CANALLS
AGROECOLOGICAL PRACTICES FOR SUSTAINABLE TRANSITION

D1.1 Agroecological contexts and needs of rural communities in the Agroecological Living Labs

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Executive Summary

This chapter summarises important policies and economic contexts that influence the development of Agroecological living labs. It summarises the background. the methodology, objectives, results, and recommendations of the assessment of the needs, context, and practices in the Agroecological Living Labs (ALLs) focal areas, and ends with mapping the food systems, value chains and markets.

The CANALLS project aims to drive Agroecological transitions in the humid tropics of Central and Eastern Africa via multi-actor transdisciplinary Agroecology Living Labs (ALLs). It starts with 8 ALLs in DRC, Burundi, Cameroon, and Rwanda, working alongside and enabling over 20,000 farmers and value chain actors to co-create and benefit from optimal combinations of Agroecological practices focusing on crops that are vital for subsistence and economic development (cocoa, coffee, cassava, rice, maize).

Our analysis relies on secondary and primary data (qualitative and quantitative). We combined desk study, 130 household surveys, 265 respondents from focus groups discussions and interviews with 35 decision makers and 55 traders in the living labs.

During the desk study, we reviewed the existing literature, following a Political, Economic, Social, Technological, Environmental and Legal (PESTEL) analysis to characterise the macro-environmental context that could affect the development and implementation of Agroecological projects in the focal countries. A desk review was also performed to identify the food systems, value chains and markets for the countries and ALLs.

We then reviewed the reports and materials published on the past and existing projects developed in the focal countries and living lab to inform the micro environmental context. The relevant topic for the micro environmental context includes landscape characteristics, socio-economic conditions, capacity building, farming practices and Agroecological context, and climate variability and adaptation. This review led to the identification of missing information.

The field data collection (interviews, focus groups) was carried out to fill in the missing information. Different materials for fieldwork were developed to capture the socio-economic and environmental contexts as well as to the mapping of the food systems, value chains and markets. Interviews with households, with traders and with decision makers using different interview guides were combined with a focus group discussion to map the food systems and markets. The socio-economic and environmental contexts were further discussed during focus groups discussions.

Agricultural and tax policies

The agricultural policy development in the focal countries can either encourage or discourage the implementation of co-created Agroecological practices in the living labs.

In Burundi where agriculture is one of the eleven pillars of its 2018-2027 development plan, the government chose to invest more than 20% of its annual budget in the agricultural sector to achieve the goals of professionalisation and food security. Many programs, subsidies, and assistance have been put in place under the National Agricultural Strategy (SAN, 2008) to facilitate access to inputs, increase the rate of use and the number of fertiliser users, without any particular interest in the promotion of organic fertiliser, and promote diversification of sources of growth and export products. Applying diversification in Burundi living labs, as one of the Agroecological principles will then be enhanced by the SAN, while the entrant subsidies would not favour input recycling, and the reduction of the input from external sources.

For the case of Cameroon, agroecology as an adaptation and mitigation option was not clearly highlighted in all strategic documents. Numerous ongoing initiatives that could be capitalised to promote agroecology include agroforestry programmes promoted by the International Institute for Research on agroforestry (ICRAF); recycling, soil, and chemical input reduction promoted by the International Institute of Tropical Agriculture (IITA) via the Integrated Soil fertility Management (ISFM) program under CocoaSoil project, synergy promoted by the Support Program on Securing the Integrated Management of Agro pastoral Resources (PASGIRAP funded by the French Development Agency (AFD)); the diversification of sources of income, biodiversity enhancement promoted under the Global Challenges Research Fund (GCRF) Trade Hub project carried out by IITA/CBI which engaged the decision makers to create favourable conditions for the development of Agroecological products.

In the Democratic Republic of Congo (DRC), the diagnosis of the agricultural and rural sector carried out within the framework of the Sectoral Strategy for Agriculture and Rural Development (SSADR) by MINAGRI and MINIDER (2010) resulted in a certain number of constraints that penalise the actors involved in the production, processing, and marketing in the sector. In 2022, the government adopted the Sustainable Agricultural Policy (PAD) as a reference instrument to deal with these constraints. This PAD adopted within the framework of the Sustainable Agriculture Management Program (PGDA) funded by the Central African Forest Initiative (CAFI) is a guiding document for the agricultural sector in the broad sense. The PAD is a great opportunity for the implementation and development of agricultural and Agroecological projects such as CANALLs. Indeed, it includes the Program for the Sustainable Development of Savannahs and Degraded Forests (PSFD), which provides technical sheets of technical itineraries on agroforestry and Agroecological practices with the aim of promoting the implementation of Agroecological principles. The contribution of the German cooperation (GIZ) stands on setting-up the participatory plan for the local Development strategy, focused of the 145 Territories targeted by the government for sustainable development by 2030. Therefore, agroecological approaches are integrated in such plans from the bottom levels.

The mission of the National Agricultural Policy of Rwanda is to ensure food and nutrition security, modern agribusiness technologies professionalising farmers in terms of production, commercialization of the outputs, and the creation of a competitive agriculture sector. The Rwanda national agricultural policy is built upon 4 pillars. The second pillar is on technological upgrading and skills development. It sets policy action about crop production (promoting research on bio-fortification and agriculture Biotechnology), soil systems and health, and animal resources, that are favourable to the development of Agroecological principles such as soil health, and animal health, and favourable to the implementation of living labs in Kamonyi (Rep Rwanda, 2018).

In sum, for all countries, fiscal policy and subsidies are instruments used either to encourage or to discourage agricultural and Agroecological production and to encourage industrial transformation in some cases in the Living Labs. Agricultural products are exempt from export duties and taxes in many countries including the focal countries. Indeed, Burundi specifies that agricultural and livestock products are VAT exempt when sold by owners and notwithstanding turnover thresholds (EAC,2022). Burundi has developed a National Fertilizer Subsidy Programme with the aim of increasing agricultural productivity. Temporal removal of taxes is also observed to face a crisis. For instance, the agricultural sector. In DRC, agricultural products are exempt from export duties and taxes. Excluding the duties and taxes on the agricultural sector is not enough to favour or to incentivize Agroecological products, that can be seen as in competition with conventional products that cost cheaper to produce. For the cases where tax exemption and subsidies favour conventional agricultural products, as in Burundi, in

DRC and in Cameroon, this hampers Agro Ecological products that become relatively more expensive to produce and thus relatively more expensive to sell, compared to the subsidised conventional agricultural products. In Rwanda, where exports and international transport are not taxed, subsidising organic fertilisers is favourable to the development of Agroecological products. Cases where fiscal policy encourages transformation are found in Cameroon. There, cocoa beans exported without processing should be subject to an autonomous exit duty at a rate of 10% of the Free on board (FOB) value to encourage national and international players in the industry to process more cocoa at the point of production.

Economic context

Burundi and Cameroon have experienced a difficult economic situation in recent years, marked by macroeconomic imbalances. Burundi's economic growth declined considerably in 2021 and Cameroon's in 2022, probably due to the poor performance of several sectors. On the other hand, economic growth in DRC and Rwanda is set to strengthen, with the mining sector remaining the main driver. In the first two countries, agriculture makes a huge contribution to national GDP.

Beside the DRC, the transboundary business within the African Great Lakes nourrishes the flow of cash food influences the household’s economics both in rural and urban cities- and certainly influences positivement the international exchange on food market and food systems standing on agroecological practices and patterns. Since DRC is a full country member of the East African Community (EAC), international programs on Economy and agriculture development look promising like RUFORUM which is boosting agricultural entrepreneurship among youths. In fact, the Eastern part of the DRC is closer to regional cities (Kampala, Dar-e-Salam, Kigali, Bujumbura, Lusaka) - therefore population movement mostly traders influencing the trades and markets diversity that covers local and foreign stuffs. Since 2010, small-scale farmers are organized around cooperatives for taping economic markets around coffee, rice, maize, beans, maize, vegetables, and milk production. Unfortunately, the markets competitiveness is higher looking to global markets and food technology. Alongside the national road (RN5) that links the biggest cities of the Eastern DRC (Kalemie, Uvira, Bukavu, Goma, Butembo, Beni, Bunia, there are many existing local markets which economically collect small-scale farmers products for regional international markets.

In Burundi, cash crops are mainly coffee, cotton, tea and palm oil, and account for the bulk of exports. Agriculture also plays a key role in Cameroon's economy, with cocoa emerging as one of the most exported cash crops. Alongside the mining sector, agriculture also remains one of the major pillars contributing to the development of the Congolese economy. For Rwanda, its strong economic growth, boosted by the development of the mining sector, is accompanied by a substantial improvement in living standards. Its economy is increasingly resilient, despite the difficult economic environment experienced in 2022.

The four countries mentioned above are open to foreign trade. Rwanda aspires to become a middle-income economy by 2035, and to join the ranks of high-income countries by 2050. Economic aspects such as the high participation of agriculture in the national GDP of all 4 countries appear to be a reason to develop the agricultural sector in a sustainable manner using Agroecological practices (Figure 1). The underlined importance of coffee and maize for the foreign trade balance in Burundi, justifies the need to practise agroecology to ensure their sustainability. DRC is one of the few African countries that has enormous potential for the development of sustainable agriculture and the implementation of Agroecological practices. The status of cassava in Rwanda’s foreign trade is very favourable for the development of Agro Ecological cassava under CANALLs, which contribute to

improving the cassava balance in foreign trade and to feeding the increasing demand from neighbouring countries.

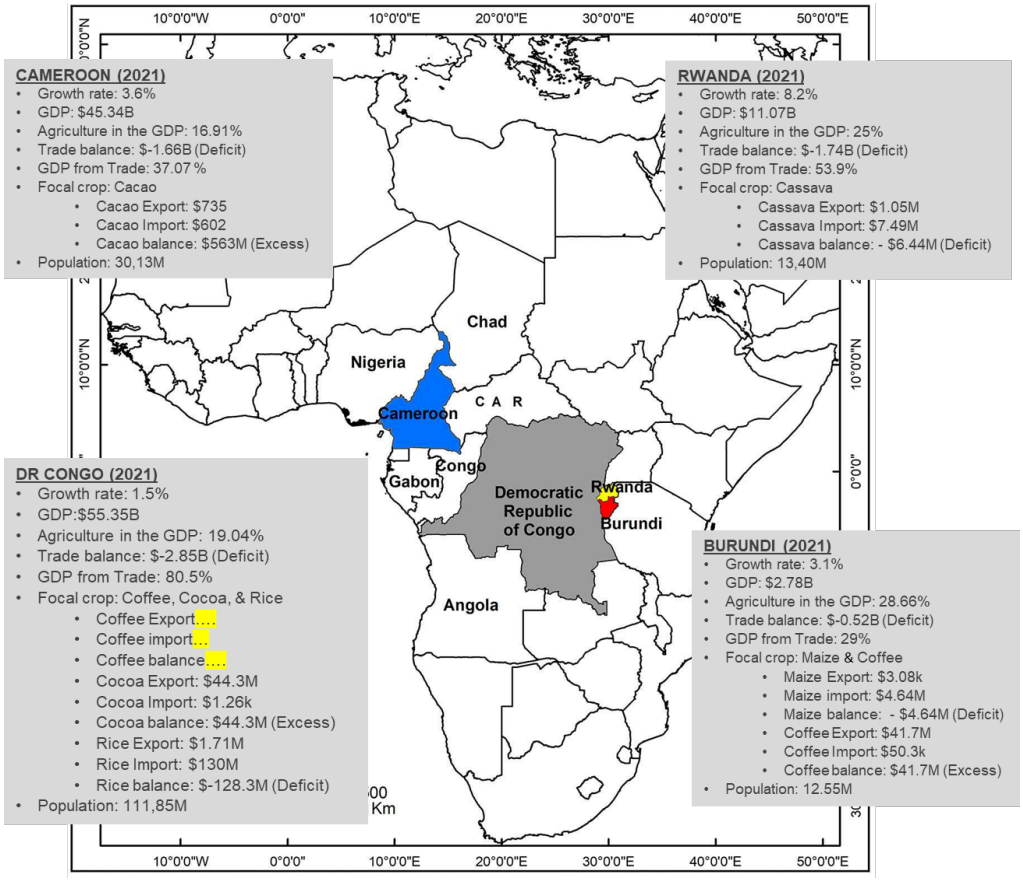

Figure 1: Comparative indicator of GDP and trade balance across CANALLS Countries

Source: Authors

Needs, contexts, and practices in the project countries.

Burundi

Conventional agricultural systems contribute to the continuous degradation of land, forests, and water, ultimately leading to low agricultural yields in most of sub-Saharan Africa, in addition to climate change. Agricultural policies for the extension of Agroecological techniques must consider the perceptions of farmers. There is also the need to build their capacity through literacy and vocational training (Tankoano and Sawadogo, 2022).

Burundi has two living laboratories, one in Bujumbura and the other in Giheta. Agriculture and livestock farming are the main activities in Bujumbura, with small-scale farming accounting for 45% and medium-scale farming for 55%. Here, 75% of households are directly involved in maize production, as the main focal crop. In the Giheta living lab, farmers are mainly involved in coffee production (3 out of 6 family members are involved in coffee production) with an average of 50 acres per family, banana being the secondary crop. Women are not very involved in coffee growing, as their

involvement depends on the tasks to be carried out on the farms, particularly during the harvest period.

In Bujumbura and Giheta, farmers are recycling farmyard manure and crop residues (coffee bean husks) and are manufacturing compost. They are reducing inputs by using fewer mineral fertilisers while using coffee bean husks as organic fertilisers. Farmers are facing many challenges relating to soil health. To unravel these constraints, they use mineral fertilisers, organic matter, compost, cover crops, and perennial plant species to improve soil health, reduce erosion, and promote soil conservation. Different types of animals are produced, and farmers use diversity of plant and tree species to improve their livelihoods, promote diversity and improve soil conservation. Agrosilvopastoral production system is used by farmers by integrating animal, plant, tree species as well as ISFM practices to improve crop production, soil conservation, and reduce the vulnerability to climate change.

Extension agents and farmers were trained in agricultural practices for maize and coffee cultivation. Farmers were also trained in social responsibility, agroforestry, and crop calendar. However, farmers expressed the need for capacity building in disease control, recycling of crop residues, mostly rice husks, irrigation techniques, use of biopesticides, crop association and rotation, soil, and animal health. The knowledge of farmers, although limited and not very widespread, is a good basis for the implementation of agroecology in the two living laboratories in Bujumbura and Giheta in Burundi.

Cameroon

The Ntui living lab in the Center Region of Cameroon has an estimated population of 20,000, with 46.49% women. Almost 41% are under the age of 14 and 49% are aged between 15 and 49. The household survey involved 30 randomly selected respondents or households. Most respondents (76.7%) were cocoa farmers, while food crops such as maize, cassava and yams represented 3.3%, 16.7% and 3.3%, of the respondents respectively. According to 93.3% of respondents, existing indigenous traditional knowledge and skills include crop rotation, fallowing, crop association, irrigation, agroforestry, wood ash as an insecticide, animal waste for manure and some compost users. Men tend to dominate the cocoa value chain, and women tend to dominate the food crop value chain. Access to land and natural resources is not equitable from a gender, youth, and indigenous peoples' perspective. Women do not have the same access to land as men, while access to finance is inclusive of women, young people, and indigenous people, with very low access. A diverse range of crops helps to improve the nutrition of the Ntui ALL population. The most important are *Zea mays*, *Sesamum indicum*, *Phaseolus vulgaris*, *Arachis hypogaea*, *Persea americana*, *Dacryodes edulis*, *Citrus* × *sinensis*, *Amaranthus viridis*, *Solanum nigrum*, *Manihot esculenta*. Ntui is a council with a strong economic potential, as its economic activities are based on trade, the exploitation of natural resources.

The indicators of climate variability are becoming increasingly apparent in Ntui. Farmers have noticed the rise in temperatures, late onset of rains, early cessation of rains, irregularity of rains, increased intensity of the sun, drying up of rivers, high wind speeds, relative delay in sowing and harvesting, reduced yields, more insect attacks, lack of rain, and extension of dry seasons. Farmers had never heard of agroecology. However, 16% and 5% of households apply recycling, using compost, manure or cow dung and vegetable-based green manures in their farming systems, respectively. Fertilisers and pesticides were considered good because they increase yields. Soil physical and chemical properties analysis are carried out to take care of organic matter and soil health.

Producers in various localities in the commune of Ntui have benefited from capacity building in good agricultural practices and integrated soil fertility management (2020-2022). However, they expressed additional needs for capacity building on the use and management of pollinators, animal feed, good selection of breeds and the management of animal diseases. Group discussions have revealed needs in new areas such as recycling, fertiliser production, irrigation, animal husbandry and agroforestry.

DR Congo

The population of Bunia in 2023 is estimated at 812,090 inhabitants.

Within the Biega ALL the main crops are coffee (40% of households), beans (100% of households), maize (60% of households), cassava 60% of households, sweet potato (20% of households) and vegetables (5% households).

The main land use in Bunia is agriculture, particularly for food crops, cocoa, and cocoa-based agroforestry. Kabare's main crop is coffee. With a population of 1,377,782, Uvira is one of the nine socio-economic towns in DRC. In Uvira, around 54.5% of households focus on paddy rice production, while 36.3% produce cassava, illustrating the importance of agriculture in the region's livelihoods. Agriculture accounts for 65% of the population's economy. About 54.5% and 36.3% of the inhabitants produce paddy rice and cassava, respectively. Maize, beans, and tomatoes are produced by 72.7%, 18.1%, and 18.1% respectively. Women are victims of harassment in several situations. Access to land and natural resources is not equitable from a gender perspective. The man owns the land. The absence of land titles as an essential guarantee prevents women from benefiting from credit. A few microfinance institutions that grant credit with high-interest rates and high guarantees are based in urban areas and are difficult to access by producers in rural areas. Some NGOs, such as Rikolto, provide financial assistance to certain farmers who participate in their activities. In terms of nutrition and health, dietary diversity and meal frequency are not sufficient. On average, 65% of adults eat only two meals a day, and only 20% of children receive meals containing the minimum acceptable level of diversity. Different climate change implications are seen in different living labs.

In Biega as well as in Kabare living laboratories extreme events include the abrupt occurrence of heavy rains when crops are blossoming, then flowers fall leading to a drastic decline of yields. The increase of temperature and drought disturbs sowing calendar, bears crop parasites and pests, and lowers cash crop harvest yield, coffee, beans, cassava, etc.,...

In Uvira, they are faced with irregular rainfall, extreme drought, landslides, and an increase in temperature. A shift in the sowing date in the agricultural calendar was observed in all the living labs. Agricultural practices in the living labs are based on traditional methods and Indigenous knowledge. Some of this Indigenous knowledge includes combining crops, burying weeds by ploughing, crop rotation, and irrigation. The working tools remain rudimentary. About 50% of farmers in Biega, 60% in Kabare, and 1% in Uvira had heard about agroecology. Most farmers in Biega use compost, manure, or cow dung in their farming systems. They harvest residues and legume-based green manures grown specifically to improve soil quality and productivity. In Kabare, around 45% of farmers use wastewater in vegetable gardens to maintain adequate humidity, and 55% of respondents use maize cobs and stalks as fuel/bioenergy for cooking and ironing clothes. About 40% of respondents in Biega, and 90% in Uvira are willing to reduce or replace chemical inputs.

Needs of capacity in terms of recycling, soil health, input use, biological control, biodiversity, and animal health have been strongly expressed in DRC.

Rwanda

With 66,622 households and a population of 377,257 inhabitants, including 52.5% men in Kamonyi district, Rwanda most respondents reported using traditional and local knowledge such as ditches, crop rotation and the use of hybrid seeds to improve crop productivity, use of wood ash and urine as insecticides and pesticides for cereals, red chilies, tobacco leaves and vegetables. Men and women have the same access to land. There are also equitable inclusion of women and young people in access to finance as people participate through a collaborative platform that facilitates dialogue and informs decision-making and promotes accountability and responsibility for action. Inclusiveness, participation, and dignity among farmers has been observed. The diverse range of farm produce in the district includes cereals and legumes, fruit trees and roots and tubers. About 70% of these farm products are for subsistence, but there is also an opportunity for income diversification through off-farming activities.

Observed changes in climate include among others, an increase in temperatures both in dry and rainy seasons, reduced rainfall, late-onset, more dry spells, more extreme floods, more extreme droughts, and increased winds. About 92% of farmers have heard of agroecology. Except for the use of leguminous-based green manures that are made by only 4% of the respondents, and for the use of reduced tillage and/or of no-tillage by 30% of the respondents, the remaining elements are adopted by 92% to 100% of the respondents. About 36% of the farmers will reduce chemical inputs in their fields, while 33% are willing to increase chemical compounds. About 47% of farmers have experienced health issues relating to agrochemicals for pest and disease control. Actions are carried out to take care of the organic matter and soil health. About 100% of the participants are taking care of the soil organic matter and soil health.

About, 92% of farmers in Kamonyi expressed a need for knowledge about Agroecological practices, capacity building on agroforestry practices, integrated use of chemical inputs and animal husbandry to optimise the benefits of agroecology. Engaging farmers in such knowledge-sharing initiatives will empower them to adapt to climate change effectively.

Food Systems, Value Chains and Markets

Agriculture is the mainstay of Burundi's economy, accounting for approximately 35-40% of Gross Domestic Product (GDP) and employing almost 96% of the country's labour force. In Burundi, more than eight percent of green coffee beans are traded internationally, and trading companies play an important role in coffee global value chains. Traders purchase green coffee from growers and grower associations and ship the beans to the end-market. Large roasters rarely source beans directly from producers.

In transitioning Burundi markets to agroecology in Bujumbura, it was noted that; presence of good quality product, increasing the demand for the product, creation of direct relations between consumers and producers, price differentiation with other products, competitive product, and regular market supply are needed. In Giheta, the key informants noted that the future of African markets is characterised by quality of the product, durability, and affordable prices over time. The various recommendations in enhancing food security, value chain and markets in Burundi were noted as; organisation of farmers into groups for collective bargaining when accessing the markets and the need for the Government to engage producers when setting commodity prices, especially coffee prices. The study notes that the ongoing regional integration process should be used to maximise Burundi's benefits from its accession to the East African Community. Reduced tariffs and non-tariff

barriers will enable Burundi to have easier access to a larger market, facilitating an increase in exports to the regional market. Besides, the country needs to develop an action plan and establish the necessary facilities/ laboratories to comply with international sanitary and phytosanitary standards. Burundi's large infrastructure gap needs to be closed, says the study. This applies to a range of areas, including roads, air transport and electricity. Regarding transport infrastructure, the insufficient availability of cold storage and a cold chain, in general, needs to be addressed.

Agriculture is the mainstay of Cameroon's economy, engaging an estimated 70 percent of the economically active population and accounting for an estimated 80 percent of the primary sector's contribution to the country's GDP. It also provides 1/3 of foreign exchange earnings and 15 percent of the country's budgetary resources. Despite this enormous potential, agriculture in Cameroon faces a plethora of challenges, thus compromising the country's capacity to sufficiently nourish its expanding food needs[1].

In transitioning Cameroon markets to agroecology markets, various recommendations were given by the respondents that included reducing imports, defining the role of each intermediary, promoting the consumption of Agroecological products, market regulation by the Government, price controls and strengthening farmer cooperatives. Farmers also lack adequate access to inputs alongside a lack of transportation and production resources. In addition, these farmers lack proper storage facilities such as warehouses to store dried cocoa. The findings also show that Cameroon, like most cocoa-producing countries, also faces many difficulties internally through implemented policy measures. In addressing this, reducing imports, defining the role of each intermediary, promoting the consumption, market regulation by the Government, price controls and strengthening farmer cooperatives and government option of a return to stabilisation will ensure efficiency in the cocoa sector.

The Democratic Republic of the Congo (DRC) is one of the most fertile countries on earth, with the potential to feed all its inhabitants and even export food commodities. It is home to approximately 80 million hectares of arable land (WFP, 2022). Agriculture and related services provide a livelihood to almost 75 percent of the population. The country enjoys one of the world's most favourable climates for agriculture and fertile soils and has the potential to feed over 2 billion people through suitable investments. However, according to the findings of the global standard for measuring food insecurity, 26 million people in DRC are currently severely food insecure, making its hunger crisis Africa's biggest. In strengthening DRC markets in transitioning to agroecology markets, in Biega ALL, key changes that need to happen in Biega ALL include strengthening national agricultural policies around agricultural cooperatives including all possible speculations that enter African food, structuring markets and linking them to agricultural areas. There are existing local markets, namely Mudaka, Katana, Kabamba which economically gathers farmers 'products towards Bukavu market (International market). Then the key role of intermediate traders and in the economic value chain is relevant since Biega ALL has poor road infrastructures.

In Kabare ALL, there was a need for horizontal and vertical integration of market actors, establishment of basic infrastructure, capacity building of farmers on sustainable good farming practices, need for good governance, good agricultural policy, close collaboration between producers and buyers at African level, and social behaviour changes in communication. In Uvira ALL, sensitization of farmers on good agronomic practices was recommended. The study identified the following recommendations in enhancing food systems, value chains and markets for cassava, cocoa, coffee, and rice sectors.

[1] https://cameroon.panda.org/our_work/food_and_agriculture/

This study showed that to increase the adoption rate of improved cassava varieties in Kabare Territory, it would be advisable for extension services to intensify the promotion of new varieties so that their characteristics might be better known. Increasing producers' access to washing stations and improving washing stations' productivity, business acumen, efficiencies, market outreach, and quality; increasing producers' awareness of the science, technology, and art of producing consistently high-quality coffee of interest to the international specialty market, developing Eastern Congo's high-altitude arabica coffees by inclusively building an enabling policy environment for a sector-prioritised, owned, and managed strategy; and researching the most productive varieties and resilient farming systems to introduce best practices for coffee. In the rice value chain, farmers lack access to finance, seeds, and other necessary productive inputs to improve their rice yields. The recommended interventions in the rice sector are increasing rural economic activity and enhancing smallholder resilience through income growth and food production.

There are substantial opportunities to advance Rwanda's food system in terms of provision of sustainable and healthy diets for all while also strengthening livelihoods. These efforts would build on Rwanda's global and regional commitments, utilise a multi-sectoral stakeholder approach and engage with the development community for support. In strengthening Rwanda's market transition to agroecology, the following needs to be done; improvement of infrastructure i.e., storage facilities, processing mechanisms, cleanliness, and safety markets should be spaces that are multi-functional, accessible to smallholder farmers, and have waste recycling facilities and processing centres. There was the need to conduct consumer sensitization on food quality. There are key bottlenecks along the cassava value chain including small holder farmers who use low-quality inputs and poor agronomic practices and have limited access to mechanisation. This has been a major determinant of Rwanda's current yield of 14.5 MT/ha as opposed to a potential of 20-30 MT/ha if mechanisation and good agronomic practices are involved. The cost of transportation from the farms to processing centres is high due to the bulky nature of cassava roots. The short shelf life of cassava roots calls for timely processing to minimise post-harvest losses, while processing equipment is costly and sometimes of poor quality. There is also the issue of price volatility because of irregular production with periods of glut when supply is high, and prices are low followed by scarcity and high price. The study identified the following recommendations that will aid in strengthening Rwanda's food systems, value chains and markets. Governments and private sector companies must devise strategies to increase commercial production, multiplication, distribution, and sales of improved stem cutting to smallholder farmers. Providing access to suitable irrigation technology such as drip irrigation, the Ministry of Agriculture must put out policies and incentives that strengthen extension services to rural farmers. Strengthening financial services: putting policies in place to ensure that farmers can access affordable loans will enhance production among the small holder farmers.

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Table 1: Acronyms

Abbreviations	Definition
AATF	African Agricultural Technology Foundation
ACEFA	Programme for the Improvement of Competitiveness of Family Agro-pastoral Farms
ADISCO	Support for integral Development and solidarity on the hills
ALL	Agroecology living lab
APDIK	Farmers' Association for the Integrated Development of Kivu
BANK PLC	A commercial bank in Rwanda, formerly Bank Populaire du Rwanda SA
BR	Burundi
BRD	Development Bank of Rwanda
CANALLS	Driving Agroecological transitions in the humid tropics of Central and Eastern Africa through traNsdisciplinary Agroecology Living LabS"
CIC	Council of coffee and cocoa
CIP	Crop Intensification Program
CLECAM	Coopérative Locale d'Epargne et Crédit Agricole Mutuelle
CMR	Cameroon
CNTA	National Food Technology Centre
CPF	Country Partnership Framework
CRSN	Natural Sciences Research Center
D 1.1	Deliverable 1.1
DHS	Demographic and Health Survey
DRC	Democratic Republic of Congo
EAC	East African Community
FGD	Focus Group Discussion
FNTP	Forest non-Timber products
GDP	Gross Domestic Product
HQCF	High quality cassava flour
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILO	International Labour Organisation
INERA	National Institute for Agronomic Study and Research
IRAD	Institute of Agricultural Research for Development
ISABU	Institute of Agricultural Sciences of Burundi
PNKB	Kahuzi Biega National Park
KI	Key informant
LBAs	Licensed buyers
MINAGRI	Ministry of Agriculture
NGO	Non- Government Organization
ONCC	National Cocoa and Coffee Board of Cameroon

PESTEL	Political, Economic, Social, Technological, Environmental and Legal
PEX	Primate Expertise
PSNEB	Programme National de Subvention des Engrais au Burundi
R&D	Research and Development
RWD	Rwanda
SACCO	Savings and Credit Cooperative
SSA	Sub Saharan Africa
SVC	Strengthening Value Chains
USD	United States Dollars
WFP	World Food Programme
WP	Work package
WRC	World Coffee Research

1. Introduction

1.1. Background

The global transition to sustainable food systems is key for delivering safe, nutritious, and affordable food for a rapidly growing population along with co-benefits for climate adaptation and mitigation that can help achieve the Sustainable Development Goals (Business, 2017). Africa is the continent with the highest prevalence of food insecurity. The main causes are poverty, economic downturns, conflict, and effects of climate change. In sub-Saharan Africa (SSA), the Central and Eastern Africa regions have consistently had the highest prevalence of undernourishment and severe food insecurity, reaching 32% and 28% of the total population respectively in 2020 (Business, 2017).

The CANALLS project aims to drive agroecological transitions in the humid tropics of Central and Eastern Africa via multi-actor transdisciplinary Agroecology Living Labs (ALLs). The project aims at enabling over 20,000 farmers and value chain actors to co-create and benefit from optimal combinations of agroecological practices focusing on crops that are vital for subsistence and economic development (cocoa, coffee, cassava, rice, and maize).

Specific objectives include (i) setting up 8 multi-actor ALLs in DRC, Burundi, Cameroon and Rwanda; (ii) developing practical tools to identify combinations of agroecological practices, (iii) create and test them, by monitoring and measuring the socio-economic and environmental performance of identified combinations of agroecological practices; (iv) delivering sustainable business models along with services and tools for facilitating access to markets and enhancing demand for agroecological products; and (v) supporting and building capacity for the adoption of agroecological practices.

The development and implementation of the CANALLS project is organised via 9 work packages (WPs). WP1 analyses the current situation across rural communities and agroecosystems. WP2 develops and finetunes the co-creation methodology and assessment framework. WP3 sets up and operates the multi-actor ALLs. WP4 focuses on monitoring and evaluating the performance and impact. WP5 designs fair, inclusive, and sustainable business models. WP6 scales innovations for agroecological transitions. WP7 organises the multi-actor dissemination, exploitation, and communication. WP8 ensures the project management and coordination, and WP9 addresses the ethical issue requirements.

The overall objectives of WP1 are to analyse current needs, contexts, and practices as well as food systems, value chains and markets, to diagnose and set the agricultural, ecological, and environmental baseline of focal agroecosystems, and to explore systemic factors, policies and innovation support affecting agroecological transitions.

1.2. Objectives of the analysis

The objective of this deliverable (D1.1) is to conduct an analysis of the agroecological contexts and requirements of rural communities. It involves a comprehensive examination of the needs, contexts, and practices of specific rural communities, alongside the mapping of food systems, value chains, and markets related to agroecological products.

First, the analysis aims to illuminate the socio-economic and environmental contexts of the rural communities within the project. It provides valuable insights into the biophysical characteristics of the farming systems, their socioeconomic conditions, and the indigenous knowledge, attitudes, and farming practices relevant to agroecology. Additionally, the analysis assesses the adaptive capacity and vulnerability of the focal communities and areas to climate change, while also exploring their needs and perceptions regarding agroecology. Moreover, the study examines the presence of innovative agroecological, and other sustainable farming practices currently implemented.

Second, the analysis comprehensively maps the food systems and markets of the farming systems and communities throughout the entire value chain. This mapping encompasses all stages, from production to food disposal after consumption, while also considering the contribution of these operations to socio-economic and environmental outcomes.

The findings from this analysis will be utilized in other WPs. Specifically, the co-creation and implementation of customized agroecological practices will be designed to address the needs identified through this analysis and will consider the specific contextual factors.

1.3. Methodology

The progress of the agricultural sector is shaped by numerous factors, encompassing both macro-environmental and micro-environmental elements. Macro-environmental factors pertain to global influences that impact the entire agricultural sector. On the other hand, micro-environmental factors are localized and involve the specific conditions within the agricultural sector, local agricultural settings, and nearby farms.

For our analysis, we utilize a combination of secondary and primary data, consisting of both qualitative and quantitative information. We conduct a desk study and gather data from various sources. Additionally, we conduct 130 households' surveys and engage in focus group discussions and interviews with 265 respondents. Moreover, we directly interact with 35 decision-makers and 55 traders in the ALLs to gather valuable insights for our analysis.

In the desk study phase, we conducted a thorough review of existing literature, employing a Political, Economic, Social, Technological, Environmental, and Legal (PESTEL) analysis to understand the macro-environmental context that may impact the development and execution of agroecological projects in the focal countries. Additionally, a comprehensive desk review was carried out to identify and assess the food systems, value chains, and markets in the countries and ALLs.

Next, we conducted a comprehensive review of reports and materials published on past and existing projects in the focal countries and regions of the ALLs to gain insights into the micro-environmental context. This analysis focused on various relevant aspects, including landscape characteristics, agroecological context, farming practices, socio-economic conditions, capacity building, and climate variability and adaptation. Through this review, we were able to identify any gaps or missing information that needed further investigation.

To supplement the missing information, we conducted field data collection through interviews and focus groups. Various materials were developed for this purpose to comprehensively capture the socio-economic and environmental contexts, as well as the mapping of the food systems, value chains, and markets. We conducted interviews with households, traders, and decision-makers, utilizing different interview guides tailored to each group. Additionally, focus group discussions were

held to further map the food systems and markets, while also delving into detailed discussions on the socio-economic and environmental contexts.

1.4. Field data collection

The field data collection was carried out in all the eight (8) ALLs. In total, 551 respondents participated in the data collection phase, exceeding the initial target of 400 for Task 1.1, and 160 respondents were involved in Task 1.2.

1.4.1. Sampling in the Agroecology Living Labs in Burundi

Bujumbura ALL

In the Bujumbura ALL, the sampling process was conducted in collaboration with partners (IITA) and stakeholders, including district leaders, extension services, and leaders of cooperatives. The primary objective was to delineate the Bujumbura ALL and select the specific districts for data collection. After thorough discussions, the districts of Mutimbuzi and Kabezi were chosen, as they represented two distinct regions. To ensure comprehensive representation, extension services and cooperative leaders from each district actively participated in the selection of households and key stakeholders involved in maize production, a main commodity in the region. A total of 3 focus groups were organized within this ALL, involving 36 farmers, of whom 18 were women. Additionally, 30 individual households were selected from different areas within the two districts, with approximately 80% of the respondents being women. For identifying traders in the area, the leaders of the respective districts and extension services were instrumental in assisting us. In total, 10 traders were identified, with 3 of them being women. Furthermore, three decision-makers also agreed to respond to our questionnaire. Overall, in the Bujumbura ALL, the interviewed participants consisted of 43% males and 57% females (as shown in Table 2).

Table 2: Sampling in Bujumbura ALL -Burundi

Country	Living Lab	Type of survey	sample size	Men	Women
Burundi	Bujumbura	Focus group	36	18	18
		Household survey	30	6	24
		Decision makers	3	3	0
		Traders	10	7	3
		Total	**79**	**34 (43%)**	**45 (57%)**

Giheta ALL

The sampling process in the Giheta ALL began with a collaborative agreement with the Cooperatives Consortium "COCOCA", a union of the Cooperatives of Coffee growers, created in October 2012, including COCOCA staff, leaders of coffee farm cooperatives, and administration staff. This mutual

understanding aimed to accurately define the Giheta ALL, which covers an agroecological zone spanning an altitude range between 1500 m and 1800 m. The Giheta ALL is situated in a coffee production zone with various farming activities centred around coffee cooperatives. The region also witnesses the presence of banana and cassava cultivation, where NGOs are actively involved, and farmers are organized into groups. A distinctive characteristic of the area is the prevalence of smallholder farmers who continue to practice their traditional culture, locally known as "Ni inde".

The questionnaire targeted specific groups along the coffee value chain, including small-scale farmers, coffee traders, and decision-makers. Data collection took place in the Giheta district, focusing on the selected farmers and various stakeholders associated with the coffee value chain within the COCOCA Cooperatives Consortium. Individual respondents answered the questions, except during the Focus Group Discussions.

In Table 3, the sampling characteristics of the Giheta ALL are presented, indicating that 55% of the respondents were males, while 45% were females.

Table 3: Sampling in Giheta ALL-Burundi

Country	Living Lab	Type of survey	sample size	Men	Women
Burundi	Giheta	Focus groups	40	20	20
		Household survey	10	6	4
		Decision makers	1	1	0
		Traders	5	4	1
		Total	**56**	**31(55%)**	**25(45%)**

1.4.2. Sampling in the Agroecology Living Lab in Cameroon

Ntui ALL

The sampling process for the Ntui ALL was based on the diverse landscape of the district. Ntui encompasses areas with predominant forest in the north, savannah in the southeast, and a savannah-forest transition area located in the southwest of the district. Each of these areas served as a sampling area, represented by the villages of Ehondo for the savannah area, Koussé for the savannah-forest transition area, and Nguila for the forest area. Three focus groups were organized, one in each of the mentioned areas. The focus groups collectively brought together a total of 29 producers, with approximately 30% being women. Notably, most of the producers selected to represent the villages in the chosen areas were cocoa producers. Due to the limited number of producers per focus group, we expanded our scope of action through household surveys. A total of 30 households from 12 villages were surveyed, with our sample comprising 37% women and 67% men. Regarding the questionnaire for decision-makers, we interviewed actors with competence across the entire administrative territory of Ntui, including the chiefs of the focal villages. Similarly, traders or sellers

were sampled according to their area of operation, ensuring representation across all identified areas, as shown in Table 4.

Table 4: Sampling in Ntui ALL-Cameroon

Country	Living Lab	Type of survey	sample size	Men	Women
Cameroon	Ntui	Focus group	29	20	9
		Household survey	30	18	12
		Decision makers	10	7	3
		Value chain actors	10	10	
		Total	**79**	**55 (69%)**	**24 (31%)**

1.4.3. Sampling in the Agroecology Living Labs in DR Congo

Biega ALL

The sampling process in the Biega ALL commenced with a mutual agreement among partners and stakeholders, which included village leaders, INERA, and APDIK, to define the real boundaries of the study site. The Biega ALL is situated in an agroecological zone within an altitudinal range of 1700 m to 2100 m and includes transitional primary forest relics from the Kahuzi Biega national park and farmland along the right side of the RN5 main road, that is in the Kabare Territory. The area has been a focal zone for INERA research programs since the 1970s. It hosts villages of indigenous people and Bantu groups living together, fostering a conducive environment for knowledge sharing. The Biega ALL is primarily a coffee production zone, encompassing several farming activities around coffee cooperatives where NGOs are actively involved, and people are organized into farmer groups. An intriguing aspect of this area is the presence of Pygmy groups settled in their own villages, functioning as small-scale farmers who aim to revive and preserve their traditional culture, which was adversely affected in 1975 when they were ejected from the Kahuzi Biega forest due to its conversion into a protected area. Under these conditions, both indigenous and Bantu groups have valuable resources to share and learn from each other. The focus on conserving the Kahuzi Biega national park and its ecosystem services fosters a collaborative effort among the different communities. The sampling characteristics of the Biega ALL are presented in Table 5.

Table 5: Sampling in Biega ALL, DRC

Country	Living Lab	Type of survey	sample size	Men	Women
DRC	Biega	Focus group (2)	23	20	3
		Household survey	11	7	4
		Decision makers	5	4	1
		Value chain actors	4	3	1
		Total	**43**	**34 (79%)**	**9 (31%)**

The sampling process was initiated through an agreement with village leaders, followed by the presence of INERA and APDIK teams in the field after a commitment meeting. Data collection was carried out using the project contents and well-prepared open-ended questionnaires, encompassing a comprehensive analysis of the entire agroecological context. The questionnaire primarily targeted small-scale farmers, coffee traders, and decision-makers. Both primary and secondary data were collected along three principal transects: Miti-Tshivanga, Kavumu-Lwiro, and Kavumu-Maziba. Information from neighbouring villages was also gathered around these three transects. Focus group meetings were conducted at the focal point of Cirheja village and Kafurumaye village, which are home to several community members. Kafurumaye, situated at an altitude of 1920 m, is near the Kahuzi Biega forest, while Cirheja, at 1750 m, is at a lower level with extensive connectivity to various farming villages and research centres such as INERA and CRSN (Centre de Recherche en Science Naturelles). The selection of resource persons for participation in the study was based on their experiences and capabilities to share insights on agroecological approaches and constraints within the area. Except for the Focus group discussion, the questions were submitted to individuals.

Kabare ALL

The primary data collection in Kabare ALL was carried out in collaboration with the leaders of the villages in 4 zones (Miti, Kabamba, Birava, and Lugendo) among the households practising coffee production as main commodity. A total of 4 focus group discussions were organised in this ALL. In Miti, 12 households were selected and these households were distributed in different villages (Bushumba, Kashanja, Miti centre, Bughore); in Kabamba, 11 households were selected in different villages (Mumbi, Lukayu, Chifinjo and Nyamiri); in Lugendo, 19 households were selected and came from different villages (Lugendo Center and Cishugi,) and finally in Birava, 35 households were selected as coffee growers from different villages (Kashimbi, Irambira North and Irambira South) in the area. A total of 77 individuals took part in the focus group discussions in the Kabare ALL. Of the 77 individuals selected, 30 were women. To identify traders in the area, the leaders of various villages and the chief of the group played a crucial role in assisting with their identification.

Table 6: Sampling in Kabare ALL-DRC

Country	Living Lab	Type of survey	sample size	Men	Women
DRC	Kabare	Focus group (4)	77	47	30
		Household survey	12	8	4
		Decision makers	7	6	1
		Value chain actors	7	6	1
		Total	**103**	**67 (65%)**	**36 (35%)**

Uvira ALL

In the Uvira ALL, the sampling was carried out through a common agreement with the village leaders who participated in the identification of farmers of target crops in the different villages. In total, 8 villages were selected and grouped into 2 zones including Kamanyola (Kaboya, Kayange, Rugenge and Busama) and Luvungi (Q. Hewa Bora, Bandare, Itara 1 and Itara 2). A sample of 24 households was selected among the households identified by the village leaders, including 3 households per village (12 households per zone); 24 individuals participated in the focus group discussions. Gender and youth were considered when selecting the participants in the focus group discussions as shown in Table 7. Finally, the traders were selected in different villages with the help of an agricultural officer in the area.

Table 7: Sampling in Uvira ALL-DRC

Country	Living Lab	Type of survey	sample size	Men	Women
DRC	Uvira	Focus group (2)	24	15	9
		Household survey	12	7	5
		Decision makers	6	4	2
		Value chain actors	8	4	4
		Total	**50**	**30(60%)**	**20 (40%)**

Bunia ALL

The ALL of Bunia is in the lowland region and targets the cultivation of the cocoa trees under shade in the forest zone of the Mombasa territory. The sampling was carried out through a common agreement with the site leaders who participated in the identification of the target crop farmers (cacao farmers) in the two sites (Kilimamwenza and Teturi). Two focus group discussions (FGD) were organized in both Kilimamwenza and Teturi. The focus groups brought together a total of 43 members randomly selected from two agricultural cacao cooperatives, the “Cacao Okapi” and “Union des producteurs de Cacao du Congo (UPCC)”. Only 9.3 % (4 participants) of these members were women. Additionally, an individual baseline survey was conducted with 23 key stakeholders selected in both Kilimamwenza and Teturi sites, as shown in Table 8.

Table 8: Sampling in Bunia

Country	Living Lab	Type of survey	sample size	Men	Women
DRC	Bunia	Focus group	43	39	4
		Household survey	**23**	**22**	**1**
		Decision makers			
		Value chain actors			
		Total	**66**	**61(92%)**	**5(8%)**

1.4.4.Sampling in the Agroecology Living Lab in Rwanda

Kamonyi ALL

In the Kamonyi ALL, sampling was done in consultation with the Director of Agriculture and Natural Resources of the district for the selection of sectors in the district where the target crop (cassava) is also the most cultivated. Seven sectors out of the 12 were identified, grouped into 3 zones where a sample of respondents was selected. Zone 1 is made of Gacurabwenge, Runda and Rugarika administrative sectors; Zone 2 made of Nyamiyaga and Mugina administrative sectors; and Zone 3 composed of Musambira and Nyarubaka administrative sectors. A list of farmer promoters[2] from the 7 sectors was picked from the total population of farmer promoters in the district. The sample included 203 farmer promoters (76 from zone 1, 67 from zone 2, and 60 from zone 3). We sampled from that list to have 30 households for the survey (10 per zone), and 36 individuals for the focus group discussions (12 per zone). Traders were identified at sector level with the assistance from the sector agronomist. In all samples, we considered gender balance as much as possible as shown in Table 9. The reason behind using farmer promoters is because they are the ones helping in promoting innovations and extension services at village level, and they are more knowledgeable and committed to provide information. They work closely with the sector's Agriculture Officer and the traditional leader of the village. In each village, there is a farmer promotor nominated by the local community who provides free service. These farmer promoters will remain the priority contact people for the implementation of the CANALLS project in the field.

Table 9: Sampling in Kamonyi ALL

Country	Living Lab	Type of survey	sample size	Men	Women
Rwanda	Kamonyi	Focus group	36	18	18
		Household survey	25	14	11
		Decision makers	3	2	1
		Value chain actors	11	8	3
		Total	**75**	**42 (56%)**	**33 (44%)**

[2] Farmers promoters are farmers who facilitate other farmers in their communities to acquire new technologies, innovations etc. They work with extension agents from the government, NGOs. They are contact persons within the farming communities, and they host demo plots for new practices etc.

1.5. Data analysis

The data collected was organized into sheets based on specific categories. Both qualitative and quantitative data were analysed using descriptive statistics as the categories were developed. Gender representation was observed in all the sites. The survey results were then categorized by topics and communities, and regional data was interpreted accordingly.

To ensure a comprehensive analysis, the results of primary data were compared with secondary data, which were used in the development of D1.1. This report will be made available to the public. Before the final submission date, the draft version underwent an internal peer review involving all partners in WP1, local partners, and WP leaders.

The survey results will also be presented in the next project's general assembly and disseminated following the CANALLS communication plan guidelines. This way, the valuable findings will be widely shared and utilized.

1.6. Challenges and limitations

The data collectors observed that most of the respondents had no clear definition of agroecology, the definition was broken down and the respondents were able to relate to the term aiding in data collection.

1.7. Data management

As per the CANALLS data management plan, personal contact data is stored in the repository of local partners. This data will not be used or disclosed publicly unless previous consent is obtained, and prior notification is provided by the local partners. The protection of this data is in accordance with the data protection national regulations of each country and target region.

The data collection procedures and outcomes comply with CANALLS data management plan.

2. Macro environment

The macro-environmental context influencing the adoption of the co-created agroecological practices (AEP) were analysed. According to the Political, Economic, Social, Technological, Environmental and Legal (PESTEL) model, macro-environmental factors that influence the agricultural sector can be grouped into 6 categories of influence. These include political factors (2.1), economic factors (2.2.), and social factors (2.3.).

2.1. Political factors influencing the agricultural sector.

This section analyses the most significant policies on the agricultural sector (2.1.1.) and the political stability and governance (2.1.2.) of the target countries of CANALLS.

2.1.1. Government policy

This section presents the key agricultural policies and the fiscal policies that might influence the development of agricultural projects, including agroecological projects.

Agricultural policy in Burundi

Burundi's 2018-2027 development plan highlights agriculture as one of its 11 pillars. This sector plays a crucial role, supplying 95% of the food and providing raw materials for the agro industry. To achieve professionalisation and food security goals, the Burundian government has allocated over 20% of its annual budget to the agricultural sector, as outlined in the National Development Plan (PND), 2018-2027.

The country's agricultural and food security policies are documented in "Vision Burundi 2025" (approved in 2010) and the Strategic Framework for the Fight against Poverty (CSLP). The National Agricultural Strategy (SAN), finalised in 2008, analyses the agricultural sector's constraints and potentials with the overall objective of contributing to poverty reduction and supporting Burundi's economic growth. The SAN is organised into four main axes:

1) Sustainable increase in productivity and agricultural production
2) Promotion of sectors and agri-business
3) Support for professionalisation of producers and development of private initiatives
4) Capacity building for management and development of the agricultural sector

The SAN is designed to tackle various challenges, including agronomic, climatic, technological, institutional, and socio-economic constraints, while also capitalizing on the strengths and potentials of the agricultural sector to foster sustainable development. In 2022, the government placed significant emphasis on an agricultural revolution and allocated a substantial budget of over BIF 100 billion (USD 35.3 million) to enhance professionalization and food security in the agricultural sector.

However, a notable limitation in some programs and subsidies lies in the predominant focus on mineral fertilizers at the expense of organic fertilizers, hindering the wider promotion and adoption of organic alternatives. The National Agricultural Investment Plan (PNIA 2012 - 2017) aimed at a 10% annual increase in mineral fertiliser consumption for agricultural intensification. To aid Burundian farmers and pastoralists in accessing mineral fertilisers, the Dutch government provided a €10 million donation to the National Fertilizer Subsidy Program in Burundi (PNSEB). This led to a significant increase in fertiliser use from 10,000 tons in 2013 to 49,462 tons in 2018.

A primary goal of the SAN to facilitate growth and diversification of export products, encompassing commodities such as coffee, tea, cotton, and cinchona. By developing a comprehensive marketing strategy for these products, the initiative aims to foster more inclusive and efficient food systems.

InterCafé (inter professional association of Burundi), ARFIC (Regulation of the Coffee Sector), and CNAC (National Confederation of Coffee Growers of Burundi) are value chain institutions and governance bodies that actively promote the Burundi coffee brand, aiming to enhance market access. The presence of these institutions creates a conducive environment for the expansion of agroecological practices since they share a common goal of promoting and enhancing agricultural production. However, it is important to consider the potential implications of the PNSEB's objective to increase input utilization in the country as a strategy for boosting agricultural productivity. This strategy may lead to higher production of non-agroecological products at a lower cost, potentially undermining the demand for agroecological products in the market.

Agricultural policy in Cameroon

In the aftermath of Cameroon's 1985 economic recession, a New Agricultural Policy was developed (1990-1998). This policy focused on implementing deregulation and privatisation to streamline resources, improve management practices, and privatise capital management of state-owned enterprises. It aimed to empower farmers for diversified agricultural production, enhance production potential, and protect domestic production. The policy's five priorities were:

1) agricultural modernisation to increase production and improve living conditions for rural populations
2) promotion of household food security and self-sufficiency
3) promotion and diversification of exports to drive economic growth and job creation
4) development and promotion of agricultural raw materials transformation
5) balancing supply chains and promoting sustainable agriculture for climate change adaptation and mitigation

Since 1999, new challenges have been integrated, including consolidating the agricultural sector as a driver of economic and social development, promoting professional organisations for economic operators, and improving food security through increased production and total income. The government's current agricultural policies align with the rural sector development strategy document (SDSR) of 2003. They aim to achieve production goals for various crops, including cocoa, and ensure food security, resilience of populations, income improvement, and contribution to growth and employment. However, agroecology as an adaptation and mitigation option has not been explicitly highlighted in strategic documents. Some ongoing initiatives could capitalise on agroecology, including agroforestry programs, soil health and chemical input reduction efforts, synergy programs for integrated agro-pastoral resource management, and biodiversity enhancement projects. These initiatives, when coupled with proper promotion of agroecological practices and principles, can help address challenges like food insecurity, soil degradation, desertification, and climate change while supporting sustainable agricultural development.

Agricultural policy in DR Congo

Agriculture remains a priority sector in DRC’s Vision 2050 National Development Strategy (PNSD, 2016). In this context, the different ministries dealing with Agriculture, Environment, Livestock breeding is interconnected around the National Development Strategy. For the fulfilment of the national strategies, it remains that the identification of a certain number of constraints that penalise the actors involved in the production, processing, and marketing in the agricultural sector. Such constraints related to governance and institutions.

1) constraints related to the financial sector such as the low national budget allocation, ± 2% per year, lower than the 10% recommended by the Maputo Declaration on Agriculture and Food Security
2) the absence of an appropriate incentive framework for private investment
3) production-related constraints such as archaic production techniques and difficulties in accessing quality inputs.

In 2022, the government adopted the Sustainable Agricultural Policy (PAD) under the Sustainable Agriculture Management Program (PGDA). This guiding document aims to boost the national economy, ensure food security, and support rural incomes while preserving forests. The PAD presents 6 specific objectives, including promoting innovative and resilient agriculture for food security

and better income, regulating agricultural product supply to benefit producers and consumers, and encouraging sustainable use of production areas and resources to maintain forest cover. Additionally, the PAD emphasises the participation of vulnerable populations (women, young people, and indigenous people) in decision-making and implementation (MINAGRI, 2022). Furthermore, the PAD includes the Program for the Sustainable Development of Savannahs and Degraded Forests (PSFD), developed with the French Development Agency and the Ministry of Agriculture, Fisheries and Livestock (MAPE) under the Central African Forest Initiative (CAFI) funding. The PSFD promotes agroforestry and agroecological practices through technical itineraries to support agroecological principles. These developments create favourable opportunities for projects like CANALLS.

Agricultural policy in Rwanda

Agriculture is a priority sector in Rwanda's Vision 2050 National Development Strategy. The government aims to replace subsistence farming with fully monetized and technology-intensive commercial agriculture and agro-processing by 2050. Principal agricultural export products are coffee, tea, and some value-added agricultural products such as canned tomatoes, honey, French beans, passion fruit, macadamia nuts, and mushrooms (ITA, 2022). The vision of the National Agricultural Policy is for Rwanda to become "a nation that enjoys food security, nutritional health and sustainable agricultural growth from a productive, green and market-led agricultural sector." The mission is to ensure food and nutrition security, modern agribusiness technologies professionalising farmers in terms of production, commercialization of the outputs, and the creation of a competitive agriculture sector. The policy objectives include increasing contribution to wealth creation, reaching economic opportunities and prosperity, improving food security and nutrition, and increasing resilience and sustainability (FAO, 2017). The fourth strategic plan for the transformation of agriculture is moving towards a shift from subsistence objectives to a knowledge-based and value-added sector that contributes to the national economy and ensures food and nutrition security (PSTA 4, 2018). The priority areas being (1) innovation and extension, (2) productivity and resilience, (3) improving market access and links between production and processing, (4) involving the public sector in the improvement of the normative framework. The Rwanda National Agricultural Policy is founded on four pillars, with the second pillar focusing on Technological Upgrading and Skills Development. This pillar outlines policy actions related to crop production, including the promotion of research on bio-fortification and agricultural biotechnology. It also encompasses initiatives aimed at enhancing soil systems and health, as well as the development of animal resources. These policy actions align well with the principles of agroecology, particularly in the areas of soil health, animal health, and the facilitation of agroecology living labs (Rep Rwanda, 2018). One of the major challenges facing Rwanda in terms of agricultural policy is access to land because most producers have small production areas and still practise subsistence agriculture. While the desired mechanization may be challenging under these circumstances, it also presents opportunities to promote agroecological practices through crop diversification and the generation of alternative sources of income among smallholder producers. However, emphasis will be placed on the use of mineral fertilisers with a view to increasing agricultural production.

The government dedicates substantial resources to strategic investment areas, with a significant focus on promoting climate-friendly agricultural production. Notably, substantial subsidies are allocated to support specific initiatives: production of organic fertilizers (amounting to 11,090,756,475 F); disease surveillance and promotion of integrated pest and disease management (totaling 14,787,675,300 F); agroforestry initiatives (with a budget of 49,611,401,879 F). The allocation of subsidies to organic fertilizers is a commendable move that actively fosters the development of

agroecological products. This approach promotes recycling, reduces dependency on external inputs, and effectively lowers the production costs of agroecological products.

Tax policy in Burundi

Tax policies impact the agricultural sector. In Burundi, the standard Value Added Tax (VAT) rate is 18%. The VAT on imported food products and processed agricultural goods and agricultural inputs is 10% and the exports and international transport are not taxed. In Burundi, crop and livestock products are specified as VAT exempt, regardless of turnover thresholds, when sold directly by their owners (EAC, 2022). As a response to the food price crisis of 2007/08, the government temporarily removed taxes on fuel for transport of goods with the objective to contain soaring food prices and revitalise the agricultural sector. In July 2009, such taxes were reinstated, along with the creation of the “Office Burundais des Recettes” OBR20 and subsequent introduction of VAT for a wide range of goods and products. From April to July 2017, cassava and cassava flour, maize and maize flour, rice and dried beans were exempted from customs duties, VAT, and administrative charges.

Tax policy in Cameroon

In Cameroon, cocoa beans are subject to an export duty of 10% of the agricultural Free on Board (FOB) value when exported, except for industrial free points which have a 2% duty. Moreover, in 2023, the government plans to provide a subsidy of CFA6.5 billion (USD 111,115) through the Cocoa and Coffee Development Fund (FODECC) to support local cocoa and coffee producers. This subsidy is intended to aid with agricultural inputs, equipment, and infrastructure. However, there is a concern that subsidizing chemical compounds may create a challenge for agroecological products, as it might make them relatively more expensive in the market.

Tax policy in DR Congo

Water and energy generated by farmers themselves for agricultural purposes are exempt from all duties and taxes. Imported agricultural inputs exclusively intended for agricultural activities are also exempt from import duties and taxes, except for administrative fees. Additionally, agricultural products are exempt from export duties and taxes. However, merely excluding duties and taxes on the agricultural sector may not be sufficient to favour or incentivize agroecological products, which could face competition from cheaper conventional products. To address this issue, royalties and fees for services rendered by public bodies at border posts are limited to 0.25% of the value of exported products. Areas designated exclusively for farming, whether built or unbuilt, are exempt from property tax. Similarly, all rolling stock used solely for farming activities is exempt from tax. Profits made by industrial agricultural operators are subject to professional income tax as per the law, while family-type farmers are subject to a professional income tax rate of 20%[3]. Imports and transactions within the country are taxed at a rate of 16%, while exports are zero-rated for VAT (Crowe, 2018). VAT has been levied since 1 January 2012, replacing the local turnover tax. Companies with an annual turnover of CDF 80 million (approximately USD 90,000) or more are eligible to collect VAT, but service providers are VAT collectors regardless of their turnover (Yav et al., 2018). All cocoa and coffee exporters are required to pay the annual "Direction Générale des Douanes et Accises" (DGDA) exportation license, and in January 2020, the South Kivu revenue authority introduced a US$3/bag stamp duty.

Tax policy in Rwanda

Rwanda's export tax is zero for all products. The highest average taxes are for beans (USD 0.07 per kg), green bananas (USD 0.03 per kg) and cassava flour (USD 0.08 per kg). All crop and livestock products, except for those processed, are exempted from VAT.

2.1.2. Governance and political stability

Governance and political stability are among macro-environmental factors that are likely to influence the agricultural sector and the implementation of CANALLS in the focal countries.

Burundi is ranked 171st out of 180 countries globally in the Corruption Perception Index (CPI), with a score of 17/100 (Transparency International, 2022). The country has faced years of conflict, and to maintain peace, increasing the autonomy of local administrations, known as "communes," has been seen as crucial. Marginalization of rural communities and centralization of economic and political power in the hands of urban elites were key sources of discontent. As a response, the Government of Burundi committed to a decentralization reform in 2009, adopting the National Decentralization Strategy to promote social cohesion, improve local governance, and strengthen basic infrastructure and service delivery in rural areas. However, the journey to decentralization has faced challenges, and there are still numerous issues that need to be addressed for the reform agenda to move forward (World Bank, 2014). As of 2021, the government effectiveness index for Burundi, which measures the quality of public services, civil service independence, policy formulation and implementation, and government commitment to policies, is -1.33. The voice and accountability index, which reflects citizens' participation in government selection, freedom of expression, freedom of association, and media freedom, is -1.41. The political stability index is -1.36, measuring perceptions of the likelihood of destabilization or unconstitutional overthrow of the government, including politically motivated violence and terrorism (The Global Economy, 2021). Burundi continues to face challenges related to refugee displacement, with over 300,000 Burundian refugees remaining displaced in neighbouring countries, most having fled after contested elections and violence in 2015. However, since 2017, more than 200,000 Burundian refugees have returned to their country. Additionally, around 75,000 people are internally displaced, mainly due to natural hazards like flooding and landslides.

Agricultural productivity in Burundi has been limited due to the impact of war, environmental factors, and inefficient farming practices. Persistent resource and food scarcity remain significant issues that need to be addressed through greater investment in education, efficient agricultural practices, and business development.

Cameroon is ranked 142nd out of 180 countries globally in the Corruption Perception Index (CPI) with a score of 28/100 (Transparency International, 2022). Despite efforts to promote good governance, the reality of good governance in Cameroon remains more theoretical than practical. The fight against corruption, embezzlement, and misappropriation at the level of state departments faces challenges, hindering accountability and transparent decision-making. To address this, the government needs to establish robust structures to combat corruption and ensure accountability, adopting a bottom-to-top approach in decision-making. This approach encourages broad-based participation, a crucial principle for achieving good governance (Ndeh, 2015). As of 2021, Cameroon's government effectiveness index, which assesses the quality of public services, civil service independence, policy formulation and implementation, and government commitment to policies, is -0.88. The voice and accountability index, reflecting citizen participation in government selection, freedom of expression, freedom of

association, and media freedom, stands at -1.16. The political stability index for Cameroon in 2021 is -1.41, measuring perceptions of the likelihood of destabilization or unconstitutional overthrow of the government, including politically motivated violence and terrorism (The Global Economy, 2021). Cameroon hosts approximately two million people of concern to UNHCR, comprising one million internally displaced people, 460,000 refugees and asylum-seekers, and 466,000 internally displaced people. The refugees predominantly originate from the Central African Republic and Nigeria, while the internally displaced persons mainly come from Cameroon's Far North, North-West, and South-West regions, affected by the Boko Haram and Anglophone crises, respectively (UNHCR, 2019).

DR Congo is ranked 166th out of 180 countries globally in the Corruption Perception Index (CPI) with a score of 20/100 (Transparency International, 2022). The country faces significant challenges related to governance and public services, as reflected in its government effectiveness index, which stands at -1.72 as of 2021. The voice and accountability index, measuring citizen participation in government selection, freedom of expression, freedom of association, and media freedom, is -1.2 in the same year. Additionally, the political stability index for DR Congo in 2021 is -1.61, indicating concerns about potential destabilization through unconstitutional or violent means, including politically motivated violence and terrorism (The Global Economy, 2021). DR Congo is grappling with one of the most complex and long-standing humanitarian crises in Africa, making it the fourth largest crisis of internally displaced people in the world. Over 5 million people are displaced within the country, and more than 1 million Congolese have sought asylum, primarily within Africa. The situation is further aggravated by disease outbreaks and natural disasters. In addition to its internal displacement challenges, DR Congo also hosts half a million refugees from neighbouring countries, with three-quarters living outside refugee camps and settlements (UNHCR, 2023).

Rwanda is ranked 54th out of 180 countries globally in the Corruption Perception Index (CPI) with a score of 51/100 (Transparency International, 2022). The country demonstrates relatively strong government effectiveness, with a government effectiveness index of 0.26 as of 2021. This index assesses the quality of public services, civil service independence, policy formulation and implementation, and government commitment to policies. Rwanda also shows room for improvement in citizen participation and media freedom, as indicated by a voice and accountability index of -0.96 in 2021. The political stability index for Rwanda in the same year is -0.17, indicating a favourable perception of the government's stability and resilience to potential destabilization through unconstitutional or violent means, including politically motivated violence and terrorism (The Global Economy, 2021). At the end of 2021, Rwanda hosted slightly over 127,000 refugees, primarily from DR Congo and Burundi. Of these refugees, 76% are women and children, with approximately 12,700 residing in urban areas. The Government of Rwanda progressively integrates refugees into national systems, allowing them the right to work (UNHCR, 2021). Additionally, there are an estimated 270,000 Rwandan refugees who fled during the 1994 genocide and remain dispersed across about a dozen major African refugee host countries, including Angola, Burundi, Cameroon, DR Congo, Kenya, Malawi, the Republic of Congo, South Africa, Uganda, Zambia, and Zimbabwe.

2.2. Economic context

Economic factors include the indicators of economic growth and the foreign trade balance (2.2.1), and the pricing, exchange rate, inflation rate, interest rates and the purchasing power of money (2.2.2.)

2.2.1. Economic growth and foreign trade balance

Burundi

In recent years, Burundi has experienced a difficult economic situation, marked by macroeconomic imbalances. Burundi's economic performance since 2000 has been highly unstable, with a declining gross domestic product (GDP) growth rate. In the 2000s, the country began its economic recovery after multiple waves of civil war, genocide, and political instability. But recent shocks (Covid-19 and the war in Ukraine) have interrupted this still fragile economic recovery and accentuated macro-economic imbalances. In 2022, Burundi's economic growth slowed considerably to 1.8%, compared with 3.1% in 2021, due to the modest performance of the industrial and service sectors (World Bank, 2023). Apart from industry and other services, agriculture alone contribute 29% to the national GDP in 2021 and employ 84% of the working population. The National Agricultural Investment Plan (PNIA, 2016-2020) has supported agricultural production through several measures, including the use of better-quality seeds, better and cheaper access to mineral fertilisers, vocational training, expanding the use of land for agricultural production and increasing finance, including for women. In general, around 7% of the focal crops is devoted to cash crops such as coffee, cotton, tea and palm oil, which account for 90% of Burundi's exports (Collins et al., 2013; CIA World Factbook 2014). Other agricultural products during the main growing season include maize, sorghum, sweet potatoes, bananas, cassava, and potatoes. Agriculture is essentially subsistence farming and is characterised by low inputs and costs, relying on bringing large tracts of land into production rather than intensive farming. Although in recent years, the production of rice, bananas and sweet potatoes has seen some positive increases due to better farming practices (World Food Program, 2008; Collins et al., 2013). Foreign trade represented 29% of Burundi's GDP in 2021. Burundi’s trade balance for 2021 was -0.52 B USD (Lloyds Bank,2023). Figure 1 below provides additional information on GDP and trade indicators. Coffee is the second source of international currencies enabling international trade, and maize is one of the main cereals consumed in the country. Maize is, however, mainly sourced from import. Developing agroecologically produced maize and coffee in Burundi is very important to improve the external balance as this will contribute to increase the export of sustainable coffee, and to substitute maize import.

Cameroon

Cameroon's GDP dropped from 4.5% to 3.6% in 2021 mostly due to continued investments and higher non-oil activity (Cameroon Economic Outlook)[3]. This economic situation is probably also linked to the effects of the Covid-19 pandemic on several sectors of the Cameroonian economy, including the oil sector, forestry, manufacturing, energy, transport, trade, hotels and restaurants, and agriculture. In Cameroon, agriculture generally accounts for more than half of the country's non-oil export earnings and employs almost 60% of the working population. About 90% of rural households are employed in agriculture in one way or another, and around a third make their living from export crops. Agriculture also provides a third of the country's foreign exchange earnings and 15% of its budgetary resources. Depending on the agro-ecological zone, the main agricultural production systems are based on combinations of food crops, combined with small-scale family livestock and cash crops for export (cocoa, cotton, coffee). Cameroon's trade balance is structurally negative. According to data from the World Trade Organization (WTO), in 2021 Cameroon recorded a trade deficit of USD 2 billion. The same source reported that the country imported USD 6.1 billion worth of goods against USD 4.1 billion

[3] https://www.afdb.org/en/countries-central-africa-cameroon/cameroon-economic-outlook

for exports. Cameroon was the 5th in cocoa bean production in 2020/21 with 290 thousand MT, but it is ranked third in world exports with 311 thousand MT, worth USD 755 million. In the same year, cocoa beans were the second most exported product in Cameroon. In 2022, with $735 million in export, cocoa was the second source of international currencies (11.8% of the export) after hydrocarbons, US$3.9 billion (62.5% of total exports), followed by Wood, $701.9 million (11.2%)[4]. The distinctive reddish colour and unique flavour of Cameroonian cocoa have gained fame, attributed to the agroecological conditions under which it is cultivated (MIT, 2021). Cameroon's top 5 position in cocoa production and the distinctive cocoa flavour resulting from its unique agroecological conditions are among the forces for the development of the CANALLs project.

DR Congo

The agricultural sector, which employs over half of the active population, is growing at a slow pace in DR Congo, with variations in performances, challenges, and opportunities across provinces. Nevertheless, due to its development potential and the fact that more than 70% of the population resides in rural areas, agriculture holds a prominent position in the Congolese economy. The DR Congo's GDP in 2021 was valued at USD 55.35 billion, with the agricultural sector contributing 19% of the GDP, like the mining sector. Agriculture remains a crucial pillar for the country's development and sustainable growth, given its vast potential for cultivable land, diverse climates, abundant water resources, significant opportunities in fishing and breeding, and openness to international trade, accounting for 80% of its GDP. From 2021, the trade surplus in goods increased to USD 3.9 billion, with imports of goods amounting to USD 10.3 billion, while exports reached USD 23.5 billion. Its main trading partners include China, Zambia, South Africa, the United Arab Emirates, and Saudi Arabia. The country is a member of various regional organizations, such as COMESA, SADC, ECGLC, and the WTO. Moreover, in 2022, the DRC signed bilateral cooperation agreements with several countries and multilateral partners in different sectors, including defence and security, infrastructure, and transport.

Rwanda

Rwanda's economic policy embraces foreign trade, which constitutes 54% of its GDP. In 2021, the country's GDP was valued at USD 11.07 billion. Rwanda's major exports include petroleum oils (13%), tea (9%), coffee (8%), gold (7%), and precious and semi-precious stones (7%). The trade balance for 2021 was -1.74 billion USD, showing a 3.46% increase compared to 2020 (Standard Bank, 2023). Agriculture contributed 25% to Rwanda's GDP in 2021. Notably, the country exported USD 1.05 million worth of cassava, ranking as the 58th largest exporter of cassava globally. Within Rwanda, cassava stood as the 98th most exported product. The primary destinations for Rwanda's cassava exports were DR Congo ($712k), Belgium ($258k), United Kingdom ($66.5k), United States ($9.09k), and Canada ($4.69k). DR Congo experienced significant growth in demand for Rwandan cassava between 2020 and 2021, increasing from $502k to $721k. On the other hand, Rwanda imported $7.49 million worth of cassava in 2021, making it the 29th largest importer of cassava worldwide. Rwanda remains a net importer of cassava. The favourable status of cassava in Rwanda's foreign trade presents an opportunity for the development of agroecological cassava under CANALLS. It may contribute to improving the cassava trade balance and meeting the rising demand from neighbouring DR Congo.

[4] Cameroon's Top Exports 2022

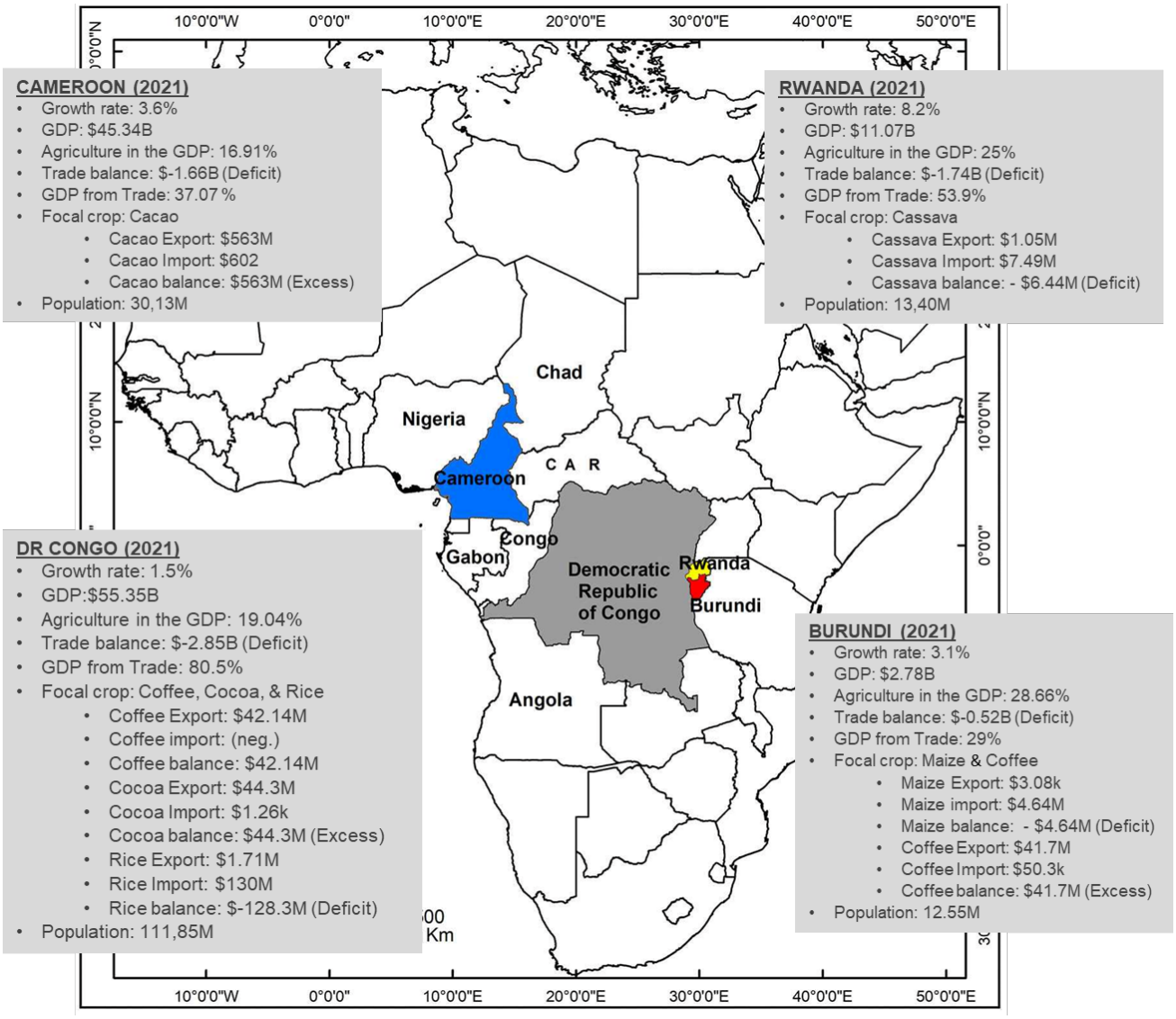

Figure 1: Comparative indicator of GDP and trade balance across CANALLS countries

Comparative assessment

Cameroon and Burundi have faced challenging economic situations in recent years, resulting in macro-economic imbalances. Burundi's economic growth is expected to decline significantly in 2021, while Cameroon's decline is projected for 2023, largely influenced by underperforming sectors. Conversely, DR Congo and Rwanda are projected to experience strengthened economic growth, with the mining sector playing a pivotal role in driving their economies.

In both Cameroon and Burundi, agriculture plays a crucial role in their national GDP. Cash crops, such as coffee, cotton, tea, and palm oil, dominate Burundi's exports, while cocoa emerges as a significant cash crop in Cameroon. In DR Congo, alongside the mining sector, agriculture remains a major contributor to economic development. Rwanda's economic growth, driven by the mining sector,

has led to substantial improvements in living standards, and despite the challenges faced in 2022, its economy shows increasing resilience.

All four countries are open to foreign trade. Rwanda has ambitious economic goals, aspiring to become a middle-income economy by 2035 and eventually achieve high-income status by 2050. The significant contribution of agriculture to the national GDP in these countries highlights the importance of developing the agricultural sector sustainably through agroecological practices. For instance, the unique characteristics of Cameroonian cocoa, with its reddish colour and distinct flavour can only be preserved in the long term through agroecological practices. In DR Congo, the abundant potential for sustainable agriculture provides an advantageous setting for implementing agroecological practices. In Rwanda, the favourable status of cassava in foreign trade creates opportunities for developing agroecologically produced cassava.

Overall, agroecological practices offer promising prospects for ensuring sustainable agricultural development and leveraging the strengths of the respective countries' economies.

2.2.2. Pricing, exchange, and inflation rate

Burundi

The Burundian Franc (BIF) continues to experience depreciation against the USD, with the official exchange rate depreciating around 10% annually and monthly inflation ranging from 25 to 30%. The increasing gap between the official and parallel exchange rates further contributes to higher monthly inflation, especially for imported goods. The parallel market exchange rate has surged, reaching around 75 percent higher than the official rate in February 2023 and approximately 100 percent higher in April. Inflation rates in Burundi have also seen an upward trend, increasing from 28% in February 2023 to 33% in March, with food inflation rising from 42 to 49% during the same period. These factors negatively impact food crops and cash crops production in the country (FEWS NET 2023). This economic situation is exacerbated by the impact of the Russia-Ukraine war on global food and fuel prices, resulting in a relatively rapid rise in food and fuel prices. Farmers in Burundi face challenges in accessing bank and microfinance loans due to exorbitant lending rates, which range from 15 to 16% in commercial banks and can exceed 35% in some microfinance institutions. Despite efforts by the government, the reduction in farm credit rates has not fully satisfied farmers' needs (Banyankiye 2019).

Imported maize into Burundi mainly comes from Tanzania, Rwanda, Uganda, and Zambia. In April 2023, the price of maize per kilogram fell from BIF 2,400 to BIF 1,700 in various markets in Burundi (Hareimana, 2023). Additionally, the price of roasted coffee remains high, with retailers in importing countries selling it for over 8 times the price paid to producers in Burundi. This disparity is partly due to an overvalued dollar in production countries, resulting in lower income for coffee producers (ICO, 2018).

The GDP per capita at purchasing power parity (PPP) for Burundi was $805 in 2021, showing a growth rate of 2.67% on average annually from $494 in 2002 (Knoema, 2023). Despite efforts to consolidate the productive base, UNICEF's budget analysis for 2022-2023 highlights that macro-economic indicators reveal low purchasing power among the population, with 51% living below the monetary poverty line.

Cameroon

In 2023, Cameroon is expected to experience economic growth of 4.2%. Foreign account projections show a drop in the current account deficit, bringing it to 2% of GDP on average over the 2023-2025 period. This positive trend is attributed to the promotion of exports in products manufactured from cocoa. However, exchange rate volatility poses a significant negative impact on agricultural trade, affecting prices for agricultural products. In 2022, an inflation rate of 6.2% was calculated, leading to adverse effects on agricultural products. The price hike is primarily attributed to the consequences of the Ukrainian war, exacerbating existing supply difficulties. According to the Central African Banking Commission (CABC, 2018), access to credit remains a challenge for agricultural households, with only 3% obtaining credit from commercial banks and microfinance institutions, mainly due to high interest rates set by microfinance institutions. Moreover, over 60% of credit extended to agricultural households is collateralized by land titles, according to the National Institute of Statistics (NIS, 2017). The agricultural value added in Cameroon increased to 3.5% in 2021 from 1.7% in 2020. However, agricultural commodity prices, such as cocoa, are estimated to experience a slight decrease in 2023 following a 22% increase in 2021, as supply conditions improve. According to statistics from the SIF (Système d'information des filières), the price of a kilogram of cocoa beans in Cameroon reached 1,200 FCFA on 15 December 2022, having previously peaked at 1,250 FCFA. In June 2020, the household final consumption price index rose by 0.1% compared to May 2020, following a previous decline of 0.2% last month. Cameroon's purchasing power parity was 227.4 FCFA per international dollar in 2021, showing a decrease of 0.61% from the previous year when it was 228.8 FCFA (Knoema,2022). Moreover, prices of agricultural products exported by Central African Economic and Monetary Community (CEMAC) countries, including Cameroon, fell by 4.9% between July and September 2022 (Business in Cameroon,2022). In 2021, inflation in Cameroon stood at 2.3%, but in the first quarter of 2022, it rose to 4.4%, exceeding the institution's target of 3% as reported by the Bank of Central Africa (BEAC, 2022).

DR Congo

The Congolese economy has experienced a strengthening recovery, with a growth rate of 3.2% in 2022, compared to 1.5% in 2021. The non-oil sector, particularly the agricultural sector (+4.9%), the timber industry (+6.5%), and increased public investment spending, were major contributors to this growth. To address concerns about inflation and low foreign exchange reserves, the Bank of Central African States (BEAC) raised the key rate to 4.0% in 2022, following a previous increase to 3.5% in 2021. In 2022, headline inflation reached 3%, with food inflation at 6.3%, influenced by rising food prices and the impact of Russia's invasion of Ukraine. Credit to the economy expanded by 6.2% in 2022, supported by economic recovery and increased household and business consumption. In 2023, inflation is projected to be 3%, rising to 2.9% in 2024, driven by increased economic activity and the impact of the Ukraine crisis on imported commodity prices. Challenges such as rising domestic demand, a 5% increase in petroleum product prices, adverse weather conditions exacerbated by climate change, could affect agricultural produce availability, leading to potential food insecurity and additional inflationary pressures. The price of maize flour per kilogram is 1,066 CDF (PAM, 2022). In North Kivu, the price has increased by 7% in the markets of Goma compared to December 2022 (WFP, 2023). In 2022, the budget deficit widened to -2.7% of GDP (from -0.8% in 2021). Approximately 62% of the country's population, around 60 million people, are expected to live on less than 2.15 dollars a day in 2022. The DR Congo's purchasing power parity has significantly increased from 137.4 CDF per international dollar in 2002 to 973.5 CDF in 2021, with an average annual growth rate of 11% (Knoema, 2022). In theory, prices are set under the supervision of the Ministry of the

Economy and an inter-ministerial price advisory commission. However, price controls, while inconsistently enforced, can significantly impact the economy as most manufactured goods and many food items sold in the DR Congo are imported.

Rwanda

According to Kabayiza et al. (2021), coffee prices have experienced fluctuations in both the long and short run due to exchange rate volatility. This volatility also led to a decline in coffee export volumes in the long run. On the other hand, real income growth in importing countries positively impacted coffee prices and export volumes in both the long and short run. The average inflation rate in Rwanda was 2.5% in 2015. Despite the Rwandan franc depreciating against the US dollar, it appreciated in real effective exchange rate (REER), helping to stabilize import prices and mitigate inflation pressures in 2022. However, this inflationary environment posed risks to vulnerable households, including farmers. Regarding loans for farmers, banks typically offered them at interest rates between 23 and 24%. To boost agricultural production, the Ministry of Agriculture and Animal Resources launched an initiative through Commercialization and De-risking for Agricultural Transformation (CDAT) to provide easy access loans to farmers at an interest rate of 8% in February 2023, the lowest available. This move is expected to have a positive impact on agricultural production and contribute to Rwanda's consistently strong GDP performance in Africa. Rwanda has a relatively high purchasing power compared to other African countries. However, the price of cassava flour has quadrupled, leading to difficulties for families to afford tubers for consumption, resulting in a situation referred to locally as "Nzaramba" or "I will endure." The purchasing power parity for Rwanda was USD 330.520 in 2021, a slight decrease from the previous year's figure of USD 335,070 in 2020 (CEIC, 2021). While prices in Rwanda are largely liberalized, the government still sets prices for petroleum products and some commodities after limited consultation with industry stakeholders. These pricing formulas vary depending on factors like supply, demand, landed cost, expected margins, and competitive alternatives. The inflation rate in Rwanda was around 18% in 2022, higher than the EU average of 9% for the same year (Table 10). This indicates the challenges posed by inflation in the country's economic landscape.

Table 10: International prices

	Exchange rate: USD 1 in 2021	Inflation rate (2021)	Interest rate (2021)	International price focal crop (2021)			
				Focal crop	Price in 2023 (USD/Tons)	National price 2023 (USD/Tons)	Purchasing power of money (%$)
Burundi	*BIF 2809.30*	*1.72%*	*23.29%*	*coffee*	*165.00*	*245.00*	
				maize	*558.22*	*238.00*	
Cameroon	*FCFA 650*	*8.3%*	*2.68%*	*cocoa*	*3326.00*	*2 224.00*	*8.7%*
DRC	*FC 2432.00*	*2.27%*	*3.3%*	*cocoa*	*3326.00*	*1560.00*	*9.2%*
				coffee	*165.00*	*3410.00*	
				rice	*2766.4*	*1378.80*	
Rwanda	*RWF 1156.33*	*-0.39%*	*13.07%*	*cassava*	*1120.00*	*1500.00*	

The mentioned focal crops, such as coffee and maize in Burundi and cassava in Rwanda, command higher prices in exporting countries compared to local markets. Conversely, cocoa in Cameroon and cocoa, coffee, and rice in DR Congo face lower prices in international markets, negatively impacting these agricultural products.

2.3. Social context

The population growth rate and age distribution (2.3.1), income level and poverty incidence (2.3.2.), and unemployment rate and local workforces (2.3.3.) are considered among the social factors for agricultural development and may influence the uptake of agroecological practices.

2.3.1. Population growth rate and age distribution

Burundi

From 1960 to 2021 the population of Burundi increased from 2.80 million to 12.55 million people. This is a growth of 350% in 61 years. The highest increase in Burundi was recorded in 2015 with 8.9%. The smallest increase was in 1973 with 1% (World Data, 2022). Today, the population of Burundi stands at 13 million people with a population growth rate of 3.6% (The World Factbook, 2023). As of 2021, the age distribution in Burundi was as follows: 0-14 years: 44% (male 2,618,868; female 2,581,597); 15-24 years: 20% (male 1,172,858; female 1,171,966); 25-54 years: 29% (male 1,713,985; female 1,748,167); 55-64 years: 4% (male 231,088; female 264,131); 65 years and over: 3% (male 155,262; female 207,899) (Figure 2) (World population Index, 2021). The population

structure of Burundi is dominated by the youth between the ages 0-24, who make up more than 60 % of the total population which is favourable for agricultural labour and thus the development of agriculture.

Cameroon

The population of Cameroon is 30 million people with a population growth rate of 2.73% (The World Factbook, 2023). The rural population was reported at 42 % in 2021 (Trading economics, 2023). As of 2021, the age distribution of Cameroon is as follows: 0-14 years: 42% (male 5927640; female 5820226), 15-24 years**:** 20% (male 2782376; female 2776873), 25-54 years: 31% (male 4191151; female 4309483), 55-64 years: 4% (male 520771; female 552801) and 64 years and over: 3% (male 404320; female 460248) (Figure 2) (Index Mundi, 2021). The population of Cameroon is dominated by the youth between the ages of 0-24, who make up more than 60% of the total population, which is favourable for agricultural labour and thus agricultural development.

DR Congo

DR Congo has a population of about 112 million people with a population growth rate of 3.13 % (The World Factbook, 2023), and it is the fourth most populated nation in Africa. Of this, 65% is classified as rural, but the share of urban households is growing at a fast rate (USAID, 2016). The age distribution of DR Congo as of 2021 is as follows: 0-14 years: 46% (male 23757297; female 23449057), 15-24 years**:** 20% (male 9908686; female 9856841), 25-54 years: 28% (male 14459453; female 14422912), 55-64 years: 3% (male 1647267; female 1769429) and 64 years and over: 3% (male1085539; female 1423782) (Figure 2) (Index Mundi, 2021). The population structure of DRC indicates that it is dominated by the youth between the ages of 0-24 years who make up about 65 % of the total population, which is favourable for agricultural labour, thus, agricultural development.

Rwanda

The population of Rwanda stands at about 13 million people with a population growth rate of 1.68 % (The World Factbook, 2023). Rwanda's rural population in 2021 was estimated at about 11 million people, a 2.23% increase from 2020. (Macrotrends, 2023). The age distribution for Rwanda is as follows: 0-14 years: 40% (male 2564893; female 2513993), 15-24 years: 20% (male 1280948; female 1273853), 25-54 years: 33% (male 2001629; female 2201132), 55-64 years: 4% (male 241462; female 298163) and 64 years and over: 3% (male 143648; female 201710). The population structure of Rwanda is mostly made up of youth between the ages of 0-24 who make up close to 60% of the total population. This is age for schooling, yet it indicates potentially higher labour force for agricultural development.

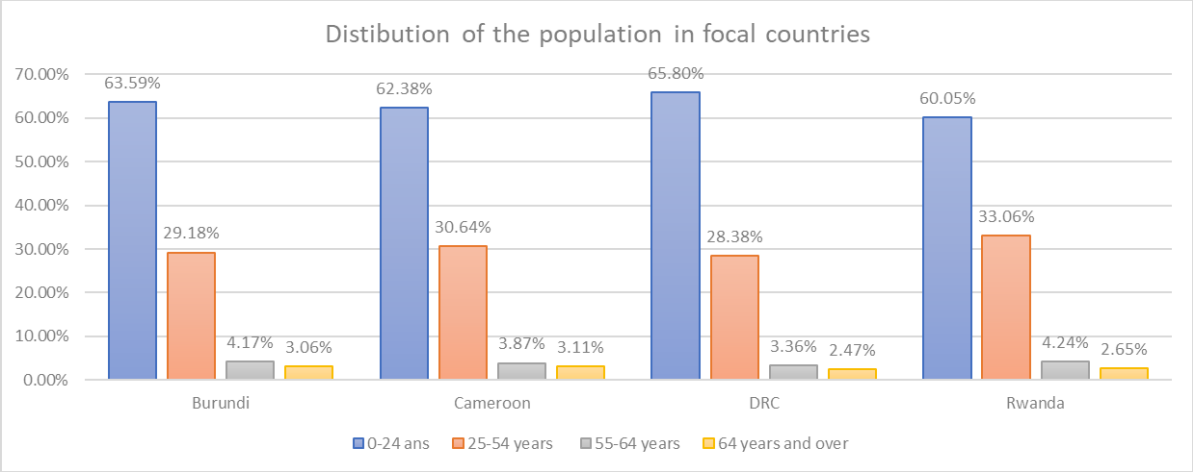

Figure 2:Distribution of population in focal Countries

The demographic profile of the four focal countries reveals that over 50% of their populations consist of youth aged 0-24. This demographic composition presents a favorable environment for agriculture labor and, consequently, supports the potential for agricultural development in these countries.

2.3.2. Income level and poverty incidence

Burundi is classified as a low-income economy, and approximately 80% of its population is employed in the agricultural sector. With a GDP per capita of USD 238, Burundi ranked as the world's poorest country in 2022. The Gini index for the same year was 38.6, indicating relatively weak income distribution inequality among its citizens. Burundi faces significant poverty challenges, with 87% of the population living below the World Bank's poverty line of $1.90 per day (U.S. Department of State, 2022). In 2022, around 65% of Burundians live below the international poverty rate of $2.15 per day. Moreover, approximately 70% of children are below the income poverty line, and 78% experience deprivation in at least 3 to 7 child well-being aspects (World Bank, 2019). The median household expenditure in Burundi is estimated to be around US$67 per month, with about 75% of households spending less than US$100 each month (Lighting Global, 2020). The minimum daily wage in rural areas is approximately 105 FBU. According to data from the International Labour Organisation (ILO) in 2017, around 3.7 million people are employed in Burundi, with women being notably more active than men. The agricultural sector employs about 86% of the total workforce, and women account for a significant 60% of employment in this sector (Danish Trade Union Development Agency, 2021).

In Cameroon, as of 2014 the number of individuals living in poverty increased to 8.3 million people, with 90% residing in rural areas and 69% in the North regions. The extreme poverty incidence, defined as living on less than $2.15 a day in PPP terms, is expected to remain almost unchanged at 24% in 2023, compared to 26% in 2022. According to the International Monetary Fund (IMF), consumers in Cameroon have experienced rising annual disposable incomes in recent years, leading to increased consumer expenditure (the per capita GDP was estimated at USD 1,650 in 2021) (IMF, 2023). In 2022, Cameroon's Gini index stood at 46.6, indicating a relatively weak income distribution inequality among its citizens. Both women and men in the agricultural sector in Cameroon are involved in various activities, including farming, livestock rearing, forestry, fishing, and fish farming. Traditionally, women focus on food crop production, while men take care of cash crops. However, this dynamic is changing as men increasingly engage in food crop production due to increased funding in the sub-sector.

Meanwhile, women are investing more in cash crops to fill the gap (FAO and ECCAS, 2019). They play a significant role in production and are somewhat less involved in processing and marketing. Many women run family businesses, with some operating as sole proprietors (FAO and ECCAS, 2019). Rural women in Cameroon are a valuable economic force and contribute to family income and community development in multiple ways. However, their contributions are hindered by limited access to resources, persistent discrimination, and gender norms. Addressing these barriers is crucial to unlock the full potential of their labour and empower women in the agricultural sector.

In 2022, DR Congo was ranked among the five poorest nations in the world, with approximately 70% of Congolese, around 60 million people, living on less than $2.15 a day. The country is home to a significant portion of extreme poverty in Sub-Saharan Africa, with one out of six people living in extreme poverty in the region residing in DR Congo (World Bank, 2023). Between 2010 and 2014, the per capita Gross National Disposable Income (GNDI) averaged 2.7% (World Bank, 2018). The incidence of poverty in DR Congo varies significantly across different livelihood types. Household practicing subsistence agriculture with food crops have the highest poverty rates (World Bank, 2016). The Gini index, which measures income distribution inequality among citizens, stands at 42.1, indicating a relatively weak income distribution inequality in the country. Regarding gender income disparities, men have slightly higher incomes than women. On average, male heads of households earned $1,116 a year, while female heads of households earned $1,092. About 25% of both categories earned less than $660. The lowest income for women was $192, compared to $180 for men, and the highest income was $3,996 for men and $3,324 for women. The narrowing gap between women's and men's incomes can be attributed to more women entering the agricultural marketing chain and participating in family farming activities (Mushagalusa et al., 2015).

From 2000 to 2013, Rwanda made significant progress in reducing poverty, with the poverty rate declining from 75 to 53% based on the international poverty line of $2.15 (2017 PPP). However, this progress has slowed down in recent years, and the poverty rate has become almost stagnant at 52% in 2022. The Gini index, which measures income distribution inequality, is relatively low at 43.7, indicating a fair level of income distribution between citizens. The slowdown in poverty reduction can be attributed to compressed household consumption in rural areas, partly due to a slow rural-to-urban transition. Approximately 60% of Rwandans still live on less than $1.90 per day. The emergence of the Covid pandemic further projected a deceleration in poverty reduction, with poverty declining only slightly from its projected level of 43% in 2019 to 42% for 2020-2021 (Himbara, 2021). Gross National Disposable Income data shows an increase, reaching RWF 6.76 billion in 2016 (equivalent to USD 5.78 million), compared to RWF 6.077 billion in 2015 (equivalent to USD 5.2 million) (IMF, 2016). Consumer spending in Rwanda has decreased, reaching RWF 1928 billion in the fourth quarter of 2022, down from RWF 2051 billion in the third quarter of the same year (Trading Economics, 2023). An integrated household living conditions survey in Kamonyi district revealed that the poverty rate is much higher among household’s dependent on agriculture (72%) than among those dependent on non-agricultural wages (23%) and the self-employed (24%) (Kamonyi district report, 2018). Furthermore, using indicators such as education, health, and standard of living (index of multiple deprivation) within similar households and communities, 54% of Rwandan households are considered multidimensionally poor, while 21% still live in severe multidimensional poverty (UN, 2018).

All four countries, Burundi, DR Congo, Rwanda, and Cameroon, share common characteristics of poverty and weak income distribution inequality among their citizens. Burundi is recognized as one of the world's most impoverished countries, while DR Congo is among the five poorest nations

globally. Rwanda has made progress in reducing its poverty rate from 75% to 53% between 2000 and 2013.

2.3.3. Unemployment rate and local workforces

Burundi's economy is primarily characterized by small-scale subsistence farming, which provides employment to over 90% of the population (FAO, 2015). However, the agricultural sector faces challenges, with many farm households operating as unpaid workers, and only a few are salaried employees. The average farm size per household is approximately 0.27 hectares, and a farming household is estimated to have 5.1 people (ENBA 2013-2014). Formal employment opportunities are limited, with 5.3% of men and 2.5% of women employed in the formal sector, while the majority (94.7% of men and 97.5% of women) are engaged in the informal sector (Douma and Seberege, 2021). To promote economic growth and reduce income disparities, addressing the challenges in the agricultural sector and creating more formal job opportunities remain critical priorities for Burundi's development. Burundi's Human Development Index (HDI) ranks the country 187th out of 189 (UNDP 2021). Although its Gini coefficient is lower than the average for sub-Saharan Africa, Burundi still faces significant income disparities, particularly affecting women, who constitute 90% of the unpaid workforce (ISTEEBU, 2015). The country also grapples with the challenge of youth unemployment, with an estimated percentage of unemployed, untrained young people at 6.2% for women and 6.4% for men in 2017 (ILOSTAT, 2019). Underemployment is a prevalent issue, particularly impacting the rural working population (42%) and urban areas (30%) (JAB, 2023). It is crucial to address these challenges to ensure inclusive, equitable, and sustainable rural development. In response, Burundi has implemented the National Employment Policy through initiatives such as the “Office Burundais de l'Emploi et de la Main d'œuvre” and local employment observatories. Efforts have been made to provide entrepreneurship training to young graduates and offer first-job internships to 250 young individuals each year (PND, 2018).

Also in Cameroon, employment remains a pressing issue. According to the latest report from the Observatoire National de l'Emploi et de la Formation Professionnelle (ONEFOP), there has been a significant increase in the number of decent jobs in Cameroon's modern or formal sector, rising from 330,903 in 2020 to 358,247 at the start of 2022, marking an 8% increase. The primary sector, encompassing activities such as agriculture, fishing, and mining, has been the leading sector in terms of job recruitment (48%). Following closely is the tertiary sector (38%) which includes commercial activities, transportation, financial services, and other services. The secondary sector (14%) accounts for the remaining share (ONEFOP, 2020). However, the Covid-19 pandemic had a significant impact on the economy, leading to a rise in the unemployment rate in 2021 compared to 2020 (INS, 2021). The informal sector is a significant provider of job opportunities, accounting for 9 out of 10 jobs in the country. The formal sector, split between the public and private sectors, accounts for only 10% of jobs. Notably, 90% of Cameroonians aged 10 and over work in the informal sector. Underemployment is a significant concern, with 12% of employed individuals involuntarily working less than 35 hours per week in their main job. Additionally, 69% of the employed earn less than the minimum wage of 23,500 FCFA, with women and workers in the informal sector, especially in agriculture, being more susceptible to underpayment. Agriculture is the sector with the highest number of workers, particularly in rural areas, where it accounts for 96% of the workforce. Unfortunately, overall, 43% of the working population in Cameroon is considered poor, with higher incidences of poverty in the informal sector, especially in rural areas (54% poverty incidence) compared to urban areas (12% poverty incidence) (INS, 2007).

DR Congo has a youthful and growing population but faces significant challenges in its labour market, particularly in terms of high unemployment rates, especially among young people aged 15-24 (16%). Young women, in particular, experience higher unemployment rates (20%) compared to young men (12%) (Kuma, 2020). Addressing these challenges requires tackling issues such as reducing unemployment and underemployment, bridging the gap between training and employment opportunities, promoting formal sector employment, reducing gender inequalities, providing opportunities for disadvantaged social groups, and creating decent job opportunities for young people at the community level (GEI, 2019). In many rural areas of DR Congo, mining is gradually replacing agriculture, and approximately 4% of individuals aged 15-64 are employed in small-scale and artisanal mining activities. However, the formal job market remains limited, and there is a lack of skilled human capital, leading to a low number of graduates finding quality employment opportunities (Sumata Claude, 2020).

In Rwanda, there is an ongoing structural shift in the economy, transitioning from subsistence agriculture to non-agricultural sectors. As a result, the share of employment in agriculture has declined from 89% in 2001 to 68% in 2014. Most of the agricultural workforce comprises self-employed farmers (65%), with paid agricultural workers accounting for 35%. Women make up 66% of the agricultural workforce. In general, men hold more paid jobs in agriculture (25%) than women (20%), while in paid non-agricultural jobs, there are more women (42%) than men (40%) (data from Sumata Claude, 2020). This shift reflects the country's efforts to diversify its economy and create more opportunities in non-agricultural sectors. The 2016 Seasonal Agricultural Survey notes that the majority (26%) of agricultural households in Rwanda were headed by someone in the 55+ age group; and that women are over-represented in this age group. At the same time, agriculture remains the most important source of employment for young people. Over 50% of rural youth (aged 16-24) still work exclusively in agriculture, and many are underemployed due to small farm size and seasonal work requirements. Beyond agriculture, the agri-food system provides employment for traders, suppliers of agricultural inputs and services, and other related sectors. Most new jobs are generated outside agriculture as well as outside the agrifood system in general. Over the period 2011-2014, business in Rwanda grew by 24% overall. In rural areas, the increase was 38% compared to 7% in urban areas. During the same period, 34% of new jobs were created by businesses (48% in rural areas compared with 22% in urban areas) (MARA,2018). Youth unemployment is higher than adult unemployment. Youth unemployment was over 21% between 2016 and 2017 and in 2018 youth unemployment decreased to 18% to become 19% in 2019. Adult unemployment is low compared to the youth and decreasing at a high rate, it was 16% in 2016 and 12% in 2018. During COVID-19 youth were heavily affected with an unemployment rate of 27% compared to adults with 18% unemployed. Unemployment was very high among female youth with 31% in May 2020 compared to male youth with 24% in the same period and had declined in February 2020 to 18% among females and 17% among male in the same period. Over the last five years the construction, wholesale & retail trade, transport and storage, tourism and hospitality sectors have been drivers of job creation. Employment opportunities are the major polling factors for rural-urban migration or urban-rural migration and thus lack of jobs in either urban or rural areas is the major pushing factor to either side (RDB, 2020).

3. Microenvironment: needs, context and practices analysis

3.1. Introduction to the needs, context, and practices

This section examines the needs, context, and practices of local communities within the ALLs. It draws on both primary data collected from the field and secondary data from desk studies to assess the landscape characteristics and biophysical features in each ALL, the socioeconomic conditions, adaptive capacity, climate change vulnerability, farming practices, needs, and perceptions about agroecology, as well as the capacity-building needs.

To analyse the agroecological contexts and needs of rural communities within each living lab, we refer to the 13 agroecological principles defined by the High-Level Panel of Experts (HLPE, 2017) on food security and nutrition (Figure 3). These principles align with five levels of agroecological transition. Levels 1 and 2 involve incremental transitions achievable within the agroecosystem through principles 1 to 7, while Levels 3 to 5 entail transformational transitions achievable within the food system.

The assessment of farmers' perceptions about agroecology and their adoption of agroecological practices is essential in the eoanalysis. Farmers' perceptions play a vital role in the adoption and intensification of agroecology. Consequently, agricultural policies for the extension of agroecological techniques should take these perceptions into account (Tankoano and Sawadogo, 2022). In this section, our focus is on the transition within the agroecosystem, specifically from level 1 to level 2.

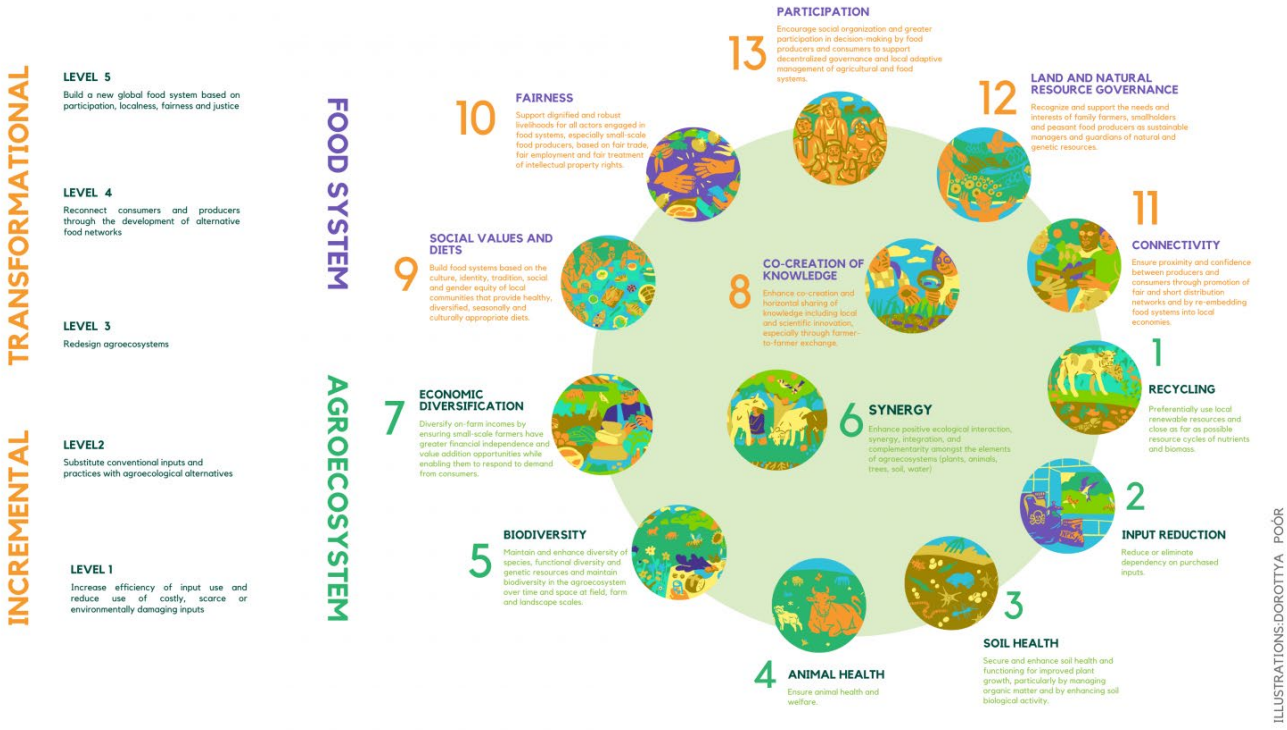

Figure 3: Levels of transition towards sustainable food systems

For each ALL, we assess the level of knowledge about agroecology in general and we assess the perception about recycling (principle 1), input reduction (principle 2), soil health (principle 3), animal health (principle 4), biodiversity (principle 5), synergy (principle 6) and economic diversification (principle 7).

Recycling is one of the AE principles that improve resource efficiency (HLPE, 2017). Recycling existing nutrients and biomass in farming and food systems leads to sustainable agricultural production with lower economic and environmental costs (FAO, 2019). For this principle, agroecology optimises and closes resource loops (nutrients, biomass) by preferentially using local renewable resources and close as far as possible resource cycles of nutrients and biomass. During the focus group discussions, respondents were questioned about their utilization of local renewable resources and their efforts to promote recycling within their farms or organizations. Six distinct resources were identified: 1) Compost, manure, or cow dung; 2) Leguminous green manures; 3) Wastewater (domestic or non-domestic); 4) Bioenergy from corn stalks; 5) Slaughter waste; and 6) Organic agricultural waste. Additionally, practices such as reduced or no tillage, the use of deep rooting plants, and the recycling of crop residues for other purposes were also discussed. Furthermore, some participants mentioned wood waste recycling for construction purposes.

As part of the incremental transformation in agroecosystems, input reduction is a fundamental agroecological principle aimed at minimizing or eliminating reliance on purchased inputs (HLPE, 2017). This principle, along with recycling, highlights agroecology's focus on resource use efficiency

through practices that reduce or eliminate the use of costly, scarce, or environmentally harmful inputs, aligning with the input reduction principle described by Wetzel et al. (2020).

During the focus group discussions, respondents were asked for their views on the usage of chemical fertilizers and pesticides. Nine elements were evaluated to assess the context of input reduction, which included the following practices: adoption of drip irrigation and improved varieties, reduction or non-application of pesticides, utilization of improved cooking stoves, optimizing seed spacing to minimize seed use, minimizing harvest waste, implementing biological control for pest management, utilizing cover cropping for pest, and weed control, and reducing the reliance on chemical inputs.

Soil health is defined as “the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans” (USDA-NRCS, 2019). In the past decade soil health has been intensively studied as a science and practised to help improve the global social, environmental, and economic sustainability. An array of soil health management practices has been recommended, including crop rotations, cover crops, conservation tillage, soil organic amendments, crop- livestock, integration, and rotational grazing (Guo, 2021). The four strategies for improving soil health are: the practice of no-tillage/ strip-tillage, adding more crops to your rotation, including cover crops, and managing nutrients. Securing and enhancing soil health for improved plant growth, particularly by managing soil organic matter and by enhancing soil biological activity is the third agroecological principle (HLPE, 2017). Farmers in the various ALLs were asked about their actions and knowledge regarding soil organic matter and soil health. Three practices were assessed during the discussions, including the use of cover crops to reduce erosion, preservation of organic matter and soil health, the adoption of perennial plant species instead of annual crops, and the adoption of conservation tillage.

The livestock farming sector is under stress as fewer people are willing or able to become livestock farmers. Contributing to the decline in the attractiveness of the profession are, among other factors, the agricultural crisis, higher consumer expectations, and difficult working conditions. Agroecology is a sustainable solution that can maintain livestock production and provide positive contributions to society without negatively affecting the environment (Duval, 2021). Good animal health and welfare is requisite, and a key domain, for the sustainability of livestock. Animal health and welfare are interconnected, with freedom from disease being a significant component of welfare. Proper care and management play a vital role in raising resilient and disease-resistant animals. The well-being of animals directly impacts their productivity, as sick or stressed animals under inadequate management tend to grow slower and produce less. Poor animal health and welfare also entail risks beyond reduced productivity, as they can compromise food security by limiting access to highly nutritious animal-source foods and pose threats to farmers' livelihoods and large-scale producers' economies (Magnusson et al., 2022). During the context analysis, we engaged in discussions with participants in the focus groups to gauge their concerns about animal health. Additionally, we assessed the adoption of two related practices: the temporary introduction of domesticated pollinators or exotic domesticated species and the level of effort taken by farmers to support livestock well-being, including species-appropriate husbandry and aquaponics. Furthermore, we recorded specific needs related to the enhancement of animal health. These steps are integral to upholding the fourth principle of agroecology, which underscores the importance of animal health and welfare in livestock farming.

Biodiversity in agroecosystems is the variety and variability of animals, plants, and microorganisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry, and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel, and pharmaceuticals. It also includes the diversity of non-harvested species that

support production (soil microorganisms, predators, pollinators), and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest, and aquatic) as well as the diversity of the agro-ecosystems (FAO, 1999). Maintaining and enhancing the diversity of species, functional diversity, and genetic resources and maintaining biodiversity in the agroecosystem over time and space at field, farm, and landscape scales is the fifth principle of agroecology (Sinclair et al., 2019). To assess the implementation of this principle, we conducted discussions with participants in the focus groups. Participants were asked about their efforts to enhance the diversity of species, functional diversity, and genetic resources in their agroecological systems. They were also questioned about the incorporation of non-crop plants in their farming practices to serve ecological functions, such as conservation, water quality improvement, or pest management. Furthermore, they were invited to share any other actions taken to support biodiversity conservation, as well as the challenges they face in this regard and their proposed solutions. These discussions provided valuable insights into the status of biodiversity conservation in their agricultural practices and informed our assessment of the fifth principle of agroecology.

The agroecological principle of synergy emphasizes the strengthening of positive ecological interactions, and the integration, and complementarity among the elements of agroecosystems, including plants, animals, trees, soil, and water. Participants in the focus group discussions were asked about their efforts to enhance positive ecological interactions and complementary practices in their agroecosystems.

1) Integrated crop-livestock systems: Participants were asked whether they develop diversified farming systems that include both crops and livestock, fostering harmonious interactions between these elements.
2) Agroforestry: The focus groups explored whether participants engage in agroforestry, which involves integrating crop production with tree cultivation to diversify the farming system.
3) Rotational/regenerative grazing: Discussions included inquiries about the adoption of rotational or regenerative grazing techniques to enhance soil quality and increase forage yield.
4) Integrating/incorporating native or locally/regionally adapted Crops and Animals: Participants were asked if they incorporate native or locally/regional adapted crops and animals into their farming practices.
5) Spatial diversification: Participants discussed whether they spatially diversify their farms through multi-, poly- or inter-cropping techniques.

By assessing these practices, the focus groups aimed to understand the extent to which positive ecological interactions and complementary approaches are implemented within their agroecosystems. Additionally, the discussions aimed to gain insights into how these agroecological principles contribute to farm productivity and income diversification while promoting sustainable and resilient farming practices. Finally, the focus groups explored how participants strive to achieve healthy diet diversification and promote local consumption through a diversified food production system.

In the following sections of the report, we present for each ALL the landscape characteristics and biophysical features, the socioeconomic conditions, the adaptive capacity and climate change vulnerability, the farming practices, the needs, and perceptions about agroecology following the methodology described above, and the capacity building needs. The needs and perception about agroecology are summarised in Table 17 to 22 in the Appendix.

3.2. Needs, contexts, and practices in Burundi

3.2.1. Landscapes characteristics and biophysical features

Burundi hosts 2 ALLs, situated in Bujumbura Rural and Giheta respectively. The province of Bujumbura Rural encompasses the city of Bujumbura being the economic capital of the Republic of Burundi, with geographical coordinates of 2°48'30" - 4°20'43" S, and 29°36'3" E. The natural landscape of Bujumbura Rural is characterized by xerophilous groves that thrive in dry environments, along with steppe, grassy savannah, and wooded savannah. Additionally, there are both artificial woodlands and natural plant formations present. The primary livelihood in this region revolves around subsistence farming, with coffee and tea production accounting for 19% and 13% of agricultural activities, respectively (Coface for trade, 2023). Livestock rearing is also a significant economic activity in Bujumbura Rural.

Bujumbura Rural is located between Lake Tanganyika, the Ruzizi River, and the crest of the Congo-Nile watershed. It experiences an average annual rainfall of 800-1100 mm and maintains a mean annual temperature of 24°C. Various types of soils can be found in this area, including hydromorphic brown soils, tropical black clays, Hygroxeroferralsols, Régosols, Hygroxeroferrisols and saline Régogleys. In general, these soils possess high nutrient content but exhibit variable levels of soil organic matter. Certain areas in Bujumbura Rural feature Kaolisols developed on gneisses and granites with interlayers of amphibole and metaquartzite, supporting a mountain rainforest with heliophilous species (Lebrun et al., 1956; Cazenave-Piarot, 1979). Bujumbura is facing challenges related to soil degradation, organic matter loss, and declining soil fertility. These issues have been noted and call for appropriate measures to address the situation.

Giheta is a commune situated within the province of Gitega in Burundi, positioned at geographic coordinates 3°21'50" S and 29° 52' 16" E. The province of Gitega is divided into three zones, namely Giheta, Kabanga, and Kiriba. Giheta boasts an extensive hydrographic network, encompassing major rivers like Ruvyironza, Ruvubu, Mutwenzi, Nyambeho, Rufunzo, and their tributaries. The eastern part of Giheta, known as Kiriba, exhibits rugged terrain with mountain ranges such as Kiriba and Gisagara, reaching elevations of 1,975 m and 1,922 m, respectively. The climate in Giheta can be described as subtropical highland or temperate oceanic, characterized by dry winters. The region receives an annual average rainfall of 360 mm and maintains a mean annual temperature of 20°C. The vegetation in Giheta is predominantly grassy savannah, interspersed with shrubs and recently introduced exotic trees like Eucalyptus, Grevillea, and Pinus. The soils in Giheta are of the sandy-clay type, with moderate fertility. The area is rich in schist, granite, and quartzite. The land in Giheta is utilized for cultivating industrial food crops, grazing pastures, and forestry. However, the topography of the region induces erosion, and the fertility of soils is steadily declining due to increased human activity in search of arable land. The high population density exerts pressure on natural resources such as forests. In response to these challenges, initiatives like tree planting are being implemented in the municipality of Giheta to combat the environmental issues and promote sustainable practices.

3.2.2. Socio-economic and environmental context

General information

Bujumbura Rural is divided into three councils: Muha (with 295,072 inhabitants), Mukaza (with 306,000 inhabitants), and Ntahangwa (with 491,786 inhabitants) and comprises a total of nine

communes, namely Kabezi, Kanyosha, Mubimbi, Mugongomanga, Mukike, Mutambu, Mutimbuzi, and Nyabiraba (Stratégie nationale agricole 2018-2027). According to FAO (2020), 36% of households across Burundi experience food insecurity, of which 7% face severe food insecurity, and 29% encounter moderate food insecurity. In the Bujumbura ALL, which consists of 308,000 households, 55,000 are directly involved with the Great Lakes Integrated Agriculture Development Project (PICAGL), with 35% of them being women. The population in this area comprises three main ethnic groups: Batutsi, Bahutu, and Batwa, and their local and indigenous knowledge is highly valued by various stakeholders. Access to electricity is limited, with less than 5% of the population having this utility (52% urban households and 2% rural households). Biomass, including firewood, charcoal, and agricultural residues, along with peat, accounts for approximately 95% of the population's energy sources. Petroleum products fulfill the remaining 2% of their energy requirements.

The Giheta council is one of eleven councils in the Gitega province. It is bordered by Bugendana commune to the north, Gitega commune to the south, Shombo commune in Karuzi province to the east, Nyabihanga commune in Mwaro province, and Rutegama commune in Muramvya province to the west. The commune of Giheta is one of the most densely populated in the Gitega province, with a total population estimated at 93,871 inhabitants, according to data collected by the communal office (Schéma Provincial d'Aménagement du Territoire (SPAT) de Gitega, 2020-2025), with an estimated annual growth rate of 2.4% (Ministry of Finance 2012). The agro-sylvo-pastoral sector focuses on several key areas to enhance and diversify agricultural practices. These include:

1) Intensification of subsistence farming: This involves the use of selected seeds, fertilizers, phytosanitary products, and modern agricultural tools to increase productivity. Additionally, erosion control measures are implemented to preserve soil quality.
2) Development of market garden and fruit crops: To meet the demands of the nearby town of Gitega, efforts are made to grow market garden crops and fruits, enhancing food supply, and generating income.
3) Regionalization of production: Special emphasis is placed on rejuvenating coffee plantations and producing terroir coffee, which is unique to the local region and can contribute to economic growth.
4) Intensification of livestock farming: Livestock farming is improved through permanent stabling, cultivating fodder crops, implementing artificial insemination techniques, and enhancing animal equipment to raise livestock productivity.
5) Reforestation of forestry sites: Initiatives are undertaken to reforest areas like Zege, Cene, Mashitsi, to promote environmental sustainability and preserve the natural habitat.

Development and diversification of alternative technologies to wood: In response to the importance of sustainable energy sources, alternative technologies such as biogas, carbonization, improved stoves, and solar energy are developed and promoted to reduce reliance on traditional wood consumption.

Households' participation in the focal crop farming

In the Bujumbura ALL, agriculture and livestock are the dominant economic activities. The agricultural sector is divided into small-scale farming, accounting for 45% of activities, and medium-scale farming, making up the remaining 55%. Maize production takes center stage in this region, with a significant 75% of households being directly engaged in its cultivation as their primary crop. Even among individuals living in single households, a remarkable 80% are involved in maize production, relying on

it as their main source of income. Additionally, crops like cassava, beans, and various fruits also make substantial contributions to the farmers' overall income.

In the Giheta ALL, coffee production stands out as the primary occupation for farmers, with 3 out of every 6 family members actively engaged in this sector. On average, each family manages approximately 50 acres of coffee plantations, while bananas are cultivated as the secondary crop. Interestingly, the involvement of women in coffee farming varies depending on the tasks required, especially during the harvesting period. While women may not be highly engaged in coffee cultivation, they have the freedom to cultivate bananas without seeking any permission. Households in Giheta adopt a mixed farming approach, combining both subsistence and market-oriented farming practices. The produce from their farms serves as a crucial source of nutrition for their families, leading to a diverse diet. The most consumed crops include maize, sorghum, rice, beans, and soybeans, ensuring a well-rounded and balanced diet for the community.

Inclusiveness and participation

The survey findings indicate that the accessibility to natural resources, particularly land, is not equal among all family members. Land access disparities were observed, but there seems to be some level of inclusion in decision-making when it comes to farm management. In Burundi, cultural norms assign different roles and responsibilities to girls and women compared to boys and men, leading to unequal situations that hinder overall development. Land acquisition in Burundi primarily occurs through inheritance and constitutes the primary means of subsistence for approximately 90% of the population, with 51% of them being women. However, there is currently no specific law governing inheritance, matrimonial regimes, or gifts, leaving women's rights to these resources subject to customs and traditions, which often discriminate against them. In this patriarchal cultural context, women are considered usufructuaries rather than true landowners, as they do not inherit land like their male counterparts. Despite these challenges, Burundian women are actively engaged in various farming activities, including ploughing, sowing, weeding, harvesting, transporting, preserving, processing, and marketing agricultural products. However, they face significant barriers when it comes to access and control over profits from their hard work. They lack the power to decide how these profits are utilized, perpetuating their limited agency and economic independence (Niyonkuru, 2009).

In Bujumbura, there is no discrimination against women and youth when it comes to accessing certain resources like land. However, in Giheta, unlike Bujumbura, both women and youth face discrimination in accessing resources. They do not have equal access to parental property, although mothers can utilize their land on behalf of children under 15 years until they reach maturity. In both Bujumbura and Giheta, farmers encounter no restrictions in accessing financial resources, as several microfinance institutions (including saving groups and cooperatives) are available to offer loans to farmers. The challenge lies in obtaining credit since formal loans often necessitate a bank account, collateral, and a substantial personal contribution. These conditions result in the automatic exclusion of many women from accessing formal loans, compelling them to resort to informal loans with excessively high interest rates.

In both Bujumbura and Giheta, there have been reported cases of sexual harassment, particularly affecting women, which has a negative impact on their ability to engage in economic activities, especially food distribution (Nzicherman, 2007). In Burundi, women and girls are almost four times more likely than men to experience sexual violence, creating a culture of silence and impunity

surrounding such crimes that further endanger their vulnerable situation (UNICEF, 2018). This culture of silence makes it very difficult for women to report instances of abuse. According to a report by UNICEF, approximately one in four Burundian women (23%) and 6% of men have experienced sexual violence, with children being particularly at risk. However, due to underreporting, the actual number of incidents is likely much higher. The rate of physical and/or sexual intimate partner violence in the last 12 months (as of 2022) was reported to be 28% in Burundi, indicating a high prevalence despite the existence of various rules and regulations against sexual harassment. Some of the measures taken to address sexual and gender-based violence in Burundi include the amendment of the Code of Criminal Procedure through Law No. 1/09 of 11 May 2018, which considers gender aspects in the acts of investigation and instruction. The National Strategy to Combat Sexual and Gender-Based Violence and its action plan have also been updated and implemented for the period 2018-2022. Additionally, the establishment of the Center of Excellence on the Fight against Sexual and Gender-based Violence (through Ordinance No. 225.01/36 of January 25, 2019) aims to strengthen the fight against sexual and gender-based violence in the country. Despite these efforts, the prevalence of sexual harassment and violence remains a significant concern in Burundi.

Nutritional and health status

Farmers enjoy a diverse array of meals, incorporating various crops such as maize, rice, beans, soybeans, peas, avocados, watermelons, mangoes, cabbages, tomatoes, and amaranth. Among these, maize, rice, and tomatoes are the most frequently consumed items. To meet their protein needs, farmers rely on a range of livestock, including goats, hens, pigs, cows, and rabbits.

Over the past five years, there has been a notable increase in the utilization of chemical inputs in farming, rising from 150 kg/ha to 270 kg/ha. However, this growing reliance on chemical inputs may have had adverse effects on farmers' health. Around 37% of farmers reported experiencing at least one health issue, with common ailments including nasal congestion, coughing, headaches, lung diseases, irritation, and nausea, among others. The prevalence of health issues can be attributed to the insufficient use of protective equipment during agricultural activities. For example, in the case of Bujumbura, only 5% of farmers indicated using any protective gear, potentially exposing themselves to health risks from chemical exposure.

Income diversification and financial assets

In the rural areas of Burundi, agricultural income plays a crucial role in determining the purchasing power of the local population (Alfred, 2013). To enhance income generation for small-scale farmers, diversification of cash crop farming has been identified as a significant opportunity. While coffee, tea, and cotton have traditionally dominated, emerging crops like avocado offer promising avenues for increased income. Apart from off-farm activities, various income-generating commodities contribute to the livelihoods of farmers in Burundi. These commodities include coffee, bananas, beans, sweet potatoes, cassavas, avocados, makumbi, peas, domestic animals, firewood, maize, honey, and goats (Hakizimana, 2011). To meet their financial needs, farmers in the Burundi ALLs often seek loans from microfinance institutions, neighbours, and savings credit groups. These financial resources help them invest in their farming activities and explore new income opportunities, contributing to the economic development of rural communities.

3.2.3. Adaptive capacity and climate change vulnerability

Farmers in both Bujumbura and Giheta are grappling with the impacts of climate change. An overwhelming 80% of respondents report that climate change significantly affects their agricultural production, primarily due to prolonged droughts and a decrease in the duration of rainfall. The observed changes include more frequent droughts, violent winds, soil erosion, flooding, hailstorms, and a decrease in soil fertility. To adapt to these climate change effects, farmers have adopted various practices. They employ irrigation techniques to supplement water supply during dry periods. Additionally, they utilize early maturing crop varieties to align with shifting growing seasons. Mulching is employed to conserve soil moisture and combat erosion, while anti-erosion ditches are constructed to prevent soil loss. Drainage is facilitated by cleaning gutters to manage excess water during heavy rainfall events. Moreover, the application of pesticides is used to mitigate the impacts of pests and diseases that might have worsened due to changing climatic conditions.

Extreme events: The Bujumbura ALL experiences the extreme event of dryness, while in the Giheta ALL, it faces the challenges of excessive rainfall or drought. Both regions also encounter a lack of reliability in their planting seasons. In Bujumbura, the long dry season stretches from June to August, and the short dry season occurs from mid-January to mid-February. In contrast, in Giheta, the long dry season begins in mid-February and lasts until mid-May, while the short dry season spans from mid-September to mid-November.

Perception: According to farmers' perceptions, climate change is evident in both Giheta and Bujumbura. In Giheta, all farmers (100%) have observed changes in the climate, including an increase in rainfall, flooding, higher temperatures, erosion, strong winds, and the presence of hailstones during the rainy season. The last four events are considered the most extreme. In Bujumbura, 93% of farmers have also noticed climate changes, experiencing major events such as drought, floods, and hailstones, affecting all of them. Notably, the sowing date in Bujumbura has shifted significantly from September 15 to November 15, leading to an extension of the harvesting period from December to February. Over the past three decades, there has been a notable 200 mm drop in rainfall in Bujumbura. Climate change has also contributed to land impoverishment. In Giheta, farmers have similarly observed a delay in the sowing date, which now occurs from May to September. The degradation of land in Giheta is attributed to inappropriate land use practices. These changes in climate and their consequences are posing significant challenges to farmers in both regions, necessitating adaptation strategies to cope with the evolving environmental conditions.

Impact: Climate change is significantly impacting agriculture in the Burundi ALLs, particularly in Bujumbura. Farmers in this region have observed a change in the growing season, with the length of the period decreasing from 4 months to 3 months, resulting in a reduction of 30 days. The sowing date has also shifted from September 15 to November 15, a delay of 60 days. Similarly, the harvest date has shifted from December 15 to end of January. These changes in the growing season and agricultural calendar are having detrimental effects on agricultural production in Bujumbura. Farmers report reduced yields of both cash crops and food crops, along with increased insect attacks due to exacerbated drought conditions. In Giheta, farmers were less motivated to provide answers related to climate change adaptation, possibly due to the predominance of coffee cultivation, which is a perennial crop with well-established practices among cooperative members. Nonetheless, farmers in Giheta still report adverse climate change effects on agriculture, including a reduction in coffee yields and modification or destabilization of the agricultural calendar.

Action: Adaptation to climate change has always been a crucial goal for both the population and the government in Burundi. Traditionally, farmers have employed various practices to cope with the changing climate, including cultivating tubers like cassava and sweet potatoes, which are more resilient to extreme weather conditions. They stagger their sowings to mitigate climate-related losses, preserve harvests in granaries to ensure food security during lean seasons, and practice transhumance for livestock. To better adapt to the changing climate, farmers have turned to gravity-fed irrigation and embraced new seed varieties, particularly early 'Bujumbura seed. They also use chemical fertilizers such as NPK 10-10-20 and NPK 21-8-4 foliar fertilizers to enhance crop yields. Agroforestry practices, like using non-competitive plants such as *Grevillea robusta*, and fallowing land for 2-3 years are adopted to manage soils effectively. Farmers combine chemical and organic fertilizers, such as *Imbura* and *Totahaza*, for planting and top dressing, respectively. Crop succession is implemented with crops like cassava, beans, soybeans, and sweet potatoes. Pesticides are used to combat insect pests. In Giheta, farmers have planted anti-erosion trees, established small nurseries in fields, intensified cover crop use, and integrated animals into their cropping systems. Agroforestry is practiced in coffee plantations, incorporating medicinal plants and legumes. Land management involves the use of organo-mineral fertilizers like *Imbura* and *Totahaza* for planting and top dressing, respectively, as well as organic fertilizers.

The adaptive strategies and climate change vulnerability in the Burundi ALLs are summarized in Table 11. These efforts aim to enhance resilience and sustainability in the face of climate challenges, ensuring food security and livelihoods for the agricultural communities.

Table 11: Adaptive strategies and Climate Change vulnerability in Burundi

Living Lab	Bujumbura	Giheta
Extreme events	Dryness	Excessive rainfall, Drought Planting season is no longer reliable
Perception	93 %	100 %
Impact	change in the growing season (reduction) Change in the sowing date. Yield reduction of cash and food crops Increase of insect attack	Coffee yield reduction Modification/destabilisation of agricultural calendars
Strategy	Adoption of gravity-fed irrigation Adoption of new seed varieties Using of chemical fertilisers (NPK 10-20 20) Using of foliar fertilisers (NPK 21-8-4) Agroforestry practices Planting trees Land fallow (2-3 years) Using of organic fertilisers Crop succession Application of pesticides Adoption of ISFM	Plantation of anti-erosion trees Set up a nursery in the field. Intensification of cover crops Integration of animals into the cropping system Agroforestry practices Using chemical fertilisers (DAP, TSP, and urea) Using organic fertilisers A mixture of cereal and legume crops Spreading fertilisers & organic matter Adoption of ISFM

3.2.4.Farming practices

In the Bujumbura ALL farm sizes range from 0.5 to 2 hectares, with an average of 0.5 hectares, whilst in the Giheta ALL farm size is between 12 to 20 hectares, with an average of 16 hectares. The homesteads are generally located close to the farms, with distances ranging from 0 to 300 meters, especially in Bujumbura. In Giheta, homesteads are situated on the farms, with a focus on accessibility, fertility, and access to water sources for irrigation. Farmers acquire their lands through various means, such as renting, inheritance, or outright buying. The length of land ownership varies depending on the method of acquisition, ranging from one season (rental) to indefinite (inheritance and buying).

In both ALLs (Bujumbura and Giheta), mixed cropping with multiple crops is a common agricultural practice. This approach involves integrating annual and perennial crops alongside fruit trees and agroforestry trees. Various tree types are deliberately planted for different purposes. Fruit trees, such as *Mangifera indica*, *Persea americana*, and *Citrus sinensis*, are cultivated for nutrition and family income through fruit sales. *Grevillea robusta* is chosen for its wood, while *Azdirachta indica* serves medicinal purposes. Additionally, some trees are strategically planted to provide shade in coffee plantations and contribute to the soil organic matter content, with an average of 20 trees associated per hectare. In the In Bujumbura, maize is the dominant annual crop, while coffee is the primary crop in Giheta, often mixed with banana. Intercropping between maize and beans is widespread. This mixed cropping strategy allows for specialization, leading to cost reduction and optimizing the efficient use of land and local climatic conditions.

One of the significant challenges affecting the cropping system is the delay in acquiring fertilizers and the availability of insufficient and poor-quality manure, which often leads to reduced yields. Farmers in Bujumbura acknowledge an increase in the quality of fertilizers after the validation of research data. Specifically, there has been an increase in the application of chemical inputs, from 150 kg to 250 kg per hectare, and chemical fertilizers are used both in Bujumbura and Giheta. In Bujumbura, the fertilizers used are Imra, N-P-K-Ca-Mg (9-22-4-13-2), and Totahaza, N-K-Ca-Mg (21-8-4-2). The formulation rate is 270 kg/ha of Imbura and 100 kg/ha of Totahaza with a frequency of application of 2 times per year during planting and weeding. Farmers in Bujumbura hold a positive opinion about these chemical fertilizers because they lead to increased crop yields. However, in Giheta, the average amount of chemical fertilizer used per household is 2 kgs. The fertilizers used are di-ammonium phosphate (DAP), triple superphosphate (TSP) and urea, but farmers express dissatisfaction and consider them too expensive. This difference in perception may affect the adoption of these inputs and highlights the need to explore more cost-effective and accessible alternatives for farmers.

3.2.5. Needs and perceptions about agroecology

The level of awareness and understanding of agroecology was assessed through focus group discussions in the 2 ALLs. Participants were asked if they had heard about agroecology, and if so, to provide an explanation of their knowledge.

In the Burundi ALLs, there is a growing awareness of agroecology among farmers. Approximately 66% of farmers in Bujumbura have heard about agroecology and possess a general understanding of the practices, although they have not yet implemented them. They perceive agroecology as a set of farming methods that involve cover cropping, the use of organic fertilizers, abstaining from pesticides, and incorporating organic manure. Similarly, in Giheta, farmers have been introduced to

agroecology. They view it as a collection of practices that prioritize the preservation of nature, the environment, and animals, while avoiding the use of chemical inputs.

Recycling: In Bujumbura, farmers have widely adopted three out of the six elements of recycling. Approximately 80% of the respondents, including 50% women, incorporate compost, manure, or cow dung into their farming systems, focusing on crops such as maize, rice, and sorghum. Additionally, about 88% of respondents, including 46% women, utilize bioenergy derived from corn stalks, slaughter waste, or organic agricultural waste. All respondents in Bujumbura recycle their crop residues for other purposes and use wood waste for construction. However, only 30% of respondents in Bujumbura reuse wastewater, whether domestic or not, in their farming practices. No respondents in Bujumbura use leguminous-based green manures, nor do they practice reduced or no-tillage or utilize deep-rooting plants.

In Giheta, different recycling elements are adopted by more than 50% of the respondents. All respondents in Giheta incorporate compost, manure, or cow dung into their farming systems. Approximately 80% and 60% of the respondents in Giheta practice reduced or no-tillage and/or use deep rooting plants and recycle their crop residues for other purposes and wood waste for construction, respectively. Moreover, about 20% of respondents in Giheta use leguminous-based green manures specifically grown to improve soil quality and long-term crop productivity. However, none of the respondents in Giheta reuse domestic or non-domestic wastewater or utilize bioenergy in their farming systems.

Input reduction: In both the Bujumbura and Giheta ALLs, participants expressed a strong preference for reducing or eliminating the use of chemical inputs in their farming practices. They are concerned about the potential negative impacts of these inputs on human health and the environment, as they may contain carcinogenic substances and harm biodiversity. Farmers are particularly cautious about the long-term effects of fertilizers, even though they acknowledge that fertilizers can enhance crop yields. They are aware that excessive use of chemical fertilizers can lead to soil degradation and environmental damage, ultimately reducing productivity. Instead of relying on chemical inputs, participants in both ALLs prefer to use natural alternatives. For instance, coffee husk is applied in the fields as a form of organic fertilizer, with no need to acquire protective gear; they reported no health issues related to chemical exposure with coffee husks.

The participants unanimously expressed their unwillingness to use chemical inputs in their fields. To support this move towards reduced chemical use, participants identified several needs, including capacity building in pest and disease management, access to biopesticide products, and improved access to high-quality seeds.

Soil health: In the Bujumbura ALL, farmers face significant challenges related to soil health, such as soil dryness, compaction, and the loss of organic matter and fertility. Additionally, there is a lack of sufficient and high-quality manure, limited use of crop rotation and fallowing practices. To address these issues, farmers have adopted various strategies. They are increasing the use of compost and manure, aiming for a maximum rate of 20 t/ha, to reduce reliance on synthetic fertilisers and enhance soil carbon sequestration. Binary fertilisers called "Imbura," containing nitrogen and phosphorus, are applied at a rate of 270 kg/ha to improve crop yields. Participants, including 50% of women, are actively taking care of soil organic matter and overall soil health. Additionally, 66% of participants and 36% of women are using plant cover crops to mitigate soil erosion, while 83% of participants (20% of women) are adopting perennial plant species and soil conservation practices to further reduce soil

erosion and improve soil nutrients and organic matter. The farmers in the Bujumbura ALL recognize the importance of raising awareness on soil health and the need for capacity building.

In the Giheta ALL, farmers are utilizing available and cost-effective resources like coffee peels and crop residues. They also apply fertilisers, including urea, DAP, and TSP. However, actions to take care of soil organic matter and soil health are relatively limited in comparison. Only 10% of participants, all of whom are women, are actively involved in maintaining soil organic matter and soil health. Half of the participants, (no women), are using plant cover crops for soil erosion control, and 80% of participants (no women) adopt perennial plant species. Additionally, 50% of participants, all women, practice soil conservation techniques. The farmers in the Giheta living lab express a need for capacity building and support to enhance practices that can improve soil health on their farms.

Animal health: In both the Bujumbura and Giheta ALLs, the most raised animals include *Bos taurus* (cattle), *Capra aegagrus hircus* (goats), *Gallus gallus domesticus* (chickens), Oryctolagus *cuniculus* (rabbits), and *Sus scrofa domesticus* (pigs). These animals are reared for their meat, eggs, and milk, providing valuable financial benefits to the producers, and contributing to improved livelihoods. Animal health and welfare are of significant concern to participants in both ALLs, with 100% of participants in Bujumbura and 46% in Giheta expressing care for animal health, and 49% in Bujumbura and 100% in Giheta supporting animal welfare practices. Additionally, both ALLs are exploring the introduction of domestic pollinators, with 36% of participants in Bujumbura and 26% in Giheta engaging in this activity. However, there is a recognized need for capacity building in areas such as animal husbandry, animal feeding, animal health management, and the proper use of domestic pollinators.

Biodiversity: All respondents (100%) in Bujumbura and 20% respondents in Giheta indicated that they enhance species diversity, functional diversity and/or genetic resources. 5% of respondents in Bujumbura and 80% respondents in Giheta incorporate non-food crops in their crop fields. These crops include mango, avocado, acacia, grevillea, calliandra, eucalyptus. These tree species are planted for their fruits (either eaten or sold), soil protection (against erosion, leaching and for improvement of fertility), timber (often sold for processing), and as a source of energy (firewood). All these benefits improve on their livelihoods as well as they greatly enhance and influence the biodiversity of their environments. The lack of modern knowledge on improving biodiversity has been one of the constraints in the ALLs, thus, there is a need for capacity building.

Synergy and diversification: In both the Bujumbura and Giheta ALLs, a significant majority of respondents (95% in Bujumbura and 100% in Giheta) are involved in integrated crop-livestock systems. The participants integrate crops and animals, creating a mutually beneficial system where animals produce manure for the crops, and plant residues are fed to the animals. This integrated approach involves incorporating goats, cattle, rabbits, pigs, and poultry with trees and food crops.

Additionally, a considerable percentage of participants (65% in Bujumbura and 100% in Giheta) practice agroforestry, which involves integrating crops and trees. The trees serve multiple purposes, acting as shade in plantations and providing litter for mulching, water retention, and soil conservation, thus enhancing soil fertility. However, the respondents express the need for establishing agroforestry tree nurseries on farmers' fields, tracing contour lines, and actively planting agroforestry trees. As for rotational/regenerative grazing, none of the respondents in both ALLs currently practice it to improve soil quality and forage yield. However, 100% of respondents in the Bujumbura ALL, and 80% in the ALL-practice multi-cropping or intercropping. For example, legumes and cereals are intercropped, where legumes fix and provide nitrogen for the cereal uptake. This approach also reduces the risk of disease infection and minimizes the need for chemical inputs. Furthermore, 50% of respondents in the Bujumbura ALL and 92% in the Giheta ALL practice diversification of healthy diets/diversified food

production systems. This strategy promotes the consumption of different types of food, leading to improved dietary diversity and nutrition.

In both Bujumbura and Giheta, farmers have adopted various agroecological practices to improve soil health, enhance biodiversity, promote nutrient recycling, reduce input usage, achieve economic diversification, and create synergies within their farming systems. In Bujumbura, these practices include gravity-fed irrigation, integrated soil fertility management (ISFM), planting trees, using organic fertilizers, rotation, and land fallow. Similarly, in Giheta, farmers adopt practices such as planting anti-erosion trees, using cover crops, adopting ISFM, and integrating a mixture of cereals and legume crops. By incorporating these agroecological principles, farmers enhance soil health and carbon sequestration, diversify species and genetic resources, reduce input usage, recycle organic materials, and create synergies between crops and animals. This contributes to an increase in their adaptive capacity and a reduction in vulnerability to climate change in both ALLs. While the application of some agroecological practices is a positive aspect in Bujumbura and Giheta, the use of synthetic fertilizers (urea, DAP, NPK) and pesticides can be seen a barrier to wider adoption of agroecology. Efforts to promote more sustainable and ecologically friendly alternatives should be considered here.

3.2.6. Capacity building needs

In the Bujumbura ALL,116 extension agents underwent training in various aspects of good agricultural practices for maize production. The training covered topics such as integrated pest management, proper seed multiplication and management, small-scale farm mechanization, and post-harvest management. The extension agents were equipped with practical knowledge and skills related to each stage of maize cultivation. In the Giheta ALL, where coffee is the focal crop, a training program was conducted in collaboration with the COCOCA consortium and Naturland. This training involved 40 extension agents and 200 farmers. Topics covered included social responsibility under the Naturland standard, agroforestry practices, developing a shade tree list, crop calendars, coffee farm, and coffee tree management, as well as soil health and fertility. Additionally, the training addressed climate variations, extension work methodologies, income diversification, and biodiversity.

Farmers in Bujumbura have highlighted several areas where they need capacity building. These include effective recycling and composting of maize and rice residues, the proper use of organic fertilizers and pesticides, increasing awareness of soil health and irrigation practices, understanding crop associations and rotations, and gaining knowledge about agroecology and disease control. Similarly, respondents in the Giheta ALL expressed the need for capacity building. They seek to improve their skills in recycling, utilizing organic fertilizers and pesticides effectively, understanding soil health, enhancing animal health management, promoting biodiversity, and adopting appropriate irrigation practices.

3.2.7. Conclusion on needs, context in Burundi

Conventional agricultural systems contribute to the continuous degradation of land, forests, and water, ultimately leading to low agricultural yields in most of sub-Saharan Africa, in addition to climate change. Agricultural policies for the extension of Agroecological techniques must consider the perceptions of farmers. There is also the need to build their capacity through literacy and vocational training (Tankoano and Sawadogo, 2022).

Burundi has two living laboratories, one in Bujumbura and the other in Giheta. Agriculture and livestock farming are the main activities in Bujumbura, with small-scale farming accounting for 45%

and medium-scale farming for 55%. Here, 75% of households are directly involved in maize production, as the main focal crop. In the Giheta living lab, farmers are mainly involved in coffee production (3 out of 6 family members are involved in coffee production) with an average of 50 acres per family, banana being the secondary crop. Women are not very involved in coffee growing, as their involvement depends on the tasks to be carried out on the farms, particularly during the harvest period.

In Bujumbura and Giheta, farmers are recycling farmyard manure and crop residues (coffee bean husks). Compost is also manufactured by farmers. Farmers are reducing inputs by using fewer mineral fertilisers while using coffee beans husks as organic matter sources. Farmers are facing many challenges relating to soil health. To unravel these constraints, they are using mineral fertilisers, organic matter, compost, cover crops, and perennial plant species to improve soil health, reduce erosion, and promote soil conservation. Different types of animals are produced by farmers to improve their livelihoods. All the farmers are supporting animal welfare. Farmers are using diversity of plant and tree species to improve their livelihoods, promote diversity and improve soil conservation. Agrosilvopastoral production system is used by farmers by integrating animal, plant, tree species as well as ISFM practices to increase crop production, soil conservation, and reduce the vulnerability to climate change. extension agents and farmers were trained in agricultural practices for maize and coffee cultivation.

Farmers were also trained in social responsibility, agroforestry, and crop calendar. However, farmers expressed the need for capacity building in disease control, recycling of crop residues, mostly rice husks, irrigation techniques, use of biopesticides, crop association and rotation, soil, and animal health. The knowledge of farmers, although limited and not very widespread, is a good basis for the implementation of agroecology in the two living laboratories in Bujumbura and Giheta in Burundi.

3.3. Needs, contexts and practices in Cameroon

3.3.1. Landscapes characteristics and biophysical features

Ntui is situated in the Mbam et Kim Division, in the Centre region, 100 km from Yaoundé and covers an area of 165,000 hectares. The commune of Ntui lies between 4° 20’ and 5°10' N and 11°10’ and 11°80’ E. The vegetation is characterised by peri-forest and pre-forest savannas (Letouzey, 1968; Youta, 1998). This floristic organisation comprises three biotopes: the semi-caducifolia forest; the forest-savanna contact zone or edge; and the savanna (Tsaleu et *al*., 2022). The flora is very rich in forest formations with a variety of woody species (*Ricinodendron heudolettii*, *Garcinia kola*, *Milicia excelsa,* etc.). The commune of Ntui is watered by the Sanaga, a river with a permanent flow of 2072 m^3/s, characterised by its waterfalls and rapids. The commune also has a dense network of rivers, the most important of which are Ossombo, Obagne, Meloko and Mpiem. The marshy banks at Ntui, in Ossombe and in the To'o district offer potential for the development of fishing activities. The topography is a peneplain with low hills that form the Sanaga catchment area. The altitude range varies between 400 and 950 m. The climate is Equato-Guinean, with bimodal rainfall. Average rainfall and average temperature in the area are 1150 mm and 25°C respectively. The soils are rejuvenated and impoverished orthic Ferralitic soils of the tropical tree savannah, red Acrisols and Hydromorphic soils with varying fertility (Onana et *al*., 2019). The geological formations consist of Gneiss and magmatic rocks. Cocoa (*Theobroma cacao*) is grown extensively in the area. Subsistence farming

such as groundnuts (*Arachis hypogea* L.), manioc (*Manihot esculenta* Crantz), maize (*Zea mays* L.), squash (*Citrullus colocynthis*) and yams (*Dioscorea alata*) are also practised by the local population. Forest resources have a broader genetic base than cultivated plants. However, they are much more vulnerable, as they are under constant threat from both anthropogenic and natural factors. Human population growth is increasing the pressure on natural resources, especially forest resources. The main drivers of deforestation are slash-and-burn agriculture and the cutting of wood for fuel and export. The rate of deforestation is 0.3% per year.

3.3.2. Socio-economic and environmental context

General information

The Ntui municipality comprises 27 villages. According to the latest census figures from 2005, it has a population of 20,000 people, with 10,702 men and 9,298 women, accounting for 53% and 47%, respectively. The area covers an expanse of 1650 km2 and is characterized by a predominantly rural age pyramid, showcasing a broad base resulting from a high birth rate. However, the population suffers from a deficit in the active age group due to the significant emigration of young adults to urban areas. This migration pattern leads to a higher number of women than men at these ages, with a slight increase in the population at advanced ages. The median age of the rural population is 15.8 years for the entire populace, 14.9 years for men, and 17.1 years for women. A strikingly young population, with nearly 41% under the age of 14 and 49% between the ages of 15 and 49, defines the demographics of Ntui. Culturally, Ntui embraces diversity, with inhabitants belonging to various tribes such as Sanaga, Vute, Baveuk, Mvele, and Batschenga. Additionally, there are non-native groups from different regions of the country, such as the Bamiléké, Bamoun, Haoussa, Yambassa, and Bororos. These communities organize themselves based on their cultural backgrounds, often referred to by their tribe's name instead of the village's original name.

The economic activities in Ntui are driven by trade and the exploitation of natural resources, including gathering, handicrafts, forestry, fishing, and processing of regional agricultural products such as palm oil and wood. The presence of numerous quarry products like gravel, sand, and gravel along the banks of the Sanaga River and other water bodies within the communal area further contributes to its economic prospects. Additionally, the sedimentation of sand from rocks adds to the region's economic potential.

The Mbam and Kim region, including Ntui, has a significant migrant settler population, estimated at 217,000 people, who have remained in the area after forestry companies brought them in for work and subsequently left. The average annual demographic growth rate in the Center Region of Cameroon stands at 3.1%. Migration in the municipality of Mbangasima, like Ntui, has been considerably high, resulting in a population increase of over 40% during the ten-year period from 2005 to 2015. This surge has led to an increased population density of 150 persons per square kilometer in the 19 villages within the region as of 2019.

Households' participation in cacao farming

Two projects, namely Cocoasoils (https://cocoasoils.org/) and CIRAD's soil carbon project are implemented in Ntui, about benefiting 500 farmers. For the household survey, 30 respondents or households were randomly selected. Most respondents, 77%, are cocoa producers, while the remaining produce maize, cassava, and yam, accounting for 3%, 17%, and 3%, respectively. On

average, a family in the study area consists of 5 members. The survey reveals that cocoa production is mainly dominated by males, comprising 60% of the producers, while women account for only 16%. The average farm size for cocoa production is 2 hectares. This aligns with findings from the IDH 2022 study, which shows that men tend to dominate the cocoa value chain, while women dominate the food crop value chain (GCLP Grand Mbam, 2019).

The household survey respondents and participants in focus group discussions highlighted the presence of traditional indigenous knowledge and skills from the past, which are still recognized and respected by the producers. These practices include crop rotation, fallowing, crop association, irrigation, agroforestry, the use of wood ash as an insecticide, and the utilization of animal waste for manure. Additionally, there were a few instances of compost usage among the producers.

Inclusiveness and participation

According to the respondents, access to land and natural resources is not equitable when viewed from the perspective of gender, youth, and indigenous people. These findings align with studies conducted by Bessem (2021) in the Center region of Cameroon, which also highlighted gender inequality in the cocoa sector, like the results found by Bymolt et al. (2018) and Fair Labor Association (2015). These studies noted that the contribution and participation of women in the cocoa sector often go unnoticed and unrecognized. Women face obstacles in accessing land, as societal norms often dictate that women who own land might be less committed to marriage. Consequently, a significant portion of land is reserved for men, who are seen as permanent members of the family responsible for its sustainability. On the other hand, equitable inclusion of women, youth, and indigenous people in accessing credits was reported. Everyone is entitled to credit at the same level, provided they meet the necessary requirements. According to the insights gathered from group discussions, women face harassment in various situations, such as seeking employment, accessing credit, purchasing land, and obtaining agricultural inputs. They are often marginalized, particularly concerning financial independence. Interestingly, all participants (100%) acknowledged that there are no gender differences in access, control, and decision-making over assets and the potential for increased production. However, disparities do exist at the level of land access. From the perspective of the participants, limited access to finances is attributed to the lack of collateral or guarantees, which hinders their ability to benefit from financial services. Acquiring financial services has its advantages for the producers, allowing them to carry out their activities and address social issues. Nevertheless, the cumbersome conditions for accessing these services and the requirement for collateral or guarantees are significant drawbacks. Regarding power distribution in agricultural activities, findings from the Tiransia (2011) reveal that both men and women participate, with women working more days in the fields than men. While most activities are performed by both genders, ploughing remains predominantly perceived as men's work. Women are heavily involved in labour-intensive tasks like weeding, which can be quite arduous, especially for the younger age group. Additionally, women tend to engage more in subsistence crops compared to men and play an active role in the sale and marketing of these products.

Nutritional and health status (source diversification)

Diverse range of crops from farming contributing to improve nutrition in Ntui ALL include *Pisum sativum subsp Sativa, Mangifera indica, Musa sp, Theobroma cacao, Annona muricata, Cucumeropsis mannii, Cucumis melo L, Abelmoschus esculenta.* However, based on their importance, the following crops stand out: *Zea mays, Sesamum indicum, Phaseolus vulgaris, Arachis*

hypogaea, Persea Americana, Dacryodes edulis, Citrus × sinensis, Amaranthus viridis, Solanum nigrum, Manihot esculenta.

Income diversification and financial assets

As per the findings from Bessem (2021), it was observed that 90% of cocoa farmers do not rely solely on income derived from cocoa. Among them, 9% exclusively depend on income from cocoa production. The remaining 91% supplement their income with on-farm activities, such as cultivating food crops, cash crops, timber products, and raising livestock. Within this group, 44% reported earning additional income through these activities. Bessem (2021) also revealed that the income generated from on-farm activities mostly falls within the range of CFA200,000 to CFA400,000 (USD342 to USD684) per annum. Furthermore, women involved in transporting cocoa beans from farms to ovens on their heads receive compensation ranging from CFA1,000 ($2) to CFA2,000 ($4) for each 80 kilograms of cocoa beans depending on the distance covered. In the context of the financial transactions involved in cocoa farming, for every 71,400 francs ($140) that a farmer makes, the broker receives approximately 1,500 francs ($30) as payment (Nakinti, 2012). Farmers mostly acquire their loans from cooperative and private structures to support their agricultural activities.

3.3.3. Adaptive capacity and climate change vulnerability

Extreme events: Ntui is situated in a forest agroecological zone with bimodal rainfall, characterized by peri-forest and pre-forest savanna vegetation. The climate in Ntui features two distinct dry seasons. The long dry season spans from mid-November to mid-April, while the short dry season occurs from mid-June to mid-September. These dry periods are critical factors that impact agricultural activities and livelihoods in the region. The area is susceptible to extreme weather events, and the most significant challenges faced are extreme drought, irregular rains, sudden cessation of rainfall, drying up of waterways, and frequent and violent winds. Smallholder farmers perceive the effects of drought, decreased rainfall, high temperatures, intense sunlight, and erratic and insufficient rainfall (Njoya et al., 2020; Awazi et al., 2020)

Perception: Smallholder farmers in Ntui are significantly impacted by adverse climate variations and changes (Awazi et al., 2020). All interviewed farmers (100%) have observed noticeable shifts in climate patterns. The changes they have experienced include rising temperatures, delayed onset of rains, early cessation of rains, irregular rainfall patterns, increased intensity of sunlight, drying up of rivers, strong and frequent winds, delayed sowing and harvesting, reduced crop yields, higher incidents of insect attacks, hotter dry seasons, and more extended periods of rain scarcity.

Impact: Climate change is significantly impacting agriculture in Ntui, with noticeable changes in the growing season. The length of the growing season has decreased by 60 days, reducing it from the previously observed 9 months to the current 7 months. All participants (100%) in the region have observed shifts in both the sowing and harvest dates. The sowing date, which was previously observed on March 15, has now shifted to April 15, causing a delay of 30 days. Similarly, the harvest date has shifted from June 15 (previously) to July 15 (currently), also with a noticeable delay of 30 days. These climate changes are having detrimental effects on agricultural production in Ntui, especially for cocoa and food crops. Farmers are witnessing reduced yields due to intensified drought and increased insect infestations. Cocoa farmers are particularly affected, with cocoa leaves drying up and plantations at risk of burning. Farmers have reported instances of cocoa farms being burned. Soil degradation resulting from inappropriate land use management practices is also a concern.

Action: In Cameroon, both the population and the government consider adaptation to climate change a vital goal. Farmers in the country are taking various actions to manage the adverse effects of climate change. These actions include diversifying their activities, adopting early planting, using short cycle crop varieties, implementing terrace farming, half-moons, and bunds (Tene, 2022; Njoya et al., 2020). In Ntui, farmers are also actively adapting to the changing climate conditions. They have modified their sowing dates and are cultivating swampy areas to cope with the challenges. Additionally, they are planting companion trees with cocoa, such as plantain and banana, to maintain soil moisture. Adopting effective soil management practices and practicing agroforestry are also part of their adaptation strategies. To improve soil fertility and cocoa yield, Integrated Soil Fertility Management is applied in Ntui. Cacao farmers use various inputs, including cocoa pod husk compost, poultry manure, urea, TSP, muriate of potash, calcium carbonate, kieserite, NPK fertilisers, and foliar fertilisers, either individually or in combination. Compost is applied at a rate of 1.2 tons per hectare, while poultry manure is used at a rate of 1.4 tons per hectare. Additionally, NPK 10-10-30 + 1.5 MgO + 0.2 B is applied at 387 kilograms per hectare, and urea, TSP, muriate of potash, calcium carbonate, and kieserite are used at rates of 42, 16, 52, and 42 kilograms per hectare, respectively. To further mitigate the impact of drought on cocoa plants, farmers in Ntui practice agroforestry. They plant trees such as avocado, safou, citrus, orange, ricinodendron (fruit trees), ayous, frake, dabema, inga, kandang (woody trees), and eteng, eba, mvout (medicinal trees). In managing pest and disease attacks to improve cocoa yield, chemical pesticides are employed. Insecticides like thiametoxam, imidachloprid, and bifemthrin are used, along with fungicides such as copper hydroxide, mefenoxam + copper oxide, and metalaxyl + copper oxide.

The adaptive strategies and climate change vulnerability in Cameroon are summarized in Table 12 for a comprehensive overview. These measures play a crucial role in helping cocoa farmers in the region cope with the challenges posed by climate change and improve their resilience.

Table 12: Adaptive strategies and Climate Change vulnerability in Cameroon

Living Lab	Ntui	
Extreme events	Extreme drought Irregular rains Sudden cessation of rains	Drying up of waterways Frequent and violent winds
Perception	100 %	
Impact	Change in the growing season. Change in sowing date. Yield reduction of cash and food crops	Increase of insect infestation Dryness of cocoa leaves Soil degradation
Strategy	Modification of sowing date Cultivation of swampy areas Planting associated trees with cocoa adoption of ISFM Use of synthetic NPK fertilisers Use of amendments like CaCO3 and Kieserite	Planting plantain and banana to maintain soil humidity. Use of foliar fertilisers (15-15-30+TE) Practice of agroforestry Application of pesticides and fungicide use of compost from cocoa pod husks and poultry manure

3.3.4.Farming practices

Ntui is a predominantly agricultural community with cocoa production being the principal occupation. In this locality farming is the main source of income. The average age of farm plots ranges from 8 to

46 years with a mean of 16 years, and the distance separating farm plots from the homestead is about 1km. These farms are either created (64%), inherited (34%), or purchased (2%), and the average length of ownership ranges from 10-15 years. The most important criteria for plot selection in this area are the age, the size, and cocoa tree density. Concerning the farm size, the average surface area of farms is 3,3 ha, ranging from 0,5 to 12 ha.

Monoculture of cocoa is not suitable, and farmers adopt diverse cropping systems. The main cropping system employed is the cocoa-based agroforestry system. Additionally, mixed annual crop systems are also practiced in this region. The cacao system incorporates a variety of trees, including natural trees and fruit trees like avocado, Safou, citrus, and orange. Farmers are motivated to include these trees in their farms to enhance soil fertility, provide shade, consume fruits for personal use, engage in commercialization, utilize them for medicinal purposes, and use the timber for construction. The sources of these trees are research institutes, neighbouring farms, and sometimes they grow naturally in the farm. The arrangement of trees within the cropping system is random, resulting in an average tree density of 48 trees per hectare. Among these, 18 trees per hectare are fruit trees, 20 trees per hectare are woody trees, 4 trees per hectare are medicinal trees, and 6 trees per hectare belong to other tree species. However, specific details regarding the types of mixed cropping systems (row, strip, relay), the order of mixed cropping systems, the duration of each set of mixed cropping system, the dominant crop in each mixed cropping system, the most threatened crop in the mixed cropping system, and the most productive crop in the mixed cropping system are currently not available for Ntui.

In the Ntui cocoa takes precedence as the primary crop of interest and serves as the main product for sale. Following cocoa, the second crop in the cropping system is plantain, and the third is cassava. Approximately 60% of farmers in the Ntui ALL cultivate cocoa as their focal crop, demonstrating its significance compared to other crops. The average pod yield for cocoa in this region is 5.85 tons per hectare. The average dry bean yield stands at 0.7 tons per hectare (ranging from 0.3 to 1.4 tons per hectare), which is half of what is obtained in Talba and Bokito, two other regions within the same country.

Food crop farming is a highly intensive activity in the locality, predominantly carried out by women and young individuals, who make up 77% of the interviewed farmers. This underscores the vital role of women and young people in contributing to food production and farming activities in the region.

Most farmers in this locality are well-informed about the shift in input usage, and the implementation of projects like Cocoasoils has led to a significant reduction in the reliance on chemical inputs in agriculture. The main fertilizers used to enhance the growth and yield of cacao are chemical fertilizers, including urea, TSP, muriate of potash, NPK10-10-30 +MgO+0.2 S, calcium carbonate, and kieserite. These fertilizers are applied at rates of 43, 145, 71, 387, 96, and 75 kg per hectare, respectively, and are applied twice a year. The first fertilizer applied is urea (21.5 N kg/ha) applied twice, followed by TSP, and NPK10-10-30 +Mgo+0.2 S. To enhance cocoa production in Ntui, farmers utilize compost from cocoa pod husks and poultry manure, either alone or in combination with mineral fertilizers. The nutrient content of compost from cocoa pod husks is about 2% N, 1.3% P, and 4% K. When used in combination with 100 kg of mineral fertilizers, the rate of compost applied is 1.2 tons per hectare, while the rate of poultry manure used is 1.4 tons per hectare to achieve the same K content. The use of compost from cocoa pod husks in combination with mineral fertilizers resulted in a 25 to 30% increase in cocoa dry bean yield compared to the control. When using mineral fertilizers alone, there was only a 15% increase in yield, and when using organic manure alone, there was a 30% increase.

The compost from cocoa pod husks showed a significantly higher yield increase compared to poultry manure, which can be attributed to its higher nutrient content.

3.3.5. Needs and perceptions about agroecology.

In Ntui, most farmers stated that they are not familiar with the concept of agroecology. Only around 2% of producers mentioned hearing about it through social networks and radio, but they lack a clear understanding of its meaning and principles. These farmers are unable to define, explain, or practice agroecology, and they are uncertain if they are currently practicing it on their farms.

Recycling: In the Ntui ALL, none of the six recycling elements considered were reported to be adopted by 50% of the households or more. Only 16% of the households declared using compost, while 5% use manure or cow dung, and a similar percentage (5%) utilize leguminous-based green manures in their farming systems. In terms of bioenergy usage, 26% of the respondents use resources such as corn stalks, slaughter waste, or organic agricultural waste. Additionally, 32% of the participants practice reduced or no-tillage and/or incorporate deep rooting plants in their cocoa production systems. Among the 26% using bioenergy, approximately 50% are women. However, none of the respondents reported reusing wastewater or crop residues in their agricultural practices.

Input reduction: In the Ntui ALL, participants value the use of farm inputs such as fertilizers and pesticides. They recognize that fertilizers boost crop yields, and fungicides (copper hydroxide, Mefenoxam +copper oxide, metalaxyl + copper oxide) effectively combat grain fungal diseases in their fields. Additionally, they find herbicides useful for weed control and insecticides (specifically Thiametoxam, Imidachloprid, and Bifemthrin) essential in managing insect pest infestations. None of the participants, 0%, expressed willingness to replace these farm inputs. The reason being the lack of available alternatives or concerns that alternative methods may not be as effective in achieving desired outcomes. However, the participants also indicated no interest in increasing chemical inputs, as 0% of the focus group participants were willing to do so. During the discussions, some participants mentioned the risks associated with handling these chemicals, such as acute infections like skin irritations, cough, and eye irritations. Only 14% of the participants reported using protective gear during application. Despite their reliance on chemical inputs, the participants expressed the need for capacity building in pest and disease management, soil fertility improvement, and irrigation techniques to effectively reduce input usage.

Soil health: In Ntui, several measures are being implemented to preserve soil organic matter and maintain soil health. These actions include conducting soil analysis to assess the physical and chemical properties of the soil, followed by the application of fertilizers (urea, TSP, muriate of potash, NPK10-10-30 +1.5 MgO+0.2 B, calcium carbonate, kieserite) to improve cocoa yield. Organic amendments are also applied, with the use of compost from cocoa pod husks at a rate of 1.4 tons per hectare and poultry manure at a rate of 1.2 tons per hectare. The sources of organic matter used were of good quality, with a C/N ratio ranging from 10 to 14. However, it is noteworthy that none of the participants were specifically focused on soil organic matter and soil health preservation. Only 13% of the participants employed plant cover crops to reduce erosion, while 28% adopted perennial plant species. A mere 11% of farmers incorporated soil conservation practices like channelling of erosion water and ploughing across the slope. During discussions, participants highlighted the need for capacity building on good agricultural practices, the production and use of organic fertilizers, financial support, and the supply of inputs.

Animal health: In the Ntui ALL, several animal species play a crucial role in supporting livelihoods. The three most important animal species are Bos taurus (cattle), Sus scrofa domesticus (pigs), and Capra aegagrus hircus (goats). Additionally, Gallus gallus domesticus (chickens), Oryctolagus cuniculus (rabbits), Ovis aries (sheep), and Clarias gariepinus (catfish) are also significant. These animals are raised for various purposes, including providing meat, eggs, milk, and a source of income to meet basic needs. Among the participants, 80% take care of animal health, demonstrating their concern for the well-being of their livestock. Additionally, 78% of the participants prioritize livestock welfare in their practices.

However, none of the participants (0%) introduce domestic pollinators, indicating a potential area for improvement. The participants expressed the need for capacity building in areas such as pollinator use and management, animal feeding practices, good breed selection, and animal disease management.

Biodiversity: In the Ntui ALL, none of the participants actively work to enhance the diversity of species, functional diversity, or genetic resources in their fields. Additionally, they do not incorporate non-crop plants into their farming practices. The participants hold the belief that biodiversity is a natural process and will develop on its own without human intervention. In their farming activities, selective deforestation is practiced, but the participants lack knowledge about which trees to cut down and the appropriate spacing for optimal crop growth. The use of the slash and burn helps clear land and may temporarily enhance crop production as the ash from burning can act as a fertilizer. However, this practice negatively impacts soil and reduces the overall biodiversity of the area. As a result, there is a clear need for capacity building to educate the participants on better ways to conserve biodiversity while maintaining good productivity in their agricultural practices.

Synergy and diversification: In the Ntui ALL, none of the respondents are currently involved in integrated crop-livestock systems. There seems to be a lack of understanding of these systems, highlighting the need for capacity building to train farmers on these integrated systems. On the positive side, 78% of the participants practice agroforestry, which involves the integration of crops and trees. The trees serve as shade in plantations, and their litter acts as mulch for water retention and soil conservation, while also providing nutrients for associated crops. However, there is a need for more knowledge on the management of agroforestry systems and the establishment of agroforestry tree nurseries. Rotational/regenerative grazing is not being practiced by any of the respondents. Similarly, only 8% of the respondents practice multi-cropping or intercropping for annual crops, which involves growing two dissimilar crops on the same piece of land. The respondents prefer monoculture as the management of monocropped fields is easier as compared to intercropped fields. Regarding diet diversity, none of the respondents currently practice diversification of healthy diets or diversified food production systems. Their food choices depend on what is available, and there is a need to promote awareness of the importance of diverse and nutritious diets for overall health and well-being.

In the Ntui ALL, agroecological practices that improve soil health (planting plantain and banana, adoption of ISFM, planting associated trees, use of manure and compost from cocoa pod husks, use of foliar fertilisers, use of soil amendments like CaCO3 and kieserite), biodiversity (planting associated trees, and agroforestry), recycling (use of organic fertilisers, planting trees, land fallow), input reduction (use of organic fertilisers, adoption of ISFM), economic diversification (practice of agroforestry) are adopted by farmers. By improving soil health and carbon sequestration, diversification of species and genetic resources, input reduction, recycling, economic diversification, smallholder farmers from Ntui increase their adaptive capacity and reduce their vulnerability to climate

change. While the application of some agroecological principles is evident and promising in Ntui, the continued use of synthetic fertilizers and pesticides may present a barrier to fully embracing agroecology.

3.3.6. Capacity building needs

Capacity building in the farming community of Ntui is an ongoing process aimed at imparting knowledge, skills, and competencies to farmers. Several approaches have been employed to enhance farmer capacity, with one of the recent initiatives being the Cocoa Soils project. The project utilized various methods, including training for extension agents, farmer field schools, on-farm demonstrations, the use of ICT tools for recording and monitoring, and group work. Multiple partners collaborated in capacity building for the CocoaSoils project, with organizations like CONAPROCAM, OLAM, and Beyond Beans extension agents actively involved. These partners played a vital role in providing farmers with valuable information on good agricultural practices and integrated soil fertility management specifically tailored for cocoa farming. In addition, capacity-building needs were strongly expressed in certain areas by the farmers of the Ntui ALL. Cocoa farmers expressed the need to strengthen their capacities in terms of recycling, good agricultural practices, the use of fertilisers, irrigation, and the use of agroforestry systems. Training in animal husbandry, beekeeping, fish farming and agroforestry was also strongly requested.

The CocoaSoils project provided capacity building for 2,428 cocoa farmers, with 104 extension Agents trained. Two manuals were produced in French and English: the extension agents training manual and the producer guide. A total of 400 booklets were distributed to producers. Each extension agent received a training manual, as did policymakers and private partners. The CocoaSoils project focused on training in ISFM and good agricultural practices, while promoting zero deforestation. This capacity building took place over the period 2020-2022. The training session encompassed three main themes, each consisting of sub-themes. The first theme, titled "Productivity and Deforestation," included two sub-themes: "Assessing Cocoa Plantation Productivity" and "Enhancing Plantation Productivity without Deforestation." The second theme focused on "Good Farming Practices to Boost Productivity" and delved into various aspects such as pruning, weeding, the judicious use of pesticides, strategies for pest and disease prevention without relying on phytosanitary products, and the significance of incorporating shade trees. The third theme revolved around "Soil Fertility Management" and covered multiple topics, including activities that may degrade soil quality, utilizing organic matter to enhance soil fertility, composting techniques, alternative methods of adding organic matter, and the proper application of inorganic fertilizers.

3.3.7. Conclusion on needs, contexts, and practices in Cameroon

The existing information and that collected on the community of Ntui provided an important database on the environmental and socio-economic description of the study area. The state of knowledge in agroecology and the needs in terms of capacity building were highlighted during the surveys. The Ntui living lab in the Center Region of Cameroon has an estimated population of 20,000, 53.51% of whom are men and 46.49% women.

The population is very young: almost 41% are under the age of 14 and 49% are aged between 15 and 49. The household survey involved 30 randomly selected respondents or households. Most respondents (76.7%) were cocoa farmers, while food crops such as maize, cassava and yams represented 3.3%, 16.7% and 3.3% of the respondents respectively. According to 93.3% of respondents to the household survey and participants in the focus group discussions, existing

indigenous traditional knowledge and skills include crop rotation, fallowing, crop association, irrigation, agroforestry, wood ash as an insecticide, animal waste for manure and some compost users. Men tend to dominate the cocoa value chain while women tend to dominate the food crop value chain. Access to land and natural resources is not equitable from a gender, youth, and indigenous peoples' perspective. Women's contribution and participation in the cocoa sector is largely unnoticed and unrecognized and they do not have the same access to land as men. On the other hand, there is equitable inclusion of women, young people, and indigenous peoples in access to finance.

A diverse range of crops helps to improve the nutrition of the Ntui ALL population. Depending on the importance we have; Zea mays, Sesamum indicum, Phaseolus vulgaris, Arachis hypogaea, Persea americana, Dacryodes edulis, Citrus × sinensis, Amaranthus viridis, Solanum nigrum, Manihot esculenta. Ntui is a commune with strong economic potential, as its economic activities are based on trade, the exploitation of natural resources such as gathering, crafts, forestry, fishing, and the processing of regional agricultural products (palm oil, wood).

Despite the strengths of this major agricultural production basin, the indicators of climate variability are becoming increasingly apparent. Farmers in Ntui have noticed a change in the climate. Events that have marked this change include rising temperatures, late onset of rains, early cessation of rains, irregularity of rains, increased intensity of the sun, drying up of rivers, high wind speeds, relative delay in sowing and harvesting, reduced yields, more insect attacks, lack of rain, extension of dry seasons. In Ntui, Cameroon, farmers said they had never heard of agroecology. In the Ntui living lab, when it came to recycling, only 16% and 5% of households respectively reported using compost, manure or cow dung and vegetable-based green manures in their farming systems. In the Ntui living lab, participants considered agricultural inputs (fertilisers and pesticides) to be good because fertilisers increase yields. Certain actions are carried out to take care of organic matter and soil health. These actions include soil analysis (physical and chemical properties) and the application of fertilisers to improve cocoa yields, the application of organic matter (compost and poultry manure), mulching and increasing water availability by planting Musa ssp in cocoa farms.

Farmers expressed the need for capacity building on the use and management of pollinators, animal feed, good selection of breeds and management of animal diseases. Producers in various localities in the commune of Ntui have benefited from capacity building in good agricultural practices and integrated soil fertility management (2020-2022). However, recent group discussions have revealed needs in new areas such as recycling, fertiliser production, irrigation, animal husbandry and agroforestry. The emphasis on the need to build farmers' capacity will ensure effective dissemination of technologies and other services to increase smallholder productivity and incomes.

3.4. Needs, contexts and practices in DR Congo

3.4.1. Landscapes characteristics and biophysical features

DRC has 4 living labs: Biega, Bunia, Kabare and Uvira, each with its own specific characteristics.

Bunia is the capital of Ituri Province in the north-east of the country (Malemba et al., 2019). Bunia's 2023 population is now estimated at 812,090. In 1950, the population of Bunia was 6,223. Bunia has grown by 44,445 in the last year, which represents a 5.79% annual change. These population estimates and projections come from the latest revision of the UN World Urbanization Prospects. It is geographically located at 1 35'N and 30 15’ E: at an elevation of 1250 m above sea level. It covers

an area of 4,500 ha and is divided into 24 districts, organised into 3 communes, namely Mbunya, Nyakasanza and Shari. There are 12 residential districts (AIP, 2007). From a phytogeographical point of view, the town of Bunia belongs to the SudanoZambézian region and the Lake Albert phytogeographical district. According to J. Lebrun, quoted by Meessen (1951), this district is subdivided into the following zones: a zone of medium-altitude savannahs with Themeda triandra, a zone of high-altitude savannahs and a Lake Albert zone. The vegetation here is characterised by tall grasses (1-3m high) such as *Imperata cylindrica* P. BEAUV, *Pennisetum purpureum* K. SCHUM, *Cymbopogon afronardus*, *Hypparrhenia s*p, etc (Meessen, 1951); shrubby and arborescent vegetation (consisting Acacia seyal, *Erythrina abyssinica* DC, *Ficus bubu*, *Psydium guojava* L., *Vernonia amygdalina* DELILE, *Bambusa vulgaris* SCHRAD, *Casuarina equisetifolia*, *Cupressus sempervirens* MULLER, *Cassia ciamea*, *Eucalyptus sp*., *Cassia spectabilis* DC, Ficus elastica) (Meessen, 1951). The town of Bunia is currently dominated by vegetation of anthropogenic origin, notably Eucalyptus and other fruit trees such as mango (Mangifera indica, Anacardiaceae) and avocado (*Persea americana*, Moraceae); mostly found in residential areas, which explains its discontinuity in vegetation (Malemba, 2019). On the sites sampled, the predominant vegetation is *Hyparrhenia diplandra* (Poaceae), *Phragmites australis* (Poaceae) and *Imperata cylindrica* (Poaceae). Analysis of LULC in Kabare from 1995 to 2018 showed a reduction in agricultural land (coffee, cassava, banana, and tea plantations) and forest cover (secondary forest: 15%) and an increase in dwellings and settlements (12%) and bare soil (33%) (Chuma, 2019; Chuma 2022). There are rivers and swampy forests in the town of Bunia. Bunia is linked to the small port of Kasenyi, on Lake Albert, by a 60-kilometre track via Bogoro, which runs a spectacular and dangerous 600 metres down the western escarpment of the Great Rift Valley. Kasenyi has a 155-metre (509-foot) jetty from which boats can reach the port of Mahagi at the northern end of the lake, as well as Butiaba and Ntoroko on the eastern shore of Lake Albert (on the Ugandan side) and Pakwach on the Albert Nile (Wikipedia). Bunia enjoys a tropical rainforest climate (Köppen Af) with hot, humid, and rainy conditions throughout the year. The average temperature and average rainfall are 24.5°C and 1,500 mm respectively.

Figure 4: Position of Biega and Kabare ALL (Apdik, April 2023)

The territory of Kabare (2°20.042′ S, 28°47.311′ E) is a devolved administrative entity of the province of South Kivu covering an area of 196,000 ha. This territory is divided into 2 Chiefdoms, likely Kabare and Nindja. The Biega and Kabare ALLs are in the Kabare Chiefdom. The chiefdom of Kabare extends on 126500 ha with about 460,000 inhabitants. It lies on the south-western shore of the lake Kivu, showing the limits with Bukavu town and the Kahuzi-Biega National Park (PNKB).

The Kabare territory lies from altitude 1460 m (lake Kivu level) up to 2500 m (Kajeje village level) and presents a typical humid tropical climate which is temperate by the large montane forest from Kahuzi-Biega national park, the altitude, and the lake Kivu. That gives 3 different agro-ecological zone that contributes to various and diverse agropastoral activities with a Coffee based agriculture system, a beans-legume based agriculture system and livestock-based agriculture. According to the Köppen-Geiger classification, it is an Aw3 climatic type. Average annual rainfall and temperature are 1656 mm and 20°C respectively. Rainfall increases with altitude, and even more so as you get closer to Lake Kivu (Muhindo et al., 2014; NCEA, 2018).

The Biega ALL is the upper land from 1700 m to the KBNP limits which extends on three administrative attachments namely Miti, Bugorhe and Irhambi. Kabare ALL and Biega ALL meet on the Irhambi catchment. The dominant soil in Biega is the volcanic soil which attract agriculture business on coffee, beans, banana, sweet potatoes, avocado trees, and vegetables. This high soil quality in Biega not only facilitates the agro- biodiversity but also the diverse ways to testing and adopting new crops. It provides the possibility to regenerate forest tree relictes of the past vegetation like Albizzia grandibracteata, Bridelia bridellifolia, Tabernaemontana crassa, Macaranga mildbraediii, Vernonia amygdalina, Ficus spp., Syzigium guineensis, as main components of the transitional forest zones These species are embedded in artificial agroforestry features developed for economic purposes.

In Biega ALL the rainfall is nearly 1800 mm and occurs from September and May. The air humidity is estimated between 68% and 75 % and medium temperature is 19,5% (Balagizi et al., 2014)

The most dominant soil units in Kabare are Ferralsols, Cambisols, Nitisols and Acrisols. Steep slopes are dominant throughout the area, although around Lake Kivu there are inland alluvial valleys with an interesting structure (Mulielu, 2014; Chuma et al., 2021). These areas are productive and suitable for vegetable production. The shallower soils are found on the hills and consist of schist and clay soils. Classified as recent volcanic (to the north, near the PNKB), the soils come from ancient volcanic substrates, mainly of the basaltic typeKabare's main catchment areas include: Mushweshwe, Irambi, Birava, Bushumba-Nyamununi, Lwiro, Bugorhe and Cinjoma. Several streams can be found along the hillsides, most of which have their source in the PNKB forest; the main ones are Nyawarongo at Irhambi Katana, Badibanga at Bugorhe, Mpungwe at Mudaka, Mpombe and Murhundu at Bushwira, and Kanzinzi at Bugobe (Chumaa et al., 2022).

Uvira (2 42'S, 29 and 22'E) is a town in the province of South Kivu made up of three communes: Kagando, Kalundu and Mulongwe, covering an area of 314,600 ha. Kabare's main catchment areas include: Mushweshwe Irambi, Birava, Bushumba-Nyamununi, Lwiro, Bughore and Cinjoma. Several streams can be found along the hillsides, most of which have their source in the PNKB forest; the main ones are Nyawarongo at Irhambi Katana, Badibanga at Bugorhe, Mpungwe at Mudaka, Mpombe and Murhundu at Bushwira, and Kanzinzi at Bugobe (Chumaa et al., 2022). The Kabare region has a humid tropical climate tempered by altitude. According to the Köppen-Geiger classification, it is an Aw3 climatic type. Average annual rainfall and temperature are 1656 mm and 20°C respectively. Rainfall increases with altitude, and even more so as you get closer to Lake Kivu (Muhindo et al., 2014; NCEA, 2018). The most dominant soil units in Kabare are Ferralsols, Cambisols, Nitisols and Acrisols. Steep slopes are dominant throughout the area, although around Lake Kivu there are inland alluvial valleys with an interesting structure (Mulielu, 2014; Chuma et al., 2021). These areas are productive and suitable for vegetable production. The shallower soils are found on the hills and consist of schist and clay soils. Classified as recent volcanic (to the north, near the PNKB), the soils come from ancient volcanic substrates, mainly of the basaltic type.

Uvira is located on the shores of Lake Tanganyika. The city is served by the national road RN 5 130 km south of the provincial capital Bukavu. It is limited to the north by the city of Kiliba-Kagando, to the south by the chieftaincy community of Kigongo and the Kambekulu River, to the east by Lake Tanganyika, to the west by the Mitumba chain. The vegetation of Uvira is mainly made up of wet grasslands, xerophilous copses, wooded savannas, and grassy savannas (the vegetation is of the "highland vegetation type and is essentially dominated by low-cover grassy savannas"). In the lowlands, there are swamps, while on the mountains there are shrubs (M'SABWE, 2000). The city of Uvira has a hot tropical climate, with an average temperature of 26°C and average rainfall of 800 mm (Ajuomaux and Alin, 2019). Uvira has a narrow space due mainly to its very contracted relief between the coastline of Lake Tanganyika and the high mountains that overlook the city. The summit of the mountain rises to 3,100 m above sea level. At the level of the lake and the Ruzizi delta, Uvira is at an altitude of 700 m, one of the lowest in eastern Kivu. The town of Uvira comprises two geological and geomorphological groups: The Mitumba massifs (2,000 to 3,000 m) to the west, formed by Precambrian terrains: quartzites and micaschists. There are also amphibolites, gneisses, pegmatites, and veins of white quartz. These rocks form layers inclined at 40° to 90° (Weiss G. 1959). The plain (774 to 900) to the east, represented by detrital fluvio-lacustrine formations from the Quaternary period. The relief of the town of Uvira is dominated by a flat surface varying between 780 and 900 m above sea level (M'SABWE, 2000). Erosion by gullying and landslides are currently observed in these areas and have shaped the whole region. Human activities (deforestation, overgrazing and

overexploitation of agricultural land) have also added further anthropogenic pressure, leading to soil erosion in these various living labs. Uvira's dense hydrographic network is made up of Lake Tanganyika and the rivers that rise from the Mintumba range, which rises to an altitude of over 1,500 m, and is organised by the plains (774-900 m) to the east (Mwenyemali et al., 2021). The main food crops grown in the Uvira area are starchy tubers (manioc, sweet potato, potato, yam, colcase); legumes (beans, groundnuts, pulses, soya); cereals (paddy rice, maize, sorghum, and wheat) (M'SABWE, 2000).

3.4.2. Socio-economic and environmental context

General information

Uvira is a city, a community-chiefdom, and a territory of the province of South Kivu. It is the capital of the chiefdom-collectivity of the Bavira people, with customary chief Mwami Lwegeleza III; at the same time the capital of the territory bearing the same name. It is among the 9 socio-economic cities of the Democratic Republic of Congo. The city of Uvira has 14 districts and 182 avenues. The population of the city of Uvira amounts to 137782 inhabitants including 42319 men and 44058 women with 1012 foreigners. It has an estimated density of 8611 inhabitants/km2. It has an important port, Kalundu, which connects Uvira to the city of Kalemie, in the north of the province of Katanga and the city of Kigoma in Tanzania. The city is 120 km from Bukavu, the capital of South Kivu, 88 km from the city of Baraka in the territory of Fizi and 26.5 km from the city of Bujumbura, the capital of Burundi, it is considered an extension of the city of Bujumbura due to its proximity to the latter. Because of its geographical location, Uvira is often victim of the wars that begin there and that have destroyed almost everything, both infrastructure and socio-economic fabric, the territory has three rural municipalities including kiiliba, Luvungi, and Sange. The major tribes that make up this city are the Bavira, the Bafuliru and the Barundi of the Ruzizi Plain. There are also other tribes in the city of Uvira that are not native which contribute to the demographic increase. These include: the babembe, the balega, the bashi, the Bakongo, the balaba, the bangala, the bangupangu, the bazimba, to name a few. The main languages spoken in Uvira are Fuliro, Kijoba, Kivira, Swahili with other languages such as Mashi, Kibembe, Kirundi and Kinyarwanda (Kinyamulenge) also spoken but not as widely as the main languages. Particularly Swahili is the one that unites all these groups and is the most spoken language. The economic activities of the city of Uvira are based on several factors including agriculture, trade, livestock, fishing, and fish farming. Industry and crafts also play an important role. Agriculture is one of the economic activities as it occupies 65% of the population of Uvira. The population of the city of Uvira practises traditional agriculture based on traditional farming methods and techniques in customary environments, and their tools (mostly hoe and machete) remain rudimentary. The main crops grown in the territory of Uvira are starchy tubers (cassava, sweet potato, potato, yam, colcase); Legumes (beans, groundnuts, small weight, soya and Vendjou) and cereals (paddy rice, maize, sorghum, and wheat). We also grow bananas. The indigenous peoples of this city are not traditionally breeders but through influences with Banyarwanda from the highlands, they have come to practise the breeding of large cattle. The main types of breeding practised in the city of Uvira are low-level breeding, small livestock, and pleasure.

Within the Biega LL the population is typically rural with strong lings on livestock breeding and coffee-based agriculture. There are two ethnic groups who speak the mashi dialect. The big challenge is bound on farming land access and land ownership’s Bantu group is agro-pastoralists with lack that targets the market grow cash crops: Coffea, beans, bananas, sweet potato, vegetables and yams

(taro). In Biega, the referential breeds are cattle, goats, pigs, chickens, rabbits, and guinea pigs. Unfortunately, more that 40% of rural households are landless living of feudal system.

Looking at all these parameters, the rural poverty is higher in Biega ALL. In between 1994-2010 due to regional et economic issues, the Biega living lab which was traditionally a forest landscape has drastically lost 387 ha of natural forests with their biological diversity and ecosystem services provision. The need for wood materials well as the Forest Non-Timber products (FNTPs) is still a big challenges. Relevant agroforestry initiatives are on progress, such the Primate Expertise (PEx) which is growing and wide spreading the Forest Ape Trees in communities in collaboration with Pygmy villages. The trees which are pouparized are *Syzigium guineensis, Ekebergia capensis, Tabernaemontana crassa, Maesa lanceolata, Bridelia brideliifolia, Myrianthus holstii*, closed to the agroforesterybased on specific trees by farmers'organization ADEA, RHUGWASANYE, like *Maesopsis eminii, Podocarpus millanjianus, Acrocarpus fraxinifilius, Grevillea robusta, Eucalyptus citriodora*.

Households' participation in the focal crop farming

Almost all the households practise agriculture and around 3000 have benefited from the supervision of the development agencies in the Living Lab of Uvira. Of these 50% of people surveyed grow rice, part of which is sold for income. According to 90.9% of household survey respondents and focus group participants, traditional indigenous knowledge and skills existed in the past and are still recognized and respected by producers today. Some of this indigenous knowledge include association of crops, burying of weeds through ploughing, crop rotation, irrigation etc. Generally, there is the use of small hoes, native seeds, group field activities, with little or no fertilisers or pesticides usage. Since farm sizes are small, there is generally the need for a smaller labour force as households can provide enough labour for the farm. An average family in the study area is made up of 7 members, but there are also some who have more, up to 14.

Inclusiveness and participation

In Uvira living lab, access to land and natural resources is not equitable from a gender and indigenous perspective; "The man is the owner of the land even if the woman dies the distribution is inequitable, the natives access the land but do not exploit it, the young people also do not have the right to it if they are still under the roofs of their parents". This result reinforces Mafurguemdjo's idea in 2013 which confirms that of the 40% of agricultural land available worldwide, women own less than 2% of it. The indigenous '' Mbuti'' do not have their own land after having abandoned the forest which was their natural habitat. Remy Balegamire in 2018 finds in his studies carried out in Idjwi one of the South Kivu territories in the DR Congo that women are more disadvantaged and affected because of their poorer socio-economic conditions than men, which indirectly reinforces the difference in access to land, to their detriment. It is in line with those of the Bessem 2021 studies in the Center region of Cameroon, which affirm that there is gender inequality in the cocoa sector, participants build on the idea by saying that Women and girls are discredited in the community according to customs, similar results were found by Khady NDOYE (2021) inequalities remain frequent and persistent, especially in rural areas in Senegal. The Senegalese State and its development partners are working to combat inequalities between men and women in the agricultural sector. They also work to promote gender and consider the differentiated needs of men and women in this agricultural sector. In the focus group, participants showed that inclusion is not equitable for women, youth, and indigenous peoples in access to funding. ''Access is possible for women but under the authorization of her husband, the

young people no, they are not credible because they do not have a reliable source'. 'The same system is developed too in Biega and kabare as well. Therefore, in the default of land ownership title, as an essential guarantee, prevents women farmers from benefiting from credit. The wife cannot access the credit because the pledge document is in the husband's name. In group discussions, it was reported that women are victims of harassment in several situations (during field work by armed people, in agricultural input shops on people with disabilities). It was reported also in the discussion group that the inclusion in access to land and natural resources is not equitable, women in general are discredited in the community according to customs.

Nutritional and health status

In Uvira living lab, as well in Biega and Kabare living labs, households' main foods are cassava, rice, maize, bananas, beans, meat, fishes, fruits and vegetables, own production or bought from the market; Livestock are cows, pigs, goats, sheep, and poultry. Pygmy groups include wild food plants like Urera hypeslodendron, wild yam (Diosorea minutiflora), caterpillars and honey. The Cannabis leaves are indluded in the food system. Diet diversity and meal frequency are not adequate. On average, 65% of adults consume only two meals a day, and dietary diversity and meal frequency for children is lacking even in urban areas. Only one in five children (20%) receive meals containing the minimum acceptable level of diversity, and 35% are fed the minimum acceptable number of times during the day. Overall, only 8% of children aged 6-23 months were optimally fed. When chemicals are used by farmers, there are usually no protective measures. Some cases of skin rashes, headaches, cough, flu, blurred vision, and vomiting have been reported during Group Consultation.

Income diversification and financial assets

In Uvira living lab, we found some microfinance institutions that provide credit such as SMICO, Paidek, COOPEC Kalundu and COOPEC RUZIZI. In Kabare as well as is Biega, two macrofinance institutions are operational Paidek and the COOPEC CHAI, whilst coffee. However, they are based in urban areas, and are difficult to access for producers in rural areas. The high interest rate and the guarantees required by the bank, are among what make farmers not getting credit. This requires the creation of an agricultural credit system... Nevertheless, some NGOs, such as Rikolto give financial assistance to some farmers who participate in their activities. The survey revealed that farmers earn income from agricultural activities: crop and livestock (85%). There are some who serve off-farm as workers, traders or craftsmen, the salary earned is around $200 to $30 per month. Among the crops that provide income, there are cassava, rice, coffee, and beans.

3.4.3.Adaptive capacity and climate change vulnerability

Extreme event: The Agroecological zone of Bunia is a forest zone with bimodal and a peri forest and pre forest savannah vegetation. The Agroecological zone of Kabare is a humid tropic with highland vegetation. Uvira is characterised by grassy savannah vegetation. The main land use in Bunia is agriculture especially for food crops, cocoa, cocoa based agroforestry. The extreme events affecting the living lab of Biega as well as the Living lab of Kabare are scarcity of rain, prolonged dry seasons up to 4 months, disease and pests and sometimes unpredicted storms and hails which destroy growing and blossoming plants and seedlings for Coffea, beans, cassava. These events affect the farming calendar. Meanwhile, in Uvira they are faced with irregular rainfall, extreme drought, landslide, and rise and temperature. In Bunia, the long dry season starts in January and ends mid-March, while

the short dry season starts mid-June and ends in August. In Biega and Kabare, the long dry season extends on three months (June to August) while the rainy season starts in September up to May; with a shorter dry season covering mid-January and -February. In Uvira, the long dry season starts in May and ends in September while the short dry season starts in February and ends in April.

Perception: In Bunia, 100% of farmers have also noticed a change in climate, with scarce rainfall, a long dry season, erosion, plant diseases and heavy rains when they occur. In Kabare, 100% of farmers say there is a change in climate, with a long dry season, strong sunshine day and night, irregular rainfall, proliferation of insects, flooding, and landslides. In Biega 100% of farmers recognize that the climate changes and negatively affects their farming business, since they do not know when exactly to sow and how to keep the seeds longer. Rising temperatures, crop pests, landslides and irregular rainfall affect focal crops. This is experienced by 100% of farmers. In Kamony, Rwanda, 100% of farmers cite irregular heavy rains, a prolonged dry season, strong sunshine, and parasitic diseases as reasons for climate change. Events affecting focal crops are rain, drought, fierce winds, and serious parasitic diseases.

Impact: Regarding the impact on agriculture, there has been a shift in the date of sowing in the agricultural calendar. In Kabare, from September to October for a harvest that now takes place in January, whereas it used to take place in December. Climate change is also affecting production, as yields are falling, and crops are being attacked by insect pests. In Biega this year the producer of Coffea as well the Buyers recognized that there was not the normal large campaign for coffee production because there was harvest no harvest. The normal rainfall from February to April was too heavy so that the farming season was ineffective. In Uvira from May to June. Degradation is caused by poor cultivation practices, bush fires, and loss of biodiversity. The trend is reversed in Bunia, where the semi-harvesting period moves closer together, from September to August. Other consequences include a 200 mm drop in rainfall over the last three decades. The degradation is caused by shifting cultivation.

Action: In Bunia, farmers are adapting to the change in the agricultural calendar, and public awareness of this change is being raised. In Kabare, mulching, changing sowing dates, using organic matter in the fields and diversifying crops, practising agroforestry, agroforestry using Grevillea, Ficus for firewood and mulching, fallowing (3-7 years), cover crops, erosion control with a mixed hedge, using organic (compost) or chemical fertilisers (NPK 17-17-17). Adaptation to climate change is also achieved using pesticides and fungicides to control insect pests and fungi, and biological control. In Uvira, riverside farming. Crop rotation is also practised to adapt to new climatic conditions (beans and corn, cassava - beans and corn; agroforestry with *Leuceana, Grevillea*, Eucalyptus...). Reintroducing biodiversity and extending food-growing practices. For pest management: a combination of agro-breeding, climate-smart agriculture, pest management; limiting the use of chemicals, natural pest control. The summary of adaptive strategies and Climate Change vulnerability in DRC is presented in the Table 13.

Table 13: Adaptive strategies and Climate Change vulnerability in DRC

Living Lab	Biega	Bunia	Kabare	Uvira
Extreme events	Scarcity of rain Prolonged dry season Disease and pest attacks heavy rain	Long dry season scarcity of rain diseases and pest heavy rain	Rise in temperature Crop pests Landslides Irregular rainfall	Irregular rainfall Extreme drought Landslides rise temperature
Perception (%)	100	100	100	100
Impact	yield reduction delay in cropping season	Shift in the sowing date	Shift in the sowing date	Shift in the sowing date
Strategy	change in the agricultural calendar, sensitization of the community on this change change of sowing dates grown under the shade of banana trees or coffee trees. staggering of sowing periods mulching of coffee trees - cultivation of cover plants that are too rich in water cultivation of drought-resistant or water-demanding varieties	Adaptation in changing the agricultural calendar. Practice of fallow (2-3 yrs.)	Mulching Change in sowing date. Use of organic matter Crops diversification Practice of agroforestry Practice of fallow -3-7 yrs.) Use of cover crops Erosion control use of compost Use of chemical fertilisers (NPK 17-17-17) Use of pesticides, fungicides, and biological control	Riverside farming Crop rotation Agroforestry practice Reintroducing biodiversity Extending food growing practices Combination of agro breeding Climate-smart agriculture Pest management Limiting the use of chemicals Natural pest control

In DRC, the extreme events reported by farmers from Biega and Bunia are prolonged dry season, pest and disease attacks, and heavy rains. The farmers from Kabare and Uvira reported extreme drought, irregular rainfall, Landslides, pest attacks, and a rise in temperature. All the farmers (100 %) from Biega, Bunia, Kabare and Uvira perceived the effects of CC. The major impacts observed in all the LLs are modification of agricultural calendar, and yield reduction. Small-scale producers in all the LLs in DRC are adopting several strategies to adapt to climate change except for Bunia. The implementation of the CANALLS project could be facilitated by these existing initiatives. However, the use of synthetic fertilisers alone and synthetic pesticides can be a barrier for the implementation of the CANALLS project in DRC.

3.4.4. Farming practices

In DRC ALL the number of plots owned by a farmer is 2 in Kabare and Biega and 1 in Uvira. The age of the plots is from 2 to 10 and 14 respectively in Bunia and Kabare and Biega while in Uvira are fields that have been exploited since colonial times.

In Bunia, Kabare, Biega and Uvira, the distances between agricultural plots and homes of farmers are about 1 to 10 Km, 0 to 1 Km, 2Km and 2 Km respectively. These plots were chosen according to whether they were close to the main road, having easy accessibility, with good security, being a fallow area for Bunia, while in Kabare and Biega there were no criterion and Uvira the choice was made according to the receipts of the plots. They are acquired in cash or in a usufructuary at Bunia and their length is unlimited, by inheritance or purchase at Kabare and Biega and by rental and purchase at Uvira for 1 year or in perpetuity when the purchase is made. The zone intervals at the highest are 100, 15X5, 200x80, unknown, 0.06 to 5 Hectares respectively in Bunia, Kabare, Biega and Uvira

Cocoa with banana also with palm oil and annual crops, rice with maize are the types of mixed crops that are practised in Bunia. At Kabare mixed cropping involves shade trees with annual crops, and at Uvira subsistence crops mixed with industrial crops are common. The order of mixed crops is not defined in Bunia but in Kabare it is coffee-banana, shade tree-annual crops and Uvira cassava in the lead plus corn and peanuts. The length of each set of mixed cropping systems depends on the site at Bunia but at Kabare coffee, banana and shade trees take many years while annual crops take 4 months and at Uvira the length is higher. Coffee remains the most dominant and productive crop in each mixed cropping system while in Uvira it is cassava and in Bunia cocoa, but palm oil and plantain can also be added for productivity. Groundnut is the most threatened crop at Uvira. In Kabare, coffee, bananas and beans are the potential crops and let's say that the practice of monoculture at a short duration is applicable unlike Bunia.

Some of the factors affecting cocoa production are:

1) Smallholders, particularly women and young people lacking market certainty, incentives, and financial and labour capacity.
2) Cocoa price fluctuations heavily impact on smallholder farmers' livelihoods.
3) Climate change threatens the global supply of cocoa.
4) An ageing farmer population, which curbs investments in innovation. Young people are increasingly abandoning rural areas.
5) Farmers' organisations often lack the capability to become trustworthy business partners that can represent their members effectively.

In the DRC everywhere they are informed about the change (reduction and/or increase) in the use of inputs due to each project and accept that there is a reduction in chemical inputs. In Bunia they use fertilizer and organic Uvira chemical fertilizer. As type of nutrients applied to Bunia Manure from the farm with a formulation rate of "3 to 4 tons per hectare, in Kabare and Biega 81.8% of the farmers apply organic fertilizer on coffee with a formulation rate of 53, 3% of farmers apply approximately 20 t/ha of organic fertilizer and to Uvira nitrogen, phosphorus and potassium fertilizer then organic matter. The formulation rate of DAP 150 kg to 250 kg, NPK 150 kg to 250 kg, Urea 100 kg. In Bunia, the frequency of application is once in the installation of the plantation, in Kabare the compost and in Uvira twice a year. Fertilizers 1, 2, and 3 used at Kabare are cow manure, goat manure and pig manure. In Bunia it is only manure and in Uvira DAP during transplanting, Urea at one and a half months after transplanting, and organic matter. In Biega sites as well as in Kabare farmers develop

negative attitudes vis-à vis of chemical fertilizers as agents of soil infertility and human body poisonings.

In the DRC, precisely at Kabare, Biega and Uvira, the range from the lowest to the highest yield of dry beans is respectively between 0.4 to 3 Tons per hectare and between 0.5 to 1.5 Tons per Hectare; the average dry bean yield is 0.8 for Kabare and 0.750 for Uvira.

3.4.5.Needs and perceptions about agroecology

In Biega, 50 % of farmers have heard about agroecology but no examples were given.
About 60% of the farmers in Kabare, have heard about agroecology during participation in agroforestry workshops, but they have vague knowledge. They also mentioned the use of compost as one practice related to agroecology. Their capacity to use compost was strengthened during some training courses.
In Uvira, only 1% of the farmers have heard of agroecology. Those who have heard about it consider agroecology as a method of cultivation of fields without destroying the environment, Highest Farmers have avoided bushfires, throwing bags everywhere, and burning plastics, conserving biodiversity by using compost and organic fertilisers.

Recycling: Almost all the interviewees in Biega living lab use compost, manure or cow dung in their farming systems, crop residues, as well as leguminous-based green manures grown with the specific purpose of improving soil quality and consequently the long-term productivity of crops, in their farming systems. None of them reuses wastewater, bioenergy, and reduced tillage. In Kabare, all the elements are adopted by more than 40% of the respondents. The adoption of compost and leguminous-green manure as well as crop residue recycling is done by all the respondents. Farmers compost and transport kitchen waste to the plot. Manure is also used as fertiliser. About 45% of the farmers use wastewater in home gardens to maintain adequate humidity. About 55% of the respondents use corn rachis and stalks as fuel/bioenergy for cooking and ironing clothes. Zero tillage is used by all respondents in the cultivation of banana and coffee to avoid damaging the roots of crops. About 48% of the farmers cut and recycle banana tree trunks as fertilisers. They also use pulp and cords as building materials. Except for the reuse of wastewater adopted by 45% of respondents in Uvira, the remaining 5 elements are adopted by all the participants in the focus group discussions.

Input reduction: In the DRC living labs, 40% of respondents in Biega and 90% respondents in Uvira are willing to reduce or replace chemical inputs, while Kabare respondents do not use chemical inputs. Across both living labs, 10% of respondents indicated the experience of diseases linked to chemicals, which include both acute hazards due to short term exposure to the chemicals especially during application (such as skin irritations, cough, dizziness etc.) and chronic hazards, due to long term exposure to these chemicals which might lead to complicated health risks. 13% of the total respondents have protective gear for chemical application. This is since only 5% of the respondents use chemicals, while 95% have never used chemicals before. 5% of the respondents stated that chemical fertilisers are good, while 95% consider them to be bad, since their effectiveness declines over the seasons and inappropriate application destroys the environment and soil.

Soil health: In the Kabare living lab, farmers are facing challenges relating to soil health like soil degradation due to soil erosion. To unravel these issues, conservation and Agroecological practices are used. Compost, cow dung, goat manure, and pig manure are used as organic matter sources at the rate of 20 ton/ha. Mineral fertilisers are not used. 73 % of the participants and 88 % of women are

taking care of the soil organic matter and soil health. Only 5 % of the participants without women are using plant cover crops to reduce soil erosion. 50 % of participants and 50 % of women adopt perennial plant species. 77 % of participants and 88 % of women adopt soil conservation practices. The participants requested the increase of organic matter supply, the establishment of water retention basins, and the construction of terraces. In the Biega living lab, 100 % of the participants are taking care of the soil organic matter and soil health using indigenous practices and knowledge. 100 % of the participants are using plant cover crops to reduce soil erosion. 10 % of participants without women adopt perennial plant species. None of the participants, 0 % adopt soil conservation practices. The participants requested the increase of organic matter supply, the establishment of water retention basins, and the construction of terraces. In the Uvira living lab, farmers are facing challenges relating to soil health like soil degradation due to soil erosion and excessive use of fertilisers, and soil fertility decline. To unravel these issues, leguminous trees, farmyard manure, water management, household waste, compost, crop residues and cow dung are used in the various production basins. Composters are installed in the various basins. Compost is used at the rate of 12 tons/ha. Diammonium phosphate, Urea, NPK fertilisers are used. DAP is used at the rates ranging from 150 to 250 kg/ha. 27 % of the participants without women are taking care of the soil organic matter and soil health. 13 % of the participants without women are using plant cover crops to reduce soil erosion. 50 % of participants and 50 % of women adopt perennial plant species. 15 % of participants and 10 % of women adopt soil conservation practices. The participants raised the need for capacity building for good agricultural and soil conservation practices.

Animal health: In the DRC living labs, livestock related to cattle, goats, chickens, rabbits, and pigs are being the three most important animal species reared, mostly for consumption. 100% of participants from Biega and Uvira, and 15% of participants from Kabare support animal health. 100% of participants from Biega and Uvira and 40% of participants from Kabare support livestock welfare, especially through the organization of breeders in a cooperative for the exchange of initiatives on animal welfare. However, 100% of the participants in discussion group in Uvira and 20% of the participants indicated the need for improvement of animal health, which included: the need to set up structures for pharmaceutical products in the villages to access animal medicines, and training on the feeding and care of animals. Twenty-eight percent of participants across the RDC living labs introduce domestic pollinators as they participate in bee farming and need more capacity building on the proper use of these bees as effective pollinators.

Biodiversity: any respondents in Biega, 85% respondents in Kabare and 88% of respondents in Uvira indicated that they enhance species diversity, functional diversity and/or genetic resources. Fifty percent of respondents in Biega, 88% of respondents in Uvira and 75% of respondents in Kabare incorporate non-food crops in their crop fields, medicinal plants, and woods. They incorporate wood trees that provide shade in coffee farms and produce wood for building and firewood. They also incorporate fruit trees that provide fruits for consumption. The benefits obtained from this incorporation improve their livelihoods as well as enhance and influence the biodiversity of their environments. However, they also practice slash and burn (reduce labor cost during field preparation for planting and low labor cost), which destroys the soil and reduces the biodiversity of the area. Among the challenges, the capacity building of farmers with regards to the valuation of biodiversity, improvement, and accessibility to improved seeds, subsidize agricultural inputs and abolition of agricultural taxes, availability of agricultural credit, and eradication of bushfires in peasant farms will all help to improve on the biodiversity of the living lab.

Synergy and diversification: All the respondents in the Biega living lab, 59% of respondents in the Kabare and 100% of respondents in the Uvira living lab are involved in integrated crop-livestock

systems with 100% of respondents of the Biega living lab, 59% of respondents of the Kabare and 90% of respondents in the Uvira living lab integrate native crops and animals. These systems are beneficial as animals produce manure for the crops and the plant residues are fed to the animals. This system makes use of the integration of goats, cattle, rabbits, pigs, and poultry with trees as well as food crops. 100% of the participants in Biega, 69% of respondents in Kabare and 36% of respondents in Uvira practice agroforestry (integration of crops and trees). These trees serve as sheds in plantations (coffee), and their litter also serves as mulch (for water retention and soil conservation), fertilizers (humus) for the associated crops. However, the respondents raised the need for the establishment of agroforestry tree nurseries, as well as the provision of better agroforestry tree species. No respondents across the DRC living labs practice rotational/regenerative grazing to improve soil quality and forage yield. In the Biega living lab, 100%, 77% of respondents in Kabare and 77% of respondents in Uvira living lab practice multi-cropping or intercropping. This practice involves the cropping of two dissimilar crops on the same piece of land to improve productivity. This could involve the intercropping of legumes and cereals where the legumes fix and provide nitrogen for the cereal uptake. This system helps to reduce the risk of disease infection as well as a reduction in the use of chemical inputs on the farm. 100% of respondents in the Biega living lab, 34% of respondents in the Kabare living lab and 100% of respondents in Uvira, practice diversification of healthy diets/diversified food production system. This involves the consumption of different types of food for better nourishment.

In Biega, Agroecological practices that improve soil health (use of organic matter, use of leguminous trees, use of cover crops, practice of ISFM, use of compost, use of fallow, no tillage, biological control of pest and disease, practice of fallow), biodiversity (practice of agroforestry, use of leguminous trees, crops diversification), recycling (use of compost, practice of agroforestry), input reduction (use of compost, use of micro doses of NPK fertilisers), economic diversification (practice of agroforestry) are adopted by farmers. In Bunia, only one Agroecological practice that improves recycling (practice of fallow for 2 to 3 years) was reported by farmers. In Kabare, Agroecological practices that improve soil health (use of organic matter, mulching, use of cover crops, erosion control, use of compost, biological control of pest and disease, practice of fallow), biodiversity (practice of agroforestry, use of cover crops, crops diversification), recycling (use of compost, practice of agroforestry), input reduction (use of compost), economic diversification (practice of agroforestry) are adopted by farmers. In Uvira, Agroecological practices that improve soil health (Practice of climate smart agriculture, natural pest control), biodiversity (crop rotation, practice of agroforestry), recycling (practice of agroforestry), input reduction (limited use of chemicals), economic diversification (practice of agroforestry), synergy (combination of agro breeding) is adopted by farmers. By improving soil health and carbon sequestration, diversification of species and genetic resources, input reduction, recycling, synergy, economic diversification, smallholder farmers in Biega, Kabare and Uvira increase their adaptive capacity and reduce their vulnerability to climate change. Adaptive strategies are limited in Bunia ALL. The application of some principles of agroecology by these farmers is a good entry point and is favourable for the implementation of the CANALLS project in the Living labs of Biega, Kabare and Uvira, except for Bunia. However, the application of synthetic fertilisers (Urea, DAP, NPK) alone, and pesticides is a barrier to the adoption of agroecology and the implementation and the uptake of the CANALLS project by the communities in the involved Living labs.

3.4.6. Capacity building needs

In the DRC, producers from the Biega and Bunia living labs benefited from capacity building in GAP, ISFM and agroforestry respectively. Producers in Uvira benefited from training led by Rikolto. These producers also expressed a need for training that could significantly increase their income.

In the living lab of Biega (DRC), producers were trained on the following subjects: assessing cocoa farm productivity, introduction to increased farm productivity without deforestation, pruning for improved soil fertility and efficient use of soil nutrients and cultural systems for improving cocoa production in Mambasa. Similarly, in the living lab in Bunia (DRC) around 1161 farmers were trained in post-harvest management, seedlings nurseries management and agroforestry. In the Living Lab in Uvira (DRC) around 3000 farmers have participated in training facilitated by Rikolto in Good Agricultural Practices, marketing and cooperative governance and financial management. Officers have received training on the GAPs, post-harvest, Nyange Nyange standards and certification, Smart valley, introduction to the SRP standard, the manufacture of organic fertilisers and biopesticides.

In the Democratic Republic of Congo, producers in Biega expressed a need for training in recycling, soil health, input use, biological control, and biodiversity. In Kabare, knowledge of input use, biological control, processing of organic waste and other recyclable organic fertilisers, animal feeding and care, training in biogas production, the importance of biodiversity, soil health and irrigation practices is also lacking. Knowledge of good agricultural practices, animal health and irrigation (Uvr) were cited as needs by the people of Uvira.

3.4.7. Conclusion on needs, contexts, and practices in DRC

According to the latest revision of the United Nations World Urbanization Prospects, the population of Bunia in 2023 is estimated at 812,090, with an annual variation of 5.79%. The territory of Kabare is a devolved administrative entity in the province of South Kivu, covering an area of 196,000 ha. Its population was estimated at 461,511 in the 1960s. Uvira is a town in South Kivu province. It is one of the 9 socio-economic towns in the Democratic Republic of Congo. Uvira has a population of 1,377,782. The main land use in Bunia is agriculture, particularly for food crops, cocoa, and cocoa-based agroforestry. Kabare's main crop is coffee In the Uvira living lab, around 54.5% of households focus on paddy rice production, while 36.3% produce cassava, illustrating the importance of agriculture in the region's livelihoods. Kabare's main crop is coffee In the Uvira living lab, around 54.5% of households focus on paddy rice production, while 36.3% produce cassava, illustrating the importance of agriculture in the region's livelihoods. Agriculture is the main source of income in these areas. In Uvira, economic activities are based on agriculture, trade, livestock farming, fishing, and fish farming. According to the survey of 11 households in the Uvira Living Lab, 54.5% and 36.3% of the 11 respondents drawn at random produce paddy rice and manioc respectively, while the others produce maize, beans, and tomatoes (72.7%, 18.1% and 18.1% respectively). Agriculture accounts for 65% of the population's economy. Agricultural practices in the Living Labs are mainly based on traditional methods and indigenous knowledge.

Some of this indigenous knowledge includes combining crops, burying weeds by ploughing, crop rotation and irrigation. The working tools (hoe and machete for the most part) remain rudimentary. According to the survey, the largest producers of paddy rice in the survey are men, who account for 60%, while women account for only 40%. Women are less present in rice value chain activities with 7% participation, while men tend to dominate with 93%. According to the information recorded during the focus groups, access to land and natural resources is not equitable from a gender perspective.

The man owns the land, even if the woman dies, so the distribution is inequitable. Indigenous people have access to the land but do not use it, and young people are not entitled to it while they are still living under their parents' roofs. The absence of land titles as an essential guarantee prevents women from benefiting from credit. The pledge document is in the husband's name. In the group discussions, it was reported that women are victims of harassment in several situations (when working in the fields by armed men, in agricultural input shops by handicapped people).

A few microfinance institutions that grant credit have been identified in the study area. However, they are based in urban areas and are difficult for producers in rural areas to access. The high interest rate and the guarantees required by the bank are among the reasons why farmers do not obtain credit. Nevertheless, some NGOs, such as Rikolto, provide financial assistance to certain farmers who participate in their activities.

In terms of nutrition and health, dietary diversity and meal frequency are not sufficient. On average, 65% of adults eat only two meals a day, and dietary diversity and meal frequency for children are inadequate, even in urban areas. Only 20% of children receive meals containing the minimum acceptable level of diversity, 35% are fed the minimum acceptable number of times during the day and only 8% of children aged between 6 and 23 months are fed optimally. Climate change implications differ between living labs. In Biega, extreme events include scarce rainfall, prolonged dry seasons, pests and diseases, and sometimes heavy rains that destroy beans and cassava. In Kabare, there is a sharp increase in temperature, crop pests, landslides, and irregular rainfall, while in Uvira, they are faced with irregular rainfall, extreme drought, landslides, and an increase in temperature. A shift in the sowing date in the agricultural calendar was observed in all the living labs.

In terms of knowledge of agroecology, 50% of farmers in Biega, 60% in Kabare and 1% in Uvira felt they had heard of it. In terms of recycling, most farmers surveyed at the Biega living lab use compost, manure, or cow dung in their farming systems, as well as harvest residues and legume-based green manures grown specifically to improve soil quality and hence long-term crop productivity. In Kabare, around 45% of farmers use wastewater in vegetable gardens to maintain adequate humidity, and 55% of respondents use maize cobs and stalks as fuel/bioenergy for cooking and ironing clothes. In the DRC living labs, 40% of respondents in Biega and 90% of respondents in Uvira are willing to reduce or replace chemical inputs, while respondents in Kabare do not use chemical inputs. In the Kabare living lab, farmers face soil health challenges, such as soil degradation due to soil erosion. In the Biega living lab, 100% of participants take care of soil organic matter and soil health. 100% of participants use plant cover to reduce soil erosion.

Apart from Kabare, producers in the DRC's live laboratories have benefited from training in previous years. Needs in terms of recycling, soil health, input use, biological control, biodiversity, and animal health have been strongly expressed in the country. Therefore, by focusing on capacity building, promoting agro-ecological practices, and addressing issues of access to land, the DRC can strengthen its adaptive capacity, improve resilience to climate change and implement inclusive and participatory approaches to ensure the dignity and well-being of all communities involved in the agricultural sector.

3.5. Needs, contexts and practices in Rwanda

3.5.1. Landscapes characteristics and biophysical features

Kamonyi is a district located at 2°00′ S and 29°54′ E in the central region of Rwanda. Kamonyi District is one of the eight districts that make up the Southern Province. Kamonyi hosts the Rwanda's ALL. It is made up of 12 Sectors: Gacurabwenge, Karama, Kayenzi, Kayumbu, Mugina, Musambira, Ngamba, Nyamiyaga, Nyarubaka, Rugarika, Rukoma and Runda: 59 Cells and 317 Villages (Ubudehe data 2017), over a total area of 65550 ha (Kamonyi District Development Plan, 2018). The vegetation of the Kamonyi district, which was originally shrub savannah, has been endangered by strong demographic pressure that has favoured agriculture. The flora is characterised by natural and planted forest and agroforestry species such as *Grevillea robusta*, coffee, avocado, eucalyptus, erythrina, pinus in hillside and papurus in uncultivated wetland. There are also several species of natural flora and the Rukaragata natural forest in Muganza-Karama. Kamonyi district is drained by the Nyabarongo river to the east and north of the district and by the Akanyaru river which borders the district to the north and east. There are also several small springs, such as Kayumbu, Bakokwe, Gikoro, Mukunguri, Nyabuvomo, Bishenyi, Gatimbazi and Ruvubu. The district has around 843 water sources. Its relief consists of low-lying plateaux, except in the western part, which is more mountainous. The district lies between 1,310 and 2,000 m above sea level. The eastern and northern parts of the district are occupied by the great Nyabarongo valley. The district's high peaks are as follows: Ijuru rya Kamonyi and "Cubi na Marenga ", while Mukunguri and Kona ka Mashyuza are the lowest points. Kamonyi district enjoys a moderate climate. Rainfall is frequent and varies between 1,200 and 1,400 mm and the average temperature is 20ºC. The soils in Kamonyi district are generally permeable and moderately fertile, mainly Ultisols, Inceptisols and Oxisols. Agricultural productivity is increasing year on year thanks to modern land management techniques. However, the district is faced with soil erosion and over-exploitation due to demographic pressure. The district's economy is based mainly on traditional agriculture and livestock farming. The main crops grown in the Kamonyi district are maize, beans, cassava, rice, soybean, vegetables, and bananas. The total area for land use consolidation is 46,268 ha, broken down as follows: 4,500 ha of maize; 27,500 ha of beans; 9,724 ha of cassava; 1,126 ha of rice; 1,644 ha of soybean; 620 ha of vegetables and 1,153.5 of improved banana. The district's wildlife has, because of the clearing and destruction of the natural forests, witnessed the disappearance of several animal species such as gazelle, jackal and hare. However, there are still a few amphibians, reptiles, butterflies, and birds.

3.5.2. Socio-economic and environmental context

General information

The Rwanda ALL Kamonyi has 66,622 households with a population of 377,257 inhabitants 197.882 males and 179,475 females. (Environmental and social management framework -ESMF, 2022). With respect to land governance and conflict regulation, customary or traditional laws are not applicable. This is regulated by the judiciary law of the state. The UN report (2017) expatriates more on this by stipulating that the rural population do not have a clear understanding of the justice system especially regarding their right and entitlement and thus tend to perceive justice as a privilege for the rich. Agricultural land in Kamonyi district can be divided into two: the up hills and the wetlands. About 100% of uphill farmers own their farmland and have total control over what they produce. However, these lands are usually not enough to meet the needs of farmers. They are however compelled to rent land

from other farmers who have enough. Wetlands are under the supervision of the government and farmers are instructed on what to produce based on the state crop priority.

Households' participation in the focal crop farming

The focal crop of the district is cassava. The economy of the district solely depends on traditional agriculture and livestock. Field surveys revealed households are involved in cassava production with an average land size of 0.5 ha. Focus group discussion and household interviews reported a 100% appreciation of traditional and local knowledge used to improve crop productivity. This knowledge ranges from creating ditches to retain water and control erosion, crop rotation and the use of hybrid seeds.

Inclusiveness and participation

There is no preference in the access to land and other natural resources among women, youth, and indigenous people. Couples, generally, have equal rights to their properties, however, the right of the child is protected by the parent land ownership right. Major agricultural decisions are taken by both men and women though men have dominant control over livestock, forest, and other natural resources like land. To increase citizen participation in development, the government created a platform that brings together authorities, citizens, organisations, and civil societies in all the districts to facilitate dialogue, debate and promote informed decision making. This ensures perfect monitoring, evaluation, and development planning as well as a system of accountability and responsibility for individual actions (UN Rwanda, 2017). This is in line with baseline studies that highlighted a collaborative platform among farmers where their efforts, knowledge and contributions are recognised and accountability provided irrespective of gender, age, social and economic status. Rwanda has a gender inequality index (GII) of 0.383, ranking it the 85th of 159 countries globally, with 57 % of women in parliamentary seat. About 10% of adult women have at least secondary education as against 16% for their male counterpart (UN Rwanda 2017). This provides a great opportunity for the initiation and promotion for specific programs that will increase women inclusiveness which was highly recommended during studies. Baseline studies revealed few cases of reported rape of young girls in the community though not very frequent.

There is no discrimination about access to credit. Respondents indicated 85% of the farm household have access to funding while 15% don't. However, though this population has access to credit only 20% seek credit (European Union, 2018). Financial institutions include the savings and credits co-operative (SACCO), commercial banks and farmers groups. However, just like most farming communities, the major difficulty in accessing credit is collateral, high-interest rates, and low farmers' income. There exists a cooperative movement., "Maize and Vegetable Farmers' Cooperative of Kamonyi" (COAMALEKA) with 1015 members (547 women and 468 men) that provides training on modern agricultural practices, provide health insurance, access to livestock, collective collection and marketing of farm produce and advocacy with donors and other external collaborators.

Nutritional and health status

A wide variety of agricultural products in the Kamonyi district have been identified as significant contributors to the nutritional well-being of the population. These include cereals and legumes, with *Arachis hypogaea*, *Phaseolus vulgaris*, and *Glycine max* being of utmost importance. Fruit trees like *Persea Americana*, *Solanum macrocarpon, Dacryodes edulis*, and *Citrus* × *sinensis* also play a crucial

role. Additionally, vegetables such as *Amaranthus viridis* and *Solanum nigrum*, as well as roots and tubers like *Manihot esculenta*, are vital components of the local diet. Among the animal species, the most significant livestock are *Gallus gallus domesticus, Ovis aries, Sus scrofa domesticus*, and *Capra Capra aegagrus hircus.* To enhance productivity and combat pest and disease challenges, farmers have resorted to the use of agrochemicals. However, the application of these chemicals has resulted in some negative effects. According to the survey, approximately 47% of farmers have reported health issues, including skin allergies and respiratory problems, arising from the handling and manipulation of these chemicals, even when using personal protective equipment such as boots, face masks, and blouses.

Income diversification and financial assets

While farm products are both for subsistence and sales, 70% of these farm products are for subsistence use. However, farmers can diversify their income through other off-farm activities like small-scale transformation and trade. The middlemen facilitate provision of loans and technical equipment to farmers and input supply. They provide important information to farmers and create initiatives for new markets. However, their negative effects on farmers' productivity such as delayed payments, low prices for farm produce, supply of poor and unverified quality inputs, high interest rates for loans, price imposition and the unavailability of loans at desperate moments to farmers were not overlooked.

3.5.3. Adaptive capacity and climate change vulnerability

Extreme events: The frequency of rainfall is rather sufficient in the Kamonyi district. Rainfall varies between 1.200 and 1.400 mm. The long dry season begins mid-June and ends mid-September while the short dry season begins mid-January and ends mid-March. Kamonyi district is, however, affected by weather variability and climate change, especially by floods, strong winds, landslides, and drought. The environment is also damaged by the traditional exploitation of mining and quarries that cause soil erosion, floods, and sedimentation. The four extreme events that have affected the district and community over the past decade are heavy rains, drought, cyclonic winds, pests, and serious crop diseases.

Perception: Farmers in Rwanda have reported significant changes in the climate over recent years. These changes encompass various aspects, including increased temperatures during both dry and rainy seasons, decreased rainfall, delayed onset of seasons, more frequent dry spells, showers, extreme floods, and severe droughts. Moreover, there have been fewer foggy days, reduced instances of frost, and increased winds, while hailstorms have become less frequent (Nkurunziza et al., 2023; Muneza, 2021). In the specific region of Kamonyi, all farmers (100%) have observed these climate shifts in the past decade. These changes are evident in irregular heavy rainfall, prolonged droughts with intense sunshine, cyclonic and unusual winds, low crop yields, and soil degradation. The growing season has also undergone a noticeable change, with all farmers (100%) in Kamonyi experiencing a reduction from 10 months to 7 months. Additionally, there has been a shift in sowing dates. These alterations in climate and agricultural schedules pose significant challenges to farmers in the region.

Impact: Climate change is significantly impacting agriculture in Rwanda, leading to a range of challenges for farmers. These include reduced streamflow, an increase in landslides, heightened soil erosion, and lower yields for crucial crops such as maize, beans, tea, and Irish potatoes. Moreover,

pests and diseases affecting these crops have seen a rise due to changing climatic conditions. Livestock farming is also affected, as there is a reduction in milk production from cows, and an increase in disease-affected cows, goats, and sheep. Furthermore, these changes have had adverse effects on human health, contributing to less healthy populations in the region (Nkurunziza et al., 2023; Muneza, 2021). One of the significant impacts of climate change on agriculture is the alteration of the growing season. Over time, the growing season has seen a decline of 90 days, reducing from the previously observed 10 months to the current 7 months. All participants (100%) have noticed a change in sowing dates as well. Previously, the sowing date occurred on 15th March, but now it takes place in September and February for the first and second seasons, respectively, with a shift of 30 days. Similarly, there has been a noticeable shift of 30 days in the harvest date, moving from January and June (previously observed) to February and July, respectively, for the first and second seasons currently.

Action: Farmers in Rwanda have employed various adaptation strategies to cope with the challenges posed by climate change. These on-farm strategies include ex-ante, in-season, and ex-post approaches. Key adjustments entail adopting improved varieties for maize, beans, and Irish potatoes, implementing increased irrigation, considering changes in farm location, sowing seeds earlier, and reseeding if necessary. Furthermore, farmers are making greater use of fertilizers and pesticides to enhance crop growth and protect against pests and diseases. Soil conservation practices, such as constructing ditches, terraces, using perennial grasses, soil cover crops, and mulching, have become more prevalent. Livestock owners are also investing in veterinary care for their cows, goats, and sheep and providing them with better feed options. In the Kamonyi region, smallholder farmers are taking specific actions to adapt to the changing climate. These actions involve early land preparation before the onset of rains, using improved crop varieties, and mulching with crop residues. Farmers are also carefully timing their sowings to coincide with optimal conditions, collecting water from house roofs and using water pumps for crop irrigation. To combat erosion, they are planting agroforestry and anti-erosion species, setting up dams on hillsides to retain runoff water. For effective soil management and yield improvement, ISFM practices are commonly used in Kamonyi. Organic fertilizers, such as compost and poultry manure, are employed alongside inorganic fertilizers like NPK (17-17-17) and diammonium phosphate. Additionally, farmers in Kamonyi utilize practices like crop rotation, mulching, and intercropping to mitigate the effects of climate change. A summary of these adaptive strategies and the vulnerability of Rwanda to climate change is provided in Table 14.

Table 14: Adaptive strategies and Climate Change vulnerability in Rwanda

Living Lab	Kamonyi	
Extreme events	Heavy rains Drought cyclonic wind pest and serious diseases	
Perception (%)	100	
Impact	Change in sowing date	
Strategy	Land preparation before the arrival of rain Use of improved varieties Mulching with crops residues Sowing at time Use of water pumps to water crops Setting up anti-erosion ditches Practice of agroforestry Planting anti-erosion species	Setting up dams on hillsides to retain run-off water. recovery of water from house roofs Use of organic fertilisers (compost and poultry manure) Use of chemical fertilisers (NPK 17-17-17) and diammonium phosphate Mulching Crop rotation Intercropping

3.5.4.Farming practices

Agriculture is a major economic sector for the people of Rwanda, employing about 70% of the total population. Crop cultivation practices are generally characterised by very low levels of inputs (e.g., fertilisers and pesticides) and limited mechanisation throughout the production process. Consequently, crop yields remain low (REMARR, 2010). Mastering farming practices is an asset for improving productivity and protecting the environment through new agro-ecological techniques.

In the Kamonyi ALL, households own a varying number of farm plots, typically ranging from 3 to 5 plots. The age of these plots is not specified. The distance from the house to the farm usually takes around 10 to 20 minutes of walking time. In certain cases, women may inherit land that is located farther from their family's settlement. For instance, one woman mentioned having land approximately 2 hours away from her current place of stay. Land acquisition in Kamonyi occurs through inheritance, renting from other farmers with larger landholdings or unused land, as well as from the government. Farmers who are part of cooperatives sign contracts with the district and pay an annual fee. The average size of each farm plot ranges from 0.1 to 0.5 hectares, and the main crops cultivated are cassava, followed by common beans and soybeans.

In Rwanda, specifically in Kamonyi, different cropping practices are observed in swamps and hillside areas. In the swamps, mono-cropping is prevalent for all crops, such as coffee and cassava (for farmers with larger land), along with vegetables. On the hillside, however, crops are mostly intercropped. The mixed cropping system involves cultivating cassava with legumes and maize with legumes. The two cropping systems offer distinct advantages. For mono-cropping, it allows farmers to precisely measure the number of fertilizers used, aids in better control of pests and diseases, and contributes to increased crop yields. On the other hand, intercropping provides benefits like promoting and sustaining crop diversity, as farmers cultivate a variety of crops. It maximizes and efficiently utilizes the available land, leading to decreased production risks.

By combining these different cropping approaches, farmers in Kamonyi are employing diverse strategies to enhance agricultural productivity and ensure food security. They utilize a range of inputs with varying reliability and ease of use. For quality inputs, farmers in Kamonyi rely on organic fertilizers, including compost, livestock manure, and toilet waste, which are used for all crops. These organic fertilizers are preferred due to the limited land available, leading to continuous cultivation of fields. Additionally, inorganic fertilizers such as diammonium phosphate, NPK 17.17.17, and urea are used to enhance crop production. NPK is applied for coffee, DAP for vegetables, maize, and beans, while urea is used for maize and vegetables.

However, farmers face several challenges in their agricultural practices. These challenges include delays in the supply of seeds and fertilizers, as well as issues with hybrid maize seeds mixed with other varieties. There is also a lack of sufficient knowledge on pesticide application, and farmers may not have access to appropriate equipment for application. The high cost of inputs is another concern, and farmers find it difficult to choose improved seeds due to limited knowledge in this area. Moreover, the quality of pesticides, cassava seeds acquired from neighbours, and vegetable seeds from agricultural traders are deemed unreliable. Additionally, there are delays in seed arrivals, further hindering farmers' efforts. Overall, inadequate knowledge about pesticide usage poses a challenge to successful crop management. In Kamonyi, there is a wide variation in crop yields, ranging from 0.01 to 10 tons per hectare for maize. Generally, yields tend to be low due to several factors. Firstly, there is a lack of sufficient organic manure, which impacts soil fertility and reduces overall productivity. Additionally, late planting is common, primarily because of the scarcity of labour in the agricultural sector. Finally, many farmers have limited land and practice intercropping, which can lead to competition among crops and ultimately result in reduced yields.

3.5.5. Needs and perceptions about agroecology

The RUNRES project (https://runres.ethz.ch/) has been actively piloting agroecology practices for the past four years (2019-2023). These practices focus on nutrient recycling through various innovative approaches. Firstly, they involve composting organic waste collected from urban households, which is separated at the source into organic and inorganic waste. Secondly, the project is raising black soldier fly larvae on organic waste and utilizing these larvae as a valuable protein source for animal feed. Lastly, cassava peels are being processed into animal feed ingredients, which can be used as a maize substitute in animal feed formulation. These initiatives have undergone development and testing stages and are now ready for scaling up. Initially, farming communities were not actively involved in these initiatives, but this is set to change during the 4-year scaling phase starting in October 2023. The project aims to benefit the farming communities around these innovations by incorporating their participation and input. In Kamonyi, a significant proportion of farmers (92%) have heard of agroecology, although specific details regarding their knowledge on the subject were not provided.

Recycling: Apart from the utilization of leguminous-based green manures, which is practiced by only 4% of the respondents, and the implementation of reduced tillage and/or no-tillage techniques, which is adopted by 30% of the respondents, all other elements are embraced by 92% to 100% of the participants. In Kamonyi, all the female participants reported adopting five out of the six elements, except for reduced tillage, which is only adopted by 4% of women.

Input reduction: In the Kamonyi ALL, participants have a mixed perspective on chemical inputs. They recognize the benefits of chemicals as they can improve crop yields and increase production.

However, they also acknowledge the negative aspects, as these chemicals pose health hazards. These hazards include acute effects from short-term exposure during application, such as skin irritations and coughing, as well as chronic effects from long-term exposure, potentially leading to more complicated health issues. A concerning aspect is that none of the participants (0%) reported using protective gear during chemical application, making them particularly vulnerable to the risks associated with these substances. In addition to health concerns, the use of chemicals, especially fertilizers, has been found to degrade the soils. Excess sodium is observed in the soil where mineral fertilizers are used, particularly in the cultivation of rice and vegetable crops. Interestingly, 36% of the respondents expressed their willingness to reduce chemical inputs in their fields, indicating a growing awareness of the risks involved and a desire to adopt more sustainable practices. On the other hand, 33% of the participants mentioned that they are willing to increase chemical use in their fields, driven by the desire to maximize yields and production.

Soil health: In the Kamonyi ALL, farmers prioritize the use of farmyard manures from pigs, poultry, and cows to maintain soil health and organic matter. The recommended rate for this practice is 10 tons per hectare. Additionally, they employ various other soil conservation measures to protect their land. To combat erosion, farmers dig holes strategically, and they plant *Pennisetum* along contour lines to retain run-off water. Furthermore, they integrate agroforestry species with food crops, which not only reduces erosion but also provides benefits like firewood, timber, and additional income. Mulching is widely adopted to preserve soil moisture, retain water, and safeguard against erosion. Organic fertilizers are applied to increase soil fertility and water retention, while crop rotation is practiced preventing soil fertility loss. All participants in the ALL are actively engaged in caring for soil organic matter and soil health. However, only 7% of the participants, excluding women, utilize plant cover crops to reduce soil erosion. On the other hand, 77% of participants and 61% of women adopt perennial plant species. Surprisingly, only 23% of participants and 11% of women incorporate soil conservation practices into their farming methods. Nevertheless, all participants express a need for support in implementing soil conservation practices. Conservation agriculture (CA) can play a significant role in maintaining soil health and building agroecosystem resilience to global change. CA involves minimal mechanical soil disturbance, permanent soil organic cover using crop residues and/or cover crops, and crop diversification. This approach has shown great promise worldwide in countering the adverse effects of conventional agriculture on soil health, preventing soil degradation, and ensuring food security (Francaviglia et al., 2023; Rodriguez et al., 2022).

Animal health: In the Rwanda ALL, *Capra aegagrus hircus, Bos stratus, Oryctolagus cuniculus, Sus scrofa domesticus, Ovis aries, Gallus gallus domesticus, Anas platyrhyncos, Meleagris gallopavo*, are the main domestic animal species present with *Capra aegagrus hircus*, *Bos stratus,* and *Gallus gallus domesticus* being the three most important. These animals are reared for livelihood and provision of some basic needs (such as milk, meat, honey, and income). 100% of participants care about animal health and support animal welfare across all the living labs. 93 % the respondents introduce domestic pollinators. All farmers, however, indicated the need for training in animal husbandry, beekeeping, and fish farming as well as the need for financial support and supply of inputs to better improve their animal health and welfare.

Biodiversity: In Kamony, all respondents indicated that they actively promote species diversity, functional diversity, and genetic resources in their crop fields. They achieve this by incorporating non-food crops alongside their main crops. These non-food crops include eucalyptus, which is used for producing planks, embers, construction materials, and watershed protection, as well as grevillea, which is grown to produce boards. These trees not only serve practical purposes but also play a crucial role in mitigating the risk of erosion and nutrient leaching. The multiple benefits derived from

these practices not only enhance their livelihoods but also have a significant positive impact on the biodiversity of their surroundings. Despite these positive efforts, there are still some areas for improvement in enhancing biodiversity. One such area is the lack of modern knowledge and understanding of how to improve biodiversity effectively. There is a need for capacity building and training in the selection of appropriate tree species to plant, establishing nurseries, and implementing measures to combat erosion. By addressing these needs, farmers can further improve the biodiversity of their farmlands and contribute to the sustainable management of their environment.

Synergy and diversification: In the Kamonyi ALL, all respondents are actively engaged in integrated crop-livestock systems, with 92% of them integrating crops and animals. The integration of goats, cattle, rabbits, pigs, and poultry with trees and food crops is widely practiced by the participants, with 100% of them also practicing agroforestry. Agroforestry involves the strategic use of trees in plantations, serving as sheds and providing litter for mulching, water retention, and soil conservation. The presence of trees contributes to improved soil fertility through the incorporation of humus from the tree litter into associated crops. Despite the popularity of agroforestry, there is a need for capacity building in this area, as highlighted by the respondents.

Interestingly, none of the respondents in the Rwanda ALL practice rotational/regenerative grazing to enhance soil quality and forage yield. On the other hand, 100% of the participants practice multi-cropping or intercropping. This approach involves cultivating two different crops on the same piece of land to enhance productivity. For instance, legumes and cereals are intercropped, with legumes fixing and providing nitrogen for the cereal crops. This system not only reduces the risk of disease infection but also decreases the reliance on chemical inputs in farming. Furthermore, all participants in the ALL embrace the concept of diversification of healthy diets/diversified food production systems. This means consuming a variety of foods for better nourishment and overall health. By incorporating different types of food into their diets, participants are promoting nutritional diversity.

In Kamonyi ALL, agroecological practices that improve soil health (mulching with crops residues, adoption of ISFM, irrigation, use of manure and compost, recovery of water from house roofs), biodiversity (use of improved varieties, planting associated trees, and practice of agroforestry), recycling (use of organic fertilisers, mulching with crop residues, land fallow), input reduction (use of organic fertilisers, adoption of ISFM), economic diversification (practice of agroforestry, crop rotation, intercropping) are adopted by farmers. By improving soil health and carbon sequestration, diversification of species and genetic resources, input reduction, recycling, economic diversification, smallholder farmers from the Kamonyi ALL increase their adaptive capacity and reduce their vulnerability to climate change. The application of some principles of agroecology by these farmers is a good entry point and is favourable for the implementation of the CANALLS project in Kamonyi. However, the application of synthetic fertilisers (urea, DAP, NPK) alone, and pesticides may be a barrier to the adoption of agroecology.

3.5.6. Capacity building needs

During the first phase of RUNRES (2019 to 2023), which focused on the development and testing of organic waste recycling innovations, no specific training sessions were conducted for communities in Kamonyi. This lack of training was primarily due to the business-oriented nature of the project. However, there was capacity building for innovation holders, specifically around cassava peels processing into animal feed ingredients. In this case, five individuals were trained, consisting of two men and three women. As the second phase of RUNRES is set to commence in October of this year, there is a possibility of organizing training sessions for new stakeholders interested in scaling up

successful innovations that were tested and proven profitable during the first phase of the project. This phase may prioritize capacity building and knowledge transfer to facilitate the expansion and adoption of viable innovations by the communities in Kamonyi.

Farmers have expressed a real need for knowledge about growing green manures, reusing crop residues for animal feed, minimum tillage, or no-till farming. Knowledge of lime application, biological control, cover crops to control weeds while feeding livestock, conservation tillage and soil health could make a significant contribution to their production. Similarly, limited knowledge of drought-tolerant forest species, reliable sources of fruit trees, conservation agriculture and crop intensification are barriers to optimal production. In terms of animal health, residents expressed a real need for artificial insemination, basic knowledge of veterinary services, feeding animals a nutritious diet, knowledge of fodder conservation and small animal rearing.

3.5.7. Conclusion on needs, contexts and practices in Rwanda

The living lab in Kamonyi district, Rwanda, has provided valuable insights into various aspects of agricultural and socio-economic development. With 66,622 households and a population of 377,257 inhabitants, 197.882 male and 179,475 females. Most respondents reported (100%) appreciation of traditional and local knowledge used to improve crop productivity such as ditches, crop rotation and the use of hybrid seeds, use of wood ash and urine as insecticide and pesticide for cereals, red chilies, tobacco leaves and vegetables.

inclusiveness, participation, and dignity among farmers has been observed. The Kamonyi living lab has shown positive steps in promoting gender equality where men and women have the same access to land. There is also equitable inclusion of women, young people in access to finance as people participate through a collaborative platform that facilitates dialogue and informs decision-making and promotes accountability and responsibility for actions, regardless of their social and economic status. The diverse range of farm produce in the district includes cereals and legumes, with *Arachis hypogaea, Phaseolus vulgaris Glycine* max being the most important; fruit trees with *Persea Americana, Solanum macrocarpon, Dacryodes edulis and Citrus × sinensis as the most important; Vegetables with Amaranthus viridis, Solanum nigrum* and roots and tubers such as *Manihot esculenta* as the most important. The most important livestock is *Gallus gallus domesticus, Ovis aries, Sus scrofa domesticus* and *Capra Capra aegagrus hircu*s. 70 % of these farm products are for subsistence but there is also an opportunity for income diversification through off-farming activities.

In the Kamonyi living lab, 100% of farmers have reported climate change, these changes range from increase in temperatures both in dry and rainy seasons, reduced rainfall, late-onset, more dry spells, more showers, more extreme floods, more extreme droughts, fewer foggy days, less frost, increased winds, fewer hailstorms. In Kamonyi, 92 % of farmers have heard of agroecology. Concerning recycling, in the Kamonyi living lab, except for the use of leguminous-based green manures that are made by only 4% of the respondents, and for the use of reduced tillage and/or of no-tillage by 30% of the respondent, the remaining elements are adopted by 92% to 100% of the respondents. In the Kamonyi living lab, the participants regard chemical inputs as being good as they improve yields and increase production on one side and bad, as they pose health hazards. 36% including 5% of the respondents were willing to reduce chemical inputs in their fields, while 33% of the participants indicated that they are willing to increase chemical use in their fields. However, it has been revealed that 47% of farmers have experienced health issues due to the use of agrochemicals for pest and disease control. Farmers also showed a concern related to marketing intermediaries' involvement,

while providing advantages such as access to funding and technical equipment on one side but can also bring negative impacts on farmers to produce due to price imposition and delays in payment as well as high-interest rate for loans.

In Kamonyi, actions are carried out to take care of organic matter and soil health. Some actions include using farmyard (pig, poultry, cow) as manures to care for organic matter and soil health. 100 % of the participants are taking care of the soil organic matter and soil health. Only 7 % of the participants without women are using plant cover crops to reduce soil erosion and 77 % of participants and 61 % of women have adopted perennial plants.

However, 92% of farmers in Kamonyi expressed a need for knowledge about Agroecological practices, capacity building on agroforestry practices, integrated use of chemical inputs and animal husbandry to optimise the benefits of agroecology. Engaging farmers in such knowledge-sharing initiatives will empower them to adapt to climate change effectively.

The living lab in Kamonyi District holds promise for furthering sustainable agricultural practices and community development. By addressing the challenges and leveraging its strengths, the Kamonyi living lab can continue to support the livelihoods of its residents and serve as a model for promoting inclusive and environmentally friendly agricultural practices in other regions.

3.6. Conclusion on needs, context and practices

In many cases like in the Burundi living labs, inclusiveness and participation of the women matters. Women and youth are discriminated against for their access to resources and lands. Most women are automatically excluded regarding access to loans as they don't meet the required conditions (a bank account, collateral, and a substantial personal contribution). In Cameroon, access to land and natural resources is not equitable from the perspective of gender, youth, and indigenous people. Women are victims of harassment when faced with several situations such as employment, credit, purchase of land, and access to inputs in almost all the living labs. The worst situation is found in Rwanda where the baseline studies revealed few cases of reported rape of young girls in the community.

The studied countries, the selected living lab, and their communities are particularly vulnerable to climate change impacts. All the farmers (100 %) in Giheta, Ntui, Biega, Bunia, Kabara, Uvira, and Kamonyi and 93 % in Bujumbura LLs are conscious of climate change and its effects. Extreme events have been experienced by farmers. They are affected by impacts of climate change, and they are developing some strategies at the farm level to mitigate the adverse effects of climate change in their rural communities.

Extreme events were reported in all the living labs relating to climate change. This includes dryness, excessive rainfall, drought, and less reliability of planting season in Burundi; extreme drought, irregular rains, sudden cessation of rains, drying up of waterways, and frequent and violent winds in Cameroon; scarcity of rain, longer dry season, disease and pest attacks, heavy rain, rise in temperature, irregular rainfall in DRC; and heavy rains, drought, cyclonic wind and pest and serious diseases in Rwanda. These events brought about qualitative impacts including changes in the growing season, change in sowing date, soil degradation, yield reduction of cash and food crops, and modification/destabilisation of agricultural calendars. This study reveals that several adaptation and mitigation strategies have been developed in the focal area of the future living labs, including some

activities relating to Agroecological principles, such as the integration of animals into the cropping system (synergy), using of organic fertilisers (recycling and input reduction) and adoption of ISFM.

Diverse range of crops from farm contributing to improve nutrition in the four living labs, including vegetables, legumes, crops, and cash crops.

The degree of knowledge about agroecology varies and is very comparable across these living labs. Living labs with higher share of farmers who know or have heard about agroecology are Kamonyi in Rwanda (92%), Bujumbura from Burundi (66%), Kabare (60%), and Biega (50%) from DRC (figure 11 in the appendix chapter). Living labs in Burundi (Giheta and Bujumbura), DRC (Biega, Kabare, and Uvira), and in Rwanda (Kamony) have higher scores in terms of applying at least one or two activities that contribute to recycling, input reduction, improving soil health, caring about animal health, biodiversity, and enhancing synergy and diversification. This level of development of the activities feeding the principles raised here is a very good opportunity for the implementation of the living labs. On the other hand, the CANALLs project is a big opportunity for the Ntui living lab to improve the adoption of Agroecological practices.

As regards capacity building needs, farmers in Ntui (Cameroon), Giheta and Bujumbura (Burundi), Bunia, Uvira and Kabare (DRC) living labs benefited from capacity building in the past project covering several topics and aspects of good practices (Table 23 in the appendix chapter). The CocoaSoils project provided capacity building for 2,428 cocoa farmers, with 104 extension agents trained in Cameroon. In Burundi, 40 extension agents and 200 farmers were trained on topics relating to organic farming, agroforestry, soil health, and fertility, income diversification in an agroforestry coffee farm, and biodiversity. In Burundi (Bujumbura living lab), 116 extension agents were trained on good agricultural practices to produce maize, integrated pest management and agricultural mechanisation and around 3000 farmers have participated in training facilitated by Rikolto in UVIRA. Although a couple of training has been carried out covering some good practices topics, framers still express the necessity for them to benefit from a variety of training, including composting maize and rice residues in Burundi, recycling, good agricultural practices, the use and manufacture of fertilisers, irrigation and the use of agroforestry systems in Cameroon, biogas production and the transformation of household and human waste into fertiliser in DRC, and growing green manure, reusing crop residues as animal feed, minimum tillage or no-till in Rwanda, to name a few. Table 24 in the appendix chapter summarises the training needs.

4. Food systems, value chains and markets

This section deals with food systems, value chains and markets for the agroecologically produced crops from the eight ALLs. It involves mapping of the food systems and markets of the farming systems and communities across the value chain. This includes examining the processes from production to food disposal after consumption, while also assessing how each stage contributes to socio-economic and environmental outcomes.

Food systems encompass the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption, and disposal of food products that originate from agriculture, forestry or fisheries, and parts of the broader economic, societal, and natural environments in which they are embedded. The food system is composed of subsystems (e.g., farming system, waste management system, input supply system, etc.) and interacts with other key systems (e.g., energy system, trade system, health system, etc).

A sustainable food system lies at the heart of the United Nations' Sustainable Development Goals (SDGs). Adopted in 2015, the SDGs call for major transformations in agriculture and food systems to end hunger, achieve food security and improve nutrition by 2030. To realise the SDGs, the global food system needs to be reshaped to be more productive, more inclusive of poor and marginalised populations, environmentally sustainable and resilient, and able to deliver healthy and nutritious diets to all[5].

Kaplinsky et al. (2002) define value chain as a full range of value-adding activities required to bring a product from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), to the delivery to final consumers and final disposal after use. Their approach tries to understand how activities are performed along the chain and how the value is created and shared among chain members.

The framework proposed by Nguyen (2018) states that in the economic dimension, a food system is considered sustainable if the activities conducted by each food system actor or support service provider are commercially or fiscally viable. The activities should generate benefits, or economic value-added, for all categories of stakeholders: wages for workers, taxes for governments, profits for enterprises, and food supply improvements for consumers (Nguyen, 2018). On the social dimension, a food system is considered sustainable when there is equity in the distribution of the economic value added, considering vulnerable groups categorised by gender, age, race, and so on. Of fundamental importance, food system activities need to contribute to the advancement of important socio-cultural outcomes, such as nutrition and health, traditions, labour conditions, and animal welfare (Nguyen, 2018). On the environmental dimension, sustainability is determined by ensuring that the impacts of food system activities on the surrounding natural environment are neutral or positive, taking into consideration biodiversity, water, soil, animal and plant health, the carbon footprint, the water footprint, food loss and waste, and toxicity (Nguyen, 2018).

A preliminary mapping of food systems, value chains and markets was performed via desk research. Information gathered was complemented with data collected from local value chain actors, market players and consumers through interviews. A total of 485 respondents were interviewed by the local partners, using guidelines provided by AATF and IITA (in Burundi, 79 respondents in the Bujumbura

[5] Sustainable food systems

ALL and 56 in the Giheta ALL, in Cameroon, 79 in the Ntui ALL, in DR Congo, 43 in the Biega ALL, 103 in the Kabare ALL and 50 in the Uvira ALL and in Rwanda 75 in the Kamonyi ALL). The number was higher than the one of 160 indicated in the project grant document. Due to insecurity challenges in the region of Bunia, primary data was not collected for the Bunia ALL. Secondary data was however used for analysing the current food system and market situation in that study region.

The section below analyses the food systems, value chains and markets for the different countries and focal crops respectively.

4.1. Burundi, Bujumbura and Giheta ALL

4.1.1. Burundi food system

Agriculture is the mainstay of Burundi's economy, accounting for approximately 35-40% of GDP, and employing almost 96% of the country's labour force (FAO, 2013b; World Bank, 2013; MINIAGRI, 2013). According to Burundi acute food insecurity situation, food insecurity in Burundi was at 36% in April-May 2022 with 10% in crisis and 26 % in stress. Climate change is also having a negative impact. The prevalence rate of stunting amongst children under 5 years of age is 57%, while the prevalence of wasting is 6%, and the underweight rate is 29%. Family farming provides 95% of the food supply but does not meet nutritional needs. Agricultural production is done on an average land area of 0.50 ha per household, but only translates into 65% of the food requirements, resulting in the country's dependence on food imports. Moreover, cereals and legumes account for less than 50% of the Burundian population's diet, who consumes a high quantity of tubers. This is leading to significant micro-nutrient deficits, with a diet that is low in protein and fat-rich foods[6].

Crop production in Burundi is primarily based on small-scale family farming. Eighty percent of the Burundian population is involved in agricultural activities, yet only 28% of total agricultural production is marketed. Farmers indicate that self-sufficiency is of large importance to them. The low level of market integration among farmers in Burundi is related to mistrust among the value chain actors such as farmers, traders, and risks concerning market fluctuations. Farmers are vulnerable to covariate risk including failing harvests and interest increases as well as idiosyncratic risk including illness of household members. This makes access to and uptake of any form of credit low, and farmers are often forced to sell their produce at very low prices.

Recommendations in enhancing food security, value chain and markets are as indicated below:

1) Organisation of farmers into groups for collective bargaining when accessing the markets.
2) The need for the government to engage producers when setting commodity prices, especially coffee.
3) Ongoing regional integration processes should be used to maximise Burundi's benefits from its accession to the East African Community (EAC). Reduced tariffs and non-tariff barriers will enable Burundi to have easier access to a larger market, facilitating an increase in exports to the regional market. This market can also be used to introduce new products and build expertise and skills before attempting to access international markets. Burundi can also largely benefit from regional infrastructure projects that could improve transport and logistics significantly.

[6] https://www.ifad.org/en/web/operations/w/country/burundi

4) Besides, the country needs to develop an action plan and establish the necessary facilities/ laboratories to comply with international sanitary and phytosanitary standards. Without compliance with these standards, it will be extremely difficult to export outside the region. Burundi could benefit from the experience of other EAC members in this area.
5) Among key priorities, Burundi's large infrastructure gap needs to be closed. This applies to a range of areas, including roads, air transport and electricity. Regarding transport infrastructure, the insufficient availability of cold storage and a cold chain, in general, needs to be addressed.
6) There is a need for continuous sensitization of the various actors on agroecology concepts.

The assessment of the Food Security Monitoring System (FSMS) of the World Food Program (WFP)/Food Safety (2021) indicated that the Food Consumption Score (FCS) was 'acceptable' for 80% of households in August 2021, while the Household Dietary Diversity Score (HDDS) was favourable (HDDS of more than 5 food groups) for 83% of the households at the national level. From the August 2021 FSMS/WFP survey, 68% and 79% of households in the Eastern and Northern Lowlands, respectively, reported an acceptable Food Consumption Score (FCS) compared to the national average of 80%. Regarding the nutritional situation, data from the September/October 2020 Standardized Monitoring Assessment for Relief and Transition Method (SMART) survey revealed a Global Acute Malnutrition (GAM) rate prevalence of 7% in the Eastern and Northern Lowlands, slightly higher than the national average of 6%. Furthermore, June 2021 malnutrition admissions closely resembled the levels observed in June 2020, suggesting that by October 2021, malnutrition rates are likely to remain around 6% nationwide and approximately 7% in the Eastern and Northern Lowlands.

Nutrition levels among young children and women in Burundi are alarmingly low, with a high prevalence of stunting affecting 56% of children and iron deficiency anaemia affecting 48% of children and 26% of women. The lack of dietary diversity among children is a significant concern, mainly due to inadequate consumption of protein-rich foods such as eggs, dairy products, and meat. In fact, the production of these essential food items, including eggs, dairy products, and chicken, is also limited compared to neighbouring countries, leading to higher prices for animal products in the market. Eggs are rarely part of the average diet, while milk consumption is more accepted. The food system in Burundi faces volatility due to heavy reliance on rain-dependent crop production and inadequate post-harvest handling, including storage and conservation. Consequently, this situation triggers seasonal nutrition gaps and periods of hunger, particularly during April – May and September – December. Moreover, nutrition security in rural areas is notably lower compared to urban areas. Additionally, there are regional differences observed in food prices, with variations within the country, and higher prices in wealthier provinces close to Bujumbura. Northern provinces experience worse nutrition security outcomes than those in the south. Investigating the root causes behind this difference is imperative to address the underlying issues effectively. Notably, nutrition outcomes for children tend to be better in well-educated and wealthier households, as well as households with a female head of the household[7].

To address the value chains and markets for agroecological products in the Bujumbura and Giheta ALLS, where maize and coffee are respectively the main crops of interest, we adopted a localized approach. By closely examining each locality, we identified similarities and conducted thorough comparisons for each indicator, as outlined in the following discussion.

4.1.2. Value chains in Burundi

Maize Value chain-Bujumbura ALL

Maize production in Burundi reached over 260,000 tons in 2020 making it the sixth-most important crop after cassava, bananas, sweet potato, beans, and potato (FAO, 2022). Yet, maize is the second most important crop in Burundi, after common beans, in terms of area cultivated. The Department of Agronomy estimates that 260 000 ha are cultivated in maize, with an average yield of 1.5 t/ha. However, it is almost always intercropped with beans, peas, or other crops. Maize becomes less important at lower elevations (800-1200 m), where cassava is grown and becomes more important in the diet.

The main actors in the maize value chain are input providers, farmers, traders/aggregators, processors (mills) and downstream participants in activities such as retail, food manufacturing, brewing, and animal production. The primary actors, along with their position in the value chain, are identified in Figure 5. The section that follows offers short descriptions of key actors in the chain.

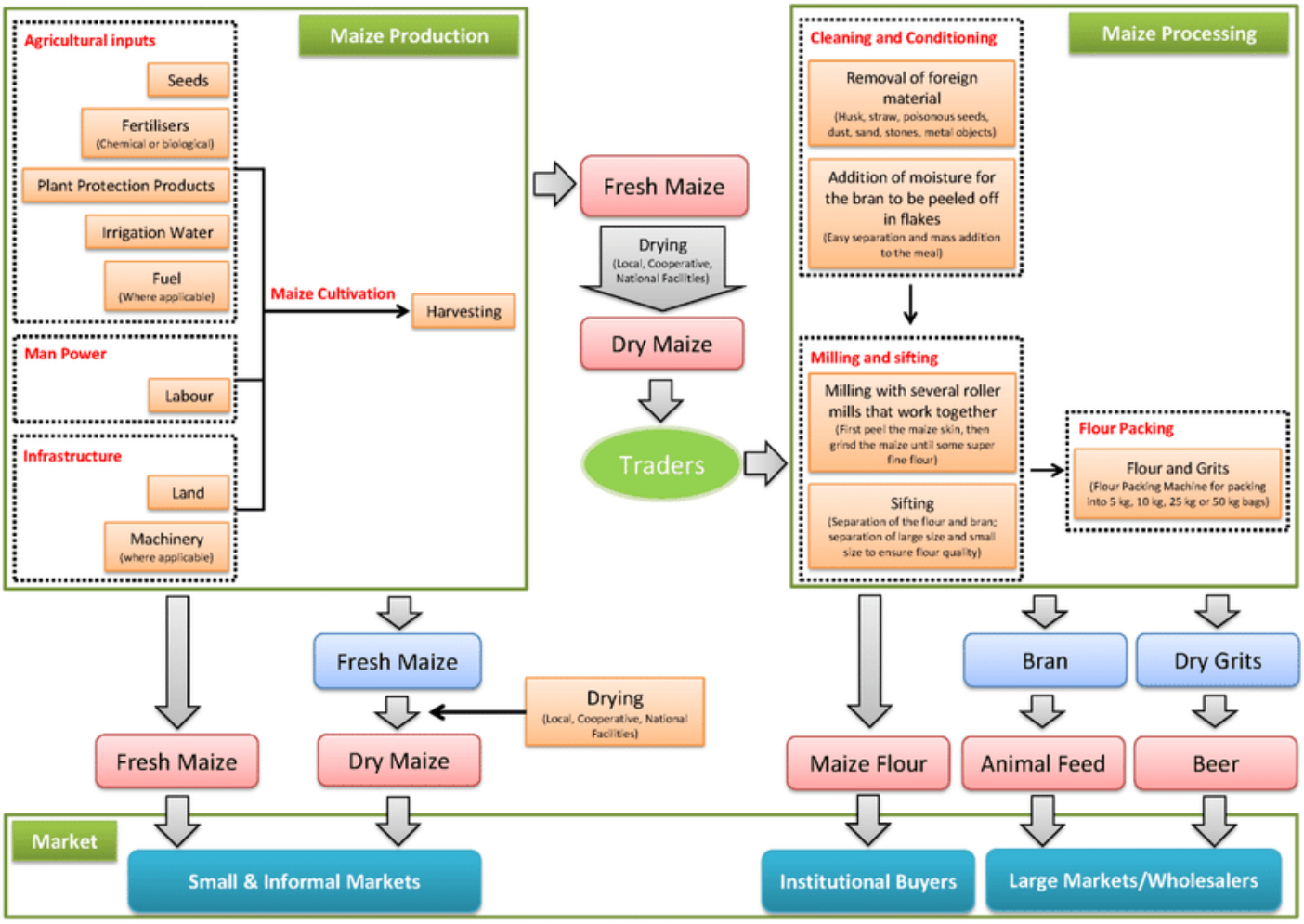

Figure 5 : Maize value chain actors and process of production. Source: Jack et al 2016

To address value chain actors in the maize value chain, the respondents from the focus group discussions indicated that the value chain actors are:

Research & Development actors play an important role in the maize value chain. For the production stage, research tends to focus on how to increase productivity, improve seed varieties, adapt existing varieties to local conditions, and improve disease and drought resiliency of crops. Research efforts also extend to other segments, including extending shelf life of products through processing technologies such as drying maize or fortifying maize flour. New technologies and techniques introduced because of this research can drive progress and help to open new markets. In Burundi, research, and development in the production stage of the chain is mostly carried out by government funded research centres, while research regarding shelf life and food processing often takes place either within private firms or universities. Ideally, research institutions must be closely linked with other value chain actors to ensure effective and efficient use of resources to support chain development (Hall et al., 2002).

In Burundi, numerous public, private, and international organizations, along with educational institutions, are actively engaged in research within the agricultural sector. With a primary focus on enhancing productivity, research and development efforts are predominantly directed towards crop production, encompassing about 45% of the research activities. Following closely is research in food technologies, constituting approximately 15%. Among the crops being extensively researched, vegetables take the lead with 10% of the research focus, followed by rice (7%), fruit (6%), and potatoes (6%) (Stads & Ndimurirwo, 2011). Public sector entities involved in agricultural research include the Institut des Sciences Agronomiques du Burundi (ISABU), Centre National de Technologie Alimentaire (CNTA), and the Agronomic and Zootechnique Research Institute (IRAZ). Among these, ISABU stands out as the country's primary agricultural research center, operating six research stations across the nation. It accounts for nearly two-thirds of the research capacity and is responsible for close to three-quarters of the total investments in agricultural research (Claes, 2013; Stads & Ndimurirwo, 2011).

The inputs segment of the maize value chain remains largely underdeveloped and continues to be concentrated by public sector actors. The formal market for seed production accounts for just 5% of the market (Bararyenya et al., 2013) and is dominated by ISABU and private research organisations.

Processing: Cereal products must be processed before being incorporated into a range of end products. Initial tasks include cleaning, drying, and grading. There are two primary milling techniques that follow for maize: dry milling and wet milling. Both processes break down maize into a range of outputs; however, there are also costs and benefits for each. Dry milling, which describes the grinding of the entire kernel in hammer or rolling mills, is less capital intensive and yields a greater array of inexpensive food outputs, including flour. The wet milling process involves a series of steps by which corn is separated into various components, which are then further processed and/or used for animal feed. The basic steps for wet milling include steeping, germ separation, fine grinding, starch separation, fermentation, and syrup conversion. While the maize in wet milling is separated from its nutritional content and therefore not used for direct human consumption, the process produces an increased range of chemical by-products (OHSA, 2014). In Burundi, processing takes place at an artisanal level, carried out by individual producers or cooperatives (USAID, 2010) although these methods are relatively inefficient compared to industrial processing.

Supporting Services: Logistics and transportation fulfil key supporting functions, while government regulatory bodies are required to approve the sanitary and phytosanitary conditions of outbound products and to ensure food safety and contain the spread of plant and animal disease domestically. Depending on the perishable nature of the product, a high degree of coordination between these

different actors along the chain may be required. Highly perishable products, require adequate transportation and coordination measures and a functioning cold chain to avoid significant losses, particularly when cultivation, packing and processing and the final market are geographically separated.

Post-harvest losses because of inadequate transportation and storage can account for as much as 30% of production in Burundi, undermining improvements in productivity and reducing incentives for producers to invest in the adoption of new techniques (Fernandez-Stark, 2013).

Coffee value chain in Giheta ALL -Burundi

Burundi has a long history of coffee production and is the 13th largest producer of exclusively Arabica coffee in the world (ICO, 2013). The sector is of strategic importance to Burundi's national economy. It employs over 1 million people, predominantly smallholder producers, with one in every two households engaging in coffee production to generate cash income (USAID, 2013). Coffee exports account for 80% of foreign exchange earnings and contributed between 4-10% of the country's GDP (USAID, 2013).

Figure 6 shows coffee value chain actors in Burundi.

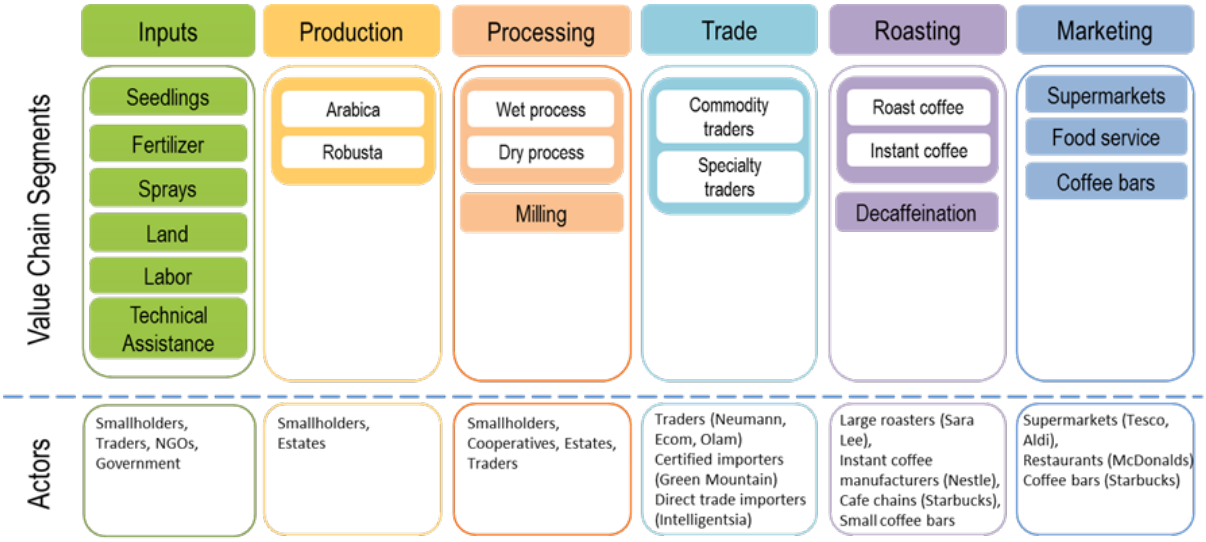

Figure 6: Coffee value chain actors. Source: Ponte, 2002

The actors in the coffee value chain sector include:

Input providers*:* These actors serve as suppliers of inputs to farmers, including essential items such as seeds, fertilizers, and other agricultural necessities. Additionally, they provide private extension advice to support farmers in their practices. In the coffee production process, several inputs are required, such as physical items like seedlings, fertilizers, and sprays, along with land and labour. The quality of these inputs plays a crucial role in determining the potential end-markets for the coffee. For instance, achieving organic certification for coffee production necessitates the use of approved organic fertilizers and sprays (TCC, 2012). Smallholders or estates typically directly source these inputs; however, traders, non-governmental organizations (NGOs), and government entities may also offer financial assistance for input purchases. Often, growers require technical assistance, such as

workforce development and agronomy services, to enhance their productivity and increase the value of their products (Murray et al., 2006).

Producers: Burundi's coffee sector is dominated by the smallholder production of Arabica coffee, with an estimated 590,000-800,000 households cultivating coffee, depending on the season. Producers can be divided into three main groups: individual producers that sell to the closest coffee washing station with little access to technical assistance or other inputs; producers that have been organised or self-organised into cooperatives, accounting for about 30% of all producers (UNIDO, 2013); and producers who have been organised into farmers groups by washing station owners to reduce transaction costs in the provision of extension services.

Processing: They offer value addition services. All coffee is either fully washed at one of the 185 washing stations or washed by traditional methods (USAID, 2010), prior to being dry milled into green coffee and shipped, primarily to European markets. Of the roughly 25,000 Mt produced annually, less than 2,000 Mt of the crop is roasted locally for domestic consumption.

Regulators: The regulation, supervision, and control of the various professions in the coffee sector is the responsibility of the Burundi Coffee Regulatory Agency (ARFIC) while the day-to-day operational responsibility of these professions (production, processing, marketing, export, etc.) is entrusted to the Coffee Inter Professional Association of Burundi (INTERCAFE). The overall responsibilities include the regulation of product quality, provision of information to actors in the coffee sector, arbitration of conflicts between coffee sector actors, contributions to policy formulation, monitoring national and international production and market tendencies, authorising of professional licences, and supporting marketing and promotional activities (World Bank, 2011).

Consumers: These are the final consumers of the product.
These actors interact in the process from coffee production to consumption:

Production: During the production stage, coffee trees are cultivated on large estates or on small farms and it takes approximately 3-4 years for a tree to become productive. There are two species of coffee grown for consumption: *Arabica* and *Robusta*. *Arabica* beans are typically considered to impart a superior taste compared to *Robusta* beans and therefore fetch a higher market price relative to *Robusta* (ITC, 2011; Ponte, 2002a).[2] Burundi's climate and geography are suited to the production of *Arabica* – but not *Robusta* – coffee.

Processing: During this stage, the coffee cherry is cured and milled to remove the fruit from the bean. Curing occurs either through dry or wet processing. Dry processing involves exposing the coffee cherries to the sun to dry for one month, at which point the fruit becomes brittle and can be easily removed from the bean. Under wet processing, the cherry is immersed in water to soften the outer layer, and the fruit is removed. Wet processing is typically seen to impart a better flavour to the coffee, which often translates into a higher price. After curing (dry or wet), the bean must then be milled and washed to remove any remaining layers of skin or husk, and the resulting product is green coffee.

Actors involved in processing can vary. In some cases, smallholders process the cherries themselves, especially with dry processing. Small farmers frequently participate in cooperatives or associations to achieve efficiency gains at the processing stage. Large estates usually process their beans on-site. In some cases, trading companies are integrated into the processing stage to ensure a steady supply of coffee with desired characteristics (Akiyama, 2001; Ponte, 2002a). Green coffee can be stored for over 10 years in an adequately controlled environment before being roasted, and therefore, is best

suited for intercontinental shipping (Daviron & Ponte, 2005; Field Research, 2013; Ribeiro et al., 2011).

Trade: More than 80% of green coffee beans are traded internationally, and trading companies play an important role in coffee global value chains (TCC, 2012). Traders purchase green coffee from growers and grower associations and ship the beans to the end-market. Large roasters rarely source beans directly from producers. This segment is highly concentrated with the six largest coffee traders controlling roughly half of the volume of coffee traded internationally (ITC, 2011; Ponte, 2002a). The official coffee price is based on the New York Stock Exchange and is influenced by numerous other factors; thus, the price fluctuates daily.

As consumer preferences in mature end-markets grow more discerning, two major niche markets have grown considerably. Each of these niche markets involves a more intensive role for traders to ensure certain production requirements are met, and they also command higher prices than the New York Stock Exchange price for regular coffee. The first expanding niche is for specialty coffees, which are of exceptional quality. The supply chain for specialty coffee involves complex, relational linkages between roasters, traders, processors, and growers. Certified coffee is the second largest niche, which involves a more complex compliance regime that aims to increase environmental or fair-trade standards in the global value chain. However, although traders frequently play a role in assisting producers to meet certification requirements (TCC 2012), the additional costs imposed on producers and processors can mean that pursuing certifications is not always cost- effective for producers and processors.

Roasting: Roasters produce roasted coffee beans and instant coffee. The roasted coffee market segment includes both blended and origin-specific beans from different traders. *Arabica* beans are more commonly found in the whole bean and ground segment, while *Robusta* beans are typically used for instant coffee.[3] If the coffee is to be decaffeinated, this process takes place just before roasting and is accomplished by passing the green coffee through a steam bath or submerging it in a prepared water solution. Roasted coffee loses quality within a matter of weeks, even with high- quality packaging, so roasting activities are typically concentrated within the major end-markets of Europe, North America and, increasingly East Asia. The high perishability of roasted coffee makes it unsuitable for shipping long distances or where logistics and customs processes lack predictability and can cause unforeseen delays. The roasting segment of the coffee global value chain is highly concentrated, particularly the instant coffee segment, where the two largest players, Kraft and Nestlé, control more than 70% of the market (ITC, 2011; TCC, 2012). In many cases, these actors will also control the marketing of their product, selling roasted coffee through in-house retail operations or exclusive distribution arrangements with supermarkets.

Marketing: The three main channels through which coffee is marketed are retail, the food service industry, and specialty coffee bars. The retail channel makes up 70-80% of coffee consumption, and the main players are supermarket chains such as Tesco, Walmart, and Aldi. Retail outlets sell commodity, specialty and certified coffee sourced from large specialty roasters as well as from smaller local and regional niche roasters. In recent years, supermarket chains have also begun roasting and marketing their own brands of coffee. Specialty coffee bars gained prominence in the US, Europe, and East Asia in the 2000s (Daviron & Ponte, 2005). These specialty coffee bars – Starbucks being the most well-known – sell both prepared coffee and roasted coffee beans, which are roasted in-house or by relatively small-scale niche roasters.

Specialty coffee bars compete based on quality, through prominently displayed certifications and the weaving of “compelling stories” about the conditions under which the coffee was produced (Golding & Peattie, 2005; Ponte, 2002a).

Specialty coffee represents the highest level of quality in the coffee industry, commanding premium prices in the market due to the exceptional attributes of its beans. Most specialty coffee comes from the Arabica variety, known for its superior taste, and thrives best at altitudes between 1,500m and 2,200m above sea level (SCAA, 2012). To attain the coveted 'specialty' status, meticulous attention is given to minimizing defects and impurities throughout the production processes. The evaluation process for specialty coffee involves highly skilled buyers or testers, also known as cuppers, who possess refined palates akin to sommeliers. These cuppers are certified by esteemed organizations like the Specialty Coffee Association of America (SCAA), Specialty Coffee Association of Europe (SCAE), and Coffee Quality Institute (CQI). Through their expert assessments, coffee is judged for its purity and unique characteristics. Given the stringent criteria for specialty coffee, effective coordination among key actors in the supply chain becomes crucial to gain access to specialty coffee markets. While both ‘specialty’ and ‘certified’ designations allow producers to gain access to higher value market niches, there are pros and cons to each approach. Certification is often costlier, but certifying agencies may offer technical assistance. Specialty coffee does not require costly certifications; however, it does require a certain level of human capital so that growers can produce high-quality beans and effectively access specialty markets.

Middlemen in the maize and coffee value chain

One frequently mentioned actor in the value chains of coffee and maize are the middlemen. In the Bujumbura ALL, middlemen in the maize value chain were appreciated for their role in facilitating access to markets, offering ready cash for farming, and collecting the produce at the farm gate. The limitation that came with middlemen in the sector was “*higher product prices, demotivation of producers and the risk of product piracy/denaturing”.*

In the Giheta ALL, the middlemen in the coffee value chain were appreciated for their role in market linkage facilitation. The limitation was the reduced profits faced by the producers due to the middlemen dictating the prices.

Gaps and bottlenecks in the maize and coffee value chain

Within the Bujumbura ALL, respondents identified various gaps in the value chain, including a lack of support, absence of monitoring agents, unreliable input suppliers, and high prices. To address these gaps, respondents emphasized the need to strengthen control services to ensure the quality of inputs, increase subsidies, and regulate prices. Regarding access to finance, all respondents acknowledged challenges such as budget deficits, high credit interest rates, demanding credible guarantees, and a scarcity of agricultural financing from banks. However, they appreciated the contributions of financial intermediaries like CILC and microfinances, which provided small loans to farmers. To tackle the finance-related issues, respondents proposed several remedies, such as organizing producers into groups to enhance their bargaining power, establishing their guarantee funds to access bank credit, securing insurance coverage, and facilitating linkages between farmers and lenders for better financial support.

In the Giheta ALL, respondents highlighted challenges in accessing agricultural credits, which significantly affected their access to finance. To address this issue, creating partnerships with financial institutions was suggested as a potential remedy. Notable institutions mentioned in Giheta include

Banks like BANCOBU, Microfinance institutions like COOPEC and MUTEC, as well as the Post and Development funds. Respondents expressed that accessing credit is challenging, mainly due to difficulties in meeting mortgage requirements.

Challenges affecting maize and coffee production

In the Bujumbura ALL, respondents identified various factors affecting the production of the product. These include climate change, the absence of improved seeds, insufficient availability of phytosanitary products, a lack of irrigation equipment (motor pump), inadequate organo-mineral fertilizers, land scarcity, limited access to inputs, and challenges in accessing finance.

In the Giheta ALL, a significant challenge identified is the shortage of land and lack of financial resources required for proper maintenance of coffee plants. Respondents also pointed out specific challenges impacting coffee production. These challenges include limited access to finance, a lack of means to cover the cost of production factors, inadequate incentives to promote coffee cultivation, poor soil fertility, and the effects of climate change.
Shade grown coffee has been planted, enhancing climate resilient livelihoods, and reducing land degradation in Burundi. However, unsustainable, and unregulated coffee production in Burundi has contributed to land degradation, which in turn depresses productivity and increases vulnerability to climate change. Coffee farmers use steep slopes, often eliminating trees on hillsides to grow coffee under full sun, practices that contribute to land degradation and biodiversity loss.

Gender sensitive value chain to support collective goals

Burundi gender strategy vision[7] is to see women and men enjoy the same rights and duties, develop all their capacities, and thus contribute, as equal partners, to the building of a just and prosperous society for all as well as to the political, economic, social, and cultural development of Burundi. Thus, the vision of the gender strategy is as follows: “Contribute to making the Republic of Burundi a country where women and men actively participate in efforts to combat poverty, sustainable development and the fight against climate change, in an approach of equity and equality socio-professional”:

Through the focus group discussions, we wanted to understand different gender experiences when it came to marketing of their product.

According to a key respondent from a female producer in the Bujumbura ALL, there is no significant difference between men and women when it comes to marketing products. However, the percentage of men engaging in marketing activities is perceived to be higher than that of women. In Bujumbura, shops are predominantly run by men, while women dominate itinerant trade.

In the Giheta ALL, to optimize productivity and benefit for smallholders, it was seen as essential (67% of traders) to collaborate and create an enabling environment that fosters the exchange of knowledge on best farm management practices and marketing opportunities. Baseline studies indicate that there is good collaboration, with recognition given to the knowledge, efforts, and contributions of farmers regardless of their gender, age, social, and economic status. Nevertheless, the studies recommend specific programs aimed at increasing youth and women inclusiveness to address their unique needs and ensure broader participation in coffee production activities.

[7] https://obpe.bi/images/pdf/gender_strategy.pdf

Non-financial support requirements to strengthen farmers' activities

The need for non- financial support was noted across the respondents in the Bujumbura and Giheta ALLs that included need for organisation support, good sectoral strategies and their implementation, agrarian reform, guarantee of sales markets, technical training, access to market information, organisation of producers, quantity and quality inputs and advisory support.

4.1.3. Maize and coffee markets access

Maize market-Bujumbura ALL

Maize end uses can be divided into three primary categories: (1) human consumption; (2) ethanol for fuel; and (3) animal feed. Prominent outputs of the milling segment that are destined for human consumption are categorised by particle size and include flour, grits, meal, bran, and kernels. All can be used for a variety of staple products.

During the years of Burundi's conflict, both formal and informal markets were largely replaced by extensive emergency food aid programs. Since then, the informal market has played a central role in the distribution of products in the country (Dihel, 2011), while in the formal market, state-owned firms have traditionally dominated and been accustomed to markets where competition has largely been absent due to small number of suppliers and supply shortage. This situation generated little or no competitive pressures on firms to invest in marketing and regularly assess and adjust their cost structures (Pandey, 2013). Burundi's accession to the East African Community, however, makes it increasingly difficult for local firms to remain competitive compared to imports from other countries unless they invest in the marketing and brand management techniques.

In the Bujumbura ALL, 83% of the producers indicated to access local markets (Muramvya, Kinama and Muzinda) while 17% did not have access to any markets. Eighty three percent of the respondents indicated that the maize supplies are enough for home supply while 17% said there are inadequate supplies.

Coffee market-Giheta ALL

Coffee farming plays a vital role in the Burundian economy, accounting for its main export revenues (one third of its total export), contributing together with tea, to 90% of foreign exchange earnings, corresponding to 6% of the country's GDP. It is the main industry and export product of the country and provides important income for the roughly 600,000 families (about 40% of the population) who grow it. The Burundian farmer's interest in growing coffee is since coffee is a seasonal product that provides a chunk of income larger than what the farmer can save during the year. For example, income from coffee growing provides 50% of family income in the northern region of Buyenzi in the Bujumbura Mairie Province. This revenue allows the farmer to finance house construction and send children to school, as well as other small investments. In addition, with the initiation of micro-credit schemes in rural areas, ownership of coffee trees is the main guarantee that farmers can offer micro-credit institutions. One should also acknowledge that the construction of de-pulping stations in rural areas led to the (modest) beginnings of industrialization, employment for local labour during the coffee campaign and the opening of rural areas through the construction of factory access roads which are also used for other purposes[8].

[8] Burundi coffee sector

To improve its position on the market, Burundi has since the 1980s invested in quality coffee by developing de-husking and washing stations where a fully washed coffee is produced after fermentation. This type of coffee differs from “washed” coffee where the husk is removed manually[9].

A committee known as "Comité de Commercialisation," comprising various stakeholders, including ARFIC, takes charge of monitoring the quality of coffee to be sold at auction in Burundi. While previously all exports were sold through auctions, ongoing reforms have led to irregular auction schedules, and there is a shift towards adopting contracts and direct sales methods. For coffee to be directly sold in Burundi, it must meet the requirements of being licensed by an exporter and qualifying as specialty coffee. Once these criteria are met, exporters can directly engage with buyers to negotiate coffee purchases, enabling more streamlined and personalized transactions.

In Giheta ALL, the participants indicated that they sell their coffee commercially through a cooperative.

4.1.4. Characteristics of (agroecology) markets in Burundi

In the Bujumbura ALL, respondents highlighted poor product quality, low competition, limited product variety, and the lack of standardized products as key characteristics of (agroecology) markets. They also observed that these markets are more oriented towards the West rather than focusing on inter-African trade. Quality standards in these markets tend to mirror European standards, and there are scarce or almost non-existent quality standards specifically tailored for local markets. Additionally, quantities available in the markets are often insufficient to meet the demand.

In Bujumbura, the future of in-country African markets was described with several key characteristics: a focus on producing high-quality products, a growing demand for these products, and heightened competition. The markets need to be well-structured around identity products specific to certain production regions. Direct relations between consumers and producers are emphasized as important. Price differentiation with other products adds to the competitiveness of the offerings. Additionally, these markets should aim to ensure a regular and consistent supply to meet the needs of consumers.

In the Giheta ALL, the agroecology markets were described as not being financially rewarding for top-of-the-range coffee, and instead, they primarily cater to lower-quality coffee. However, in Giheta, key informants highlighted the future of African markets, which they believe will be characterized by a focus on product quality, durability, and affordability over time.

Territorial market

In the Bujumbura ALL, the territorial market was identified as a market that supplies foodstuff to the population of a given district.

One of the KI noted that *“It is a market for a specific territory with specific products that cannot be found elsewhere. It consists of organising production, collection and distribution while respecting traceability and guaranteeing quality*”.

Barriers associated with territorial markets were identified. These barriers include inadequate legislative frameworks, consumer preferences for exotic products, poor packaging technology, hygiene issues throughout the supply chain, and limited product diversity.

[9] Burundi coffee sector reform

In the Giheta ALL, a territorial market was described as a platform that facilitates exchanges of local and regional products to a certain extent. The main challenge faced in this market is the importation of poor-quality products at low prices.

Interestingly, in Bujumbura, 100% of the respondents expressed that the current liberal economic model is unable to protect the African territorial market. In contrast, in Giheta, respondents believed that the liberal economy could safeguard the territorial market if accompanied by effective policies, awareness campaigns, information dissemination, and population training.

Regarding the potential of agroecological products against industrial food systems, there were varying responses. In Bujumbura, all respondents expressed doubts, stating that limited quantities of agroecological products put them at a disadvantage compared to industrial food systems. However, in Giheta, respondents saw a chance against the industrial food system due to increased productivity resulting from training in agro-ecological practices. Furthermore, in Bujumbura, it was noted that small farmers play a vital role in supplying raw materials to the modern food system through their production, while the response to this question was not provided by the Giheta ALL respondents.

Strengthening Burundi markets in protecting farmers' rights

In the Bujumbura ALL, the observation was made that strengthening African markets can play a crucial role in safeguarding the rights of workers and consumers. By reducing the excessive involvement of middlemen who often take a significant portion of the margins, this approach can help control soaring consumer prices.

"It will also make agro-ecological farming more profitable than imported products by giving consumers continuous access to local agro-ecological products through protection of producers and traders of local agro-ecological products."-KI ADISCO

In Giheta ALL, it was noted that strengthening African markets can protect the rights of workers and consumers as it will seek to strengthen the partnership between farmers and consumers through ongoing dialogue to find sustainable solutions to each party's concerns and requirements.

Changes that need to happen to Burundi markets for the transition to agroecology

In the Bujumbura ALL, several key changes were identified as essential to transition African markets to agroecology. These include raising awareness among consumers and stakeholders, improving the legal framework to support agroecological practices, and promoting a shift in African consumption habits to Favor locally produced goods. Strengthening and organizing producer organizations involved in agroecological product production, along with developing marketing infrastructures such as roads and transport, are crucial steps to facilitate the transition. Additionally, establishing a constructive business dialogue between agroecological farmers and food processors/retailers, and implementing contractual agreements between producers and processors/retailers, will contribute to the successful transition to agroecology.

In the Giheta ALL, one of the key changes required for transitioning Africa markets to agroecology is the creation of awareness among African markets about the benefits and importance of adopting agroecological practices.

Consumers' willingness to pay more for agro-ecologically produced products

In the Bujumbura ALL, the respondents noted that there are no experiences where consumers pay more for agroecological products. The case was different in the Giheta ALL that indicated that consumers get to pay more for the agroecologically produced/organic coffee.

Both the Bujumbura and Giheta ALLs indicated that consumers are willing to pay more for certified and traceable foods.

In the Bujumbura ALL, the respondents indicated that no mechanisms exist in verification of agroecologically produced products.

In Giheta ALL, it was noted that training of producers, internal inspections and external audits do exist when it comes to traceability of agroecologically produced/organic products. The cost of verification is met by the coffee cooperatives.

Feasibility of certification of the Agro-ecologically produced products

The key informants from the Bujumbura ALL indicated that certification is feasible because agroecological products contain virtues in terms of human health, agronomy, and the environment, making them top-of-the-range products. The same was echoed by Giheta ALLs who indicated that certification is possible though it may be expensive.

Solutions for increasing the production of safe African food

The rising demand for safe African foods among middle and high-income consumers has created opportunities, but small producers face challenges in tapping into this market. The constraints arise from factors such as limited quantities and seasonality of production, as well as concerns related to food safety.

In the Bujumbura ALL, various recommendations were proposed to address these issues. They include organizing producers to enhance collective strength, certifying ecological products to build consumer trust, and supporting agro entrepreneurs in developing sustainable and competitive agroecological farms. Additionally, efforts to stimulate increased production involve establishing connections between producers and niche markets, opening new avenues for small producers to access and meet the demands of safety-conscious consumers.

In the Giheta ALL, this question was not addressed.

Participatory guarantee systems

In Bujumbura ALL, 67% of the respondents indicated that participatory guarantee systems apply in focal communities and standards are set by the institutions responsible for the certification of the products. 33% of the respondents indicated that standards do not apply.

In Giheta ALL, the respondents indicated that standards do exist and are set by the government.

In Bujumbura ALL, it was noted that the demand for natural and organic food products is increasing though the notion of agroecology is still new.

In Giheta ALL, it was noted that organic coffee produced using agroecological practices is more popular with consumers.

4.1.5. Enabling environment for agroecology

In the Bujumbura ALL, respondents emphasized the necessity of creating an enabling environment for agroecology. To achieve this, entrepreneurs require a deep understanding of the added value of agroecology. Additionally, they emphasized the importance of having an appropriate and supportive legal framework along with access to funding. Promoting local consumption of agroecological products was also highlighted as a vital aspect of creating a conducive environment for agroecology.

In the Giheta ALL, respondents highlighted the essential steps to foster an enabling environment for agroecology. They emphasized the significance of implementing favourable policies that specifically address agroecological practices. Furthermore, ensuring protection for products obtained through agroecological methods was considered crucial in promoting and sustaining agroecology.

Policies surrounding agroecology

The Burundi government has made agriculture a priority, committing to increase spending on agriculture to at least 10% of the national budget as per the Maputo Declaration. Burundi has several policies and strategies governing agricultural production, trade, and food security. There is a need to build on those policies for further improvements and implementation. To date, some agricultural policies have been developed to boost the national economy. The approach in the formulation of agricultural production is based on a long-term Burundi Vision 2025, a national Poverty Reduction Strategy Plan, a National Agriculture Strategy (2008), the National Agricultural Investment Plan 2012–2017, and a Comprehensive Africa Agriculture Development Programme.

In the Bujumbura and Giheta ALLs, the respondents indicated the existence of policies, no examples were given though.

In Bujumbura ALL, the respondents noted that; sensitization of decision-makers and farming professionals to make agroecology a national priority and demonstrate the differences in quality between agroecological products and conventional foodstuff. Producing solid arguments and demonstrating the added value of agroecology, mobilising all the actors, and leaving no one behind, developing lobbying and advocacy strategies.

In the Giheta ALL, the respondents indicated that encouraging synergies between national and international stakeholders to drive a global movement will enhance agroecology markets.

In the Bujumbura ALL, the respondents noted that there were no local or national budgets supporting agroecology. In the Giheta ALL, the respondents noted that they have seen allocation of budgets in promoting agroecology though no examples were given.

Physical infrastructures enabling trade in the region

It was noted that the region lacks physical infrastructure that enable trade in both the Bujumbura and Giheta ALLs. In addressing the above, the respondents from the two ALLs indicated that small-scale producers could address the issue by supporting the structuring of growth-generating value chains through cooperative development and incentives offered to agro-entrepreneurs.

Positioning of agroecology in reducing food waste in Burundi

In the Bujumbura ALL, it was recommended to provide training to various actors on the utilization of all components of agroecological food to minimize food waste. One key informant noted that "*The food deficit is so great that we cannot speak of food waste except for losses in post-harvest processing!"*.

In the Giheta ALL, responsible management of agricultural products and harvest waste through composting was quoted in reducing food waste.

4.2. Cameroon-Ntui ALL

4.2.1. Food systems in Cameroon-Ntui ALL

Agriculture is the mainstay of Cameroon's economy, engaging an estimated 70% of the economically active population and accounting for an estimated 80% of the primary sector's contribution to the country's GDP. It also provides one third of foreign exchange earnings and 15% of the country's budgetary resources. Despite this enormous potential, agriculture in Cameroon faces a plethora of challenges, thus compromising the country's capacity to sufficiently nourish its expanding food needs.

In most Sub-Saharan African countries, including Cameroon, there has been an increase in food availability since the second half of the period 1960-2013 (Berkum et al., 2017). However, Cameroon, like most SSA countries, is becoming more and more dependent on food imports. Statistics show a significant increase in the importation of animal products (meat, dairy, and fish), cereals (including processed), fruits and vegetables (fresh and processed), oils and fats, and other food products (mainly sugar) as shown in Table 15.

Table 15: Food imports in Cameroon (million USD) for 2000/2001 and 2014/2015

Foods categories	2000/2001	2014/2015
Animal products	58	369
Cereals	139	616
Fruits and vegetables	6	23
Oils and fats	9	26
Other (sugars)	45	78

Source: Adapted from Berkum et al. (2017)

When considering the share of imports in domestic food supply (in kcal/capita/day), food imports globally account for close to 10% of domestic consumption, but imports of fish, sugar, and cereals account for close to 60%, 50%, and 30% of domestic consumption respectively (Berkum et al., 2017). Hence, to break this import dependency, Cameroon needs to step up its food production by putting in place serious measures. The 2017 Comprehensive Food Security and Vulnerability Analysis carried-out by the World Food Program (WFP) in Cameroon revealed that approximately 16% of households in Cameroon are food insecure (moderately food insecure and severely food insecure).

The WFP also found that a higher percentage of households in rural areas are food insecure than households in urban centres. At the regional level, the Far-North has the highest prevalence of food insecure households with 34%, followed by the Northwest with 18% and the West with 18% (WFP and FAO, 2017). The WFP and FAO reveal that a considerable proportion of households in rural areas (27%) have inadequate diets and about 5% of these households consume poor diets. The West region has the highest percentage of households consuming a poor diet (9%).

Based on data collected from 600 rural households in the West region of Cameroon, the food system appears to be economically sustainable for most rural households, with only 6% experiencing low household food supply. However, concerning the social domain, the food system is not sustainable, as 21% of households are vulnerable to food insecurity, and 18% are food insecure. The nutrition quality analysis of the food consumption score indicates that a significant number of households have inadequate consumption of hem-iron, protein, and vitamin A rich foods. Regarding the environmental domain, the food system demonstrates relative sustainability, as only 1% of households always discard food. Globally, developing countries contribute to 7% of food loss and waste at the consumer level, while developed countries are responsible for 28%. Looking at specific food types, fruits and vegetables account for 44% of the weight of loss and waste, followed by roots and tubers (20%), and cereals (19%). In general, in Sub-Saharan Africa, food waste is minimal, with no waste reported for dairy products and approximately 2% for cereals, roots and tubers, meat, and meat products. For fish and seafood, it is below 2%, while for fruits and vegetables, it is close to 5%.

Focal crop: cocoa

Cocoa is one of the main cash crops and exports of Cameroon, accounting for approximately 90% of the income of rural communities involved in cocoa production. Cocoa from Cameroon is the most sought-after cocoa brand in the international market (Uba, 1999). Cocoa occupies about 450 000 ha (37%) of the total cultivated area in Cameroon with average farm sizes of about 5 hectares. The Southwest province is the highest cocoa producing region in the country (CTA, 2012). Cocoa production in Cameroon is on the rise, growing from 220,000 tons in 2014 to 270,000 tons in the 2019/2020. Despite the vital role played by the cocoa industry in the economy of Cameroon, the sector is still highly under-performing, plagued by low productivity, low quality, low prices etc.

4.2.2. Cocoa value chain in Cameroon

Our analysis adopted a value chain approach, i.e., it did not focus solely on one production sector but extended the analysis to include major value-added activities. Key informants dealing with cocoa in its raw state; cocoa bean i.e., producers, but also traders and those who provide direct support to production activities e.g., input and service providers and/or advisors, and cocoa processors involved in the transformation of cocoa beans into semi-finished and finished products i.e., manufacturers of chocolate and related products, were surveyed.

Value chain actors in the cocoa industry in Cameroon

A typical cocoa value chain system involves the operation of five major segments: cocoa bean production, sourcing and trading, marketing, processing, distribution, and retailing to the final consumers as shown in Figure 7.

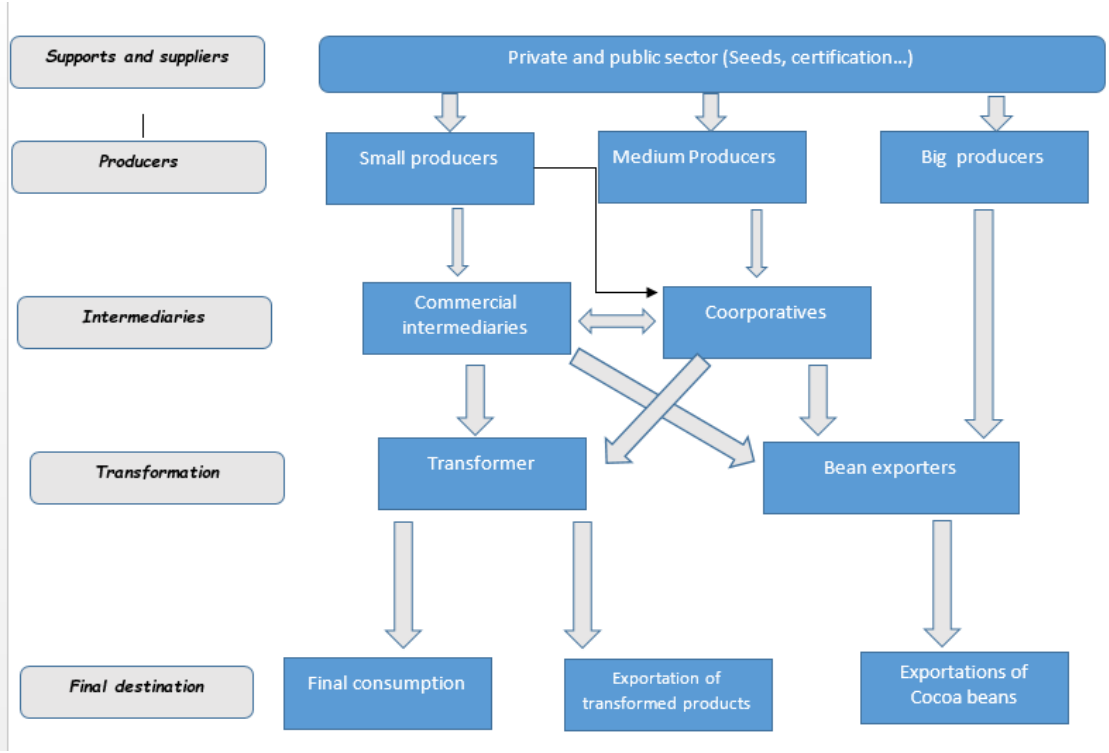

Figure 7: Cocoa value chain actors in Cameroon. Source: Production value chain of cocoa in Cameroon.

The value chain of cocoa starts with (mainly small-scale) farmers. There are about 600,000 cocoa farmers across Cameroon who run their plantations, harvest cocoa pods, and carry out the first processing steps, fermentation and drying, of the beans. The producers sell the cocoa directly or via cooperatives and/or traders to exporters or to the local industry. The traders sell the beans to grinders, which often also produce industrial chocolate and other downstream products. The last steps of the value chain are retailers who sell chocolate bars and other products to consumers. Chocolate is sold directly to the consumer as solid bars of eating chocolate, as packaged cocoa, and as baking chocolate. It is also used by confectioners as coating for candy bars and boxed or bulk chocolates, by bakery product manufacturers and bakers as coating for many types of cookies and cakes, and by ice-cream companies as coating for frozen novelties. Cocoa powders, chocolate liquor, and blends of the two are used in bulk to flavour various food products and to provide the flavours in such “chocolate” products as syrups, toppings, chocolate milk, prepared cake mixes, and pharmaceuticals.

Beside the stakeholders which are directly involved in the growing, processing and selling of cocoa, a huge number of further actors participate in the value chain. This includes producers of input, pesticides, fertilisers, machinery, and packaging material, as well as research institutions, growers of cocoa plants, providers of transport and storage facilities and financial institutions as discussed below.

People as labor, decision-makers, and consumers

People here refer to both individuals and groups, working in agricultural production (labour), distributors (wholesalers and retailers), decision-makers and consumers. Those working in the agricultural sector include landless agricultural labourers either attached to or working for other farmers, small, medium, and large-scale farmers as well as all those involved at different levels of the agricultural production chain.

Role of middlemen in the value chain in Cameroon

According to the participants, the advantages of intermediaries are timely provision of money for social needs (advance on sales), rapid resolution of emergencies, pre-financing of the harvest, easy and direct sale, and supply of inputs. Their disadvantages are explained by; trafficking of balance (truncated), reduction of the official cost, clandestine operators, incentive to produce low quality cocoa.

According to Lionel et al. (2020), informality in the cocoa marketing chain is a well-established reality that cannot be eliminated overnight simply through prohibition. Furthermore, there is uncertainty about whether its disappearance would necessarily improve the performance of the cocoa marketing chain. However, if informality were to be addressed, various interventions could be considered. One potential intervention is for cooperatives to enhance their internal organization and provide essential services that are currently mainly offered by coaxers. Integrating the competencies of coaxers as collecting agents within cooperatives, with a substantial monthly salary, could minimize the risk of farmers being deceived by coaxers and improve the quality control process conducted at the cooperatives. In addition to the immediate formalization of coaxers, more comprehensive interventions are required. These should focus on finding innovative ways to deliver services that coaxers currently provide to cocoa producers, formal intermediaries, and exporters. These new service delivery approaches must surpass the existing ones to be effectively adopted. The government's support is crucial in boosting the performance of cooperatives. Existing assistance, such as strengthening their technical capabilities, may not be sufficient, as it lacks a realistic assessment of the role and performance of coaxers. A more thorough evaluation of the significant challenges present in the cocoa sector is necessary to develop effective strategies for improvement.

Financial intermediaries

These were quoted as producer cooperatives that were applauded for facilitating access to finance. To increase the efficiency of the cocoa and coffee sectors, the Fund for Development of the Cocoa, and Coffee Value Chain (FODECC) was created in March 2006 by Presidential Decree No. 2006/085 of 9 March 2006. Its main mission is to support this sector through the financing of projects aimed at securing, increasing, and guaranteeing the good quality of cocoa and coffee production[10].

From the primary data collected, the respondents did not mention the fund hence there is need for sensitization if the producers on the fund.

Research

In Cameroon, cocoa research is handled by the Institute for Agronomic Research (IRAD) that conduct research on perennial crops such as (cocoa, coffee, fruit, oil palm and rubber) and marketable tubers such as (root tuber, market gardening crops, and plantains). The key informants also indicated the same type of value chain actors exist in the cocoa industry.

[10] Cocoa Exports of Cameroon 2018

Gaps, bottlenecks, and risks in the cocoa value chain in Cameroon

Due to recurrent poverty, smallholder cocoa farmers suffer immensely from inadequate access to economic and social resources which endanger the cocoa sector and their entire livelihood. Farmers also lack adequate access to inputs such as fungicides, pesticides alongside a lack of transportation and production resources such as trucks to convey cocoa from farms to homes, and homes to markets, diggers, vessels, tarpaulins, and ovens. In addition, these farmers lack proper storage facilities such as warehouses to store dried cocoa. There is absence of proper sound market knowledge to avoid that prices are being dictated to farmers by buyers. The government has neglected the sector since its privatisation without necessarily educating farmers on privatisation that led to the collapse of the National Produce Marketing Board (NPMB) (Ngoe et al 2018). Although these factors were acknowledged, many interviewees named the cocoa price as one of the main issues within the cocoa value chain.

The risks that seem to affect women most in the value chain included limited access to markets and low prices offered for their produce. Higher prices of agroecological products would be an important incentive to attract especially young people to stay in the cocoa sector.

In addressing the above gaps, the following recommendation measures were suggested by the respondents.

1) Facilitate access to finance by reducing the interest rates,
2) Enhance capacity building among the farmers and
3) Support input and output market linkages.

The focus discussion group respondents also noted programs that could partner together with the farmers in addressing the gaps as; "*Trade Delegati*on, ACEFA, C*ocoaSoils, Agriculture Delegation, IRAD Research Station*".

4.2.3. Cameroon cocoa market

In Cameroon, in the aftermath of liberalisation, the activities of most agents in the cocoa market were dictated by private exporters, who are registered as Licensed Agents at the Ministry of Trade (Kamdem et al., 2013, Gbetnkom and Khan, 2002). In this marketing system, two new organisations, the ONCC (National Cocoa and Coffee Board), a public establishment, and the Interprofessional Council of Coffee and Cocoa (CICC), which is the body of the sectoral organisation are central. The responsibilities of the ONCC are to ensure compliance with the respective rules and regulations, supervise export quality control, represent the interests of the stakeholder groups, and provide information on prices on the international market. The ONCC does not intervene in the financing of marketing and cocoa production. Since it does not carry out price stabilisation, there are no more guarantees on the prices (Inter-réseau, 2008). Exporters now have the flexibility to purchase cocoa from any market actor willing to sell. However, they primarily buy from licensed buyers and licensed buying agents, and to a lesser extent from cooperatives. Occasionally, they also buy directly from farmers and from informal buying agents, also known as "coaxers," to some extent, although the exact proportion is unknown. Even though licensed buying agents acquire a significant portion of their cocoa from coaxers, exporters prefer to buy from them due to their role in standardizing, grading, and packaging the cocoa, which is critical for maintaining quality. Moreover, purchasing small quantities from multiple sources would result in high transaction costs for exporters. Licensed buying agents, therefore, play a crucial role by efficiently collecting small amounts and consolidating them for sale in

large quantities within a short timeframe. Processors, on the other hand, exclusively buy cocoa from exporters and licensed buying agents and not from coaxers or farmers. This preference is driven by the need for standardized and graded produce, ensuring consistent quality in the processing phase (Adubi and Okunmadewa, 1999).

The survey results revealed that most of the respondents (97%) sell their products in the local market, while only a small portion (3%) sell in both local and national markets. Among the respondents selling in the local market, 52% were female producers, compared to 48% male producers. Interestingly, women producers were found to have a larger share in regional and international markets, accounting for 90% of those markets, while their male counterparts represented only 10%. It was observed that most producers faced no significant challenges in accessing the local market. However, they encountered difficulties in accessing national and international markets. This finding aligns with previous research indicating that smallholders are often inadequately connected to agricultural markets (Gabre-Madhin, 2009; Kamdem, 2016; Key et al., 2000).

Regarding cocoa exports from Cameroon, approximately 83% of the exports are in the raw state, specifically cocoa beans. The main destination for these exports is the Netherlands (68%), with Malaysia, Belgium, Spain, and Indonesia accounting for 13%, 6%, and 5.5%, respectively (ITC, 2016).

The survey findings showed that 83% of respondents believe that the cocoa supply is insufficient to meet the demand, while only 17% indicated that the supply is adequate. The prevailing situation arises from the fact that the demand for cocoa is increasing.

Challenges affecting markets and recommendations

The shift towards liberalised markets in Cameroon was aimed at increasing efficiency and competition within the Cameroon cocoa sector in general, and in the marketing chain in particular, it has been claimed that, in some cases, the abolition of Marketing Boards slowed down the performance of the supply chain regarding the quality of the output and the share of margins among market actors within the chain (Gilbert, 2008[11]). The Cameroonian law N°95/11 of 27 July 1995 states that every intermediary agent in the cocoa marketing chain must sign a statement of existence. Nevertheless, it is widely observed that apart from the formal market intermediary agents— licensed buying agents and Cooperatives— there are informal buying agents (*coaxers*), small travelling traders who operate mostly with the farmers and deal directly with them. They trade in small volumes at a time, use limited amounts of money, and utilise simple means of transport, such as bicycles, motor bikes and cars (Lenou, 2017)[12]. They principally buy from farmers who are dispersed in rural areas that are difficult to access and are poorly organised. The low level of organisation allows them to buy cocoa at low prices. The most significant factor is that *coaxers* perform pre-financing and, in addition, pay at purchase, which is usually not the case for licensed buying agents, cooperatives nor exporters. *Coaxers* also lend money to producers at the beginning of the agricultural season, obliging farmers to sell their harvests to them. According to Bagal et al., (2013), this flexibility offered to producers explains the prevalence of *coaxers* in the marketing system despite the fact that they often misinform

[11] Gilbert, 2008 C.L. Gilbert value chain analysis and market power in commodity processing with application to the cocoa and coffee sector

[12] https://www.sciencedirect.com/science/article/pii/S0016718520302311#bb0135

the producers on the quantity and quality of their cocoa. Some estimations state that about 70% of the cocoa beans exported are bought by *coaxers* at the farm gate (Inter-réseau, 2008[13]).

Various challenges were quoted by the respondents, including high transportation costs and taxation. The country's poor transport infrastructure, being landlocked, lack of structured markets, low-quality roads, and inadequate storage facilities further compound the difficulties. To enable and improve trade, respondents proposed several recommendations. These include the reduction of taxation by the government, the organization of markets to streamline the trading process, investments in physical infrastructure to enhance transportation and storage, mechanization of agriculture to boost productivity, and the utilization of motorbikes for efficient product transportation.

Economic, social, and environmental impact of cocoa in Cameroon

Cameroon is currently the fourth largest cocoa producer in the world, with a production level between 280,000 and 290,000 MT per year in the last two years. The cocoa sector is an important source of job creation, with an estimate of around 400,000 jobs generated by the cocoa value chain: 293,000 farmers, 2,800 formal workers, 73,000 rural workers at full-time equivalent, and 29,200 family jobs. Moreover, cocoa is an important source of state revenue. The cocoa value chain in Cameroon generates a total (direct + indirect) value added of €400 million and contributes 1.2% to the national GDP and 8.2% to the agricultural GDP. When considering the €7,8 million invested in public subsidies and several projects, the cocoa value chain generates a balance of around €37 million per year contributing to the public finances of the country. The Cameroonian government recognizes the importance of the cocoa sector for its economy and announced ambitious goals to expand cocoa production to 600 000 MT by 2025 and doubling this quantity by 2030.[14]

However, the agriculture sector has been identified as a driver of deforestation and forest degradation. The principal agents behind the drivers were identified to be small and medium holder farmers. Sub-sector identified were cocoa, rubber, coffee, cotton, oil palm, etc. Some studies have reported agriculture activities within protected areas, but this has not been clearly articulated by the government as a threat to forests.

Characteristics of (agroecology) markets

As per the respondents' communication, a key characteristic of (agroecology) markets is the rich variety of available produce, including indigenous foods, diverse food items, and products sourced from different locations. Another prominent aspect is the diversity in market structures, sizes, and scales, ranging from small local markets to large-scale regional ones. The (agroecology) markets exhibit diversity in their setup and structure, and their geographical scope extends to encompass local, national, and regional levels. This diversity is further evident in the wide range of actors involved, including producers, consumers, traders, and other stakeholders who actively participate in and contribute to the market ecosystem.

According to the key informant from the Programme for the Improvement of Competitiveness of Family Agro-pastoral Farms (ACEFEMA), the (agroecology) market in Cameroon is characterized by relatively large quantities of cocoa produced and a high demand for sought-after cocoa quality.

[13] https://www.sciencedirect.com/science/article/pii/S0016718520302311#bb0105

[14] Cocoa in Cameroon

Although the shift towards liberalised markets aimed at increasing efficiency and competition, our findings indicate that prices of (agroecology) cacao products in Cameroon are solely determined by the markets-traders making the producer to be more of a price taker than price givers. The poor infrastructure of roads, landlocked and low purchasing power of producers was also noted as a limitation to the producers in accessing the markets.

Characteristics of markets in the context of the transition to agroecology

A shift in consumer awareness is evident as more people now prioritize healthy, wholesome, and indigenous food produced through agroecological methods. This trend is driven by the growing understanding of the health benefits and broader environmental and socio-economic advantages associated with buying local and agroecologically produced food. As a result of this heightened awareness, there is an increased demand for and preservation of traditional and indigenous foods, as consumers recognize their unique value. Furthermore, the adoption of Participatory Guaranteed Systems (PGS) in labelling and packaging plays a pivotal role in enhancing consumers' trust in the food source and safety at markets. PGS systems ensure that packaging aligns with environmental sustainability principles, emphasizing the use of biodegradable materials and promoting composting practices.

In general, a paradigm shift in the perception of markets and food production methods fosters an enabling environment and culture for agroecology. Favorable policies play a crucial role in guiding and supporting the expansion of agroecology and African markets. As a result of these supportive policies, markets experience improvements in infrastructure, quality control, and overall organization. They become cleaner, more hygienic, and efficiently managed, equipped with essential facilities like cold storage to preserve produce. Additionally, enhanced transport systems and improved connectivity make these markets more accessible to smallholders and consumers alike, further promoting the adoption of agroecological practices (Shaping the Future of African Markets Towards Agroecology, 2020).

Territorial market in Cameroon

Territorial markets are: “diversified markets, through which most food consumed around the world passes, which can operate on a local, cross-border or regional scale, in rural, peri-urban, or urban, or all these contexts; and they are directly related to local national, or regional food systems, since this food is produced, processed, and marketed within these systems”. Further characteristics of territorial markets include being formal or informal, rooted in the territory, and occupying different scales.

In our study, we aimed to assess the awareness of territorial markets among the key informants. Territorial markets were defined as local markets within the district, facilitating exchanges between unions, cooperatives, and producers. The key informant from one of the banks highlighted two main barriers associated with the territorial market. Firstly, they mentioned issues of enslavement, which could refer to exploitative practices or dependency on certain buyers. Secondly, there was a concern about insufficient supply of products, indicating a potential challenge in meeting demand. The key informant from the Ministry of Trade added further insights into the barriers of territorial markets and noted that poor road conditions in the region posed a challenge for market accessibility. Additionally, being landlocked could limit market opportunities. There were also issues related to price-fixation by buyers, where buyers may exert control over prices, and imposition of prices on producers, potentially affecting their income. Lastly, low purchasing power among producers could affect their ability to engage in fair and profitable trade in these markets.

We also interrogated whether the current liberal economic model could protect Cameroon's territorial markets and ensure access to food. Among the key informants, 30% believed that the current liberal economy could safeguard the Cameroonian territorial markets, while the remaining 70% disagreed with this statement. Similarly, 25% of the respondents indicated that a liberal economy could secure access to food, while 75% expressed their disagreement, believing that it would not ensure food access. The informants cited several reasons for their scepticism. They mentioned that prices in the market are influenced by international bodies and the decisions of the first consumers, resulting in challenges for local producers and consumers. Additionally, the low purchasing power among consumers hindered their ability to access sufficient and affordable food. Regarding the chances to compete with the industrial food system, 50% of the respondents believed that Cameroon had a chance due to increasing consumer interest in products that prioritize health. On the other hand, the remaining 50% were sceptical, pointing out that limited quantities of agroecology production might impede competitiveness against the industrial food system, despite the health benefits it offers to consumers. The informants from the ACEFA program highlighted an additional challenge, stating that a lack of food safety standards and limited requirements for agroecological products would hinder the industrialization of the of the agroecology food system.

Strengthening Cameroon markets with a strong emphasis on agroecological produce will promote consumers' rights to safe, healthy, and diverse food and thus to greater overall health for them and families. They will be able to make more informed decisions.

According to the respondents, there is often a conflict between the rights of producers and consumers, particularly concerning the pricing of goods, leading to actions that may Favor one group over the other. To address this issue, the establishment of a closer relationship between producers and consumers within an Agroecological market becomes crucial. Such closer links will help ensure that producers are well-organized and promote fairer prices for their products, fostering a more equitable and balanced market environment.

All respondents (100%) expressed concerns related to finance in the agricultural sector. The reasons cited included the absence of dedicated agricultural banks, high interest rates imposed on loans, diminishing agricultural land availability, the lack of credible guarantees, and stringent conditions for accessing land.

Several recommendations were put forward to address the financial challenges. These included the creation of dedicated agricultural banks to cater to the needs of the sector, as well as a reduction in loan interest rates to make borrowing more affordable. Extending the payment period for bank loans was suggested to ease the burden on borrowers. Additionally, easing the conditions for accessing loans would help more farmers and entrepreneurs qualify for financial assistance. Creating new banks specifically aimed at financing small and medium-sized enterprises (SMEs) and ensuring the operational efficiency of existing banks were also proposed. Establishing agricultural credit unions to provide financing options for producers and offering financial education programs for young entrepreneurs would enhance financial literacy and empower individuals in the industry. Lastly, conducting pre-risk studies and presenting them to banks when applying for loans could improve the chances of loan approval and support the growth of agricultural projects.

All respondents (100%) emphasized the necessity of non-financial support to bolster farmer activities. The identified support areas included capacity building and regular monitoring of farmers' fields to enhance their skills and knowledge. Additionally, there was a call for the provision of improved seeds

to help improve crop yields and quality. Furthermore, respondents highlighted the importance of offering mechanization services to farmers to enhance efficiency and productivity. Lastly, the provision of essential inputs such as fertilizers and pesticides were recognized as essential in supporting the farmers' endeavours.

Transition of Cameroon markets to agroecology

Despite its many benefits, agroecology requires further support, which can be attained through collective learning amongst farmers and accelerating the transition from mainstream agriculture to agroecology. To make agroecology more profitable, various recommendations were given by the respondents that included reducing imports, defining the role of each intermediary, promoting the consumption of agroecological products, market regulation by the government, price controls and strengthening farmer cooperatives.

Traceability of agro-ecologically produced products in Cameroon

The concept of traceability holds different meanings for various actors within a value chain, depending on their specific roles. For instance, for consumers, traceability is associated with the assurance of product safety and sustainability. On the other hand, companies view traceability to enhance supply chain management, address risks related to safety, quality, and sustainability in production and supply, and even track payments to farmers. For authorities, traceability serves as a valuable tool to ensure compliance with sector policies and sustainability requirements, as well as to verify payments made to farmers and farmer organizations. The definition of traceability may vary between actors, with some companies having their own unique understanding, while others rely on definitions provided by certification bodies or have implicit definitions. Companies participating in this survey cited accountability to sustainability commitments and the improvement of product quality as their primary objectives for implementing a traceability system[15].

Cocoa traceability systems provide a foundation for improving transparency along value chains, and facilitate the development of monitoring systems, allowing access to information, and improving the reliability of sustainability claims. By enabling transparency, traceability systems can build bridges between producers, governments, non- governmental organisations, and market actors, whilst providing a basis for ensuring that sustainability initiatives and standards are contributing to real impact[15].Inspections and compliance with the specifications defined by the producer via monitoring was quoted as a verification method for agroecologically produced produce. The respondents indicated that the producers and consumers are feasible given the low level of development of local markets. There are some traceability requirements in place in Cameroon, mainly regarding quality control and assessment of quantity. Buyers are required to report weekly on quantities and qualities of cocoa bought. Exporters are required to report on the quantity and quality of cocoa exported. Transport of cocoa is checked at district level with paper-based waybills. Finally, within the cocoa sector, there are currently two main standard setting bodies, Fairtrade International, and Rainforest Alliance. They were both pioneers in establishing the minimum requirements for sustainability and traceability in the cocoa sector. Private companies work with one set of standards, or both, and opt to apply their own company schemes. The adoption of standards set by these bodies has unravelled

[15] Cocoa traceability

sustainability issues in the cocoa sector, and helped pave the way for organisations trying to determine ways in which they can tackle these issues.

Willingness to pay for the agroecology produced product

According to the survey results, 80% of the respondents mentioned that consumers are willing to pay more for agroecology products, while the remaining 20% disagreed with this statement. Those in Favor of consumers paying more highlighted that agroecologically produced products are often perceived as expensive due to limited supply in the market. On the other hand, those who stated that consumers do not pay more emphasized the importance of raising awareness about the benefits of consuming agroecological products to increase consumer willingness to pay a premium. Among those who agreed that consumers are willing to pay more, 71% mentioned that consumers are ready to pay for certified products, citing the assurance of quality as the driving factor. However, 29% of respondents disagreed, suggesting that consumers are not willing to pay more, and one of them pointed out that there is no price differential between certified and non-certified or traceable products (as mentioned by the KI for the divisional office).

The rising demand for safe African foods among middle and high-income consumers presents an opportunity for small producers in Cameroon. However, they face challenges related to limited quantities, seasonal production, and food safety concerns. To address these issues, the respondents proposed several solutions:

1) Raising awareness: Educating both producers and consumers about the importance of producing and consuming healthy foods and reducing the reliance on chemical inputs.
2) Improving prices: Implementing strategies to ensure fair prices for small producers, enabling them to compete more effectively in the market.
3) Increasing arable land: Exploring ways to expand agricultural land to accommodate higher production levels and meet the growing demand.
4) Capacity-building and monitoring: Providing training and support to farmers to enhance their skills and practices while implementing monitoring systems to maintain quality standards.
5) Promotion of local consumption and processing: Encouraging the consumption of locally produced foods and promoting value addition through processing to add value to the products.

Participatory guarantee system application in cocoa or any other commodity

Participatory Guarantee Systems (PGS) are locally focused quality assurance systems. They certify producers based on active participation of stakeholders and are founded on trust, social networks, and knowledge exchange (IFOAM, 2019). 67% of the respondents indicated the presence of a PGS, the standards are set up by the Interprofessional Council for the Cocoa and Coffee (CICC) and the state. 33% indicated lack of a PGS in the cocoa commodity.

4.2.4. Enabling the environment for agroecology

To foster an enabling environment for agroecology, respondents emphasized the importance of several factors. These include creating markets, ensuring access to land, providing access to financial resources, technologies, and essential infrastructure for producers. Additionally, price structuring and government subsidies for inputs were identified as crucial measures.

When assessing the impact of local and national budgets on promoting agroecology, the opinions were divided. 50% of the respondents acknowledged witnessing the positive effects of budget allocation towards agroecological initiatives. In contrast, the other 50% did not observe such impacts or were not aware of any significant changes resulting from the allocation of budget resources.

To engage policy makers in reinforcing policies for agroecology markets, the respondents highlighted various essential strategies. These include raising awareness about the advantages of agroecology, demonstrating the detrimental effects of climate change, and emphasizing the health benefits of producing and consuming agroecological products. Furthermore, involving all relevant stakeholders and ensuring effective communication about the proposed changes were seen as crucial steps. Setting up dedicated development units to support agroecology initiatives, providing premiums on the production of agroecological products, and promoting improved production practices were also identified as key measures. Additionally, reducing waste in the value chain and establishing strong financial linkages to support producers were recognized as essential components to strengthen agroecology markets.

Even though Cameroon is a founding member of the World Trade Organisation (WTO), it is still lacking in the domain of the implementation of the WTO policies. This is mostly because of the lack of the necessary facilities and resources to implement the rules. Nevertheless, with Cameroon involvement in other regional trading agreements like the European Union Economic Partnership agreement, (EUEPA), Economic and Monetary Community of Central Africa (CEMAC), African Growth and Opportunity Act, (AGOA), amongst others, it has helped to boost its trade potential. At the internal level, the government's objectives for boosting trade consist of ensuring regular supplies in the domestic market under healthy conditions of competition and, at the international level, seeking new markets for Cameroon's goods and services, particularly those with high value added. The government's trade policy objectives also include African trade integration, mainly with Nigeria and within the Economic Community of Central African States (ECCAS) (Pefala 2018).

According to the respondents, 80% stated that there are existing subsidies and taxation policies for agroecology products, including cocoa. One of the respondents mentioned the "Financial support for cocoa producers from the Fonds de Développement des Filières Cacao et Café, FODECC" provided by the Ministry of Agriculture and Rural Development. However, 20% of the respondents expressed that there are currently no subsidies or policies supporting cocoa production in the cocoa sector. A respondent from the Ministry of Trade indicated that these policies might have ceased to exist.

Positioning of agroecology in reducing food waste in Cameroon

In positioning agroecology in reducing food waste, the respondents highlighted several key strategies. These include raising awareness among stakeholders about agroecological principles, increasing the production of agroecological products, and developing food preservation methods to extend shelf life. Additionally, they emphasized the importance of utilizing compost to minimize waste and promote sustainable agriculture practices. Creating product processing units and establishing efficient food collection routes were also identified as feasible approaches to address food waste and enhance the value chain.

Conclusions

The purpose of this section was to present, in a general manner, the organisation, structure and operating mechanisms of the Cameroon food systems, cocoa value chain actors and markets.

Majority of the respondents (97%) sell their products in the local market and only 3 % sell in both local and national markets. In the local market. Due to recurrent poverty, smallholder cocoa farmers suffer immensely from inadequate access to economic and social resources which endanger the cocoa sector and their entire livelihood. Farmers also lack adequate access to inputs alongside a lack of transportation and production resources. In addition, these farmers lack proper storage facilities such as warehouses to store dried cocoa.

There is absence of proper sound market knowledge to avoid prices as such prices are being dictated to farmers by buyers. The government has neglected the sector since its privatisation without necessarily educating farmers on privatisation that led to the collapse of the National Produce Marketing Board. The findings also show that Cameroon, like most cocoa-producing countries, also faces many difficulties internally through implemented policy measures.

To make agroecology products more profitable, various recommendations were given by the respondents that included reducing imports, defining the role of each intermediary, promoting the consumption of Agroecological products, market regulation by the Government, price controls and strengthening farmer cooperatives.

Other corrective measures envisaged are, in the internal marketing of products, improve the producer price; cushion the impact of international price fluctuations on producer prices, restore the differentiated collection of products and the deterioration of export quality; fight against the under-payments of the products, improve the competitiveness of cooperatives; institute a framework for consultation involving all public and private stakeholders. The government option of a return to stabilisation will reaffirm the place and the role of the state in the management of the sector. About the constraints related to external marketing, to remedy this, the government option for external marketing is the establishment of a system of advanced sales, controlled by the State, through centralization sales and monitoring of their quantitative and qualitative execution to the ports of destination.

4.3. Democratic Republic of Congo- Biega, Uvira, Bunia, Kabare ALLs

4.3.1. Introduction to DRC food system

The Democratic Republic of the Congo (DRC) possesses remarkable agricultural potential, boasting vast fertile lands covering approximately 80 million hectares, capable of providing sustenance for its entire population and even surplus for exportation (WFP, 2022). Around 75% of the population relies on agriculture and related services for their livelihoods, benefitting from the country's favourable climate and rich soils, which could potentially support food production for over 2 billion people with appropriate investments. Despite these promising prospects, the DRC faces a severe food crisis.

Currently, 26 million people in the country experience acute food insecurity, making it Africa's largest hunger crisis, second only to Yemen globally. This dire situation is exacerbated by various factors such as poor harvests, violence-induced displacement, diseases, unemployment, and crumbling infrastructure. The situation is worsened by inadequate agricultural practices and mining activities, which contribute to deforestation and loss of biodiversity. This negatively impacts natural resource-dependent communities, indigenous groups, and women who heavily rely on the agricultural sectors for their well-being.

In 2019, the agrifood systems generated 35% of total GDP in DRC and about 75% of total employment, while agriculture alone represented 12% and 56%, respectively. This section provides data on the structure of the DRC's economy as a whole and of its agri-food system in 2019.

Table 16 shows the breakdown of national GDP, employment, and trade.

Table 16: Structure of DRC economy in 2019

Economic sector	GDP	Share of employment of total employ-men	Exports	Imports
Total	**100**		**100**	**100**
Agriculture	**12.3**	**56.3**	**0.6**	**6.1**
Crops	10.4	43.6	0.4	5.0
Livestock	0.4	1.8	0.0	0.0
Forestry	1.1	3.4	0.2	0.0
Fishing	0.5	7.4	0.0	1.1
Industry	**52.7**	**34.4**	**98.2**	**87.0**
Mining	25.2	2.9	97.3	2.4
Manufacturing	12.2	6.6	0.9	84.2
Electricity & water	5.1	0.2	0.0	0.3
Construction	10.3	24.8	0.0	0.0
Services	**34.9**	**9.3**	**1.1**	**6.9**
Trade & transport	10.7	3.3	1.1	4.4
Hotels & food services	3.0	0.4	0.0	0.0
Finance & business services	16.3	1.7	0.0	1.4
Government, health & education	3.7	3.4	0.0	0.7
Other services	1.3	0.5	0.0	0.4

Source: IFPRI estimates using supply-use tables, national accounts, and ILO employment data. GDP is gross domestic product measured in constant 2019 USD.

Agriculture is an important part of the DRC's economy – it generated 12% of national GDP and 56% of total employment in 2019. Crops dominate the sector. Part of agriculture's output is supplied to the manufacturing sector for processing. Total manufacturing generated 12% of GDP and 7% of employment. DRC depends heavily on mining exports, especially copper and cobalt. Most foreign

earnings are used to pay for imports of refined petroleum and manufactured goods, such as machinery and vehicles. About one third of total GDP is generated from services with finance and business and trade and transport the largest service subsectors.

The importance of agriculture for the economy extends well beyond the sector itself, with many industrial and service sectors forming parts of the agrifood system. in DRC, agriculture generated $6.1 billion in GDP and employed 16.6 million workers in 2019. Agro processing generated a further $4.7 billion in GDP and 1.5 million jobs. Both sectors use domestic inputs, whose production creates more value-added jobs.

Another large off-farm component is the trading of agriculture-related products between farmers, processors, and consumers. This created $3.7 billion in GDP and employment for 3.5 million workers, making it the third largest component of DRC's agribusiness system and responsible for more than two-thirds of the total trade and transport GDP. In total, DRC's agrifood systems generated 35% of total GDP and 74% of employment in 2019[16].

DRC has the Agricultural Sector and Rural Development Strategy that prioritises family-based food-producing agriculture by smallholders and improved access to markets. It also has the National Agricultural Investment Plan (NAIP) 2014-2020, which outlines how family farming will gradually lead to the development of the agrifood sector, with high returns for smallholders. Under the plan, the private sector is being asked to contribute to the development of the agrifood industry and the Government expects the living conditions of farmers to improve through the creation of "poles of agricultural enterprises".

4.3.2. Value chain actors in DRC

In both Biega and Kabare ALL, the focal crop is highland coffee.

Key players in the coffee value chain include producers, processors, marketers, and consumers as shown in figure 8 below.

Biega, which borders the Kahuzi National Park is an agro-forestry area inhabited by a mixed population of indigenous and Bantu peoples. Agriculture is the main activity of the Bantu people, while the indigenous people are more involved in woodworking (embers and planks). Coffee is the most widely grown crop and is also the best-selling product, followed by cassava and onions. Crops such as maize, beans, manioc and vegetables are often produced for home consumption, and are rarely brought to market.

The agricultural producers in Biega face a significant challenge due to the geographical location of the region. After harvesting their produce, they are compelled to undertake arduous journeys of over 15 kilometres to reach the distant markets where they can sell their goods. Unfortunately, at these markets, the producers are not able to negotiate prices. Instead, the prices are dictated and imposed upon them by the resellers, who essentially act as their only customers. Given the long and difficult journey, the burden of carrying their merchandise, and the lack of alternative customers back home, the vulnerable and disadvantaged producers have no choice but to accept the prices forced upon them by these resellers. This situation leaves them with little bargaining power and limited options, leading to economic hardships for the agricultural community in Biega.

[16] https://doi.org/10.2499/p15738coll2.136652

Coffee value chain in Biega and Kabare, DRC

Figure 8 shows the coffee value in DRC.

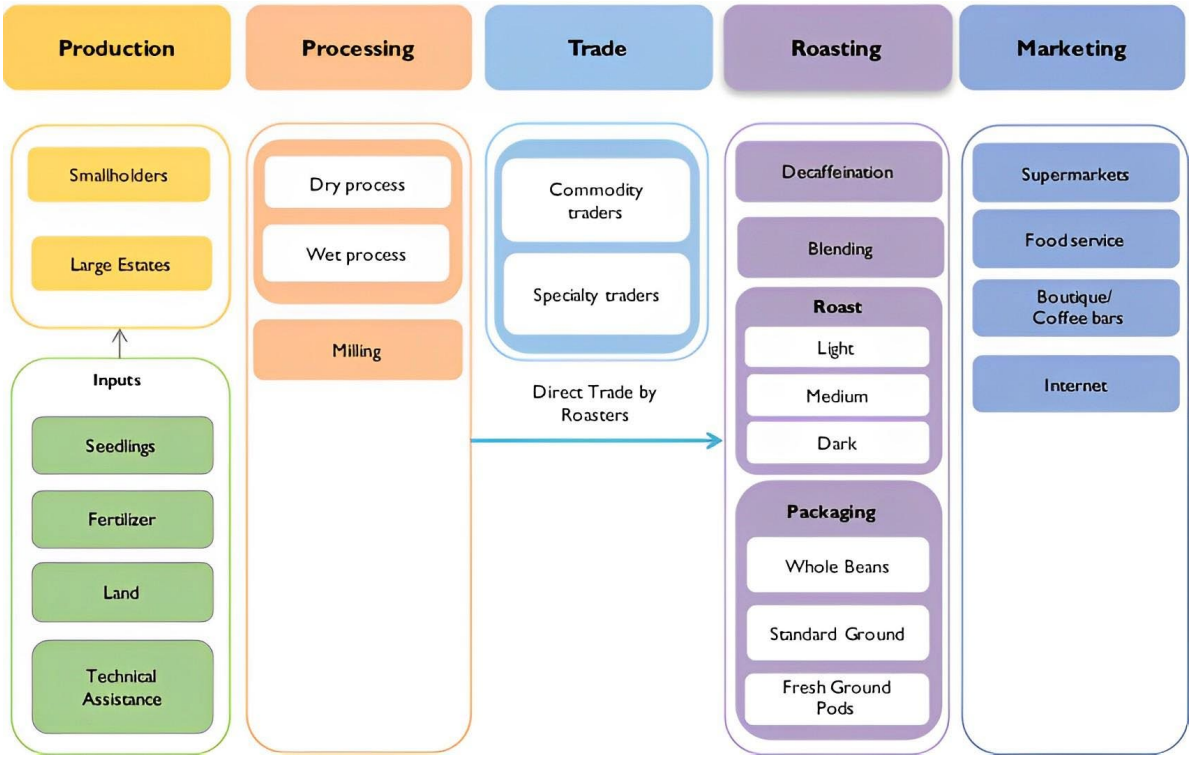

Figure 8:Coffee value chain in DRC. Source: Feed the Future DR Congo Strengthening Value Chains activity, 2017.

Inputs. The production process for coffee requires several inputs, including physical inputs (seedlings, fertilisers, and sprays), land and labour. The qualities of the various inputs can determine the types of end-markets in which the coffee may ultimately be sold. For example, for coffee production to be certified as organic, growers may only use types of approved organic seedlings and inputs. Wet process Supermarkets Dry process Milling Decaffeination. These inputs are typically sourced directly by smallholders or estates; however, traders, non-governmental organisations (NGOs) and government actors may aid finance the purchase of inputs.

Production. During the production stage, coffee trees are cultivated on large estates or on small farms and it takes approximately 3-4 years for a tree to become productive. Nearly 70% of the global coffee supply is produced on small coffee farms of 1-5 hectares, often involving family labour, although additional labour is sometimes hired during harvesting periods. Arabica coffee trees thrive only in particular geographic conditions, such as an altitude of 1,000-2,000 metres and average temperatures between 15° and 24°C. They are also more prone to pest and disease and therefore require additional care for growth.

Processing. During this stage, the coffee cherry is cured and milled to remove the fruit from the bean. Curing occurs either through dry or wet processing. Dry processing involves exposing the coffee cherries to the sun to dry for one month, at which point the fruit becomes brittle and can be easily removed from the bean. Under wet processing, the cherry is immersed in water to soften the outer

layer, and the fruit is removed. Wet processing is typically seen to impart a better flavour to the coffee, which often translates into a higher price.

Actors involved in processing can vary. In some cases, smallholders process the cherries themselves, especially with dry processing. Small farmers frequently participate in cooperatives or associations to achieve efficiency gains at the processing stage. Large estates usually process their beans on-site. In some cases, trading companies are integrated into the processing stage to ensure a steady supply of coffee with desired characteristics.

Traders purchase green coffee from growers and grower associations and ship the beans to the end-market. Large roasters rarely source beans directly from producers.

Liberalisation of the coffee sector, together with new opportunities being opened for producers to expand incomes through the rise of specialty coffee market interest in Congolese coffee and the emergence and rehabilitation of producer associations, can in turn spawn expanded producer income that can be invested into farming systems to increase household incomes and access to nutrient-rich crops. Against this backdrop, increased state support for technical assistance institutions, especially the National Agricultural Study and Research Institute (INERA), and the evolution of new corporate relationships between concessions and tenant smallholders, holds the potential to foster news avenues for investments through introduction of technical assistance, capital assets, market linkages, and potentially finance, for the value chains. Taking a market systems facilitation approach, the Political Economy Analysis (PEA) team implementation recommendations fall into three broad categories: facilitation of coffee sector governance strategy, facilitation of technical assistance and finance linkages between technical assistance and finance institutions and value chain stakeholders, and facilitation of linkages between concessions and tenant producers.

Cassava production in Uvira, DRC

Figure 9 below shows value chain actors involved in cassava processing in DRC.

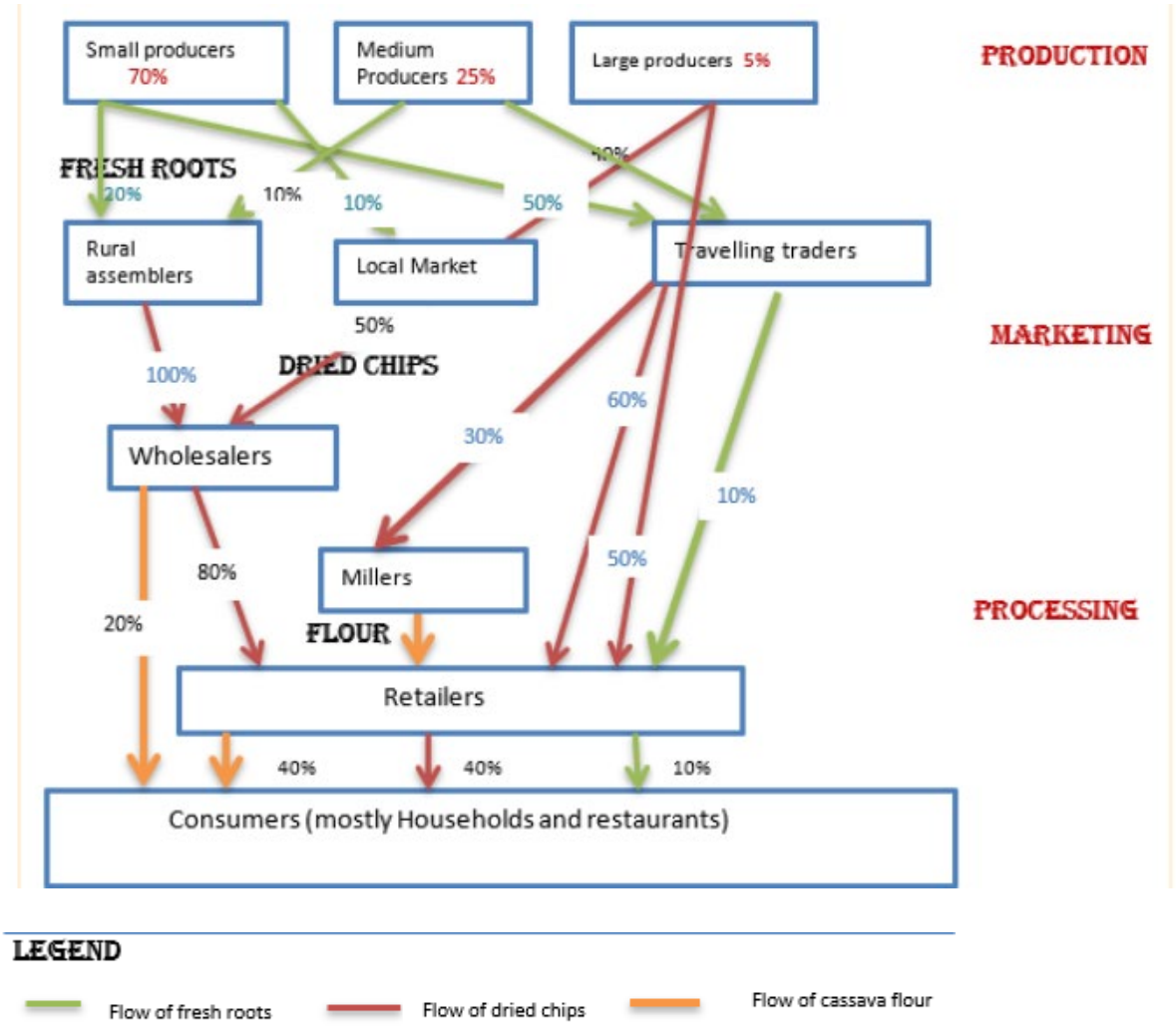

Figure 9: Cassava value chain actors in DRC. Source; Rikolto project

Generally small-scale farmers mainly rely on traditional technologies and do not use improved inputs such as improved planting material and fertilisers. Production practices are however improved among medium-scale producers who often tend to have good relationships with extension service, have access to good planting material and training; commonly use hired labour, and sometimes apply integrated soil fertility management (ISFM) although not sustainably. In general, large-scale farmers - who comprise businessmen and large landowners - are the most innovative among the producers. The large-scale producers frequently hire technicians to manage their farms, combine crops with livestock production activities, and apply improved inputs including planting material and fertilisers.

Practices during cassava marketing also vary with the scale of production activities. Small- and medium-scale producers frequently sell their cassava as fresh roots in comparison to large scale producers who add value by processing the roots into dried chips. Market outlets among the small and medium scale producers include travelling traders (about 50% of the produce), rural assemblers (10% to 20% of the produce) and local markets (10% of the produce). Large scale producers on the other hand sell their produce directly to either the wholesalers or retailers (50% of the produce in each case).

Rice production in Uvira, DRC

Rice is a crucial staple crop in the Democratic Republic of Congo (DRC), and it is consumed by both rural and urban populations. Smallholder farmers are responsible for producing around 50% of the 700,000 MT of rice consumed in the country, while the remaining 50% is imported. The rice produced by local farmers is mainly consumed by themselves and purchased by local market consumers. In contrast, imported rice is consumed in urban areas and used by breweries. Unfortunately, the current cultivation systems used by approximately 800,000 smallholder farmers are highly inefficient and mainly rely on pluvial (rainfed) cultivation, yielding only 0.8 MT/ha, while only 32,000 farmers practise flood irrigation, yielding about 2 MT/ha.

In DRC, traditionally, four main functions and actors are identified but due to weak organisation/structuring, some actors see themselves playing several roles and find themselves at several stages along the value chain. In addition, in the urban and rural market, end consumers (of table rice) are confronted with several actors in the value chain ranging from producers to retailers. Indeed, producers have access to the final consumer of the production area (rural market) and on the urban market, several actors meet there, collectors-wholesalers, processors-traders, wholesalers, and retailers. Figure 10 shows the process through which the rice product passes from production to its final consumption. It is observed that from the paddy harvest, producers are confronted with several actors to whom they sell their raw production (paddy) or after having transformed it (white rice). This multitude of intermediaries generates several circuits in the value chain which sometimes poses coordination difficulties.

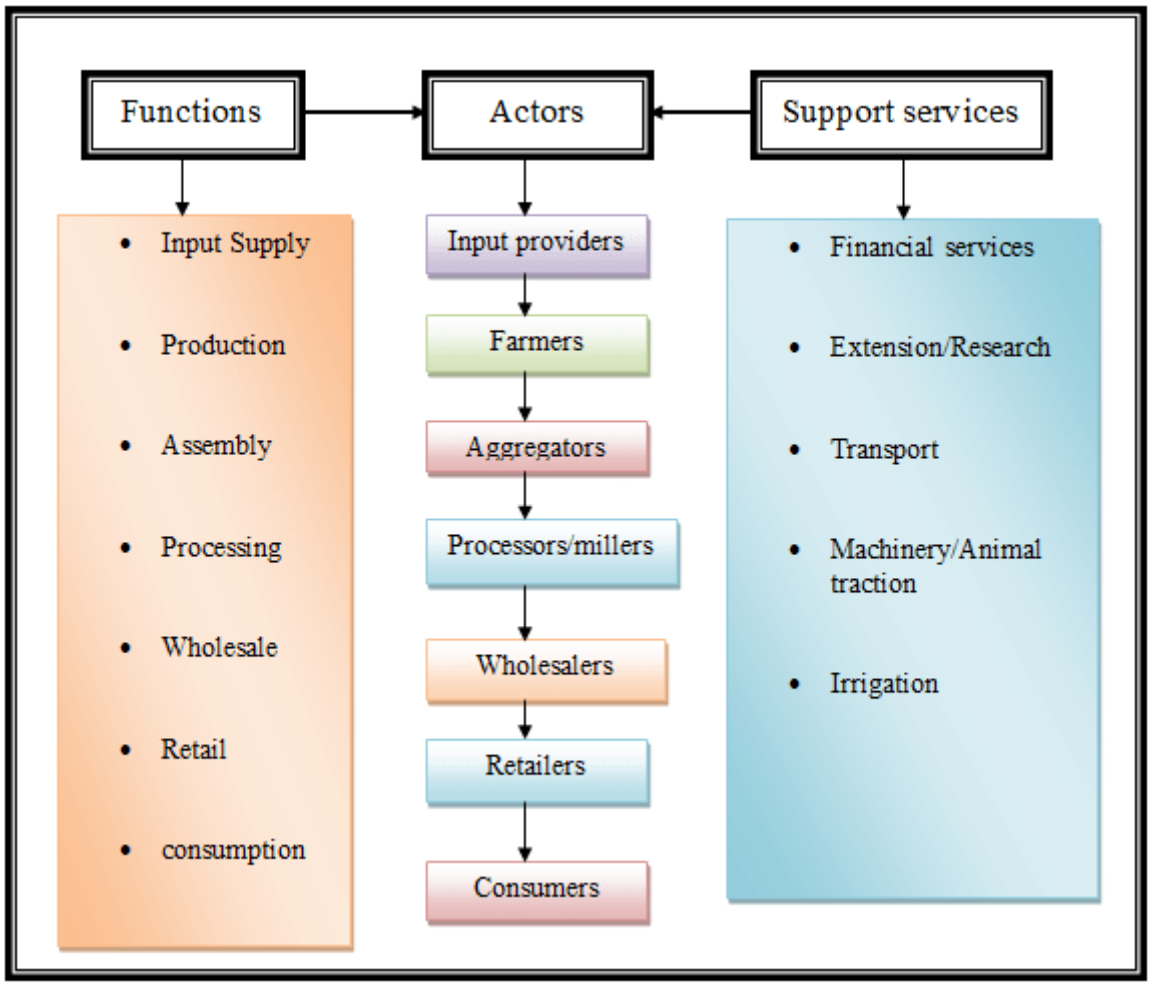

Figure 10: Rice value chain in DRC. Source: Authors compilation

The rice value chain in DRC begins with inputs used in rice production which include seeds, fertilisers, and pesticides. As much of the rice produced in DRC is grown by smallholder farmers, input use is very low, negatively impacting yields. There are two smallholder cultivation systems for rice in DRC: flooded rice and pluvial cultivation. These systems differ in terms of area planted, input use, and expected annual yield. Harvested rice is processed in local mills for onward sale to middlemen and wholesalers who distribute primarily to local retailers unless the end user is a brewery. Imported rice is bought by traders for urban retail distribution and by breweries.

Inputs: Seed Improved seed use is very low among rice farmers in the DRC. It is common for smallholder farmers to reuse their own open-pollinated rice seed from year to year. Farmers view this as a cost saving technique, but repeatedly reusing seed without introducing variation results in poor yields. Unfortunately, smallholder farmers in DRC have little alternative. Commercial and government-led rice seed production and distribution services are nearly non-existent. In the Ruzizi Plain, DRC's largest and most commercial flooded rice production area, the practice of reusing seed is widespread. According to a 2015 survey, for all varieties combined, 73% of rice farmers in Ruzizi use their own seed from the previous harvest, and 21% of farmers buy rice seed from neighbouring producers.

Fertiliser: Smallholders in the Ruzizi Plain are the only group to use fertiliser, but they use very low quantities. Slash-and-burn farming is common in which farmers cut sections of forest, burn it, and

plant fields in the ashes where organic material remains to nourish the crops. Unfortunately, this highly destructive and unsustainable practice does not remain effective for many seasons, leading farmers to repeat the process again and again. The practice persists because the remote location of the pluvial rice farmers hinders commercial delivery of chemical fertilisers, and the farmers themselves lack purchasing power due to poor market linkages. Donor activities in recent years have encouraged the application of chemical fertilisers (primarily urea and nitrogen, phosphorus, and potassium (NPK)), but the uptake remains small. Official imports and legitimate commercial delivery of fertiliser is hampered in the territory by smuggling from bordering Rwanda and Burundi where fertiliser is subsidised and far less expensive. The black market that has grown in the area has made it difficult for legal importers to compete.

Processing: Rice processing is typically carried out on-farm or brought to mills near the main production hubs. After harvest, farmers dry their paddy, remove stones and debris, and either dehusk the paddy manually or take it to a mill in the nearby population centre. De-hulling involves removing the outer husk of the rice grain. This is followed by milling in which the rice is further processed to remove the bran and germ layers, leaving the white rice grain. This is done in one of the dozens of rice mills in the main production hubs.

Supporting functions:

Seed providers: There are effectively no commercial rice seed providers in DRC. ICT Corporation in Lubumbashi used to offer rice seed, but it has not sold any in the last two years. Local multiplication of improved seeds is erratic at best with very low volumes, unreliable availability, and uncertain quality.

Agro-dealers: There are still very few agro-dealers offering agro-chemicals to rice producers. Most of them target NGOs rather than smallholders and have not developed smallholder-focused marketing strategies.

Agricultural extension: Public extension services face several challenges, including limited funding, inadequate infrastructure, and insufficient numbers of trained extension agents. Training on modern agronomic practices is provided mainly by NGOs, but a patchwork of goals, project areas, and funding streams hamper sustainable delivery of these services. Because farmers are remote and cash poor, no private agricultural extension system exists.

Agricultural research: Locally adapted rice seed varieties have been developed by INERA, but it lacks the capacity and systems for regionally specific research and wide dissemination.

Processing: Rice mills are mostly concentrated in major production areas. They are often inefficient and outdated, leading to breakage and impurities. This makes locally finished rice less marketable to urban consumers who have access to clean, high-quality imported rice.

Access to finance: Developing production and support services (mills, branding, etc.) requires capital. Unfortunately, DRC banks are highly risk-averse and will not support the agricultural sector. This affects production by hampering farmers' ability to purchase fertilisers or use other productivity enhancing technologies. It also makes it difficult for commercial farmers and processors to invest in land preparation for flooded rice production, milling equipment, or to improve storage facilities.

Cocoa production in Bunia

Over the years, the cocoa value chain has been lacking in sustainability, due to the vicious cycle of low income, poor soil fertility, increased incidence of pest and diseases as well as low productivity. Figure 11 shows cocoa value chain actors in DRC.

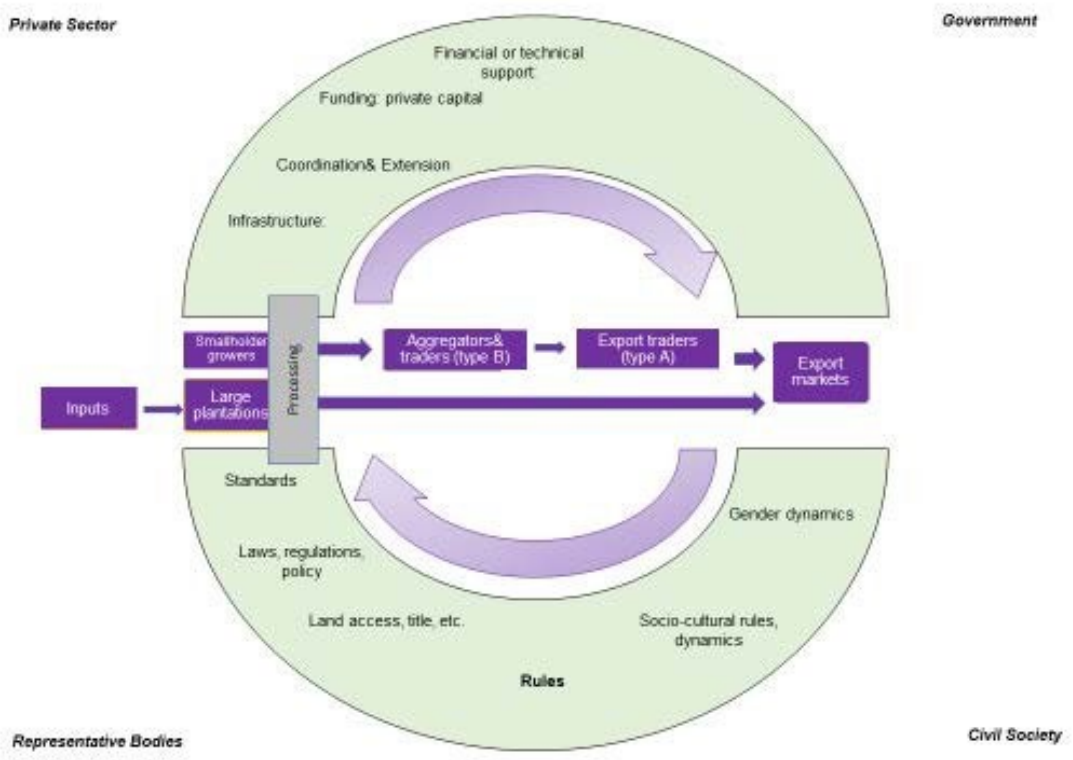

Figure 11: DRC Cocoa value chain actors. **Source :** ***https://static1.squarespace.com/static/5bc4882465019f632b2f8653/t/5c0a95d6562fa712d48be763/1544197611819/MSA+Cocoa.pdf***

Input supply

The DRC agro-chemical market is extremely thin, and consequently, most farmers meet fertilization needs through composting organic matter which they purchase from itinerant pastoralists. As most of the production has been organically certified there is a growing market for organic fertilizers, but no evidence has been found of organic pesticides or herbicides. Agro- chemicals are squarely in the domain of the private sector but are out of physical and financial reach for most small-scale producers. In general, the decline of commercial plantations has significantly lowered demand for and availability of agro-chemicals. In North Kivu, there are a handful of formal and informal input suppliers (based in urban centres). However, they do not specialize in cocoa products, have inconsistent products stocks, and are often accused of selling adulterated products.

There is no government institution that supplies improved planting material or plants. The only farmers that have nurseries use their own material without using any criteria for selecting the trees to reproduce (marking) and they do not sell their plants to any farmer.

Production

Cocoa smallholder production is a harvesting culture with no investment in agricultural practices such as pruning, shadow management, de-weeding, etc. For many years harvesting was not even done as there were no buyers for the cocoa. This has changed over the last years with the increase in world cocoa prices and the entrance of a new buyer from Kinshasa, and the re-appearance of buyers from neighboring countries. In Most of the production is currently internationally certified. Also, some producers are associated in cooperatives which also allows fair trade certification.

Processing

Cocoa typically has two harvests per year. Once the fruit is harvested, the pod is cut open and the seeds are removed. To produce the highest quality, beans should be fermented within six hours of being removed from their pod. Fermentation is the key to unlocking the beans' flavor and aroma but is a step that is often skipped by small producers, which degrades the quality of even the best cocoa varieties. Fermentation involves placing beans in covered boxes or wrapping them in banana leaves until they reach 47-49 degrees Celsius, have defined ridges and a pink/brown color. The process typically takes 6-8 days and results in beans with a 60% moisture content. Next, the beans are dried either in the sun or by machine until their moisture content is reduced to approximately 7.5%. Like fermentation, drying is a critical and delicate step in the production of high-quality beans. Beans that dry too quickly become overly acidic and brittle, while beans that do not dry quickly enough grow mould. Machine drying also enables polishing, which protects beans from fungal infections. Once they are adequately dried, beans are packaged and shipped to a processor to be roasted and ground into liquor. The liquor is then pressed to extract the cocoa butter, which makes up approximately 55% of the weight of a dry bean. The remaining cake is milled and sieved to produce cocoa powder. A portion of the cocoa butter is then remixed with cocoa powder and other ingredients to produce plain chocolate. Cocoa butter is also used frequently in cosmetic or pharmaceutical products.

In some places, there is the introduction of community wood fermentation boxes, which increase the quality of fermentation, as temperature is uniformly distributed, and cocoa can be entirely mixed. The boxes are protected by a palm roof to avoid humidity during fermentation.

Financial services

Financial services for the agricultural sector in general are extremely limited and the cocoa sector is no exception. Though the large commercial banks such as BIAC, TMB, Rawbank, BIC, BCDC, etc. all have a presence in Mbandaka and Goma (and some even have a presence in smaller towns like Gemena, Beni and Butembo), financial services are limited and available only for the most established actors.

Lack of access to affordable capital is a major constraint. While exporters in Cameroon, the Republic of Côte d'Ivoire, Rwanda, and Uganda can secure working capital from local commercial banks for their buying campaigns by using their purchase agreements from traders as collateral for short term loans, Equateur and Kivu exporters are forced to rely primarily on private capital. The lack of liquidity in the cocoa sector, significantly constrains Congolese exporters from buying enough dry cocoa and slows the overall pace of investment.

Business development services

The role of the Office National du Café has diminished significantly since the liberalization of the sector in the nineties. The ONC is responsible for providing services to the sector including agricultural extension, processing facility inspection, quality analysis, price dissemination, export documentation and marketing. The ONC levies a fee based on the FOB value of the cocoa of three.%.

The role of cocoa quality contrôle lies with OCC, which is charged of doing the laboratory analysis of, certifies national agricultural production, manages warehouses, and produces export crop statistics, among others.

Intermediaries in DRC cocoa value chain

In the Biega ALL, respondents highlighted that intermediaries play a crucial role in encouraging agricultural production, reaching production areas, and indirectly connecting sellers to markets. They encourage farmers to align their production with the demands of both local and external markets. However, the downside mentioned is that these intermediaries do not safeguard the farmers from multiple taxes, potentially leading to market distortions. It was noted that: “The collectors advance the money to the producers at the production and fix the price in advance, which does not affect the latter at the harvest. The producers sell to the highest bidder, hence the presence of conflicts” Moreover, they may impose prices that discourage producers, and many of these intermediaries are not officially recognized by the coffee structures, which allows them to manipulate prices at their discretion. In the coffee value chain, most intermediary activities are performed by women. The women receive money in advance from buyers, collect produce from farm gates and furnish wholesalers based in Goma or Bukavu. The village savings and loan associations (VSLAs) are common in the area. Their strengths include provision of credit, savings, and empowerment of women. However, the weaknesses associated with the financial intermediaries include, non-reimbursement of credits, absence of legal documents, and financing goes through intermediaries lengthening the time of loan receipt.

In the Kabare ALL, the middlemen were praised for simplifying the collection and packaging of coffee produce, as well as facilitating the connection between producers and markets. They also raise awareness to assist in securing credit, which can be repaid with coffee cherries or monetary means. The financial institutions quoted were Cahi Savings and Credit Cooperative, Nyazera Savings and Credit Cooperative, Support Program for Economic Development Initiatives in Kivu, and Forex traders. The financial institutions were applauded for ease of access to credit. Their limitation was high interest rate and non-humane credit recovery mechanisms.

In the Uvira ALL, it was indicated that middlemen contribute to the efficient collection and packaging of raw produce, along with connecting producers to markets. They also play a role in raising awareness to facilitate credit access, allowing payment with rice or money, even for medical care. However, the downside is that producers in Uvira may lack comprehensive market information due to reliance on middlemen. Additionally, these intermediaries sometimes fail to uphold the law, especially concerning prices dictated by buyers and fair competition. In Uvira ALL, the intermediaries were associated with offering high loan products and not being credible. It was stated that cooperatives and VSLAs provide instant loans though charge high interest rates.

In bunia, the middlemen were appreciated for their role in offering ready market for the cocoa product. They were however associated with promotion of thuggery in the region due to uncontrolled market.

Gaps, bottlenecks, and risks in the value chain

In the Biega ALL, respondents emphasized that coffee consumption is not prevalent locally, and the pricing of coffee is primarily controlled by the buyers. Additionally, challenges such as theft by indigenous communities and deforestation were identified as significant issues affecting the coffee sector. During the focus group discussion, it was noted that the market for coffee is unstable, and the lack of profitability makes it challenging for producers. To address these challenges, the respondents suggested several measures. First, they recommended the establishment of a village cooperative to collectively set fair prices for coffee. Secondly, they stressed the importance of raising awareness among producers about market dynamics and pricing. Finally, they proposed providing seedlings to producers to improve productivity and encourage sustainable coffee farming.

In the Kabare ALL region, gaps in the coffee value chain were identified, including the absence of storage facilities, collection depots, and processing plants. Moreover, pricing decisions were found to be dictated by the buyers, leading to limited benefits for the coffee producers. To remedy these shortcomings, the involvement of the government was deemed essential. The respondents proposed facilitating access to financing for agricultural activities. Additionally, they emphasized the need for capacity building initiatives, the supply of necessary equipment, and establishing market linkages for the sale of coffee-derived products.

In the Uvira ALL area, financial constraints emerged as a significant concern for rice production, limiting the area that can be cultivated. This issue is further compounded by poor infrastructure, including roads and communication systems, leading to limited access to information, particularly in agriculture, such as pricing, new technologies, and potential partners for contracting. “During processing, the processing units are insufficient, during the harvest, transport is a serious problem, the roads have agricultural access, the product market is not available.” Difficulties in enforcing contracts and widespread rent-seeking behaviours also contribute to the challenges faced by producers.

In Bunia, non-regulation of the market is affecting trade in the sector leading to low prices of cocoa offered by middlemen and market inconsistence.

Markets are as well unstable, partly because smallholder farmers and other role players have little storage and other capacities to absorb shocks, and the impact of production fluctuation is then largely transferred to poor producers through fluctuating prices. Intra-seasonal price variation has also risen with market liberalisation. To address, the respondents noted the need to facilitate access to agricultural finance by the producers, capacity building on use of modern equipment, facilitate access to cold storage facilities, market linkages and provide synergies between the farmer, breeder, and government.

Women-owned farming businesses encounter numerous constraints compared to their male counterparts. These constraints include lower mobility, limited access to training opportunities, restricted access to market information, and inadequate access to productive resources. Additionally, family, and ethnic backgrounds can pose further challenges for women in agriculture, contributing to their disadvantaged position. Furthermore, women-owned farming businesses tend to receive fewer services and less support compared to businesses owned by men. One significant obstacle that women face in their agricultural endeavours is the lack of market information, particularly regarding pricing. This dearth of crucial market information poses a serious hindrance to the success and growth of their farming businesses.

More generally, according to Njiraini et la (2018)[17] women are under-acknowledged participants in Africa's agriculture and food sector, supplying a large share of the labour, but facing significant obstacles, including unequal access to land, traditional division of labour, restrictions on mobility, unequal educational attainment, financial exclusion, and gender norms. As a result, women are being constrained to lower productivity jobs and earning less than men. Their underrepresentation persists all along agricultural value chains. These inequalities translate into lower welfare outcomes for women in addition to inefficient productivity gaps with negative consequences for food security on the continent. Technical and institutional innovations in agricultural value chains must therefore be developed and implemented in a way that considers the constraints faced by women in agriculture to be fully effective and to avoid further solidifying gender roles and gaps. These could include suitable labour-saving technologies, financial innovations, mechanisms for collective action, and an improved access for women to extension services.

4.3.3. Markets (cassava, coffee, rice, cocoa)

DRC cassava market

Mumbeya (2012)[18] notes that agricultural markets in DRC are structured around Kinshasa and Lubumbashi. The two biggest cities represent two pools of consumption with about 10 million and 6 million inhabitants respectively. The two cities have the highest per capita income, therefore denoting an effective demand for food stuff. Kinshasa receives products from Congo central, Bandundu, Equateur et Province oriental. Lubumbashi has Kasai, Lomami, Kasai central, Maniema and Tanganyika as food markets. The cities of Bukavu and Goma being based along the borders have intense trade connections with Rwanda, Uganda, and Burundi. At the provincial level households sell their products at the farm gate or on the local market as sellers or buyers. Collectors gather products from neighbouring farms to feed urban markets. As for traders, in addition to agricultural products, they also sell inputs such as tillage tools, chemical fertilisers, pesticides and other phytosanitary products. The predominant type of market in the region is retail. Cassava, banana beans, maize, potatoes, and rice are the most sold food products. They are sold raw with little or no added value.

The main dish for the average Congolese household is made of cassava, banana or rice varying from one province to another. This dish is served with meats, fishes, and vegetables and is taken 2 to 1 time a day. According to the National Institute of Statistics (2021), 43% of average household expenditure is devoted to food, 23% to housing, 7% to transportation, and 4% to schooling. For household consumption about 85% of food purchases are made in the informal sector.

Prices of cassava products in DRC were found to be high, due to the high costs of production, processing, and marketing of cassava at different levels of the market chain. Poor market linkages lead to low utilisation of value addition technologies, and this contributes directly to poor market opportunities. This results in a wide range of negative aspects for the sector, such as decreasing incentives for the production and consumption of cassava products and lack of sufficient competitiveness to make cassava a significant commercial commodity. Investment in the sector is considered risky by different chain actors and is limited because of the overall non-competitiveness of the sector.

[17] https://www.econstor.eu/bitstream/10419/187481/1/zef-wp-175.pdf

[18] http://hdl.handle.net/2263/26621

DRC coffee market

The demand for high-quality coffee is on the rise globally, but the coffee production industry faces significant risks. Climate change-induced rising temperatures, adverse weather conditions, and disasters threaten the mountainsides necessary for the thriving of high-altitude coffee plants. In the DRC, Arabica coffee production is grappling with serious challenges, primarily due to low prices in the world market. Coffee farmers in the DRC rely heavily on intermediaries who sometimes exploit them by selling their coffee without providing little valuable services in return. These intermediaries offer credit for the recent coffee harvest at extremely low rates, leaving the farmers struggling to make ends meet. Furthermore, exaggerated taxation compared to neighbouring countries and complicity of certain state departments in fraudulent coffee exports add to the hardships faced by the coffee producers. The official volume of coffee exported is severely reduced, only representing a fraction of its actual capacity. Moreover, the efforts of quality coffee producers often go unrewarded due to the lack of direct access to the international market. However, the NGO Rikolto DRC is actively supporting coffee producers by helping them establish quality coffee processing cooperatives and connecting them with gourmet coffee buyers. These cooperatives are centred around micro-washing stations, each serving around one hundred members with coffee fields nearby (Rikolto DRC, 2021).

Coffee is transacted via formal (i.e., direct, recorded) and informal (i.e., indirect, unrecorded) channels. In DRC, while middlemen work along both channels, providing market-making, prefinance, transportation, and other forms of services, their core business is commonly centralised on the informal side. In the latter, local and regional traders' source de-pulped or dried cherries from producers via intermediary networks, evading barriers, borders, and fees. Cooperatives, middlemen, and contracted agents are vital for aggregating and consolidating DRC's coffee supply. However, despite their function and proximity, coffee cooperatives are often unable to serve as market makers for members, accounting for just under one-quarter of licensed (i.e., reported) exports. As a result, many cooperatives report exporting only half of their members' production. Concurrently, exporters who maintain an arms-length relationship with smallholders comprise most formal coffee exports[19].

DRC rice market

Rice processing is typically carried out on-farm or brought to mills near the main production hubs. After harvest, farmers dry their paddy, remove stones and debris, and either dehusk the paddy manually or take it to a mill in the nearby population centre. De-hulling involves removing the outer husk of the rice grain. This is followed by milling in which the rice is further processed to remove the bran and germ layers, leaving the white rice grain. This is done in one of the dozens of rice mills in the main production hubs. At one time, there were about sixty in the Ruzizi Plain, but many are no longer operational. Dated milling equipment negatively impacts the paddy-to-rice conversion rates, processing volume capacities, and the quality of rice (i.e., resulting in a high proportion of broken grains). In addition to commercial millers, some wholesalers such as Olive in Ruzizi also provide milling services on a fee basis. Some farmers associations provide milling services as a member benefit or on a fee basis. Most rice mills in DRC process an estimated 300–400 MT of paddy per year except for about four or five larger mills that process between 500–600 MT/year.

19 https://static1.squarespace.com/static/5bc4882465019f632b2f8653/t/60f957893e1092304970fa07/1626953615497/Specialty+Crops+Tax%2BRegulation+Brief+%28Elan+Format%29+FINAL.pdf

Wholesalers aggregate the milled rice for distribution and sale. There are three categories of wholesalers: large to medium-scale formal wholesalers such as Olive, small-scale female entrepreneurs known as “mamas,” and farmers’ associations. The larger, formal wholesalers are often integrated with mills and sell rice primarily to the Bralima Brewery. The mamas are part of an informal network that purchase rice from individual farmers or associations and transport and resell it in rural and urban food markets. The associations focus sales on local markets, except in Ruzizi, where several cooperatives trade rice with Bralima. Retail branded rice is uncommon on DRC market shelves, although several domestic businesses have begun packaging branded rice, but their volumes are very small[20]. Rural rice production is consumed locally, as poor infrastructure and vast distances hamper rice marketing outside of rural areas. As a result, most of the estimated 350,000 MT of rice produced in rural DRC is consumed near production centres. Three provinces account for the bulk of production and consumption: Oriental Province (9.4 kg per capita), Sankuru, and Maniema (17.5 kg per capita). The production in the Ruzizi Plain is commercially focused use flood cultivation methods. However, most rice farmers are pluvial cultivators with little to no access to the broader market outside their neighbouring communities.

Urban consumers rely primarily on imported rice, driving up import volumes over the past decade. Growth in rice consumption in DRC is driven by growth in urban areas where the convenience of preparing rice over cassava or plantain is a key selling point. Long shelf-life, ease of storage, and short cooking times are all attractive attributes of rice. Based on industry consultations, it is estimated that 95% of the rice consumed in large cities is imported. Consumers value the year-long availability of imported rice, superior quality, and labelled packaging which includes a variety of smaller packaging sizes down to 1 kg. Where there is locally produced and packaged rice, it is typically slightly more expensive than imported rice or of poorer quality at a comparable price. Because of the availability of imported rice, consumption is higher and increasing much faster in urban centres than in rural areas. This increased demand has meant that imports have increased sixfold between 2010 (55,000 MT) and 2019 (306,000 MT).

Breweries use local and imported rice to supplement barley in beer production. The DRC’s two large breweries, Bralima and Bracongo, both use rice as a key ingredient in their beer. Rice reduces the cost of brewing beer. In DRC, rice in beer is derived from both imported and local sources. Bracongo reported using around 7,000 MT of rice annually, all of which is imported. Bralima reported using around 10,000 MT of locally sourced rice and 7,000 MT of imported rice per year and is the only industrial off taker that provides predictable demand for local producers. Depending on the location of the brewery and its proximity to import infrastructure, the price of locally sourced rice is typically on par or up to 20% cheaper for the breweries.

DRC cocoa market

The cocoa market is dominated by firms based in the Beni/Butembo region. DRC's cocoa supply chain is far more concentrated that that of coffee. This concentration affords cocoa exporters greater oversight and decreases the prevalence and influence of middlemen, granting them better control of aggregation and consolidation costs. As a result, cocoa exporters enjoy an enhanced ability to influence quality, transformation, and export processes over their coffee supply chain counterparts.

[20] Rice in DRC-market system approach

The value chain is profitable for most of the actors involved. Cocoa represents 57% of the value of the exports and it contributes significantly to the agricultural GDP (17%). Production, processing, and export actors favour job creation at all levels of the value chain. In this context, incipient but promising initiatives are starting to arise on artisanal or semi-industrial processing of chocolate products for both the export and the domestic markets. The value chain is competitive at the international level, with encouraging perspectives for the sub-chains of fine or flavour quality and of certified cocoa. Despite this, the value chain remains vulnerable to the drop of cocoa price at the international level, which can jeopardise its economic sustainability, especially with regards to conventional production.

Table 17 shows the social analysis for the cocoa sector in DRC.

Table 17: Social analysis for the cocoa sector in DRC

Working conditions	Cooperatives and formal companies guarantee overall safe working conditions for their workers. Child labour is not officially declared even though some children are pushed by their families to help in agricultural activities.
Land and water rights	Access to land and water is guaranteed overall. Land transactions are based on negotiations between the seller and the buyer.
Gender equality	Gender equality is formally recognised, but not fully practised. Women are present in all the VC steps but in most cases, their role is limited to minor technical and traditional tasks. Women do not have managing roles, except in some local processing companies.
Food and nutrition security	Farmers can cultivate and/or have access (thanks to the selling of cocoa) to a great variety of food products such as avocado, cassava, sweet potato, fish etc Touristic projects linked to cocoa increase commercial opportunities and the increased profits can be used to buy food products, among other uses.
Social capital	Cooperatives are production umbrella organisations, with a social dimension for producers (managing premium, providing technical assistance, etc.). The negotiating capacity to deal with medium and large companies is still low (as regards to inputs, volumes, sale prices, etc.).
Living conditions	Support given by several private and public projects through investments to the building/ rehabilitation of infrastructures, building of schools, transport, construction of water supply facilities in communities, etc.

The value chain is socially significant despite the situation being variable. Some areas need improvements, notably on the role of women, often employed only in minor and traditional tasks but without any decision-making role. The cooperative model has the advantage of adding a social dimension to the farms' development. However, even with the presence of cooperatives and associations, the interests of small producers are scarcely considered, and their negotiating power is limited.

Environmental analysis-cocoa

The assessment of the environmental impacts shows results typical of an agricultural value chain using low inputs and with relatively simple agro-industrial processing activities. The conventional sub-chain has bigger impacts, meaning that the certified and biological production can better guarantee environmental conservation and protection in the longer term. This depends mostly on the fact that this sub-chain needs less transport for the cocoa (pulp and beans) and the production inputs (lime, herbicides, etc.). The key aspects that will ensure the environmental sustainability of the value chain are the conservation of the soil fertility, the improvements in water management, here including in the upscaling of irrigation systems.

Transition to agroecology market in DRC

In the Biega ALL, it was noted that national markets are subject to several taxes. The market itself is diverse, featuring a wide array of local products and imports from foreign countries. The strengths identified include the existence of a local market for food crops and the availability of industrial and agricultural products from other provinces. However, for transitioning to an agroecology market, respondents mentioned certain weaknesses. These included insufficient production to meet demand, the promotion of conventional agricultural products without proper identification of their origins and lack of a traceability system, as well as limited access to local markets in Mudaka and Kavumu. The geographical location of Biega poses a significant challenge for its agricultural producers. After the harvest, these producers face the onerous task of walking long distances (more than 15 km) to reach markets, which are situated far away. At the market, they have little bargaining power as the prices are dictated and imposed upon them by resellers, who effectively act as their sole customers. Due to the hardships of the journey, the weight of their merchandise, and the absence of other potential buyers at home, the impoverished farmers are compelled to accept the prices set by the resellers.

In Kabare ALL, the market is of international significance, involving multiple countries and various actors. It operates on a large scale and extends to a certain extent the principles of agroecology. This market integrates regional and local trade and serves as a means of decolonizing African agriculture. It represents a holistic way of life and work for the entire community. According to the response from a key informant, the national markets in the locality are highly outward-oriented because the local production falls short of meeting the population's demand for essential products. Some of the produced goods do not adequately cater to the normal needs of the people, leading to unhealthy markets, inadequate price regulation, and scarcity of certain products.

In the Uvira ALL, the market involves the participation of several countries and actors, constituting a vast and dynamic marketplace. It extends to a certain extent the principles of agroecology and embraces the integration of regional and local trade, presenting a path towards decolonizing African agriculture and fostering a holistic way of life and work for the entire community.

In Bunia ALL, the strengths identified include the existence of a local market for cocoa. However, for transitioning to an agroecology market, respondents mentioned unregulated markets and insufficient production to meet demand.

The local African markets, however, are faced with certain challenges. Local production is limited in its organic quantities, leading to unhealthy market conditions, weak price regulation, and scarcity of specific products. As mentioned by one of the respondents, the production for the African market falls short of meeting the normal needs of the population. This limitation arises from the fact that local producers lack adequate financial support along the value chain, hindering their ability to meet the demands of the community. Despite these constraints, the respondent highlighted the potential of the region's untapped resources. There are vast areas of unexploited land that could significantly contribute to increasing the market output. Comparatively, national markets thrive because they benefit from financial and technical support, enabling them to produce larger quantities of goods.

In the context of transitioning to agroecology, the future of national and African markets is characterized by several essential aspects. Promoting local knowledge and expertise becomes imperative to ensure sustainable agricultural practices. Preserving natural resources, including soil, water, and biodiversity, and actively participating in their renewal are crucial elements. The adoption of good space management practices is key to optimizing agricultural productivity per hectare. Additionally, agroecology offers localized solutions to enhance food security, catering to the specific needs of local communities. Moreover, it contributes to the improved health security of farmers and consumers alike, fostering healthier and more sustainable agricultural practices.

Territorial market

In the Biega ALL region, respondents identified a territorial market as one that links industrial products to foreign traders. However, they also acknowledged that this type of market is not favourable for small-scale producers due to the large volumes of products demanded. The main barriers to entry for small-scale producers in this market were attributed to weak agricultural policies affecting the sector, limited government control leading to excessive taxation, and a lack of infrastructure for conservation, storage, and processing.

In the Kabare ALL area, a territorial market was described as a market limited to a defined geographical region, such as Central Africa. It is a market where local products are sold under a public contract, and it is controlled by the local public authorities. This type of market plays a significant role in contributing to the economic development of the region.

In the Uvira and Bunia ALL region, a territorial market is characterized as a marketplace where local products are sold, and it is under the control of the public authorities of the territory. Some respondents highlighted barriers associated with this market, including limited access to public procurement, unequal treatment of sellers, lack of transparency in procedures, and high prices set by traders.

In the Biega ALL, it was observed that the current economic model in the DRC is inefficient as it fails to provide adequate protection and support to agricultural producers. All respondents agreed that this model is unable to safeguard Africa's territorial market. One of the key informants emphasized the potential of distributing natural agroforestry species from the forest, which could lead to increased access to alternative food sources, such as caterpillars, while also promoting soil conservation and reducing conflicts related to product theft. The respondents further highlighted that the industrial food system poses a challenge to the agroecological market as it prioritizes lower prices, potentially

hindering the growth of agroecology. The main issue lies in the fact that agroecological agriculture necessitates product diversification, which may not align with the selected products and marketing strategies in the industrial food system. Despite the challenges, the respondents acknowledged that there is still a chance for the agroecological system to coexist with industrial food production if all stakeholders collaborate to address the obstacles that have been impeding optimal production thus far.

In the Kabare ALL, the respondents were divided in their views on the liberal model's ability to protect African territorial markets. 60% of the participants believed that the liberal model could offer some protection, while 40% opposed the idea. The respondents identified several key barriers hindering the functioning of the territorial market. One significant obstacle is the lack of access to public procurement, which limits opportunities for sellers. Additionally, the transport, storage, and processing infrastructure in the market is considered obsolete, leading to inefficiencies in the supply chain. Furthermore, poor infrastructure for transportation exacerbates the difficulties in reaching and accessing the market. Low productivity levels and limited purchasing power among the local population also contribute to the challenges faced by sellers in the market. Lastly, the respondents noted that sellers in the market are subjected to unfair treatment, which further hampers their ability to participate effectively. One of the key informants, representing IPAGRI/SK, expressed their belief in the potential of ecological agriculture for Africa, particularly in the DRC. They emphasized that by supporting the local processing of agricultural products, added value can be generated, making ecological agriculture a viable option. On the other hand, another KI respondent held a different view, expressing concern about the impact of competition between the rich and the poor in the markets. They argued that the current economic model in the DRC is inefficient and fails to provide adequate security for agricultural producers, particularly disadvantaging the poorer segments of the population.

In Bunia ALL, the respondents noted debated on liberal model's ability to protect African territorial markets. 30% indicated It may protect the market while 70% were opposed to the idea.

Physical infrastructure enabling trade

In both the Biega and Kabare ALLs, there is a common issue with poor road infrastructure and inadequate transport facilities, which significantly hinders trade among small-scale producers. The lack of proper physical infrastructure for facilitating trade was also identified as a problem in Uvira ALL. One of the respondents from Uvira expressed frustration with the government's lack of intervention in constructing agricultural service roads. As a result, small farmers face difficulties in transporting their produce to the market, often resorting to burning or discarding their products due to the lack of viable transportation options. In Bunia, poor road infrastructure was associated with promoting thuggery of cocoa produce as the farmers cannot access the market on time.

Relationship between the modern food system and the farmer market

In the Biega ALL, it was observed that there is a flow of information between consumers and the market. The modern food system in this region primarily revolves around cheaper products that align with international models.

In the Kabare ALL, the modern food system has a significant impact on the produce available at farmers' markets. It often transforms the offerings of farmers' markets, and these markets are considered integral components of the overall modern food system. Prices of products in modern

markets are determined solely by buyers, without any consultation with the farmers, creating an imbalanced relationship.

Similarly, in the Uvira ALL, the relationship between the modern food system and farmers' markets is defined by the production and processing chain. The modern food system tends to alter the products available in farmers' markets. Additionally, an unfair relationship exists between the modern market and farmers, as prices are dictated by buyers in modern markets without seeking input from the farmers themselves.

In Bunia, it was observed that there is limited flow of information between consumers and the market. This leads to unfair competition with traders dictating the cocoa prices to the farmers.

Strengthening of DRC Markets in protecting farmers' rights

In the Biega ALL, the respondents emphasized the importance of strengthening agricultural cooperatives to ensure competitiveness in the market. They highlighted the need to secure agricultural fields and support farmers' production activities. Strengthening these cooperatives would pave the way for the protection of farmers' and consumers' rights by enacting favorable laws and regulations that prioritize their interests.

In the Kabare ALL, strengthening African markets will enable farmers to produce food that meets the needs of consumers and niche markets, limit importation of products, raise public awareness on the need to consume local products, and provide financial support for local producers. The intervention will lead to respecting price regulation standards for agroecological products.

In the Uvira ALL, it was noted that once markets are strengthened, social and commercial standards respected, farmers will see their rights respected and promoted. Farmers will succeed in producing food that meets the needs of consumers and enumerating markets, limit importation of external products, and create awareness of the population to have consumed local products. The strengthening of African markets will see compliance with price regulation standards for agroecological products. In Uvira, organisation of markets and regulation of the cocoa industry will ensure that farmers rights are protected as they get to negotiate for better prices.

Changes in strengthening DRC markets for the transition to agroecology

In the Biega ALL, several key changes are deemed necessary for market development. Strengthening national agricultural policies, particularly regarding agricultural cooperatives, is crucial. This includes addressing various aspects related to African food speculations and establishing well-structured markets that effectively connect to agricultural areas. To facilitate these changes, research structures like INERA play a vital role. They need to conduct in-depth studies to understand the challenges affecting the agricultural sector and propose appropriate recommendations for improvement. A clear call was made to the government to increase the areas dedicated to arable land and ensure better access to improved crop varieties. These steps are essential to enhance agricultural productivity and diversity. Moreover, the respondents highlighted the significance of involving indigenous peoples of Congo, who predominantly engage in hunting and gathering activities, in the transition.

In the Kabare ALL, various essential measures were identified to enhance the agricultural market. These include both horizontal and vertical integration of market actors, establishing basic infrastructure, and providing capacity-building opportunities for farmers to adopt sustainable and

effective farming practices. Furthermore, there is a pressing need for good governance and a well-defined agricultural policy to support the sector. Encouraging close collaboration between producers and buyers at the African level and promoting communication for social behaviour changes were also highlighted as crucial aspects for improvement.

In Uvira ALL, a key recommendation was to sensitize farmers on good agronomic practices.

In Bunia ALL, linkages to finance platforms, organisation of markets, regulation of traders will enhance cocoa trade.

4.3.4.Enabling environment for agroecology

In the Biega ALL, entrepreneurs stressed the importance of reinforcing existing laws, raising awareness about agroecology, maintaining infrastructure, and ensuring easy access to credit for promoting agroecological practices. However, they also noted that there is currently no budgetary allocation dedicated to promoting agroecology in Biega.

Similarly, in the Kabare ALL, the promotion of agroecology was recommended through policy enactment, improved access to finance, collaboration among different actors in the value chain, capacity building on agroecological practices, financial linkage, and infrastructure development. Respondents from the Kabare ALL shared the same sentiment about the absence of budgetary allocation for promoting agroecology. They mentioned that local organizations, such as the Grouping of Farmers and Livestock Breeders of Kabare, are currently taking the initiative in this regard.

In the Uvira ALL, entrepreneurs emphasized the importance of providing incentives to producers, enacting favorable agricultural policies, ensuring access to finance, and fostering collaboration among different actors in the value chain to promote the adoption of agroecology practices. However, they also noted that there is currently no allocation of budgets dedicated to supporting agroecology initiatives in Uvira. One of the key informants from the Uvira ALL further highlighted this issue, expressing concern about the lack of sustained and continuous investment within the national budgets.

In Bunia ALL, the respondents indicated need to have regulatory environment on sale of cocoa, enhanced access to extension services and finance, good infrastructure in promoting the enabling environment.

In strengthening the policy environment, various recommendations were noted as discussed below.

In the Biega ALL, the key recommendations included the need to sensitize local opinion leaders and collaborate with agricultural decision-makers like the National Seed Service. Intensifying activities with farmers to promote agroecological approaches and products was also highlighted, along with sensitizing decision-makers about the rights of farmers. Encouraging farmers to organize themselves into solidarity groups for collective bargaining was seen as essential for their empowerment.

In Kabare ALL, the recommendations focused on raising awareness about the benefits of agroecology among the population. It was suggested that the government allocate substantial budgets exclusively for agroecology programs and establish laws to secure markets for agroecological products. Building capacity among key actors in agroecology, local authorities, and leaders, and increasing the demand for agroecologically produced products were also considered vital. Additionally, creating local

initiatives and awareness campaigns were seen as essential steps to foster the growth of agroecology in the region.

In Uvira ALL, the respondents proposed the development of laws to safeguard markets for agroecological products and raising awareness among local authorities and leaders. Building the capacities of key players in agroecology and supporting committed farmers with technical assistance were considered important. Moreover, the idea of creating portable gardens in the community was highlighted as a practical approach to promoting agroecology at the local level.

In Kabare ALL, the recommendations focused on raising awareness about the benefits of agroecology among the population and aligning the same to policy development.

Regulatory and institutional framework taxes and fees

The following examples have been gathered from stakeholder accounts, public filings, and industry reports regarding taxation in different regions:

In the Biega ALL, the stakeholders reported the presence of coffee taxes.

In the Kabare ALL, the regulation of coffee production and sales falls under the responsibility of the National Coffee Board.

In the Uvira ALL, respondents highlighted the existence of taxes on various agricultural products such as cassava, rice, and maize.

In Bunia ALL, respondents highlighted the existence of taxes on cocoa.

To limit redundant activities and realign agency remuneration with the type, frequency and quality of services rendered, the 2015 decree temporarily reduced Office Congolais de Contrôle (OCC) fees, an aggregate export tax of 0.25% of Free on Board (FOB) value on agricultural products. However, stakeholder accounts note that by the end of 2019, the OCC had not only introduced a US$100/lot "surveillance fee" but institutionalised the practice, requiring the issuance of a "ready for export" declaration. Commercial operators decry the fee and practice, citing that services were rarely performed, are ill-aligned with sector needs, and offer little to no value. In January 2020, the South Kivu revenue authority introduced a US$3/bag "taxe d'estampillage des emballages" (or stamp tax). An equivalent tax of US$0.20/bag is charged in North Kivu. In addition to the National Office of Agricultural Products of Congo's (ONAPAC) "certificat de qualité," a fee deemed by stakeholders and comparative standards as excessive for the service rendered. ONAPAC charges US$10/MT for a provincial "certificat d'origine."

All cocoa and coffee exporters are required to pay the annual Direction Générale des Douanes et Accises (DGDA) "license d'exportation." However, over and above the annual national export license fees and customs fees which effectively authorise clearance, documentation reveals that, in South Kivu, the provincial government charges an additional US$59/lot "export authorization fee."

Various rules and regulations affect the rice sector that include[21];

Seed regulation: The absence of a national seed law and implementing regulations creates uncertainty and unpredictability in the application of seed regulatory procedures. As a result, the seed sector relies on informal seed replication. With only limited coordination among seed sector

[21] Rice in DRC-Market system approach

stakeholders at the national and provincial levels, stakeholders have been unable to mount a concerted lobbying effort that can generate the political will for reform.

Formal and informal taxation: There are numerous formal and informal taxes which affect actors throughout the rice value chain. It is not always clear which taxes are official, and in some cases, it is not even clear who is collecting the tax. While the Agricultural Code provides tax exemptions on imported agro-inputs and certain agricultural equipment, this is rarely applied, and businesses continue to pay high taxes on such imports. This opens the door for smuggling and the establishment of a black market for inputs.

Sectoral policies

An ambitious national rice strategy was adopted in 2013, and a rice seed strategy in 2016. The government is currently finalising a new one. However, concrete actions are lacking, and insufficient resources have been allocated. Because most produced rice is traded informally, there are no quality control standards with respect to colour, impurities, and breakage. Since prices rarely reflect differences in quality, this provides little incentive for farmers and millers to invest in improved postharvest processing or other practices to enhance the quality of rice. This disadvantages local producers as urban consumers expect the same high quality as they find in imported rice.

Finance

In the Biega ALL, it was observed that the Support Program for Economic Development Initiatives in Kivu focuses on providing agricultural credits. However, the reimbursement process becomes complicated due to climatic disturbances or land disputes. Unfortunately, the indigenous group and neighbouring communities are not adequately considered in this program. To address these challenges, the respondents offered several recommendations. Strengthening agricultural cooperatives and promoting farmers' adoption of good agricultural practices were suggested to enhance overall productivity. Additionally, facilitating access to affordable finance was deemed crucial to support farmers' endeavours. Furthermore, non-financial support is equally essential in strengthening farmers' activities in Biega ALL. This support includes providing agricultural inputs, particularly certified organic seeds, to ensure sustainable and environmentally friendly practices. Capacity building on agro-pastoral techniques and good agricultural practices would also play a vital role in improving agricultural outcomes and empowering farmers in the region.

In the Kabare ALL, concerns regarding access to finance were highlighted, with stringent conditions for obtaining credit and high interest rates being major hurdles for farmers. Additionally, the lack of agricultural subsidies further compounds the financial challenges. To tackle these issues, respondents proposed creating a government-backed bank specifically designed to cater to farmers' needs. They recommended placing guarantee funds with this bank to facilitate easier access to credit and advocated for reducing the interest rates imposed by financial institutions. Non-financial support was also identified as essential in Kabare ALL. This support includes capacity-building initiatives to enhance farmers' skills and knowledge, ensuring access to profitable markets, providing extension services to offer technical guidance, and facilitating the acquisition of legal documents for land ownership.

In both Uvira and Bunia ALL, it was observed that the agricultural sector lacks subsidies, and farmers face challenges with low grace periods and high credit interest rates. To tackle these issues, respondents suggested the creation of agricultural banks as a potential solution. This would help to

address the limited access to financial institutions that promote agricultural credit. Additionally, the lack of a reliable pledge or mortgage system poses a challenge to land security for farmers. Regarding non-financial support, respondents emphasized the importance of extension services to provide technical assistance and guidance to farmers. Linkages to markets were also identified as crucial to help farmers access profitable opportunities for their produce.

Experiences where consumers pay more for agro-ecologically produced products

In the Biega ALL, the survey revealed that 20% of the respondent's indicated consumers are willing to pay more for agroecology products, while 80% expressed that they are not willing to do so. One respondent who said that it is only a small minority that shows willingness to pay more, particularly for products like coffee, biofortified beans, plain rice, and local vegetables.

In Kabare ALL, 75% of the respondents indicated that consumers are willing to pay more for agroecology products, while 25% opposed the idea. One key informant highlighted that certain products like coffee from the Biological Products Grouping of Farmers and Livestock Breeders of Kabare are more expensive due to their agroecological nature.

In Uvira ALL, the survey indicated that 17% of the respondents believe consumers are willing to pay more for agroecology products, while 83% said no. One respondent mentioned that consumers may pay more, especially, due to the higher cost of seeds and fertilizer associated with agroecological practices.

In Bunia, this was not responded to.

Traceability of agroecology products

In the Biega ALL, the mechanisms for verifying agroecologically produced products should include assessing factors like product size, colour, and information obtained from sellers. Respondents also mentioned that the Grouping of Farmers and Livestock Breeders of Kabare Coffee in Biega is certified. In Biega, there is a recognized need to further strengthen the principles of agroecology in a comprehensive manner. This requires the involvement of capable facilitators and sufficient resources. International policies are also seen as necessary to support food security and strengthen the efforts of agricultural cooperatives. Additionally, documenting traditional food systems is considered important to preserve and promote indigenous knowledge and practices related to agriculture and food production.

In the Kabare ALL, respondents acknowledged that certification for agroecological products is feasible if they enter the international market. Traceability measures are in place, including regular monitoring of farmers' fields, external audits by certifiers, public inspections by the Congolese Office of Control, and certification services that regulate and define quality in the sector. To enhance the sector and support small producers, the respondents stressed the importance of organizing them into cooperatives, recognizing that strength lies in numbers. Structural improvements are needed to enable farmers to meet the desired quantities and qualities of products. Creating an agricultural fund, identifying agricultural producers by sector, providing financial and technical support, establishing channels for their production, setting up agricultural micro-credits, and ensuring proper storage facilities for their production are among the essential steps to promote the growth and success of small-scale farmers in Kabare.

In the Uvira ALL, the respondents reported that traceability measures are currently lacking. One respondent suggested that the government should take necessary steps to ensure that entities like the Congolese Office of Control can effectively carry out their control duties. Despite the absence of traceability measures, the respondents in Uvira indicated that certification is still possible, especially with the strict enforcement of regulations by the government and decision-makers, as well as the involvement of other stakeholders. To address the challenges and enhance the agricultural sector, the proposed solution includes identifying agricultural producers by sector and providing them with financial and technical support. Additionally, establishing channels for their production, developing micro agricultural credits, and ensuring adequate storage facilities for their produce are seen as essential steps to promote their success and productivity.

In Bunia, the respondents indicated that traceability options are currently lacking. To address this, the proposed solution includes identifying agricultural producers by sector and providing them with financial and technical support and registration of cocoa traders to promote healthy competition.

Participatory guarantee system applies to focal commodities

In the Biega ALL, a participatory guaranteed system is absent due to the lack of understanding and mastery of the terms of references among the involved actors. Moreover, the actors suffer from monetary poverty and possess varying skill levels that do not align well.

In the Kabare ALL, there was a split response with 50% stating "yes" and 50% saying "no". One key informant, a village leader, expressed, "Yes, the public service involved in the sector sets the standards."

In the Uvira ALL, the response was affirmative, with one key informant stating, "Yes, we can do it for the focal product and any other product. The standards are determined in coordination with the focal point and the investor. However, there are some farmers who resist development in this area, so training sessions will be necessary to help them understand the importance."

In Uvira, this question was not addressed.

Extent to which the current DRC market driving agroecology practices

In the Biega ALL, the emphasis was on organizing agricultural cooperatives, popularizing the use of seeds, donating seeds, and establishing associations of small-scale farmers. Additionally, there was a call for raising awareness on good agricultural practices, particularly in the context of coffee production, which is seen as a rare product that can entail agroecological practices.

In the Kabare, it was observed that a significant number of consumers prefer organic products in their food choices. However, these organic products tend to be more expensive than non-organic alternatives. The region also benefits from extensive training in good agricultural practices provided by NGOs.

In the Uvira ALL, a current market demand is driving agroecology, as many consumers actively seek out organic products. Additionally, there is significant support from NGOs that offer training in good agricultural practices to farmers in the region.

In the Bunia ALL, a current market demand is driving agroecology, as many consumers actively seek out organic products. It was also noted that the farmers had plated shade trees in efforts on conserving the environment.

Positioning of agroecology in reducing food waste in DRC

In the Biega ALL, respondents emphasized the importance of integrating agriculture and animal husbandry to reduce waste.

In the Kabare ALL, waste management is seen as playing a crucial role in agroecology. Both household and non-household waste are composted, with degradable waste used for fertilization in the fields, and non-degradable waste recycled for various purposes, such as making paving slabs. Agroecology in this region focuses on specific objectives with a target market, incorporating waste treatment structures as a key component. This approach ensures sustainability and enhances agricultural production in terms of both quantity and quality.

Similarly, in the Uvira ALL, agroecology should follow an objective-based approach with a market focus and incorporates waste treatment structures as an integral part of the system. This strategy ensures the sustainability of agricultural practices, optimizing production in terms of quantity and quality. Moreover, agroecology in Uvira is seen as promoting practices that maximize agricultural output while minimizing the use of fertilizers and pesticides, emphasizing integrated soil fertility management.

In Bunia ALL, the respondents indicated the integration of crop and livestock, and shade trees are playing a critical role in promoting agroecology as no chemical fertilizer is used.

Conclusions

The study findings revealed that the Democratic Republic of the Congo (DRC) is one of the most fertile countries on earth, with the potential to feed all its inhabitants and even export food commodities. It is home to approximately 80 million hectares of arable land (WFP, 2022)

Agriculture and related services provide a livelihood to almost 75 percent of the population. The country enjoys one of the world’s most favourable climates for agriculture and fertile soils and has the potential to feed over 2 billion people through suitable investments. However, according to the findings of the global standard for measuring food insecurity, 26 million people in DRC are currently severely food insecure making its hunger crisis Africa's biggest; globally it is second to Yemen. Hunger here is triggered by poor harvests, violence-driven displacement, disease, unemployment and collapsing infrastructure (WFP 2022).

The study identified the following recommendations in enhancing the highland and lowland coffee, cocoa, cassava, and rice sectors as indicated below.

This study showed that to increase the adoption rate of improved cassava varieties in Kabare Territory, it would be advisable for extension services to intensify the promotion of new varieties so that their characteristics might be better known; ensure the availability of planting materials; initiate a participatory plant breeding program that consider regional farmers' preferences during variety development scheme; and to encourage actions of intervening actors in agricultural credit.

Many state agencies involved in DRC's cocoa and coffee sectors lack the resources to provide services despite maintaining considerable liabilities. In addition, there are often duplicative mandates among national and provincial agencies.

Industry Associations Industry associations are relatively new to DRC's cocoa, coffee, and cocoa sectors; however, they are growing in number, increasingly seeking ways to differentiate themselves from one another, and expanding membership numbers and reach. Formalising a group and schedule for key stakeholders to regularly meet and discuss challenges, organically determine priorities, and chart an agreed-upon pathway forward. Industry (government, individual private sector, associations, technical assistance providers) should improve coordination so that the entirety of DRC's cocoa and coffee sectors are represented at national, regional, and international events (i.e., Saveur du Kivu, International Coffee Day, etc.).

Farmers lack access to finance, seeds, and other necessary productive inputs to improve their rice yields. The outdated rice processing equipment in DRC also impedes the production of high-quality, locally branded rice products. The two recommended interventions in the rice sector are increasing rural economic activity and enhancing smallholder resilience through income growth and food production. To achieve these goals, it is necessary to collaborate with wholesalers and non-finance institutions to deliver improved seeds and productive inputs, as well as provide extension services and access to non-bank finance. These interventions will help increase rice production in the DRC and improve the overall quality of locally produced rice.

The key elements of Strengthening value chain approach to enhancing coffee production are; (1) providing agronomy training via on-farm Coffee Farm Colleges; (2) increasing producers' access to washing stations and improving washing stations' productivity, business acumen, efficiencies, market outreach, and quality; (3) increasing producers' awareness of the science, technology, and art of producing consistently high-quality coffee of interest to the international specialty market; (4) developing Eastern Congo's high-altitude arabica coffees by inclusively building an enabling policy environment for a sector-prioritised, owned, and managed strategy; and (5) researching the most productive varieties and resilient farming systems to introduce best practices for coffee.

4.4. Rwanda-Kamonyi ALL

4.4.1. Rwanda food system

The food systems of Rwanda, which are a hybrid of rural/traditional and informal/expanding archetypes, have a vital role within the country's economy, with the agricultural sector serving as a notable source of competitive advantage. These systems encompass a wide array of actors and interconnected activities that contribute value throughout the entire cycle, starting from the creation, collection, and processing of agricultural, livestock, and fisheries products, to their distribution, consumption, and responsible disposal of resulting waste. These systems also encompass various sub-components, including input provision, farming practices, irrigation, waste management, and more, which interact with other crucial systems such as energy, trade, healthcare, and more.

Between 2001 and 2011, the agricultural sector was estimated to account for a third of overall poverty reduction. However, food supply chains do not yet meet the population's needs for a healthy diet, due to insufficient production and low crop yields (crop production remains at ~45% of potential yield) due

to small landholdings, limited use of agricultural inputs and mechanisation as well as constrained access to finance. Limited diversity in production with a focus on priority, staple crops (e.g., maize, potatoes) and cash-crops (e.g., coffee, tea), resulting in low productivity, affordability, and availability of nutrient-rich foods (e.g., vegetables, fruits). Supply chains remain underdeveloped due to insufficient private sector investment, resulting in challenges related to accessibility and limited value enhancement. Inadequate transportation, storage, and distribution infrastructure contributes to notable food losses, reaching 10% for vegetables, 11% for fruits, and 7% for cereals.

In 2020, agriculture contributed 26% to GDP and engaged 67% of the active workforce. On the other hand, Rwanda is highly vulnerable to the effects of climate change and natural disasters (landslides, floods, droughts) as about 70% of land is on hillsides (MINAGRI, 2017), with limited terracing and low levels of irrigation (about 1.6% agricultural operators have invested in irrigation) (National Agricultural Policy, 2017). Challenges in the food systems result in poor nutritional, livelihood, and environmental outcomes – high levels of undernourishment, leading to negative health outcomes such as stunting (33% of children under-five) (DHS-2019-20). While the rates of wasting and stunting among children under five years has steadily decreased since the early 2000s, undernourishment in the general population has risen from 22% in 2012 to 36% in 2020.

Cassava in Rwanda

Cassava (*Manihot esculenta Cranzt*) ranks as the sixth most important food crop worldwide and the fourth after rice, maize, and wheat among developing and emerging countries (Otekunrin and Sawicka, 2019; Saranraj et al., 2019). In Rwanda, cassava is the third most important crop after banana and sweet potato (Night et al., 2011). Because of its importance in several tropical regions and its relatively good performance on marginal lands under suboptimal climatic conditions (Burns et al., 2010), cassava is recognized as a subsistence crop to overcome food insecurity for the fast-growing population in areas prone to important climatic changes (El-Sharkawy, 2004; Chavez et al., 2005; Lobell et al., 2008; Burns et al., 2010). Although cassava plays an important role as a food security crop in sub-Saharan Africa, it is also used as a cash crop in various cassava-growing regions (Spencer and Ezedinma, 2017; Munganyinka et al., 2018).

In 2017, the world cassava yield was about 11.1 tons of fresh roots per hectare, and the top cassava producer (Nigeria) had an average yield of 8.7 tons per hectare, followed by the Democratic Republic of Congo with 8.1 tons per hectare (FAO, 2019[22]; Otekunrin and Sawicka, 2019). Cassava production in Rwanda varied between 3,0 and 3,7 MT of fresh roots per year from 2015 to 2018 with a reported average yield of about 14.5 tons per hectare (FAO, 2018[23]).

The southern province including the Muhanga, Ruhango and Kamonyi Districts and the eastern province including the Gatsibo and Kirehe districts are zones of high cassava production in Rwanda. Cassava production is best at mid to lower altitudes, and the crop is usually grown in rotation with a wide range of other staple crops, such as beans, maize, and sorghum. The production cycle lasts 12-15 months from planting of cuttings to harvesting. Cassava roots deteriorate rapidly once removed from the ground and are left in the soil until needed for sale, consumption, or processing[24].

[22] FAO (2019). *FAOSTAT Statistical Database, Statistical Division.* Geneva: FAO.
[23] FAO (2018). "Food outlook—biannual report on global food markets—November 2018," in *Global Information and Early Warning System on Food and Agriculture*. Geneva: FAO. doi: 10.1044/leader.PPL.19102014.18
[24] https://pdf.usaid.gov/pdf_docs/PNADU495.pdf

4.4.2. Cassava value chain in Rwanda

The Rwanda Cassava Value Chain Platform was launched with support of Ministry of Trade and Commerce in April 2018 to bring together cassava producer groups (farmers and cooperatives), processors, off-takers, financiers, and the public sector to work together on building links and communication channel between actors along the chain at the national level. It focusses on cassava value chain development by linking agricultural technologies and best practice development to market demand. It creates linkages with other national and regional initiatives and programs to improve communication and information exchange.

The CANALLS team collected primary data with key respondents (value chain actors) to understand the cassava value chain from production, processing, distribution, preparation, and consumption of cassava, as well as the outputs of these activities, including socio-economic and environmental outcomes as discussed below.

A cassava value chain encompasses all the activities involved in making a cassava product and delivering it to retailers and the consumer. The cassava input suppliers consist of fertiliser companies, chemical companies and farmers supplying stems for propagation. These activities include design, sourcing of raw materials and all other inputs, production, processing, and distribution as shown in Figure 12.

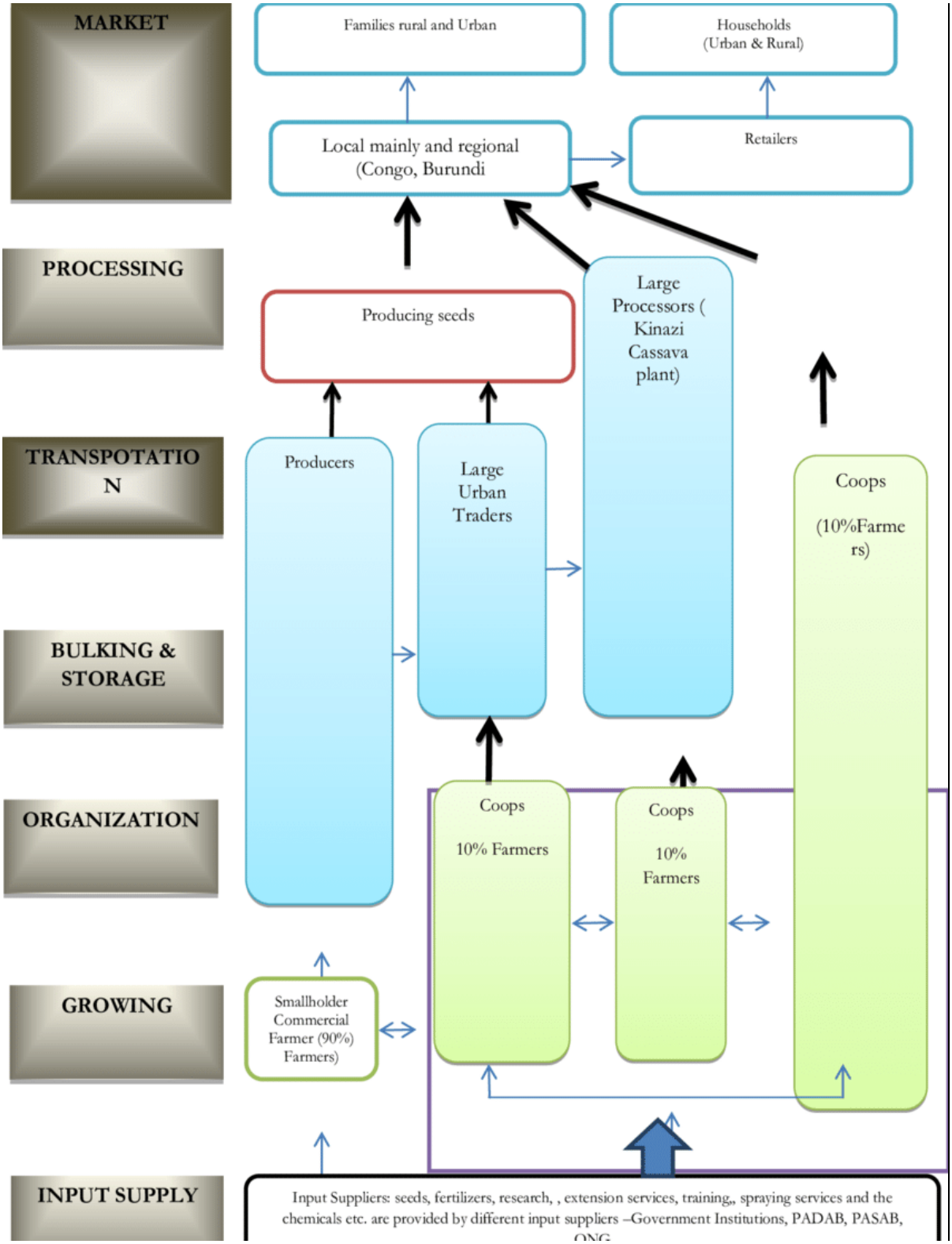

Figure 12: Cassava value Chain in Rwanda[25]. *PADAB-Bugesera Agricultural Development Support Project and PASAB-Projet d'appui à la Securite Alimentaire au Bugesera*

[25] Cassava Value chain in Rwanda

https://www.researchgate.net/figure/Cassava-value-chain_fig8_264288676

The cassava value chain actors were identified through focus group discussions. These findings align with the observations made by USAID (2010), as presented below:

Input suppliers: The main input are the cassava cuttings. Normally the cuttings are provided by the farmers on their farms. However new varieties are given by the Rwanda Agricultural Board (RAB) for multiplication. RAB then transfers the planting materials to secondary multipliers, who may consist of model farmers or their respective organizations. Subsequently, these planting materials are disseminated to individual farmers or cooperatives.
Producers: There are two categories of cassava producers; individual farmers who may be small or large and associations or cooperatives.
Middlemen: These individuals are traders who purchase cassava at low prices and gather substantial quantities. They are numerous within rural regions. Both small-scale and large-scale traders engage in the purchasing of cassava, subsequently selling it within urban regions.
Transporters: In rural areas some of the transports use human labour, bikes, and vans to transport cassava to collection centres or rural markets while the transport to regional and national markets is mostly done by truck.
Storage: The role of cassava storage is often undertaken by a combination of actors, including individual farmers, agricultural cooperatives, local traders, and larger agribusinesses. They employ different storage methods and facilities such as traditional storage structures, modern warehouses, or community storage centres.
Processing: At the household level, processing is typically carried out individually using traditional methods, often employing a mortar. For commercial purposes, processing is undertaken by millers. Notably, the Kinazi Cassava Plant factory conducts extensive cassava flour processing on a large scale, with a capacity of producing 20 tons of flour daily. This facility is a collaborative endeavour between private sector investors and the government. Additionally, smaller-scale processing predominantly occurs through cooperatives or private sector ownership.
Retailers: Local markets, small shops and supermarkets have cassava flour at different prices depending on the selling point
Consumers: Most of the consumers are cassava growers, people of low and middle income in rural and urban areas, and schools.
Research: The Rwanda Agricultural Board conducts research on cassava including research on adaptability of varieties, pests and diseases, and soils
Banks: The Banque Populaire du Rwanda (BPR), CLECAM and CAF ISONGA Ltd (two Rwandan microcredit institutions) are the major source of loans for cassava farmers but currently the Development Bank of Rwanda (BRD) has also started to give loans to cassava farmers approved by Kinazi Cassava Plant.
Influencers: The government through the Ministry of Agriculture and Ministry of Commerce are the main influencers in the agriculture sector and cassava field specifically. Their significant influence is predominantly evident in policy formulation, including initiatives such as the land consolidation policy, regionalization of crops policy, and distribution of enhanced cassava cuttings policy. Furthermore, local governance bodies, such as district administrations, have also exerted an impact on cassava cultivation. Ensuring adherence to safety standards and standardization falls under the purview of the Rwanda Bureau of Standards.

Intermediaries in the cassava value chain

The advantages associated with middlemen in the cassava value chain sector were provision of low-interest rate loans to farmers and provision of technical equipment and inputs used in agriculture. These intermediaries also play a crucial role in identifying markets for farmers, relaying information regarding market prospects and prices, and extending valuable technical guidance and advice to enhance farming practices. Drawbacks encompassed elevated input costs, delayed remittances to farmers, procurement of cassava from growers at unfavourable rates, inadequate consultation during price determination, prolonged loan acquisition processes, imposition of steep interest rates on loans, insufficient availability of requested funds for farmers, and a shorter grace period for loan reimbursement.

Entities acting as financial intermediaries within this sector comprised Clecam, Savings and Credit Cooperatives (Saccos), BPR, BRD, Cooperative of Progress and Financing (CPF), and Individual Savings. In contrast to other intermediaries, their advantages lie in providing localized financial services and extending sufficiently generous repayment grace periods. However, a drawback associated with these intermediaries was the prolonged time taken to address crop losses, along with the imposition of high interest rates on loans.

Gaps and bottlenecks in the cassava value chain

Traditionally, farmers source the propagating material (cassava stems) from neighbouring farms, open markets, and large cooperatives. Stem prices vary across regions, largely due to seasonal availability, the differences in land area devoted to cassava farming across regions, and the concentration of processors. Cassava production is dominated by smallholder farmers who use low-quality inputs and poor agronomic practices and have limited access to mechanisation. This has been a major determinant of Rwanda's current yield of 14.5 t/ha as opposed to a potential of 20-30 t/ha if mechanisation and good agronomic practices would be involved.

There are key bottlenecks along the cassava value chain that hinders the potential of the crop for income and food security. Most cassava farmers adopt manual labour for land preparation, weeding, and harvesting which account for ~90% of the total production cost. The cost of transportation from the farms to processing centres is high due to the bulky nature of cassava roots. The average starch percentage for cassava varieties produced by smallholder farmers and supplied to industrial processors is low. However, stems of the improved varieties containing at least 25% starch, that are developed by research institutes are not readily available to farmers due to the long duration of traditional cassava stem multiplication techniques. The short shelf life of cassava roots calls for timely processing to minimise post-harvest losses while processing equipment is costly and sometimes of poor quality. There is also the issue of price volatility because of irregular production with periods of glut when supply is high, and prices are low followed by scarcity and high price[26].

Various gaps were quoted by the respondents of the focus group discussions affecting the cassava value chain. They included pests and diseases, lack of subsidies, limited access to finance and low prices for the commodity.

[26] https://sahelconsult.com/wp-content/uploads/2021/12/Sahel-Quarterly-_The-Cassava-Value-Chain-Volume-28-1.pdf

Recommendations in addressing the gaps

Recommendations for addressing the identified gaps include:

1) To combat pests and diseases while simultaneously enhancing yield, the International Institute of Tropical Agriculture (IITA) has developed and introduced six improved high-yielding cassava varieties that exhibit resistance to two viral ailments: Cassava Brown Streak Disease (CBSD) and Cassava Mosaic Disease (CMD). The institute has additionally facilitated the establishment of clean cassava seed systems, providing support to RAB.
2) It is advisable for the Ministry of Agriculture and the Ministry of Commerce to consider the insights of farmers during the formulation of laws and regulations that are favourable to producers.
3) Respondents also stressed the importance of government engagement with farmers in determining prices, while also advocating for stringent measures against those who disregard these regulations.
4) Ensuring timely provision of planting material to farmers is crucial for adhering to proper seasonal cycles.
5) Facilitating interest-free soft loans to farmers can contribute to boosting the supply of produce to the market, particularly within the seed value chain.

Sahel (2021) notes that increased adoption of improved planting material and mechanisation will improve the efficiency of smallholder cassava farmers and increase productivity to achieve a vibrant cassava sector.

4.4.3. Cassava market in Kamonyi-Rwanda

Cassava marketing chains in Rwanda are dominated by small-scale informal intermediaries, including farmers, rural assemblers and traders, transporters, urban wholesalers, and retail traders. Some intermediaries combine different functions. Farmers sell their produce in the field, along the road, at the farm gate on a daily, weekly, and biweekly basis. The transaction volume is small, and prices are negotiated at the time and place of sale based on bargaining power between the buyer and seller. Transport from the farm to marketplaces is a major problem for this staple crop. A strong tradition of rural farmer groups, cooperatives and associations exists, who bulk their produce in rural areas and organise transport to urban markets to obtain a better price. There are at least four to five seasonal wholesale markets in each cassava growing province. In Kigali, wholesale trade is organised through many informal wholesale markets. These wholesale markets specialise in all perishable items including banana, vegetables, fruits, and roots and tubers, including cassava. Most vendors are women or transporters, and their clients are retailers and urban consumers.

In Rwanda, reliable market access remains a significant challenge for many cassava farmers. The Ingabo Syndicate, an organisation of Rwandan agricultural cooperatives, supports its 15,000 farmer members at all steps of the value chain, helping them strengthen their technical and economic capacities and become strong market actors. Most members are also organised into cooperatives, making it easier for the syndicate to deliver support at the group level[27].

The cassava produced in Kamonyi is mainly sold at the local market. The producers identified the Nyabugogo market in Kigali and indicated that middlemen sell their produce to the market. Out of the

[27] https://www.ifad.org/en/web/latest/-/ingabo-syndicate

surveyed participants, 80% expressed their lack of awareness regarding the ultimate utilization of the purchased cassava, whereas 20% confirmed their knowledge of value addition processes. An individual respondent, a male cassava producer, specifically shared, "Yes, I do. My cassava is taken to the Kinazi Cassava Plant." With expected export of 500-1000 tons of cassava flour to the US before end of this year, Emile Nsanzabaganwa – Managing Director of Kinazi Cassava factory says that Kinazi has upgraded its production capacity to 30 tons of cassava flour daily – hence the quest for new markets.[28].

So far, cassava has only been processed in Rwanda to produce cassava flour that is mainly used for *ugali* or *foufou*. However, cassava is also a source of good quality flour for baking, which Rwandan cassava processors have not previously been able to produce.

Processing and storage

Over the past two years, cassava has become a high priority crop for the Government of Rwanda; at least ten semi-industrial processing facilities were constructed across the country, with a concentration in Bugesera in Eastern Province and some facilities in Southern Province Districts including Kamonyi, Muhanga, Ruhango, and Nyanza. A big industrial plant is being launched in Ruhango District in Southern Province. It will be managed by the Banque Rwandaise de Developpement (BRD) and later transferred to the private sector through the Build-Operate-Transfer (BOT) scheme. Other cassava processing facilities include the Centre de Services aux Coopératives-UGAMA processing facility in Gatsibo in Eastern Province. This facility may become operational again if (a) the district cedes the facility to the Cassava Initiative Platform (CIP) and (b) CIP receives technical and financial assistance needed to renovate facilities and can undertake processing facilities in Bugesera.
The cassava cuttings are sold to producers while fresh sweet cassava is sold in the rural market/local market. USAID (2010) notes that the major outlets for cassava are local markets for flour and potentially DRC markets. Numerous products, not yet manufactured in Rwanda, can be produced from cassava roots. These include livestock feed, for which demand is anticipated to grow due to the Government of Rwanda “One Cow per Family” program.
High quality cassava flour markets are associated with mid- to high-income consumers and sold in domestic and export markets. The main destinations of cassava exports from Rwanda are: Democratic Republic of the Congo ($712k), Belgium ($258k), United Kingdom ($66.5k), United States ($9.09k), and Canada ($4.69k). The fastest growing export markets for cassava in Rwanda between 2020 and 2021 were Democratic Republic of the Congo ($502k), Belgium ($256k), and United Kingdom ($42.5k).

Some of the high-quality cassava uses are:

1) Bakery products – High-quality cassava flour can be used at levels of 10 - 35% in bakery products.
2) Glucose syrups – A controlled process was developed for conversion of high-quality cassava flour into sugar syrups with a range of dextrose equivalents to meet different end-user requirements.
3) Industrial and potable alcohol – A system was developed for conversion of sugar syrup into ethyl alcohol for industrial or potable use.

[28] Kinazi plant

4) Adhesives - High-quality cassava flour blended with soluble borax and caustic soda to produce Bauer-type paperboard adhesive that could completely replace imported starch-based materials.

Besides, high-quality cassava flour is used for complete substitution of wheat flour as an extender in urea and phenol formaldehyde resin plywood adhesives.

Low quality cassava is consumed by low-income consumers. The target market is domestic and regional markets.

Post-harvest losses

The USAID (2010) report outlines various post-harvest losses linked to cassava, including:

1) Deterioration of the root's quality and quantity right after harvesting due to physiological factors.
2) Processing-related losses in both quantity and quality; insufficiency of clean water for soaking peeled roots and inadequacy of proper drying facilities. These factors lead to the formation of cassava "chips" that tend to spoil rapidly without processing.
3) Quality losses attributed to artisanal flour production methods, resulting in flour of uneven quality.

Contribution of cassava to the Rwanda economy, social and environmental impact

Agriculture is the main economic activity in Rwanda, involving more than 80% of the labour force and contributing 33% to GDP. Of all crops, cassava is ranked third in importance for household income and food security.

Cassava protects the soil against soil erosion.

Agroecology markets in Rwanda

The respondents noted that African markets are characterised by production of agricultural and livestock products which can be processed or unprocessed.

To what extent is the current market driving agroecology practices?

According to the respondents, there is a minor inclination towards the consumption of agroecologically grown products, although their high prices pose a significant obstacle. The influence of the international market has impacted the adoption of agroecological practices. An emerging trend in demand for organic products is observed, and factors such as improved life standards, such as changes in diet and the growth of coffee shops, are shaping agroecological practices. In terms of strengths, the respondents highlighted several positive aspects. They recognized a favourable political stance towards agroecology, emphasized the market's role in connecting to regional markets, and pointed out its diversity and relatively adaptable standards. On the other hand, weaknesses within these markets were also identified by the respondents. They noted a lack of comprehensive label information on processed products, including details like shelf life and cooking time. Market instability and price volatility were highlighted issues, along with challenges related to low production, a multitude of value chain actors, and comparatively lower remuneration.

Changes that need to happen to strengthen Rwanda markets' transition to agroecology

The respondents emphasized several actions necessary to fortify the transition of African markets toward agroecology:

1) Improvement of infrastructure, including improved storage facilities, processing methods, cleanliness, and safety measures.
2) Transformation of markets into multifunctional spaces accessible to smallholder farmers, equipped with waste recycling facilities and processing centres.
3) Heightened consumer awareness regarding food quality. Suggestions included the creation of dedicated market areas for agroecological produce, providing information on its benefits to increase consumer knowledge, and offering extension services on agroecology principles and practices.

Regarding supply and demand, 20% of respondents indicated that the supply is adequate for household use, whereas 80% highlighted that the current supply falls short of meeting demand.

Characteristics of Rwandese markets in transition to agroecology

In Rwanda, it was noted that the markets should provide full information and specifications of the products. Additionally, these markets should embrace advanced processing technologies and incorporate laboratory testing for product verification. The respondents linked markets to an enhancement in quality and standardization.

Territorial market

A territorial market was identified as a limited market/ zoned market in which grains, tubers, horticultural and cash crops are traded. It was associated with small-scale processors and traders who sell to the local consumers. The barriers associated with the market were limited market development (in terms of physical infrastructure), post-harvest losses, price volatility and no market diversity.

Current liberal economic model

All the respondents indicated that the current liberal model could protect the African territorial market and ensure food security. One of the key informants from the Ministry of Agriculture noted that:" *Yes, it is one of the best approaches to increase access to food as intra-regional trade is expected to increase, allowing the flow of more affordable food for the benefit of consumers"-KI response.*

50% of the respondents noted that there is a chance of successful competing with the industrial food system compared to quantities produced using agroecological farming while 50% did not agree with the statement.

The respondents noted that there was a need to increase production using agroecology farming. The food supply should be demand-driven which means that if countries are to promote agroecological farming, the major factor is to stimulate the demand for it. On the supply side, strategies should be making the farming system more attractive to producers (through increasing its productivity and access to profitable markets). It was also noted that agroecological farming should target specific niche markets, not necessarily the common segments, at least in the transition phase.

The respondents highlighted the presence of existing infrastructure, including roads, although their condition is suboptimal. Similarly, postharvest and processing infrastructure is accessible but lacks adequacy. A respondent underscored the costliness of physical infrastructure, which often exceeds the capacity of small-scale farmers to invest individually. Instead, they rely on assistance from the Government and Development Partners. In Rwanda, infrastructure funding primarily derives from the Government budget, with ongoing plans for continued support. To tackle the infrastructure predicament, the suggestion arose that farmers should unite into cooperatives or groups to access collective support from government initiatives.

Strengthening of Rwanda markets to promote/protect farmers' and consumers' rights

The respondents emphasized that reinforcing the markets would lead to improved access for farmers to more profitable and diverse markets, while consumers would benefit from affordable food and a relatively steady supply. Regarding necessary changes, the respondents identified several key aspects: ensuring food sustainability, enhancing farmers' capacity, and promoting agroecology value chains are pivotal for strengthening African markets towards agroecology. All respondents unanimously expressed that consumers are willing to pay a premium for agroecology products, including certified ones.

It was noted that aside from products destined for export, traceability mechanisms are yet to be well-established. Small and Medium Enterprises (SMEs) obtain certification through the Rwanda Standard Board (RSB), using the Standard-mark on their products for marketing certification.

It was noted that there is an increasing demand for safe African foods by middle and high-income consumers and yet the small producers are not able to sell to them either because of the small quantities and seasonality of production and/or the food safety concerns. The following recommendations were given by the respondents.

1) Provision of good quality food.
2) Development of adequate infrastructures such as irrigation facilities to cope with effects of climate change.
3) Capacity building and promotion of large-scale production as well as intensification.
4) Capacity building of the businesses on the standards and their enforcement

Participatory guarantee systems

The respondents noted that a participatory guaranteed system does exist especially in the cassava value chain. It was indicated that Rwanda Inspectorate, Competition and Consumer Protection Authority (RICA) and Rwanda Food and Drug Administration (FDA) are involved in the guaranteed system supply and regulations and do set the standards.

4.4.4. Enabling environment for agroecology

The respondents highlighted several recommendations for financial institutions, including the reduction of interest rates to incentivize entrepreneurs, the provision of capacity building in skills and financial resources to strengthen extension services.

In terms of non-financial support, the respondents emphasized the need for research to disseminate information on optimal agricultural practices, climate change adaptation and mitigation, and disease control. They also emphasized in-kind assistance, such as providing equipment, technologies, physical infrastructure, including mobile dryers, and offering technical support.

All respondents acknowledged the allocation of budgets for promoting agroecology within the national budget. These allocations cover initiatives like constructing terraces, utilizing organic manure, and environmental protection.

Regarding policy setting, regular stakeholder engagement was noted, although this was not specifically directed towards agroecology markets. However, all engagements align with the broader goal of sustainable agriculture development. Policies governing various activities, including agroecology development, are established by the government and other partners, although there is room for increased focus on agroecology.

The respondents indicated the existence of a subsidy system in the crop value chain, excluding cassava, and commodities enjoy tax exemptions. Investments have been made in the Kinazi Cassava Plant as a cassava processor. Tax exemptions are also applicable to agricultural equipment in agro processing for all value chains, along with farm machinery. Subsidies are granted for seeds, fertilizers, irrigation equipment, and postharvest infrastructure. Finally, national laws and policies are in place for various value chains, including cassava.

Positioning agroecology in reducing food waste

In positioning agroecology in reducing food waste, the respondents noted that this can contribute to control of pests and diseases to increase the production, can contribute to control of soil erosion through on-farm practices such as nutrients recycling. One key informant notes that “Food waste is still a challenge though we have no evidence on this. Any attempt to upgrade our food systems should not ignore this”.

Conclusions

The findings indicated the substantial opportunities to advance Rwanda's food system in terms of provision of sustainable and healthy diets for all while also strengthening livelihoods. These efforts would build on Rwanda's global and regional commitments, utilise a multi-sectoral stakeholder approach and engage with the development community for support.

There are key bottlenecks along the cassava value chain that hinders the potential of the crop for income and food security. Cassava production is dominated by smallholder farmers who use low-quality inputs and poor agronomic practices and have limited access to mechanisation. This has been a major determinant of Rwanda’s current yield of 14.5 MT/ha as opposed to a potential of 20-30 MT/ha if mechanisation and good agronomic practices are involved.

Most cassava farmers adopt manual labour for land preparation, weeding, and harvesting which account for ~90% of the total production cost. The cost of transportation from the farms to processing centres is high due to the bulky nature of cassava roots. The average starch percentage for cassava varieties produced by smallholder farmers and supplied to industrial processors is low. However, stems of the improved varieties containing at least 25% starch, that are developed by research institutes are not readily available to farmers due to the long duration of traditional cassava stem

multiplication techniques. The short shelf life of cassava roots calls for timely processing to minimise post-harvest losses while processing equipment is costly and sometimes of poor quality. There is also the issue of price volatility because of irregular production with periods of glut when supply is high, and prices are low followed by scarcity and high price.

The study identified the following recommendations that will aid in strengthening Rwanda's food systems, value chains and markets.

1) Scaling Up the Commercialization of Seed Systems: Governments and private sector companies must devise strategies to increase commercial production, multiplication, distribution, and sales of improved stem cutting to smallholder farmers. More sustainable seed businesses must be established by recruiting and enabling seed entrepreneurs. Area mapping should be done, to effectively capture cassava farming communities and create seed markets that are accessible by these farmers. Like the Direct Seed Market approach deployed by the Ethiopian government in 2011[29]Seed commercialization must be encouraged, with more rural entrepreneurs (within the reach of farming communities) taking up the seed business and exploring market linkages.
2) Public Investment in Irrigation Programs: According to a 2019 publication by Alliance for a Green Revolution in Africa (AGRA), irrigation in Africa has the potential to boost agricultural productivity by 50%. Cassava farming in Africa is largely rainfed, hence the burden impacted by climate change. On their own, smallholder cassava farmers cannot afford automated irrigation technologies such as drip or sprinkler irrigation. Providing access to suitable irrigation technology such as drip irrigation or tube wells (which are easier and cheaper to install and maintain), and intensive training programs will not only increase existing farmer yields but also encourage entry into cassava farming.
3) Strengthening Extension Services: The Ministry of Agriculture must put out policies and incentives that strengthen extensions services to rural farmers. Farmers should be trained and made aware of climate change, its effects, and best adaptation practices specific to their location. Conclusion Unlike other staples in Africa, cassava can thrive under harsh climate conditions; however, pests and diseases of cassava thrive in these same conditions and affect cassava yields annually. Current coping strategies employed by farmers, and several initiatives by government and development organisations have not achieved much success beyond the pilot phases and focus areas. There is an urgent need for interventions that upscale existing programs by actors across the cassava value chain to boost the natural resilience of cassava against climate change, as a tool for achieving a food secure Africa.
4) Strengthening financial services: putting policies in place to ensure that farmers can access affordable loans will enhance production among the small holder farmers.
5) Investment in the sector; establishment of processing plants closer to the producers will reduce post-harvest losses due to the shorter cassava shelf life. Manual and labour-intensive processes in production and processing such as the peeling and roasting steps which are currently the least mechanised but represent the largest costs and biggest bottlenecks in cassava processing should be mechanised to save time, and money.

[29] https://sahelconsult.com/wp-content/uploads/2021/12/Sahel-Quarterly-_The-Cassava-Value-Chain-Volume-28-1.pdf

5. Conclusions

The CANALLS project aims to drive Agroecological transitions in the humid tropics of Central and Eastern Africa via multi-actor transdisciplinary Agroecology Living Labs (ALLs). It starts with 8 ALLs in DRC, Burundi, Cameroon, and Rwanda, working alongside and enabling over 20,000 farmers and value chain actors to co-create and benefit from optimal combinations of Agroecological practices focusing on crops that are vital for subsistence and economic development (cocoa, coffee, cassava, rice, maize).

Specific objectives under the CANALLS project include setting up 8 multi-actor Agroecology Living Labs (ALLs) in DRC, Burundi, Cameroon and Rwanda; developing practical tools to identify combinations of Agroecological practices, create and test them, monitoring and measuring the socio-economic and environmental performance of identified combinations of Agroecological practices; delivering sustainable business models along with services and tools for facilitating access to markets and enhancing demand for Agroecological products; and supporting and building capacity for the adoption of Agroecological practices.

The development of the agricultural sector is influenced by many factors, including both macro-environment and micro environmental factors. Macroenvironmental factors include global factors that influence the entire agricultural sector. Microenvironmental and local factors include the situation in the agricultural sector, local agricultural conditions, and nearby farms.

Our analysis relies on secondary and primary data (qualitative and quantitative). We combined desk study, 130 household surveys, 265 respondents from focus groups discussions and interviews with 35 decision makers and 55 traders in the living labs.

During the desk study, we reviewed the existing literature, following a Political, Economic, Social, Technological, Environmental and Legal (PESTEL) analysis to characterise the macro-environmental context that could affect the development and implementation of Agroecological projects in the focal countries. A desk review was also performed to identify the food systems, value chains and markets for the countries and ALLs.

We then reviewed the reports and materials published on the past and existing projects developed in the focal countries and living lab to inform the micro environmental context. The relevant topic for the micro environmental context includes landscape characteristics, socio-economic conditions, capacity building, farming practices and Agroecological context, and climate variability and adaptation. This review led to the identification of missing information.

The field data collection (interviews, focus groups) was carried out to fill in the missing information. Different materials for fieldwork were developed to capture the socio-economic and environmental contexts as well as to the mapping of the food systems, value chains and markets. Interviews with households, with traders and with decision makers using different interview guides were combined with a focus group discussion to map the food systems and markets. The socio-economic and environmental contexts were further discussed during focus groups discussions.

In many cases like in the Burundi living labs, inclusiveness and participation of the women matters. Women and youth are discriminated against for their access to resources and lands. Most women are automatically excluded regarding access to loans as they don't meet the required conditions (a bank account, collateral, and a substantial personal contribution). Women are victims of harassment

when faced with several situations such as employment, credit, purchase of land, and access to inputs in almost all the living labs. The worst situation is found in Rwanda where the baseline studies revealed few cases of reported rape of young girls in the community. The selected living lab, and their communities are particularly vulnerable to climate change impacts. All the farmers (100 %) in Giheta, Ntui, Biega, Bunia, Kabara, Uvira, and Kamonyi and 93 % in Bujumbura LLs are conscious of climate change and its effects. Extreme events were reported in all the living labs relating to climate change. This includes dryness, excessive rainfall, drought, and less reliability of planting season in Burundi; extreme drought, irregular rains, sudden cessation of rains, drying up of waterways, and frequent and violent winds in Cameroon; scarcity of rain, longer dry season, disease and pest attacks, heavy rain, rise in temperature, irregular rainfall in DRC; and heavy rains, drought, cyclonic wind and pest and serious diseases in Rwanda. These events brought about qualitative impacts including changes in the growing season, change in sowing date, soil degradation, yield reduction of cash and food crops, and modification/destabilisation of agricultural calendars. Several adaptation and mitigation strategies have been developed in the focal area of the future living labs, including some activities relating to Agroecological principles, such as the integration of animals into the cropping system (synergy), using of organic fertilisers (recycling and input reduction) and adoption of ISFM. Diverse range of crops from farm contributing to improve nutrition in the four living labs, including vegetables, legumes, crops, and cash crops. The degree of knowledge about agroecology varies and is very comparable across these living labs. Living labs with higher share of farmers who know or have heard about agroecology are Kamonyi in Rwanda (92%), Bujumbura from Burundi (66%), Kabare (60%), and Biega (50%) from DRC. Living labs in Burundi (Giheta and Bujumbura), DRC (Biega, Kabare, and Uvira), and in Rwanda (Kamony) have higher scores in terms of applying at least one or two activities that contribute to recycling, input reduction, improving soil health, caring about animal health, biodiversity, and enhancing synergy and diversification. This level of development of the activities feeding the principles raised here is a very good opportunity for the implementation of the living labs. On the other hand, the CANALLs project is a big opportunity for the Ntui living lab to improve the adoption of Agroecological practices. Although a couple of training has been carried out covering some good practices in all the living labs, framers still express the necessity for them to benefit from a variety of training, including composting maize and rice residues in Burundi, recycling, good agricultural practices, the use and manufacture of fertilisers, irrigation and the use of agroforestry systems in Cameroon, biogas production and the transformation of household and human waste into fertiliser in DRC, and growing green manure, reusing crop residues as animal feed, minimum tillage or no-till in Rwanda, to name a few. The CANALLs Project will consider the training already given and provide capacity building that address the needs stated by the farmers.

Burundi's food insecurity and malnutrition are becoming chronic. The various recommendations in enhancing food security, value chain and markets in Burundi are organisation of farmers into groups for collective bargaining when accessing the markets, and the need for the Government to engage producers when setting commodity prices, especially coffee. The study notes that the ongoing regional integration process should be used to maximise Burundi's benefits from its accession to the EAC. Reduced tariffs and non-tariff barriers will enable Burundi to have easier access to a larger market, facilitating an increase in exports to the regional market. Besides, the country needs to develop an action plan and establish the necessary facilities/ laboratories to comply with international sanitary and phytosanitary standards. Burundi's large infrastructure gap needs to be closed, says the study. This applies to a range of areas, including roads, air transport and electricity. Regarding transport infrastructure, the insufficient availability of cold storage and a cold chain, in general, needs to be addressed.

The 2017 Comprehensive Food Security and Vulnerability (CFSV) Analysis carried-out by the WFP in Cameroon revealed that approximately 16% of households in Cameroon are food insecure (moderately food insecure and severely food insecure). The WFP also found that a higher percentage of households in rural areas are food insecure than households in urban centres. Due to recurrent poverty, smallholder cocoa farmers suffer immensely from inadequate access to economic and social resources which endanger the cocoa sector and their entire livelihood. Farmers also lack adequate access to inputs alongside a lack of transportation and production resources. In addition, these farmers lack proper storage facilities such as warehouses to store dried cocoa. The findings also show that Cameroon, like most cocoa-producing countries, also faces many difficulties internally through implemented policy measures. In addressing this, reducing imports, defining the role of each intermediary, promoting the consumption, market regulation by the Government, price controls and strengthening farmer cooperatives and government option of a return to stabilisation will ensure efficiency in the cocoa sector.

The Democratic Republic of the Congo (DRC) is one of the most fertile countries on earth, with the potential to feed all its inhabitants and even export food commodities. It is home to approximately 80 million hectares of arable land (WFP, 2022). Agriculture and related services provide a livelihood to almost 75 percent of the population. The country enjoys one of the world's most favourable climates for agriculture and fertile soils and has the potential to feed over 2 billion people through suitable investments. However, according to the findings of the global standard for measuring food insecurity, 26 million people in DRC are currently severely food insecure making its hunger crisis Africa's biggest. The study identified the following recommendations in enhancing food systems, value chains and markets for cassava, cocoa, coffee, and rice sectors. This study showed that to increase the adoption rate of improved cassava varieties in Kabare Territory, it would be advisable for extension services to intensify the promotion of new varieties so that their characteristics might be better known. The key elements of Strengthening value chain approach to enhancing coffee production are; providing agronomy training, increasing producers' access to washing stations and improving washing stations' productivity, market outreach, and quality; increasing producers' awareness of art of producing consistently high-quality coffee of interest to the international specialty market, developing Eastern Congo's high-altitude arabica coffees by inclusively building an enabling policy environment for a sector-prioritised, owned, and managed strategy; and researching the most productive varieties and resilient farming systems to introduce best practices for coffee. In the rice value chain, farmers lack access to finance, seeds, and other necessary productive inputs to improve their rice yields. The recommended interventions in the rice sector are increasing rural economic activity and enhancing smallholder resilience through income growth and food production.

There are substantial opportunities to advance Rwanda's food system in terms of provision of sustainable and healthy diets for all while also strengthening livelihoods. These efforts would build on Rwanda's global and regional commitments, utilise a multi-sectoral stakeholder approach and engage with the development community for support. There are key bottlenecks along the cassava value chain including small holder farmers who use low-quality inputs and poor agronomic practices and have limited access to mechanisation. This has been a major determinant of Rwanda's current yield of 14.5 MT/ha as opposed to a potential of 20-30 MT/ha if mechanisation and good agronomic practices are involved. The cost of transportation from the farms to processing centres is high due to the bulky nature of cassava roots. The short shelf life of cassava roots calls for timely processing to minimise post-harvest losses while processing equipment is costly and sometimes of poor quality. There is also the issue of price volatility because of irregular production with periods of glut when supply is high, and prices are low followed by scarcity and high price. The study identified the following recommendations that will aid in strengthening Rwanda's food systems, value chains and markets.

Governments and private sector companies must devise strategies to increase commercial production, multiplication, distribution, and sales of improved stem cutting to smallholder farmers. Providing access to suitable irrigation technology such as drip irrigation, the Ministry of Agriculture must put out policies and incentives that strengthen extension services to rural farmers. Strengthening financial services: putting policies in place to ensure that farmers can access affordable loans will enhance production among the smallholder farmers.

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Annexes

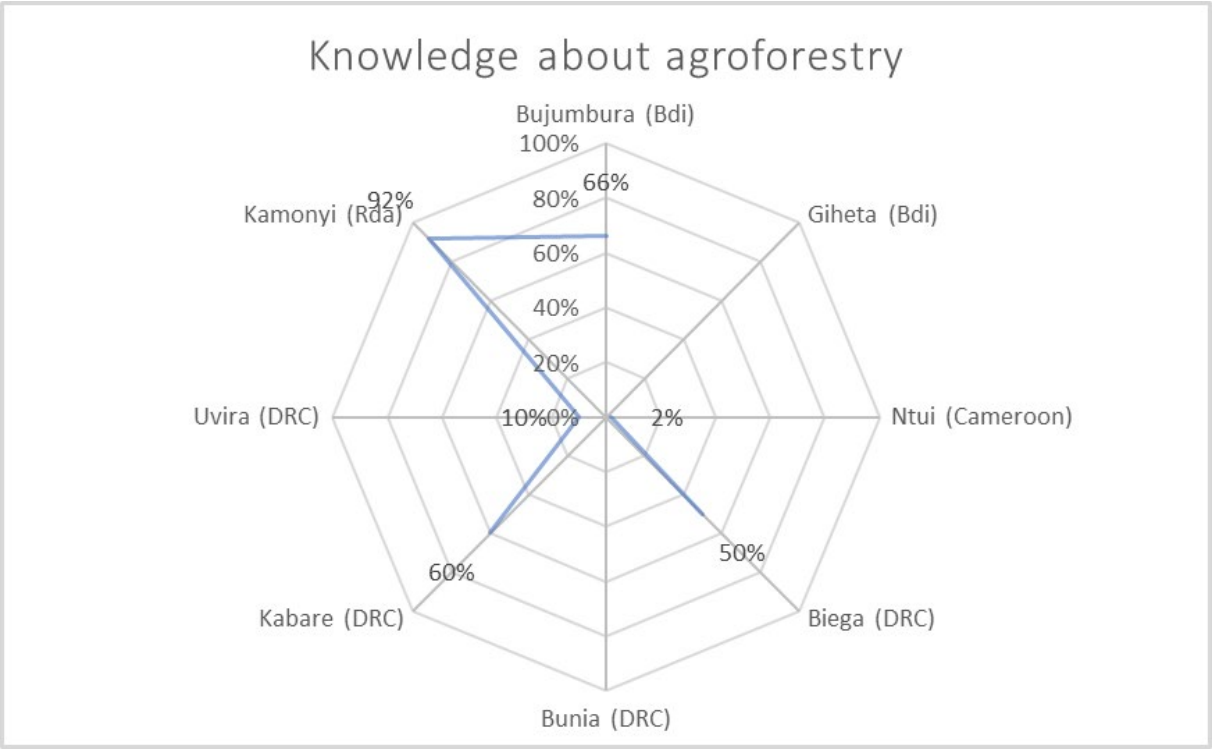

Figure 13: Knowledge about agroforestry

Table 18: Recycling

	Burundi		Cameroon	RDC			Rwanda
	Bujumbura	Giheta	Ntui	Biega	Kabare	Uvira	Kamony
Compost-manure-cow dung (%)	80	100	16	100	100	100	100
Leguminous green manures (%)	0	20	5	100	100	100	4
Reuse of wastewater (%)	30	0	0	0	55	45	92
Bioenergy (%)	88	0	26	0	55	100	100
Reduced/no-tillage/deep-rooting plants (%)	0	80	32	0	100	100	30
crop residues/wood waste recycling (%)	100	60	0	100	48	100	92

Table 19: Input reduction

	Burundi		Cameroon	RDC			Rwanda
	Bujumbura	Giheta	Ntui	Biega	Kabare	Uvira	Kamonyi
Who is reducing, replacing, or eliminating inputs (%)	0	0	0	40	0	90	61
Drip irrigation/improved varieties (%)	30	0	0	0	100	100	100
Recycling of crop residues (%)	100	60	0	100	65	100	100
Reduced / non-application of pesticides (%)	0	80	0	100	55	63	0
Improved cooking stoves (%)	27	70	0	100	65	100	100
Reduce seed use, optimal seed spacing (min - max distance) (%)	100	90	0	100	66	63	69
Reduce waste harvest, improved storage facilities (%)	20	46	0	100	85	0	69
Pest management - biological control (%)	23	40	0	0	66	0	4
Cover crops for pest management and weed control (%)	36	0	0	0	77	1	7
Increase of chemical inputs (%)	95	40	0	10	5	1	48

Table 20: Soil health

	Burundi		Cameroon	DRC			Rwanda
	Bujumbura	Giheta	Ntui	Biega	Kabare	Uvira	Kamonyi
Caring about organic matter and soil health	*100%*	*10%*	*0%*	*100%*	*73%*	*54%*	*100%*
Use of plants covers crops to reduce erosion	*66%*	*50%*	*13%*	*100%*	*5%*	*0%*	*7%*
Adoption of perennial plant species	*83%*	*80%*	*28%*	*10%*	*50%*	*100%*	*77%*
Adoption of soil conservation practices	*50%*	*100%*	*11%*	*0%*	*77%*	*9%*	*23%*

Table 21: Animal health

	Burundi		Cameroon	RDC			Rwanda
	Bujumbura	Giheta	Ntui	Biega	Kabare	Uvira	Kamonyi
Takes care of animal health (%)	100	46	8	100	15	100	100
Introduces domestic pollinators (%)	36	26	0	0	28	0	93
Support livestock welfare (%)	49	100	78	100	40	100	100

Table 22 : Biodiversity

	Burundi		Cameroon	RDC			Rwanda
	Bujumbura	Giheta	Ntui	Biega	Kabare	Uvira	Kamonyi
Enhance the diversity of species, functional diversity and/or genetic resource (%)	100	20	0	0	85	88	100
Incorporating non-crop plants (%)	5	80	0	50	75	88	100

Table 23: Synergy and diversification

	Burundi		Cameroon	RDC			Rwanda
	Bujumbura	Giheta	Ntui	Biega	Kabare	Uvira	Kamonyi
Integrated crop-livestock systems (%)	95	100	0	100	59	100	100
Agroforestry - crop and trees (%)	65	100	78	100	69	36	100
Rotational/regenerative grazing to improve soil quality and forage yield (%)	0	0	0	0	0	0	0
Integrating native crops and animals (%)	70	100	0	100	59	90	92
Spatially diversified farms by multi-, poly- or inter-cropping (%)	100	80	8	100	77	77	100
Diversification of healthy diets/diversified food production system (%)	50	92	0	100	34	100	100

Table 24: Capacity building provided in different living labs of project CANALLS

Crop	Topic	BUR		CMR	DRC			RWD
		Bujumbura	Giheta	Ntui	Biega	Kabare	Uvira	Kamonyi
Cocoa	Assessing Cocoa Farm Productivity				X			
	Post-harvest management					X		
	seedlings nurseries management					X		
	Introduction to Increased Farm Productivity Without Deforestation			X	X			
	Pruning for Improved Soil Fertility and Efficient Use of Soil Nutrients			X	X			
	Cultural systems for improving cocoa production in Mambasa				X			
	Fermentation for producing high quality of cocoa for importation				X			
	Weeding for Improved Soil			X				
	Fertility and Efficient Use of Soil Nutrients			X				
	Introduction to Pesticides Application			X				
	Handling and Applying Pesticides Without Contaminating Your Soil			X				
	integrated Pests and Diseases Management Practices			X				

	Planting Shade Trees to Improve Yields and Preserve Soils			X				
	Activities That will Degrade the Soil on Your Farm			X				
	Organic Matter to Improve Soil Fertility			X				
	Compost			X				
	Other Ways to Bring Organic Matter to Your Farm			X				
	What to Know About Inorganic Fertiliser Application			X				
	Applying Inorganic Fertilisers			X				
Maize	Good agricultural practices of maize	X						
	Integrated fight against FAW	X						
	How to install and manage the FFS	X						
	multiplication and proper seed management	X						
	Small agricultural mechanisation and post-harvest management	X						
	practice of each stage of maize cultivation	X						
Coffee	Effect of Mucuna cover crop in banana and coffee plot for improved Soil Fertility and efficient Use of Soil nutrients, water						X	

	conservation and forage production for livestock							
	social responsibility regarding Naturland standard		X					
	Why agroforestry		X			X		
	developing of a shade trees list		X					
	how to draw village and farm map topic		X					
	Identify major crops periods and rain/dry seasons Cropping calendar topic		X					
	Problems/challenges on climate change and impacts of climate change on environmental, economic, and social level and working on solutions		X					
	Methodologies for extension work/advisory work and how to improve them		X					
	Farm management of coffee farm		X					
	Management of coffee tree		X					
	soil health and fertility		X					
	Diversification of income in a coffee farm under agroforestry and biodiversity		X					

	Why agroforestry and how to implement agroforestry in coffee farms		X					
	How to draw village and farm map		X					
Cassava and rice	Good Agricultural Practices: Farmer Field School (IFSM&RIS), Biological fertilisers							X
	Marketing and cooperative governance: Business Plan, financial education, Negotiation for the market							X
	Cooperative governance, financial management							X

Table 25: Capacity building needed.

Improving of Specific needs expressed by farmers		BUR		CMR	DRC			RWD
		Bujumbura	Giheta	Ntui	Biega	Kabare	Uvira	Kamonyi
Recycling	Capacity building on effective recycling and composting of maize and rice residues	X						
	Recycling methods		X	X	X		X	
	Training in the production of biogas, transformation of household and human waste into fertilising materials					X		
	Knowledge about growing green manure, reusing crop residues as animal feed Knowledge about minimum or no tillage, mulching using organic compost,							X
Reduction of inputs	Use of organic fertilisers and pesticides	X						
	Knowledge to produce biopesticide products and access to seeds.		X					
	Best agricultural practices, fertilisers, and irrigation			X			X	
	Knowledge of the use of inputs and biological control				X	X		X
Soil health	Raising awareness of soil health	X						
	Knowledge in soil health and irrigation practices	X	X			X		
	Training for good agricultural practices, the manufacture of fertilisers and their application			X				
	Knowledge in soil health and technical support needs				X			
	Knowledge on good agricultural practices						X	
	Knowledge of no-till tillage, Knowledge of cover crops and application of lime,							X
Animal health	Knowledge on Animal health	X	X				X	
	Training in animal husbandry, beekeeping and fish farming, financial support, and supply of inputs			X				
	Capacity building, ideal treatment, local veterinary pharmacy, need for				X			

	new breeds tolerant to epidemics							
	Training of the peasants on the feeding and care of animals. Need to set up structures for pharmaceutical products in the villages to access animal medicines, set up a veterinary clinic, and train the peasants on the feeding and care of animals.					X		
	Artificial insemination, Basic knowledge of veterinary services, Information on new species such as rabbits, Knowledge of feeding animals with a nutritious diet, need for subsidies for veterinary products, Knowledge of fodder conservation, Knowledge of raising small animals, Setting up veterinary laboratories and clinics, Knowledge of veterinary practices and training"							X
Biodiversity	Training on crop association, crop rotation, awareness-raising of agroecology, and disease control. setting up input shops in the locality	X						
	Knowledge about biodiversity		X		X			
	Knowledge in agroforestry and best agricultural practices Capacity building, supply of plants, financial support for establishment and monitoring			X				
	Training on importance of biodiversity, need for coffee growing materials, need for quality seeds					X		
	Capacity building, distribution of tree seedlings or seeds of leguminous species						X	
	Contour line and agroforestry practices (fruit trees), Planting agroforestry species and flowers, Forests, coffee							X

Questionnaires;

1. Guide for Focus Group Discussion and Actor Mapping Guide
T1.1 & 1.2 - IITA & AATF

Project Title: Driving Agroecological transitions in the humid tropics of Central and Eastern Africa through traNsdisciplinary Agroecology Living LabS

Name of the ALL: ……
Target Audience: Farmers/rural stakeholders

Time: 2 hours
Respondent: Farmers

Instructions to the team
General information to be completed by the research team.
What is the focal crop for this ALL?

Introduction: Please introduce yourselves by stating your name, then, explain the purpose of the research and obtain consent from the respondents, using the preamble below.

Preamble
The CANALLS project aims to drive Agroecological transitions in the humid tropics of Central and Eastern Africa via 8 multi-actor transdisciplinary agroecology living labs. …….. is one of the 8 locations for the implementation of the project. The activity /focus group discussion we want to carry out with you today is for the purpose of analysing the current situation and forest transition landscapes, current needs, contexts, and practices as well as food systems, value chains, and markets for Agroecological products. The information we are going to gather will be used specifically to address the challenges in the value chains and personal information will be kept confidential. We seek your consent to gather this information. If yes, we continue with the interview/discussion and we will have your name on the list of participants.

State: *I'd like to start our interview by asking you some questions about the situation of farmers in these communities (state the communities that have been merged for the FGD).*

The socio-economic and environmental context of our rural communities.

1.0. SOCIOECONOMIC AND DEMOGRAPHIC CONDITIONS

. *Are there indigenous and local knowledge recognized and respected?*
. *Are there gender, youth, and indigenous equitable inclusiveness regarding access to lands and natural resources (Yes/no)? please explain. . Provide some examples where women, or youth or indigenous are marginalised as regards access to land and natural resources*
. *Are there gender, youth, and indigenous equitable inclusiveness regarding access to finance, (Yes/no)? please explain. Provide some examples where women, or youth or indigenous are marginalised as regards access to finance Are there inequitable inclusiveness regarding access to lands and natural resources (Yes/no)? p Could you remember the last time you heard about or you were victim of sexual h harassment, violence against gender?*
. *List diverse range of cereals, pulses, fruits, vegetables, and animals from farms contributing to improve nutrition. What are the 3 most important? List them according to most-least important*
. *Did you experience any health issues relating to the manipulation of empty contents and of chemical compounds (list the illness. What is the % of FG participants who faced at least one of the listed health issues. %.....*
. *Who of you do use any individual protection equipment during pesticide, herbicide, or chemical application? please raise your hand and argue (type and purpose of the equipment used)*

2.0. ADAPTIVE CAPACITY AND CLIMATE CHANGE VULNERABILITY OF OUR FOCAL COMMUNITIES AND AREAS

. *Did you experience any changes in the climate during the past 10 years? ……% of farmer reporting changes. Please list the changes ……..*
. *What are the extreme events affecting the focal zone/landscape/community in the past decade? Name 4 of them from the main event to the 4th*
Main event
Secondary event
Third event
Fourth event
. *Did you experience any changes in Length of Growing Period (%, number of days, …)? Please indicate the previous length of growing period and the actual length of growing period*
. *Did you notice any change in the crop sowing calendar? Please indicate the previous sowing date, the actual sowing date, the previous harvesting date, and the actual harvesting date.*
. *What are the main actions developed at community level /by farmers in the community/by your organisation as adaptation strategy to climate change?*

In the following questions (3.1) questions with percentages – Calculate the number of respondents that carry out the practice on the total number of respondents.

3.0. NEEDS AND PERCEPTIONS ABOUT AGROECOLOGY.

3.1. Awareness of the existence of agroecology: Have you already heard about agroecology? If yes, what do you know about it?	**□Yes, □No** **Please give the reason**	
3.1.1. Recycling: Who of you uses local renewable resources and/or promotes the recycling of inputs or outputs within his farm/organization? Raise your hand if you practice the following:		
Practices	**% users**	*%women users*
Use of Compost, manure, or cow dung	|___|	|___|
Use of leguminous green manures	|___|	|___|
Reuse of wastewater (whether domestic or no)	|___|	|___|
Use of bioenergy from corn stalk, slaughter waste, Organic agricultural waste etc…	|___|	|___|
Reduced or no tillage and/or use of deep rooting plants	|___|	|___|
Recycling of crop residues for other uses, wood waste recycling for construction	|___|	|___|
3.1.2. Do you have any specific needs regarding the recycling of input (capacity building, ….)? If yes, list them		
3.1.3. Input reduction/replacement: what is your opinion on chemical fertilisers? Good or bad? why? What is your opinion on pesticides? Good or bad? why?		
3.1.4. Who of you reduces, replaces, or eliminates, the purchased inputs for agricultural production in his farm /his organisation? If none, why? If someone, how does it happen (example)? Raise your hand if you practise the following:		
Practices	**% users**	*%women users*

Drip irrigation or improved varieties	|___|	|___|
Recycling of crop residues for other uses, wood waste recycling for construction	|___|	|___|
Reduced or non-application of pesticides	|___|	|___|
improved cooking stoves	|___|	|___|
Reduce seed use, optimal seed spacing: (Min distance between 2 plants…...? Max distance between 2 plants……	|___|	|___|
Reduce waste Timely harvest, improved storage facilities	|___|	|___|
pest management through biological control / enhance or conserve pest enemies/antagonists (including predators, parasitoids, pathogens, and competitors)	|___|	|___|
Cover crops for pest management and weed control	|___|	|___|
Increase of chemical inputs	|___|	|___|
Reduction of chemical inputs	|___|	|___|

3.1.5. Do you have any specific needs regarding the Input reduction/replacement (capacity building, ….)? if yes, list them

3.1.6. Soil health: Who among you cares about organic matter and soil health? if someone, explain how? if not, why? Raise your hand if the practice the following

Practices	**% Users**	*%women users*
Planting cover crops to reduce erosion, increase soil organic matter and improve soil drainage	|___|	|___|
Adoption of perennial plant species in place of annual crops	|___|	|___|
Adoption of conservation tillage or no-till practices	|___|	|___|
Do you have any specific needs regarding the improvement of soil health? if yes, list them		

3.1.7. Animal health (if applicable): Who of you cares about animal health? if someone, explain how? if not, why? Raise your hand if the practice the following

Practices	**% Users**	*%women users*
1) Temporary introduction of domesticated pollinators or introduction of exotic domesticated species	|___|	|___|
2) Efforts to support livestock well-being (e.g., Species-appropriate husbandry, aquaponics…)	|___|	|___|
3) Do you have any specific needs regarding the improvement of animal health? if yes, list them	|___|	|___|

3.1.8. Biodiversity: Who of you enhance the diversity of species, functional diversity and/or genetic resources? if someone, explain how? if not, why? Raise your hand if the practice the following

Practices	**% Users**	*%women users*

1) Incorporating non-crop plants in Agroecological systems for ecological functions such as conservation, water quality or pest management	|___|	|___|
2) Any other action in favour of biodiversity Conservation? ……	|___|	|___|
3) *What are the challenges faced? What could be the solution according to you?*		
4) *Do you have any specific needs to enhance biodiversity? if yes, list them*		

3.1.9. 3.1.6. Synergy & Economic diversification: Who of you enhance positive ecological interactions and complementary in the agroecosystems (Animals, crops, trees, soils, and water)? and promote productive and income diversification on farms? if someone, explain how? if not, why? *Raise your hand if the practice the following:*

Practices	**% Users**	*%women users*
Integrated crop-livestock systems: diversified farming system including both crops and livestock	|___|	|___|
Agroforestry: diversified farming system integrating crop and trees	|___|	|___|
Rotational/regenerative grazing to improve soil quality and forage yield	|___|	|___|
Integrating/incorporating native or locally/regionally adapted crops and animals	|___|	|___|
Spatially diversified farms by multi-, poly- or inter-cropping: %	|___|	|___|
Diversification of healthy diets and consumption locally through a diversified food production system……%	|___|	|___|
Do you have any specific needs regarding the synergy and economic diversification? if yes, list them		

4.0. LIST THE SOURCE OF INPUTS (SEEDS, FERTILISER, PESTICIDES ETC) (ACCESSIBILITY) USED THE PRODUCTION SYSTEM

4.1. Could you say more about the quality inputs you use in your farming systems? What about reliability? Are they easy to use? Please describe the main challenges you face regarding access to quality inputs on time.

5.0 MAPPING OF VALUE CHAINS/ACTORS

5.1.1. Let the participants identify and map the existing value chain for the focal crop i.e (producers,' 'input suppliers,' 'aggregators,' 'distributors,' 'processors,' 'different markets', 'waste managers,' and 'end consumers,' explaining the activities performed by the specific groups. disaggregated by gender. NB: they might not find all the links of the supply chains. Then limit the existing links in the supply chains.

Focal food Crop		*Focal Cash crop*	
Value chains actors	*Roles performed*	*Value chains actors*	*Roles performed*

Second food Crop		*Second Cash crop*	
Value chains actors	*Roles performed*	*Value chains actors*	*Roles performed*
Third food Crop		*Third Cash crop*	
Value chains actors	*Roles performed*	*Value chains actors*	*Roles performed*

5.1.2. Next, ask some of the participants to tick the links of the supply chains needed for that living lab?

□ *input suppliers*	□ *aggregators*	□ *distributors*
□ *processors*	□ *different markets*	□ *waste managers*
□ *business and technical assistance*	□ *programs/extensions,*	□ *Access to finance*
□ *policy and regulation,*	□ *research and capacity building*	□ *good access to water and energy*
□ *storage facilities*	□ *safety measures at the marketplaces*	□ *any other information on markets*

5.2. GAPS, BOTTLENECKS AND RISKS IN THE VALUE CHAIN

5.2.1. What are the policies, institutions, or programs that are most important to be addressed for an efficient value chain-focal crop focused? This means what are the policy gaps or interventions that need addressing.
5.2.2. What are the major gaps and bottlenecks that affect the supply chains? How are we going to address these gaps and bottlenecks? Are there programs or policies that can help us?
5.2.3. What are the risks to women and other producers in the value chain? What can be done to protect ourselves from these risks?

5.3. INTERMEDIARIES AND MIDDLEMEN

5.3.1. What are the bad and the good of intermediates and middlemen? Describe Middlemen's positive and negative role in all the aspects of the market, including access to quality input on time, access to market, pricing, access to credit/loan, ect…
5.3.2. List existing financial intermediaries in the focal Area (Micro-finance, Village-level initiatives, banks, …), describe their bad and good in providing proximate financial services. Are there difficulties in access to finance? Please describe

2. Target Audience: Households engaged in the Focal Crop as Primary Producers and knowledgeable about access to agroecology Markets.

Name of the ALL: …….

Time: 2 hours

Instructions to the team

General information to be completed by the research team.

What is the focal crop for this ALL?

Introduction: Please introduce yourselves by stating your name, then, explain the purpose of the research and obtain consent from the respondents, using the preamble below.

Preamble: The CANALLS project aims to drive Agroecological transitions in the humid tropics of Central and Eastern Africa via 8 multi-actor transdisciplinary agroecology living labs. …….. is one of the 8 locations for the implementation of the project. The activity /focus group discussion we want to carry out with you today is for the purpose of analysing the current situation and forest transition landscapes, current needs, contexts, and practices as well as food systems, value chains, and markets for Agroecological products. The information we are going to gather will be used specifically to address the challenges in the value chains and personal information will be kept confidential. We seek your consent to gather this information. If yes, we continue with the interview/discussion and we will have your name on the list of participants.

State: *I'd like to start our interview by asking you some questions about the situation of farmers in these communities (state the communities that have been merged for the FGD).*

IDENTIFICATION OF RESPONDENT

1 Name …….. 2. Age…….. 3. Gender(M/F/NA) ……..…… 4. Contact…… 4. Focal crop or activity/area covered……
5. Number of years in this activity/focal crop…… ……Nature of activity formal/informal……

IDENTIFYING LOCAL PRODUCTION POTENTIAL

. What did the community produce in the past (10 years) that is no longer produced or where the production is greatly reduced? Which products were (more) produced by men and which by women?
. What are the factors that stopped the production of these products? Can the changed conditions be addressed? Which ones? Are there any changes between the products produced now by women and men? What has led to these changes?
. What knowledge (specify whether traditional or modern) and skills existed in the past? Is that knowledge still needed to be developed? List them and provide additional comments.
. Are there resources that were used in the past still in the community but are no longer in use now? for example: ……. Please list them.
. Ask the participants to think about their community and then draw the resources that help them produce certain products (focus on focal crop) or in production generally. They should include:
. Land and/or other natural resources (like forests, sources of water –to drink, to give to animals, pastures and to produce) currently used and land/natural. Indicate whether women or men control these.

. *Location and distribution of inputs (seeds, fertilisers, manure, compost, organic pesticides, wood and timber, credit, extension). Some of these inputs may be available outside the community; this should be indicated.*
. *Transport facilities, routes, conditions, and frequency for various products*
. *Storage facilities and what is stored there.*
COMPONENT 2: PROCESSING UNITS
2.1. List other resources critical for production.
. *What markets (local, national, international) do you sell focal crops? Do you experience any difficulty or any facility to access local, national, and international markets? Please describe in 2 sentences.*
. *As regards the projection of the demand and supply of the focal crops, is the supply enough to feed the demand (yes/no + one sentence comment)? Please indicate the share of deficit in supply or demand*
. *What assets are already in use? Which ones are idle but could be used?*
. *What resources are used for subsistence (please put 2 examples of resources and then, ETC…)? And which ones for the market? If both, what is the approximate distribution between home and market use?*
. *Is there adequate supply for home use?*
. *What prevents you from increasing the production of existing products (focal crop)? Are there environmental, cultural, social, financial and or political factors? Please list them.*
. *What resources do you see that could be used to produce new or different products? What are these new products?*
. *What are the limiting factors?*
0. Are there gender differences in access, control and decision-making over these assets and the potential for increased production and/or new products?
1. List and prioritise 6 main commodities that are being produced in the area. What other commodities do you think should also be produced?
2. What are the opportunities for increasing production and/or for developing new products? What are the biggest opportunities?
3. What are the barriers to increasing production of the focal crop? What is the biggest one?
COMPONENT 3.: COLLECTIVES' REFLECTION ON THE MARKET
. *What is your experience of marketing your products? let them name the product, please capture women's and men's experiences separately.*
. *What markets do you have access to and what markets (local, regional, international markets) did you identify where you do not currently sell your products? Describe the 'channel' (middleman, local shops, supermarket, etc.). identify the actors in this channel?*
. *What are some of the conditions, hurdles, and steps that you will need to face to be able to sell in these markets?*
. *Do you have any idea on the use of your products by your clients after they have bought it? please explain.*
. *What are the differences in marketing farm products for women and men*

. *Has the focal product been transformed from its original state before sale? List and quantify any other product you proceed at least to the first transformation before selling. (Value addition)*

3. **Target Audience: Traders/sellers of agricultural products e.g., agro-dealers, processors, middlemen, brokers**
Name of the ALL: ……..

Time: 1 hours

Instructions to the team

General information to be completed by the research team.
What is the focal crop for this ALL?

Introduction: Please introduce yourselves by stating your name, then, explain the purpose of the research and obtain consent from the respondents, using the preamble below.

Preamble: The CANALLS project aims to drive Agroecological transitions in the humid tropics of Central and Eastern Africa via 8 multi-actor transdisciplinary agroecology living labs. …….. is one of the 8 locations for the implementation of the project. The activity /focus group discussion we want to carry out with you today is for the purpose of analysing the current situation and forest transition landscapes, current needs, contexts, and practices as well as food systems, value chains, and markets for Agroecological products. The information we are going to gather will be used specifically to address the challenges in the value chains and personal information will be kept confidential. We seek your consent to gather this information. If yes, we continue with the interview/discussion and we will have your name on the list of participants.

State: *I'd like to start our interview by asking you some questions about the situation of farmers in these communities (state the communities that have been merged for the FGD).*
1.Name …….. 2. Age……... .3. Gender(M/F/NA) ……..……) 4.. Contact……
4. Focal crop or activity traded……
5. Number of years in this activity …… ……

COMPONENT 1 ANALYSING THE MARKET SITUATION INCLUDING CHANNELS AND ACTORS

. *What is your target market (local, regional, international)*
. *who are the actors involved in marketing your products to the market, list them down and identify the role played by each*
. *For each market, please describe who the consumers are. Are they women or men? Are they end consumers or intermediary markets? If an intermediary market, who is the end consumer?*
. *What do the buyers like in the product? Why are they buying it? What attracts them to make this purchase? Is it how it is packaged? Specific attributes of this product? Size? Colour? Others? Do consumers buy more in certain seasons?*
. *What are the advantages of this channel? (For example, you don't need to pre-package the product. A buyer will take any size or shape).*
. *What are the disadvantages of this channel? (For example, you need to have significant quantities. The quality requirements are very high. The price is low).*
. *What role do women play in marketing and in the market*

COMPONENT 2: BUILDING RELATIONSHIPS WITH MARKETS

. *What are some value propositions (benefits) that already exist for your focal product?*
. *What additional products could you produce? What will be the value proposition of these items?*
. *Who are your collaborators/competitors/other actors in your field? Can you recommend some other actors we could contact for such an interview?*

4. **Target Audience: Actors in the value chain/Decision Makers/Development Agencies -Access to Agroecology Market**

Name of the ALL: …….

Time: 2 hours

Instructions to the team
General information to be completed by the research team.
What is the focal crop for this ALL?

Introduction: Please introduce yourselves by stating your name, then, explain the purpose of the research and obtain consent from the respondents, using the preamble below.

Preamble: The CANALLS project aims to drive Agro Ecological transitions in the humid tropics of Central and Eastern Africa via 8 multi-actor transdisciplinary agroecology living labs. …….. is one of the 8 locations for the implementation of the project. The activity /focus group discussion we want to carry out with you today is for the purpose of analysing the current situation and forest transition landscapes, current needs, contexts, and practices as well as food systems, value chains, and markets for Agroecological products. The information we are going to gather will be used specifically to address the challenges in the value chains and personal information will be kept confidential. We seek your consent to gather this information. If yes, we continue with the interview/discussion and we will have your name on the list of participants.

State: *I'd like to start our interview by asking you some questions about the agroecology environment*
Name of the respondent:
Organisation name: Phone no/contact email:
Designation/position: Age: Gender:

1. *What are the most important characteristics of in-country and African markets? Their strengths & weaknesses?*
2. *What do we see as the characteristics of the future in-countries and African markets in the context of the transition to agroecology?*
3. *Could you clarify what a territorial market is, what it consists of, and the main barriers?*
4. *The current liberal economic model – is it able to protect African territorial markets? Can it secure access to food?*
5. *Do we have a chance against the industrial food system when compared to the (limited) quantities produced using Agroecological farming?*
6. *Are there good physical infrastructures enabling trade (road, transport mean…), Are there any issues in this vein? How can small-scale farmers deal with such issues in the food system?*
7. *What are the good and the bad of middlemen in the focal value chain? How could we sort that out?*
8. *What is the relationship between the modern food system and the farmer market?*
9. *How can the strengthening of African Markets promote/protect farmers' and consumers' rights?*
10. *What do entrepreneurs need to create an enabling environment for agroecology?*
11. *Are there issues relating to access to finance? loan, credit, …, present the issues and discuss what you think could be the solutions.*
12. *Are there some non-financial support requirements to strengthen farmers' activities?*
13. *What are the key changes that need to happen to strengthen African markets for the transition to agroecology?*
14. *Are there existing experiences where consumers pay more for agro-ecologically produced products? What works and what does not work?*
15. *What mechanisms (e.g., traceability, …) exist to verify whether the products are Agro Ecologically produced or not? Who bears the cost of verification ?*
16. *Is certification feasible given the low level of development of local markets?*
17. *There is an increasing demand for safe African foods by middle and high-income consumers and yet the small producers are not able to sell to them either because of the small quantities and seasonality of production and/or the food safety concerns. What do you see as a solution to these challenges?*
18. *Does any participatory guaranteed system apply in focal commodities or any other commodity? If yes, who sets the standards? What are the compliance challenges farmers are facing?*
19. *Are consumers willing to pay more for food which is certified and traceable?*
20. *In your experience, have you seen the effect of the local or national budgets in promoting agroecology? Quote examples if applicable.*
21. *To what extent is the current market driving agroecology practices?*
22. *To what extent is agroecology related to deforestation and environmental degradation?*
23. *How do we engage with policymaking and ways to invest, mobilise, and strengthen policies around agroecology markets*
24. *How can agroecology be positioned to reduce food waste and consumer food waste?*
25. *Are there any subsidy policies, any taxation policy, any tariff policy, for the focal crop? What are the major National & international laws, rules and regulations that apply to the focal crop?*

THANK YOU FOR YOUR TIME