recommendations

According to CIAPEC members, there is no state support. However, there are agroforestry policies and strategies that can be designed and implemented with a participatory and inclusive approach, involving all key actors, from farmers and rural communities to governments and the private sector. To drive wider adoption of agroforestry systems, it is essential to implement a number of strategic changes, ideally with the support of external partners.

- Establish public policies that support agroforestry, promoting landscape restoration and the integration of sustainable practices into value chains.
- Create incentives such as payments for environmental services (PES) and access to markets for forest products.
- Promote policies that encourage soil restoration, biodiversity and economic profitability.
- Involve producers, communities, governments and the private sector in the design and implementation of agroforestry strategies.
- Promote the certification of agroforestry products to improve their market positioning.
- Develop lines of research to improve post-harvest protocols and add value to products.
- Facilitate access to carbon credits and other financing mechanisms.
- Promote diversified agroforestry systems for ecosystem services such as carbon sequestration and water regulation.
- Implement strategies such as adjusting planting density and improving shade management.

7.4 General conclusions from a comparison with other case studies

The authors have also studied three other agroforestry systems including the producer groups Asociación de Caficultores de Taipiplaya (ASOCAFE – Coffee Growers Association of Taipiplaya), Central Local de Cooperativas Agropecuarias Caranavi (CELCCAR – Local Centre of Agricultural Cooperatives of Caranavi), Asociación de Productores de Café Ecológico (Aprocafe Bolivia – Association of Organic Coffee Producers) and CIAPEC. The comparison highlights their common focus on promoting agroforestry systems, promoting adoption among their members with the aim of improving livelihoods, and fostering climate-resilient landscapes. Table 7 details the key similarities.

Table 7. Common elements between four coffee-based agroforestry systems

Element	Detailed similarities
Main objective	Promote the adoption of AFS to improve members' livelihoods and create climate-resilient landscapes. All organisations seek to harmonise agricultural production with the preservation of the environment, improving the livelihoods of their members through sustainable practices.
Structure of the AFS	Implementation of AFS with three main strata: upper (timber trees as cedar, toco and mara), middle (fruit trees and leguminous plants such as siquili, avocado and banana), and lower (coffee and other crops such as bean). The appropriate selection of species for each stratum is fundamental to optimise the benefits of the AFS, such as improved coffee quality, reduced environmental impact and income diversification for producers.

Common species	Use of species such as siquili (<i>Inga edulis</i>), cedar (<i>Cedrela odorata</i>), mara (<i>Swietenia macrophylla</i>), avocado (<i>Persea americana</i>) and banana (<i>Musa paradisiaca</i>) in the AFS. These species are consistently found in the AFS implemented by the different organisations, although there may be variations according to local conditions and individual farmer preferences.
Training and technical assistance	Each offers workshops and courses on agroforestry practices and plantation design. Forest and farm producer organisations (FFPOs) provide technical training through workshops and meetings, explaining the benefits of agroforestry systems and best practices for their implementation. FFPO technicians provide guidance on the design of agroforestry components, seed selection and pruning techniques. Some plots serve as demonstration plots, where partners and other producers can directly observe the benefits of the agroforestry system.
Seed and seedling sources	Seed is obtained from various sources: farmers' plots, farmer-to-farmer exchange, external projects (such as CLAC and FFF) and FFPO-supported or own nurseries. Farmers obtain seed from their own plots, identifying mother plants with good characteristics, such as good grain, high productivity or pest resistance. In some cases, farmers share or exchange seeds among themselves. FFPOs facilitate access to seeds of improved varieties and seedlings from national coffee programmes and external projects.
Perceived benefits	Income diversification, improved soil health, increased biodiversity, food security and climate resilience. Partners perceive multiple benefits in the overall productivity and health of their farming systems by implementing agroforestry practices. The presence of trees and other species in their AFS contributes to the generation of organic matter, which enriches the soil with nutrients. AFS promote biodiversity by attracting pollinators and other beneficial organisms.
Common challenges	Management of coffee diseases (rust, ojo de gallo), low soil fertility, high labour demand (especially for weeding), price instability and compliance with EUDR regulations. Disadvantages of AFS in coffee production include management complexity that requires greater knowledge and skill, as well as a higher labour requirement, especially for weeding. Production costs are mainly focused on labour, seedlings and fertilisers.
Markets	Sale of products in local, national and international markets. Each emphasises organic and fairtrade coffee production to access better prices. The main end markets for members' AFS products include local, national and international markets. FFPOs facilitate the marketing of organic coffee to international markets and establish partnerships with key buyers.
Key innovations	Implementation of techniques such as no-burn check, organic manuring, pruning, use of efficient microorganisms, contour planting design and crop diversification. FFPOs have been instrumental in the adoption of more diverse AFS by their partners through several key mechanisms, such as training and technical assistance. They have also facilitated access to improved seeds and seedlings and promoted the renewal of coffee plantations with more productive and resistant varieties.
Recognition of producers	Recognition of partners through assemblies where they share knowledge and experiences of innovations they use. It is important to note that the innovations are not necessarily complex technologies, but rather practices adapted to the local context and based on traditional knowledge, observation and experimentation.

7.5 Model agroforestry system adaptable to Bolivian conditions

From this comparative analysis, we propose a model of agroforestry system based on the experiences of ASOCAFE, CIAPEC, CELCCAR and Aprocafe Bolivia, for this it is important to consider the common elements and the specific adaptations of each organisation. Table 8 summarises a diversified coffee agroforestry model, adaptable to the local conditions of each context. Table 9 then presents the common advantages and disadvantages found in the ASOCAFE, CELCCAR, Aprocafe Bolivia and CIAPEC studies with respect to agroforestry systems. Finally, Table 10 provides an overview of the key findings and most important recommendations, highlighting the importance of integrated support, innovation, adaptation and active participation for the success of agroforestry systems.

Table 8. Proposed diversified coffee agroforestry model, adaptable to the local conditions

Component	Description	Common species	Benefits
Canopy timber trees	Timber trees that provide regulated shade, sequester carbon and generate long-term income.	Cedar (<i>Cedrela odorata</i>), toco (<i>Enterolobium contortisiliquum</i>), mara (<i>Swietenia macrophylla</i>) and laurel (<i>Laurus nobilis</i>).	Sunlight regulation, carbon sequestration, improved soil structure, timber sales revenue.
Medium-canopy timber trees	Fruit trees and leguminous plants that diversify income, provide food and improve soil fertility.	Siquili (<i>Inga edulis</i>), avocado (<i>Persea americana</i>), banana (<i>Musa paradisiaca</i>), citrus (orange, lime, mandarin), ceibo (<i>Erythrina poeppigiana</i>).	Income diversification, food security, nitrogen fixation, pollinator attraction, soil health improvement.
Shade-tolerant crops	Cultivation of improved and disease-resistant coffee varieties.	Coffee (<i>Coffea arabica</i>) (caturra, catuaí rojo, castilla, pacamara and mondo novo varieties).	Production of high-quality coffee.
Root crops and within the AFS	Combination with subsistence crops for food security.	Bean (<i>Phaseolus vulgaris</i>), maize (<i>Zea mays</i>)	Food security, income generation.
Management practices	Organic compost and mulch: Use of natural compost and mulch from the decomposition of tree leaves and leguminous plants. Shade control: Regular pruning of trees to adjust the amount of light reaching the coffee.	Efficient microorganisms, natural compost, mulch, fungi and decomposed leaves.	Improved soil fertility, erosion control, moisture regulation, reduced need for chemical fertilisers.

Table 9. Common benefits and disadvantages of agroforestry systems for coffee

Aspect	Common benefits	Common disadvantages
Diversification	<p>Increased diversity of food and useful household products.</p> <p>Diversification of income through the sale of multiple products (coffee, fruit, timber).</p> <p>Reduced dependence on coffee as the only source of income.</p>	<p>Complexity in handling requiring greater technical knowledge and skill.</p> <p>Need for more manual labour, especially for weeding and maintenance of the system.</p>
Environmental	<p>Improved soil health and green manure production.</p> <p>Erosion control and water management.</p> <p>Increasing biodiversity by creating habitats for beneficial insects, pollinators and birds.</p> <p>Adaptation to climate change by regulating temperature and providing shade and carbon sequestration.</p>	<p>Difficulty in the initial set-up of the system.</p> <p>Possible depletion of nutrients in the soil if not properly managed.</p> <p>Climatic risks such as droughts affecting resource availability.</p> <p>Excessive shade can affect coffee production if not properly managed.</p>
Economic	<p>Access to international markets that value sustainable production and fair trade.</p> <p>Potential to improve coffee quality and obtain better prices.</p> <p>Increased resilience to market fluctuations due to product diversification.</p>	<p>Instability of coffee prices and difficulty in accessing stable markets.</p> <p>High costs of implementing and maintaining the AFS.</p> <p>Dependence on external financing to cover production costs.</p> <p>Lack of marketing and management knowledge on the part of producers.</p>
Social	<p>Benefits shared by all family members, including women and youth.</p> <p>Preservation of traditional agricultural practices and local knowledge.</p> <p>Improved food and nutrition security for families.</p>	<p>Low youth participation and need for greater awareness of the benefits of AFS.</p> <p>Lack of internal communication and governance in some organisations, leading to mistrust.</p> <p>Division in the communities, where some members have left the cooperative.</p>

Table 10. Summary findings and recommendations from case studies of four Bolivian agroforestry systems

Organisation	Key findings	Key recommendations
ASOCAFE	ASOCAFE has proven to be a key actor in the promotion of AFS in Taipiplaya. Through training, innovation and diversification, the organisation has improved the living conditions of its members and contributed to environmental conservation. However, to ensure long-term sustainability, more external support and clear government policies are needed.	Implement governmental public policies to support agroforestry. Strengthen technical assistance. Ensure access to fair markets. Promote research and innovation. Improve the harvest and post-harvest process, modernise drying, rearrange coffee plantations with leguminous and forest species, increase exports, position its brand, include more women and youth, establish a coffee roaster and seek financing for expansion.
CELCCAR	It is crucial that CELCCAR improves its governance and internal communications to foster trust and active participation of partners. It should explore new marketing channels to re-export its coffee and diversified products and ensure access to stable markets that offer fair prices. CELCCAR should also encourage the adoption of innovative practices and approaches to improve the productivity, sustainability and resilience of AFS.	Train technicians in agroforestry management practices with a practical approach, valuing the local experience of producers. Develop markets for forest products, facilitate access to mini-processing plants, diversify markets for coffee, provide continuous financial support, and train producers to promote their autonomy.
Aprocafe Bolivia	Aprocafe Bolivia has been instrumental in the adoption of more diverse AFS by its partners through several key mechanisms. First, the organisation has provided training and technical assistance to farmers. Aprocafe Bolivia has also facilitated access to improved seeds and seedlings and promoted the renovation of coffee plantations with more productive and resistant varieties.	Aprocafe Bolivia can overcome the challenges by strengthening its internal organisation, adopting sustainable agricultural technologies and practices, and diversifying its products. It should also encourage the creation of support networks and the exchange of knowledge between farmers, extensionists and scientists.
CIAPEC	CIAPEC has implemented several key strategies to facilitate the adoption of more diverse AFS among its smallholder members. It offers training and hands-on workshops (one of the decisive ways in which CIAPEC drives the adoption of AFS) as well as workshops that require the implementation of what has been learnt directly.	Promote the certification of agroforestry products to improve their market positioning. Develop lines of research to improve post-harvest protocols and add value to products. Facilitate access to carbon credits and other financing mechanisms. Promote diversified AFS for ecosystem services such as carbon sequestration and water regulation.

In addition, the following should be considered:

- **Comprehensive support:** An approach that combines financial resources, technical assistance, access to markets and favourable public policies is crucial to the success of agroforestry initiatives, as well as external support partners who value local expertise.
- **Innovation and adaptation:** Encouraging the adoption of innovative practices and approaches will improve productivity, sustainability and resilience of agroforestry systems. Technical recommendations should be adapted to local conditions and preferences, as well as species diversity and system sustainability.
- **Active participation:** All members should actively participate in the decision-making and management of the co-operative.

Appendix 1. Testimonials from CIAPEC members

Alfredo Espinosa Cárdenas, Hernando Magallanes community, CIAPEC

Alfredo Espinosa Cárdenas shares his experiences with his agroforestry system, highlighting the following points:



- **Beginnings in agroforestry:** Alfredo is relatively new to implementing an agroforestry system, having acquired an abandoned plot of land about two years ago. He was encouraged by a neighbour to adopt agroforestry practices, which proved beneficial to his plot.
- **Institutional support:** Alfredo's father received support from ITC and UPEA2. Alfredo mentions that CIAPEC provides coffee seedlings, which are essential to establish his plot under the agroforestry system.
- **Costs and financing:** Alfredo estimates that he has spent between 35,000 and 40,000 bolivianos per hectare on his plot, although he does not keep detailed records of costs. He mentions that he has received training from CLAC Fair Trade and that he approached Rabobank for a loan. They are currently working with the FFF project for coffee and forestry nurseries.
- **Key practices:** Alfredo mentions the importance of non-burning, hulling coffee beans and weeding as key activities. He also highlights pest and disease management, such as managing the fungal disease *ojo de gallo*.

Figure 5 is a hand-drawn diagram by Alfredo showing the structure of his agroforestry system and its components in cross-section.

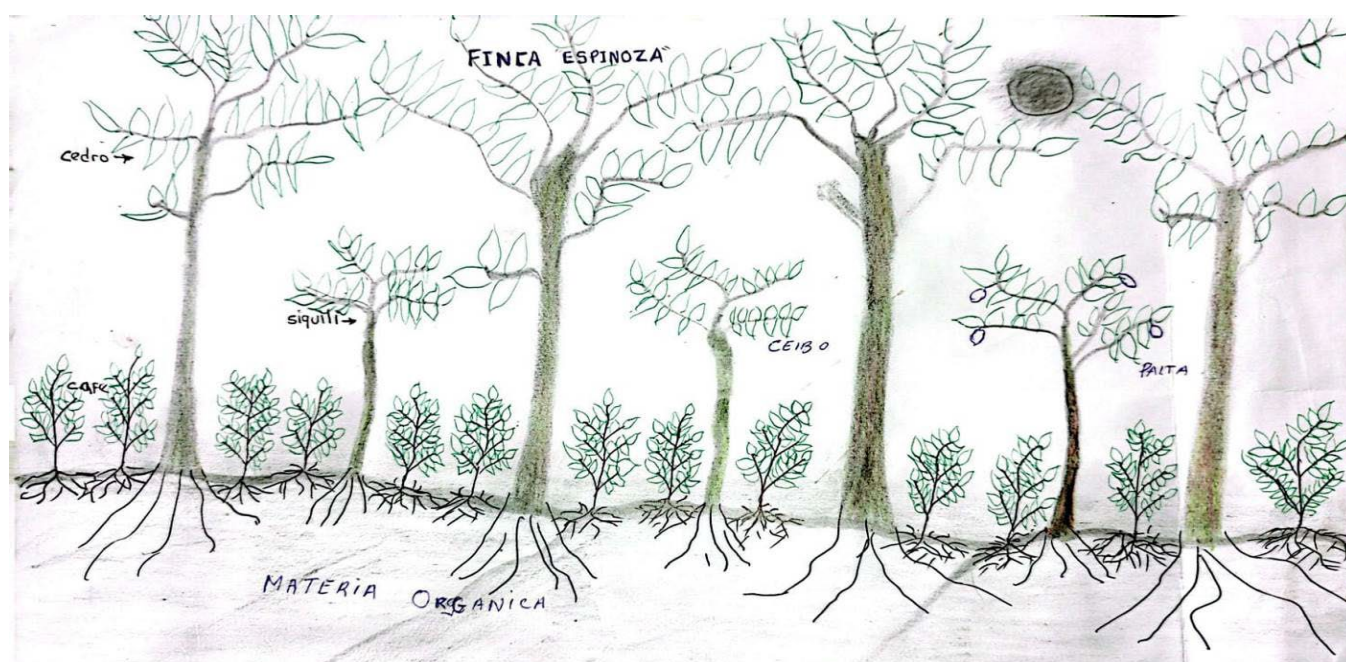


Figure 5. Diagram of a coffee agroforestry system by Alfredo Espinosa Cárdenas

Celia Condori Condori Limache, Ascensión community, CIAPEC

Celia Condori Limache is the vice-president of her local FFPO. In her testimony, Celia shares valuable information about her experience with agroforestry systems.



- **Species grown:** On her plot, Celia grows red siquili (four years old) and walnut (40 years old). She also tried to grow siquili corico, but it did not adapt well. The walnut tree, although old, sometimes damages the coffee.
- **Phytosanitary problems:** Celia has observed a white fungus on coffee fruits, identified as *bauberia*. In addition, she uses mountain micronutrients, which she has in liquid form.
- **Technical knowledge:** Celia mentions that the FFPO (through CIAPEC) provided workshops where technical knowledge was imparted on seed selection and branch management to obtain quality grain. These workshops taught farmers how to select seeds, discarding those of lower quality.
- **Adaptation and learning:** Despite feeling less capable than a man in her position, Celia is learning and applying the knowledge she has acquired in CIAPEC's workshops.

Figure 6 is a black and white hand-drawn diagram by Celia showing the structure of her agroforestry system and its components in cross-section.

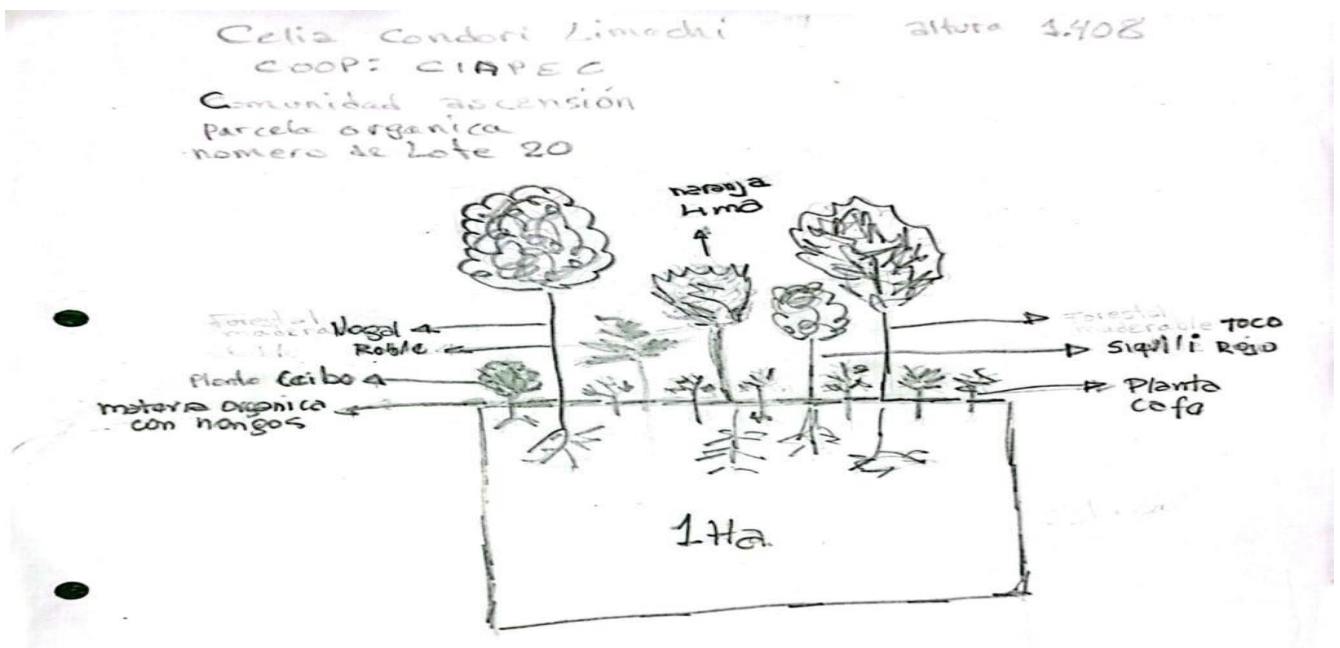


Figure 6. Diagram of a coffee agroforestry system by Celia Condori Limache