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Functional analysis of the cocoa (*Theobroma cacao* L.) value chain in the Tshopo province in Democratic Republic of the Congo, A review

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Abstract

Cocoa (*Theobroma cacao* L.) was introduced in the Democratic Republic of the Congo (DRC) in 1885, and in Tshopo province, it was first introduced in Barumbu (1914) and Ngazi (1920). However, since the 20th century, the cocoa value chain (CVC) has remained underdeveloped, despite original breeding research. Therefore, a functional analysis of this value chain and mapping of actors to identify bottlenecks impeding its revitalisation is essential. This research is based on documentary and analytical methods, as well as interviews with key actors involved in this value chain. The governance of the CVC remains ineffective, despite the involvement of a wide range of actors. Indeed, cocoa is produced and exported without a clear vision or regulatory framework; nevertheless, the ratification of the Abidjan agreement, which recommends operational planning for cocoa-producing countries. The lack of horizontal coordination among various cocoa initiatives has exacerbated the overlap of the actors' roles in the CVC. The availability of arable land and suitable ecology for cocoa (strengths) and mobilization of numerous actors as well as abundance of cocoa materials selected in Yangambi (opportunities) constitute comparative advantages for the CVC in Tshopo. The lack of expertise in cocoa post-harvesting and the less involvement of autochthons (weaknesses), as well as the risk of land conflict (threat), could impact the CVC if strategies are not undertaken. The limited adoption rate of improved cocoa cultivars developed by the INERA research centre in Yangambi could accelerate the dissemination of cocoa diseases across the Tshopo landscape and further jeopardize the sustainability of the CVC. This study recommends an interprofessional re-organisation to align all cocoa initiatives, strengthen governance and boost cocoa production to diversify the Congolese economy. Therefore, the functional analysis can serve as a baseline for strategic development and decision-making by international agencies, public authorities, scientists and private investors.

Keywords: Functional analysis, Cocoa value chain, SWOT analysis, Cocoa selection and Yangambi

Abbreviations

AFD	Agence Française pour le Développement (French Development Agency)
AfDB	African Development Bank (Banque Africaine de Développement)
ALE	Agence Locale d'Exécution (Local Implementation Agency)
AVENIR	Appui à la Valorisation de l'Économie rurale et à l'Innovation Régionale (Support for the Development of the Rural Economy and Regional Innovation)
CAFI	Central African Forest Initiative (Initiative pour les Forêts en Afrique Centrale)
CLD	Comité Local de Développement (Local Development Committee)
COCUCT	Coopérative des Producteurs du Cacao dans la Tshopo (Tshopo Cocoa Producers' Cooperative)
DGDA	Direction Générale des Douanes et Assises (Directorate-General for Customs and Taxation)
FONAREDD	Fonds National REDD (National REDD Fund)
GASH	Groupement des Associations Socio-Humanitaires (Consortium of Social and Humanitarian Organisations)
INERA	Institut National pour l'Étude et la Recherche Agronomique (National Institute for Agricultural Research and Studies)
IPAGRISA	Inspection Provinciale de l'Agriculture et Sécurité alimentaire (Provincial Inspection of Agriculture and Food Security)
MEDD	Ministère de l'Environnement et du Développement Durable (Minister of the Environment and Sustainable Development)
MINAGRISA	Ministère de l'Agriculture et Sécurité Alimentaire (Minister of Agriculture and Food Security)
MRSIT	Ministère de la Recherche Scientifique et Innovations Technologiques (Minister of Scientific Research and Technological Innovation)
OCC	Office Congolais de Contrôle (Congolese Control Office)
OCEAN	Organisation Concertée pour les Écologistes et Amoureux de la Nature (Concerted Organisation for Environmentalists and Nature Lovers)
ONAPAC	Office National des Produits Agricoles du Congo (National Office for Agricultural Products of the Congo)
PARRSA	Projet d'Appui à la Réhabilitation et à la Relance du Secteur Agricole (Project to Support the Rehabilitation and Revitalisation of the Agricultural Sector)
PCCBMS	Promouvoir la Cacaoculture sous ombrage pour améliorer la Conservation de la Biodiversité et les Moyens de Subsistance (Promoting shade-grown cocoa to improve biodiversity conservation and livelihoods)
PGDF	Programme de Gestion Durable des Forêts en RDC (Sustainable Forest Management Program in the DRC)
PIREDD/MBKIS	Programme Intégré REDD dans le bassin de Mbujimayi, Kananga et Kisangani (Integrated REDD Program in the Mbujimayi, Kananga and Kisangani basin)
PIREDD-O	Programme Intégré REDD dans la province Orientale (Integrated REDD Program in the Oriental Province)

PNRCo	Programme National de Recherche sur le Cacao (National Cocoa Research Program)
PRAPO	Programme de Réhabilitation Agricole dans la Province Orientale (Program for the Revitalisation of Agriculture in Orientale Province)
PRODAT	Programme de Développement Agricole dans la Tshopo (Agricultural Development Program in Tshopo)
PSFD	Programme d'appui pour la mise en valeur des Savanes et Forêts Dégradées (Support Programme for the rehabilitation of Degraded Savannahs and Forests)
REDD	Réduction des Émissions issues de la Déforestation et de la Dégradation des forêts (Reducing emissions from deforestation and forest degradation)
UCLA	University of California, Los Angeles (Université de Californie, Los Angeles)
UCP	Unité de Coordination Projet (Project Coordination Unit)
PIF	Projet d'Investissement pour la Forêt (Forest Investment Project)
UGP	Unité de Gestion de Projet (Project Management Unit)
UPDKIS	Union Paysanne pour le Développement de Kisangani (Farmers' Union for the Development of Kisangani)
VCA4D	Value Chain Analysis for Development (Analyse de chaînes de valeur pour le développement)

1 Introduction

Cocoa (*Theobroma cacao* L.) is widely recognized as a cash crop and contributes to the gross domestic product (GDP) of producing and chocolate-manufacturing countries (Boysen et al., 2021; Armengot et al., 2023). Unfortunately, cocoa producers are mostly smallholders, estimated at around 5 to 6 million farmers worldwide who live generally below the poverty line (Boeckx et al., 2020; van Vliet et al., 2021; Boysen et al., 2023). The CVC still faces huge challenges in improving smallholder livelihoods and productivity, and in reducing deforestation (Atangana et al., 2025; Akowuge and Zandersen, 2025). Currently, the global cocoa-growing land is around 12 M ha and represents 0.25% of arable land, with a global production estimated at 5.2 M tons in 2024 (FAOSTAT, 2024). The global market of this value chain is marked by two macro indicators: the global value for cocoa beans, which is estimated at approximately $26.7 billion and the global chocolate market, which is estimated at around $119.3 billion in 2023 (Market Expert Research, 2023; Chocolate Market Size, 2024). However, its sustainability and inclusivity, as called for by the Abidjan declaration in 2012, have not yet been achieved in the DRC (WCC, 2012).

Cocoa is mainly grown in tropical regions between 20° N and 20° S of the equator (Kongor et al., 2016). It requires an average temperature between 24 and 28°C, with a mean maximum annual temperature between 30° and 32°C, and a mean minimum annual temperature not below 18°C (Van Himme and Snoeck, 2001; CIRAD, 1989). Cocoa demands abundant and well-distributed rainfall. The annual minimum rainfall is estimated at ca. 1500 mm, but an annual precipitation above 1700 mm is preferred, despite the ability to adapt to a short dry season (Konstantas et al., 2018; Van Himme and Snoeck, 2001). The relative humidity recommended for cocoa is around 80%, which must stay stable. It is typically grown at altitudes between 0 and 700 m above sea level (Etaware, 2022).

Even though cocoa originated in Central America, West Africa is the world's leading cocoa-producing region with around 70% of worldwide cocoa bean production. In particular, Côte d'Ivoire and Ghana together account for more than 50% of the global cocoa bean supply (Wilson et al., 2019; Effendy et al., 2019; Asante et al., 2022; Boysen et al., 2023; Donkor et al., 2023). As such, this value chain contributed to the GDP of Côte d'Ivoire and Ghana with USD 3.85 and 1.37 billion, respectively, in 2020 (Kongor and Muhammad, 2023; Siaw et al., 2023). In both countries, the liberalisation process, which had affected other cocoa-producing countries, has been implemented progressively through the Office du Café et du Cacao and the Ghana Cocoa Board (COCOBOD), respectively (Ton et al., 2008; Verter, 2016; Teye and Nikoi, 2021).

However, Côte d'Ivoire and Ghana have been facing challenges of cocoa-driven deforestation, ageing plantations, pest and disease attacks, as well as the threats of climate change, which could compromise the sustainability of global cocoa supply (Boysen et al., 2021; Artavia and Croppenstedt, 2023). Cocoa demand is increasing as the chocolate and other cocoa-related product industries expand rapidly (Beg et al., 2017; Morel et al., 2019; Asante et al., 2022; van Vliet et al., 2023; Armengot et al., 2023). This demand is exacerbated by the consumption of chocolate and related cocoa products in emerging markets like India, China and Latin America (Parra-Paitan et al., 2023; Krumbiegel and Tillie, 2024). The International Cocoa Organisation (ICCO) reported a deficit of 439,000 tons of cocoa beans in 2023/2024, leading to a significant increase in the price of this commodity to over USD 10,000 t^{-1} (ICCO, 2024). Given the threats of climate change in West Africa, the restructuring of cocoa production across other tropical regions is now urgent for diversifying the sources and ensuring sustainable cocoa production.

To address the growing cocoa demand, Congo basin countries could play an important role in scaling sustainable cocoa production by implementing appropriate policies and innovations (Kehoe et al., 2017). However, this basin hosting the second-largest block of tropical forest (Hubau et al., 2020), could be threatened by the same scenario of deforestation from cocoa expansion if no precautions are taken. Meanwhile, the reduction of emissions from deforestation and forest degradation (REDD) programs initiated in this basin are promoting cocoa agroforestry to reconcile biodiversity conservation and enhance local community livelihoods (Enongene and Fobissie, 2016; Katayi et al., 2023). For instance, Cameroon is the 5th largest cocoa producer worldwide, with 300.000 metric tons in 2022, while DRC is ranked only 16th with 20.000 metric tons in 2022 (FAOSTAT, 2023). Literature, however, reveals that the DRC has comparative advantages for CVC over other countries in this basin (Huart and Mumbere, 2021; Kamath et al., 2024). Indeed, the DRC was the first country in the Congo Basin to introduce cocoa in 1885 and holds comparative advantages in terms of the largest suitable land availability, a favourable climate, and long history of cocoa selection through the "Programme National de Recherche sur le Cacao" (PNRCo) of INERA/Yangambi since 1933, much earlier than other Congo basin countries (Figure 1) (Van Himme, 1973; Lescuyer et al., 2019; Verleysen et al., 2021; Sibret et al., 2022; Batsi et al., 2023).

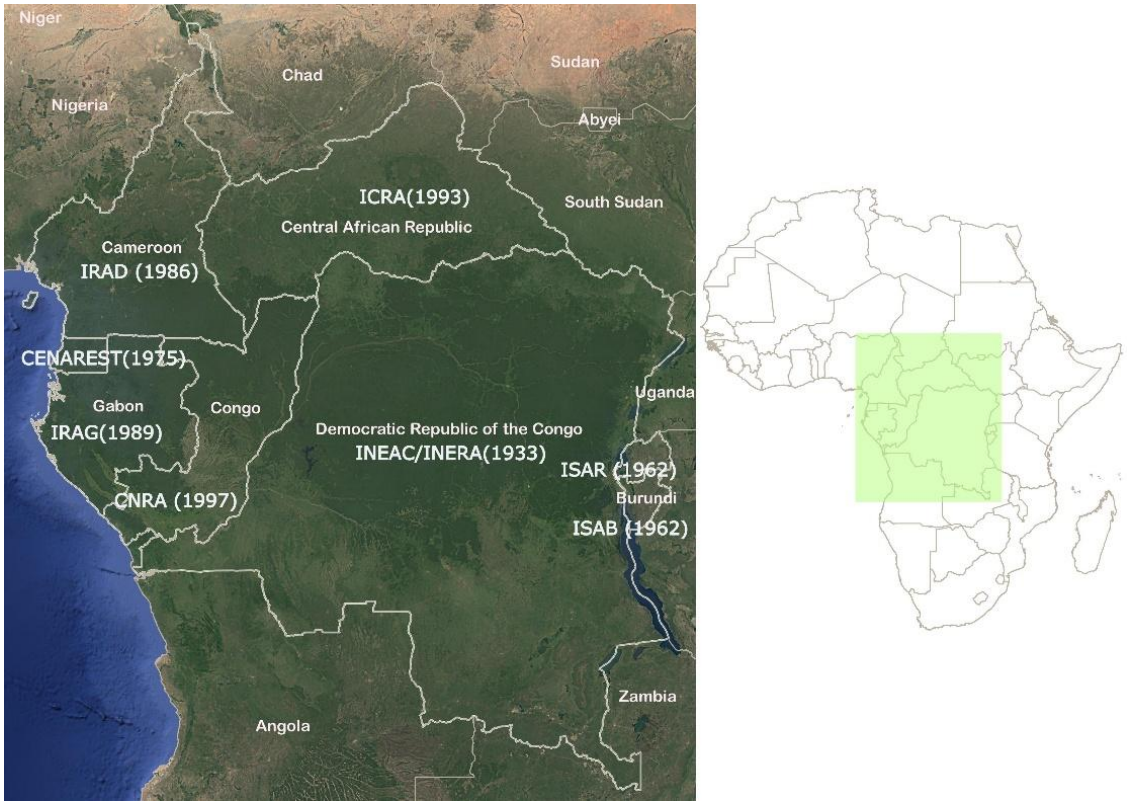


Figure 1. Agronomic research institutes in Central Africa and the date of their creation. ISABU: Institut des Sciences Agronomiques du Burundi ; ISAR: Institut des Sciences Agronomiques du Rwanda; INERA: Institut National pour l'Étude et la Recherche Agronomique; SNRVA: Système national de la recherche et de la vulgarisation agricoles; ICRA: Institut Centre Africain de Recherche Agronomique; IRAD: Institut de Recherche agricole pour le Développement; ITRAD: Institut Tchadien de Recherche Agronomique pour le Développement; CENAREST: Centre National de Recherche Scientifique et Technologique and IRAG : Institut de Recherche Agronomique de Guinée.

Meanwhile, the pathway for the development of the cocoa sector in the DRC was interrupted due to the independence and Zairianization reforms (i.e., confiscation of cocoa plantations from colonists and their distribution to local elites without a business plan) (De Beule et al. 2014). Colonial-era cocoa plantations in Mayumbe, Barumbu, Ngazi, Lokolela and Eala belonging to colonial investors were registered in *Regies des Plantations au Congo* (REPCO) to supply the international market (Rottiers et al., 2018). Considering that colonial plantations had been abandoned by the Zairian owners, the PNRCo set up a nursery in Yangambi (Tshopo province) in 1974 to supply producers with cocoa material and boost this cash crop. This experiment was a national collection based on a massive selection of the most productive and adapted varieties from Eala, Likimi, Lokolela, Mobwasa, Ngazi, and Mayumbe regions. Unfortunately, these experiments were not pursued owing to the high cost of cocoa research for the Zairian government (Limba et al., 2017). Subsequently, the former president Joseph Mobutu initiated the

Cacaoyère de Bengamisa (CABEN) program in partnership with the African Development Bank (AfDB) in 1980 to boost Zairian cocoa production, but funding from AfDB was cancelled due to the poor management of this program.

In 2008, the Congolese government signed a convention with Esco-Kivu to implement cocoa and coffee projects through a public-private partnership in Mambasa (Ituri) and Beni-Mutwanga (North Kivu). This partnership, based on the exoneration of cocoa and coffee export fees, led to the first success story with more than 10.000 ha of cocoa farmlands in this eastern region. However, this region is threatened by insecurity caused by different militias (De Beule et al., 2014; Huart, 2024). Otherwise, as a pilot country to implement REDD programs, including PIF-PIREDD, PIREDD-O, PIREDD-MBKIS, PIREDD Mongala, PIREDD Plateaux, etc., from 2013 up to 2024, DRC targeted the promotion of cocoa production in many provinces to reduce deforestation (Majambu et al., 2023). Although these programs have involved various actors, including donors, international agencies, public technical agencies, and national NGOs, the governance aspects of this value chain have received little attention.

Recent research on cocoa in the Tshopo region has focused primarily on ecological aspects, i.e. carbon sequestration, deforestation risk and biodiversity (De Beule et al. 2014; Batsi et al. 2020; Batsi et al. 2021), without examining the functioning of the value chain. Additionally, growing interest from diverse actors, without a clear policy framework (strategic and operational planning) as well as formal rules, could increase the risk of deforestation in this landscape and make this CVC ungovernable in the future. Therefore, this study aims to serve as a baseline for various cocoa-based initiatives promoting the sustainability of the value chain.

This paper aims to provide an in-depth analysis of the functioning of the CVC in the DRC, in general, but especially in Tshopo province since independence in 1960. We test three hypotheses:
(i) the CVC has undergone significant progress as a result of various developmental projects implemented in the DRC, as well as in Tshopo province; (ii) the PNRCo in INERA Yangambi plays a significant role in promoting the adoption of high-performing cocoa varieties within the Tshopo region, and (iii) the limited involvement of public institutions, the poor coordination (horizontal and vertical), and the weak structuring of the CVC result in ineffective governance.

2 *Methods*

2.1 Study area

This study was conducted in Tshopo province, located in the northeastern ecoregion of the DRC and crossed by the equator (Figure 2). This province has approximately 19.8 M ha of forest cover (Omasombo et al., 2020; Global Forest Watch, 2024). Its vegetation is characterised by a diversity of forests, e.g., dense humid (evergreen), semi-deciduous and secondary forests, which are facing anthropogenic pressures (Bauters et al., 2021; Luambua et al., 2021). Its climate is a humid tropical (Af) according to Köppen classification, with an annual average rainfall of 1837 mm and an average annual temperature of 25.5°C (Kasongo et al., 2023).

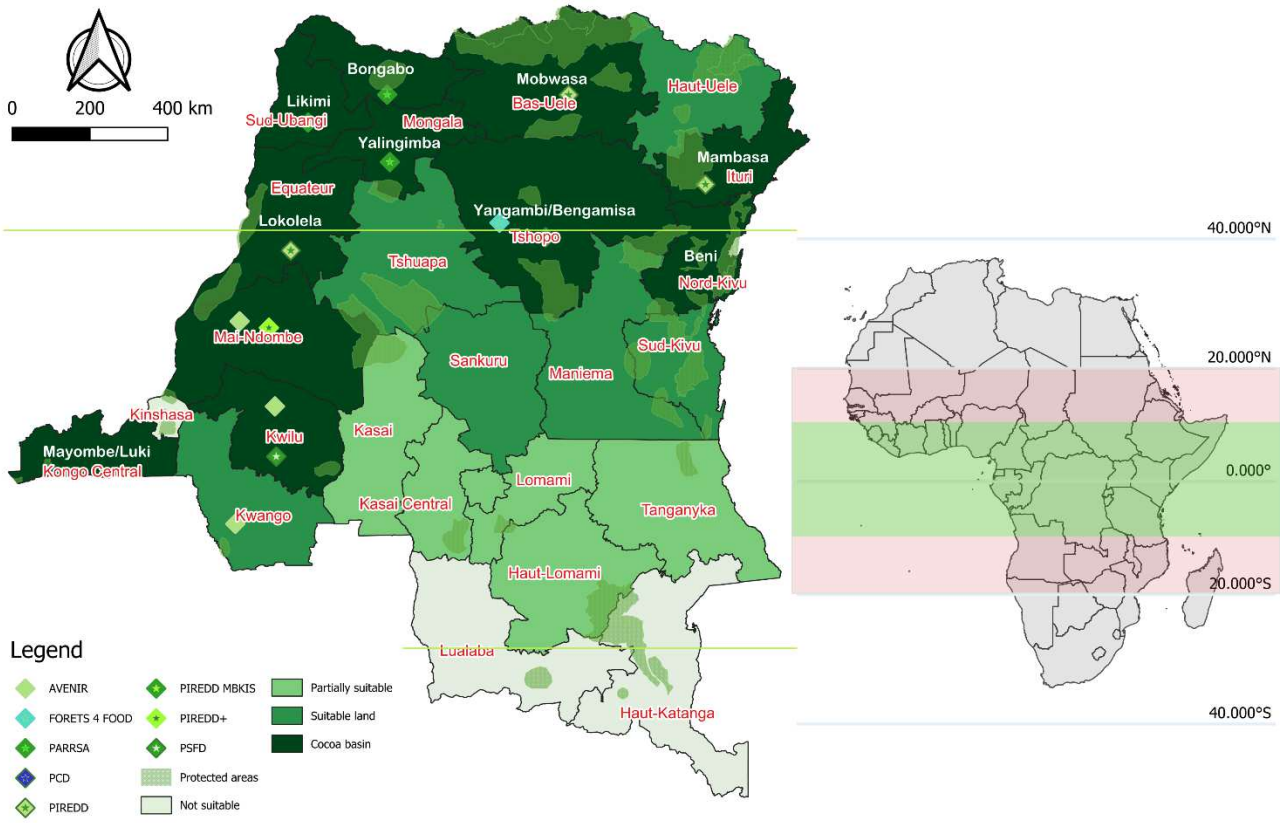


*Figure 2. Mapping cocoa-producing basins (based on historical ecological and climatic conditions) in the DRC (Limba et al., 2017). Projection of the DRC in Africa's cocoa belt (20°N and 20°S as well as 10°N and 10°S (*Ameyaw *et al.*, 2018; Kongor *et al., 2024). This map emphasises different cocoa-related projects* (*see legend*) *implemented in the DRC.*

2.2 Data collection

This paper used two types of data: documentary data from published and unpublished documents, and field data from interviews with key actors of the CVC in Tshopo. Specifically, we conducted a systematic investigation at the INERA library in Yangambi and the State Archives of Belgium to document the history of cocoa research conducted by INERA/PNRCo. We analysed annual reports from 1933 to 1985 to trace cocoa-related activities in the DRC. Otherwise, the documentary method was performed with "*Google Scholar*", "*Semantic Scholar*" and "*Web of Science*" search engines with 3 queries: *"Cocoa and value and chain and DRC",* "*Cocoa and value and chain and Tshopo",* and *"Cocoa and sector and Yangambi and Zaïre"*. We found a total of 125 related documents, which were filtered by using the criteria of "*cocoa in DRC*" and "*cocoa in Zaïre*" to retain only 15 documents, including non-peer-reviewed documents (Klein, 1972; Kalala, 1989; De Beule et al., 2014; Rottier et al., 2018; Limba et al., 2021; ONUDI, 2021; Batsi et al., 2020; Batsi et al., 2021; Batsi et al., 2023). The topics focused on the economy of Zaïre, description of the agricultural sector, genetic analysis of Yangambi cocoa cultivars, diseases, suitability for cocoa in Tshopo province, value chain diagnostic in Western DRC, carbon sequestration, as well as biodiversity.

In addition, interviews with key actors, i.e., IPAGRISA, ONAPAC, SCAK, VOLCANO, CABEN, PNRCo/INERA, COCUCT, UPDKIS, Esco-Kivu and Rikolto, were conducted to provide complementary information on the functioning of the CVC throughout Tshopo province. An in-depth analysis of agricultural programs was also carried out to list cocoa-related initiatives undertaken in the DRC and in Tshopo province. These programs involve various actors, including donors, development agencies, international and national NGOs, influencing the governance of the CVC at multiple levels. The variables, i.e. program cycles, budgets and locations, enabled to make a critical analysis of cocoa production relative to the budgets invested in these programs without assessing internal management or technical and financial aspects. Data on cocoa production in Congo Basin countries were obtained from FAOSTAT (2024) and used to analyse the evolution of cocoa production in the DRC. This functional analysis was complemented by a meta-analysis (Figure 3) following the VCA4D approach to map the CVC at the national level, with a specific focus on Tshopo province (Lescuyer et al., 2019).

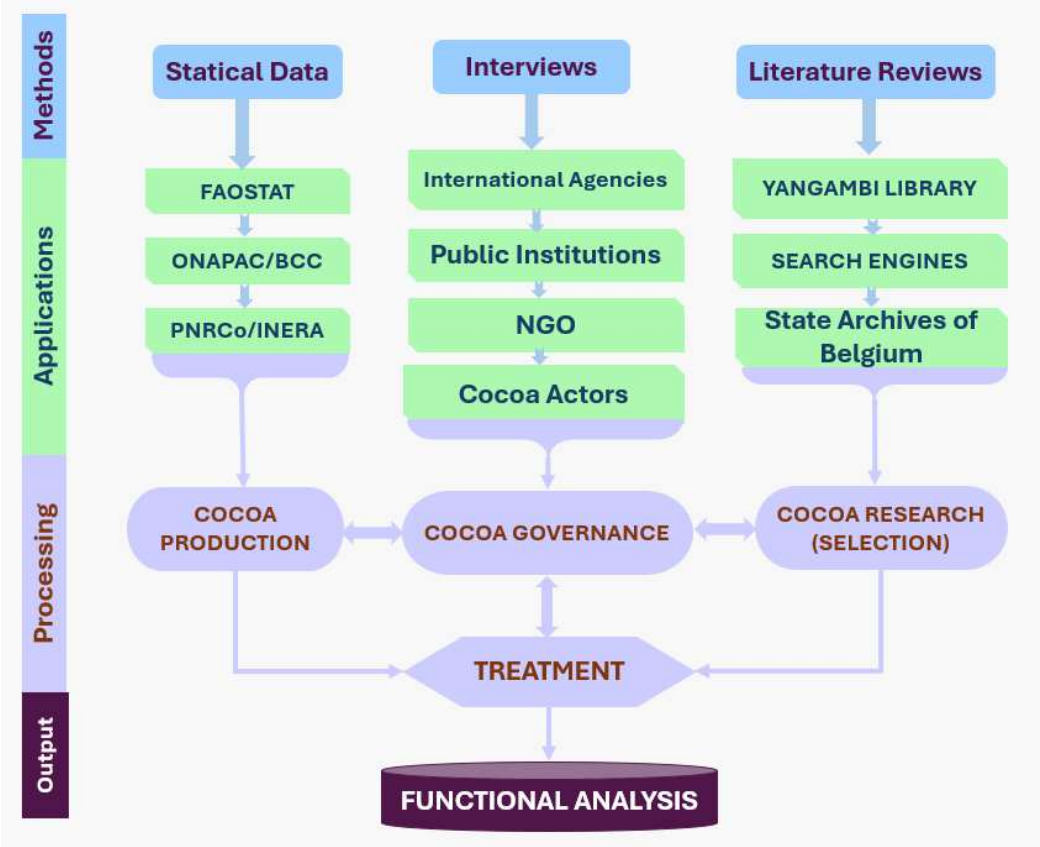


Figure 3. Meta-analysis framework used for assessing the functioning of CVC in Tshopo province in DRC

2.3 Data analysis

To assess the functioning of the CVC, quantitative analyses on cocoa production data from 1961 to 2024 were performed with R-Studio 4.4.1 (ggplot2 package) to compare production trends in the DRC with other Congo Basin countries (Cameroon, Republic of Congo, Central Africa, Gabon and Equatorial Guinea). The governance analysis was based on three key criteria: (i) coordination among actors at various levels; (ii) involvement of state agencies in the implementation of the various projects and (iii) alignment of policies with internationally ratified commitments and agendas. A critical analysis of project initiatives and public-private partnerships was then conducted, considering the theory of change and the real impact on cocoa production as indicators.

A critical analysis of cocoa selection based on various annual reports was undertaken not only to review the history of cocoa research in the DRC, and more specifically in Yangambi/PNRCo, but

also to highlight the methodological limitations of these experiments. In this study, this approach involved a descriptive analysis of the annual reports to identify future research perspectives (Badaha et al., 2023). Additionally, interview data were analysed using the SWOT method, which examines strengths and weaknesses as internal factors of the value chain, and opportunities and threats as external factors which could affect the value chain in the future (Leigh, 2010; Puyt et al., 2025)

3. Governance of the CVC

3.1 Cocoa production in the DRC within the Congo Basin from 1960 to 2022

The trend of cocoa production in the Congo Basin (Figure 4) illustrates the stagnation of this value chain over the past 65 years, both in the DRC and across the basin more broadly, except for Cameroon (ca. 300 k t yr^{-1}). For the DRC, comparison of cocoa production trends based on FAOSTAT and Banque Centrale du Congo (BCC) data revealed no significant difference between the sources (p-value: 0.5151). Despite the significant variation (p-value: 1.384e-06) in the annual trend during this period, the average (7096 ± 4632 t of cocoa beans) remains too low. However, this poor performance is not only due to low productivity, but more importantly, to the ineffective governance of this value chain.

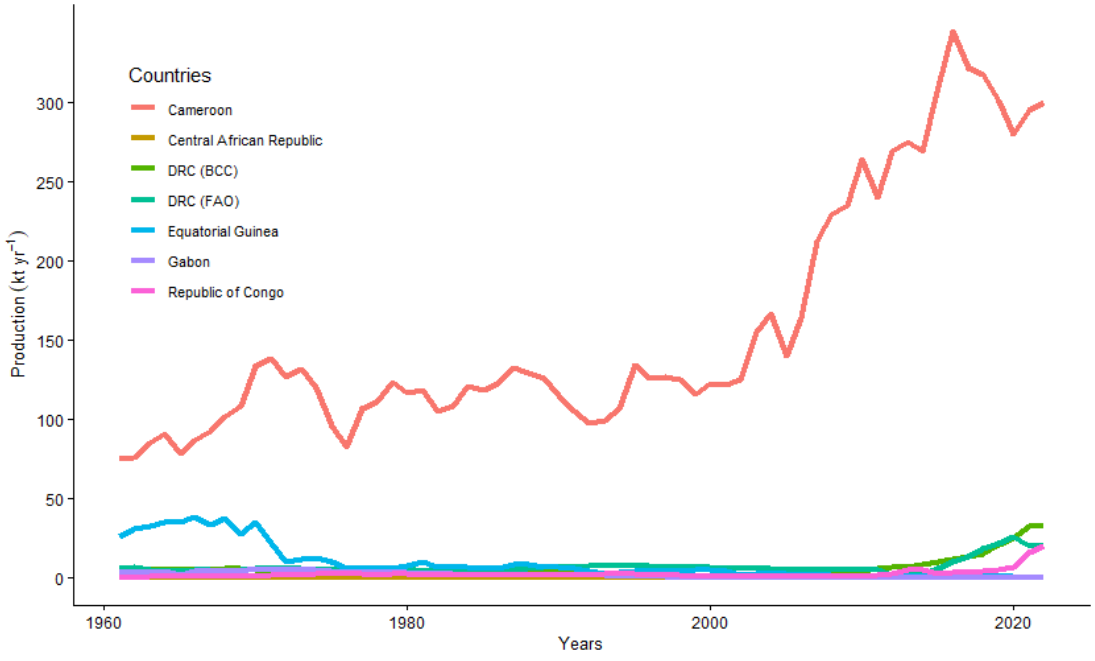


Figure 4. Cocoa production in the Congo basin countries from 1961 to 2022 (FAOSTAT, 2023).

In the DRC, ONAPAC is a dedicated service for collecting statistics on perennial crop production, but the cocoa production data are often overestimated. For instance, ONAPAC reported 56 k t of cocoa beans produced in 2022, while the BCC, Huart (2024) and FAOSTAT (2024) reported, respectively, 32.5 k t, 49 k t and 20 k t for the same year. Additionally, fraud and tax evasion are reported to hinder traceability of cocoa beans in the DRC (Joshi et al., 2024). These practices are widespread in the north, via the Zongo port and Ifondo, where some Congolese beans enter the Cameroonian market, and in the eastern region via Kasindi and Ariwara, where most traders declare Congolese beans in Uganda (Titeca, 2009; Furlan and Agano, 2025).

In terms of cocoa production, the Congo Basin remains far behind the West African region, the major production hub. Yet cocoa has great potential in this basin, not only to mitigate the agricultural nomadism driving deforestation but also to improve the livelihoods of the local communities. Moreover, to address global cocoa shortages, diversifying sustainable production to other suitable tropical countries such as the DRC, which has sufficient suitable agricultural land, is now recommended, rather than concentrating global production in Côte d'Ivoire and Ghana where climate forecasts are uncertain (Boeckx et al., 2020; Parra-Paitan et al., 2023).

3.2 Governance of the CVC in Tshopo (DRC)

The cocoa value chain involves several actors at national, regional and international levels, and they often interact through development programs implemented across the DRC. The literature review provided an overview of the various stakeholders involved in this value chain. Although these programs are not exclusively dedicated to cocoa production, they nevertheless offer an insight into the governance of this sector, as they all include aspects of support for cocoa production.

Table 1. Development programs implemented in the DRC within a cocoa component in their portfolio

Projects/Programs	***Concerned provinces***	***Funders / Partners***	***Budget (USD)***	***Duration***
CABEN	Tshopo	AfDB	12.013.300,00	1980-1987
PRAPO	Tshopo	IFAD/UNOPS	26.000.000,00	2007-2014
PIREDD MBKIS	Kasaï Oriental	AfDB/MEDD/ALE	6.800.330,00	2013-2023

	Kasaï Central and Tshopo			
PRODAT	Tshopo	ENABEL	15.000.000,00	2014-2023
PIREDD Maidombe	Maindombe	World Bank, UC-PIF, WWF	36.900.000,00	2015-1019
PARRSA	Mongala, Nord- and Sud-Ubangi	World Bank UCP-MINAGRI	75.000.000,00	2016-2020
PIREDD-O	Ituri, Tshopo and Bas-Uélé	CAFI, PNUD FONAREDD, Tropenbos DRC	33.000.000,00	2017-2024
PIREDD-Maidombe	Maindombe	World Bank, CAFI FONAREDD/MED	20.000.000,00	2018-2022
PIREDD Équateur	Equateur	FAO, WWF, MED, GASH	10.000.000,00	2018-2023
PIREDD Kwilu	Kwilu	CAFI/JICA	7.388.895,00	2019-2024
PGDF	Maindombe, Equateur, Mongala, Tshopo and Ituri	CAFI, AFD, FONAREDD, Nature+, OCEAN	15.264.953,00	2019-2023
PIREDD-Mongala	Mongala	CAFI/ENABEL	12.000.000,00	2019-2022
PSFD	Tshopo and Kwilu	CAFI, AFD MINAGRI	15.000.000,00	2020-2024
PCCBMS	Ituri	USAID, WCS UCLA, CBI, IITA, RIKOLTO	1.850.000,00	2021-2026
AVENIR	Kongo Central, Kwango, Kwilu and Maindombe	CAFI, IFADA, AFD	2.166.957,00	2022-2026
PIREDD Plateaux	Maindombe	CAFI, WWF, UNOPS	11.000.000,00	2023-2026
FORETS FOR FOOD	Tshopo	UE, CIFOR-ICRAF	Not available	2023-2027[1]

[1] Project implemented mainly in Yanonge, but no report available online to get information about the budget

These programs indicate multi-level governance of the value chain due to the involvement of international, regional and national actors. Although the Congolese government recognizes cocoa as a cash crop through the "*Programme National d'Investissement Agricole*" (PNIA), public agencies are not playing a central role in these programs (MINAGRIDER, 2013). Interviews with ONAPAC and PNRCo revealed their limited involvement in these programs due to the liberalisation of the CVC. In fact, the main link reported by PNRCo is the marketing of cocoa seeds as well as post-harvest processing, crucial for the sustainability of this value chain, but without building partnerships. Moreover, ONAPAC, OCC and DGDA mostly limit their intervention to taxation aspects. The effectiveness of this value chain requires a hierarchical governance model centred at the state as the key actor, rather than an overlapping model, which already proved its limitations (Panke and Stapel, 2024).

Undoubtedly, these programs were evaluated by the relevant experts and brought certain desired changes, but their impact on the functioning of the CVC remains undocumented. Given their total budget (ca. USD 300 million), and even though cocoa production was not the main target, their impact on the CVC could be significantly increased and better integrated within public policies. But most of these programs often follow the funders' guidelines instead of strengthening the national agricultural policies to regulate this value chain. Indeed, there is no national policy or appropriate strategies for aligning the objectives of these programs as well as defining the roles of actors through the CVC. Otherwise, the poor monitoring of the public service in these programs could be justified by the lack of national indicators as well as the limited power of public services over development agencies. However, the DRC's national REDD+ strategy, which is a main reference for REDD programs, targets the sustainability of the forest landscape rather than CVC issues (Majambu et al. 2023). The lack of a national action plan for this value chain, like in Cameroon, Ghana and Côte d'Ivoire, makes the DRC uncompetitive on the international market and does not clearly define the roles of the involved actors. Unlike development projects, the Congolese government established a public-private partnership with the ESCO-Kivu company in 2008 through a contract granting 10 years of tax exemption on exports. This partnership continues to impact the cocoa sector; not only has it succeeded in producing over 40,000 hectares in the Beni-Mutwanga and Mambasa basin, but it has also encouraged several households to integrate and adopt this cash crop (De Beule et al., 2014).

Especially in Tshopo, interviews with beneficiaries of cocoa-related initiatives emphasised their low appropriation to maintain cocoa farms after the program cycles due to a lack of training in plantation management, post-harvest processing, and networking for market access. Besides, no provincial consultation framework exists to regulate the CVC. Therefore, the governance of the value chain is characterised by the overlapping roles between actors. For instance, cocoa planting materials are from various origins in this province, i.e. PNRCo, DOKAS, ONAPAC, CABEN, Mambasa (Okapi cocoa variety) and Beni (varieties from Uganda). Regrettably, the uncertified cocoa accessions spread throughout this landscape have not completed the selection process, which required approval for disease resistance by their providers or the quarantine service. This risks compromising the future of the value chain and severely affecting the livelihoods of households dependent on it.

Besides, the attractive price of beans in the Kisangani market (USD 4–5 kg^{-1}) since the cocoa boom in 2024-2025 has increased enthusiasm among several actors to invest in the CVC. The cocoa market in the Tshopo province is currently more profitable than other cash crops (e.g., banana, coffee, oil palm). So various actors have spontaneously mobilised at several levels, unfortunately without an interprofessional organisation to ensure their coordination. Figure 5 below illustrates the complexity of CVC governance in Tshopo Province.

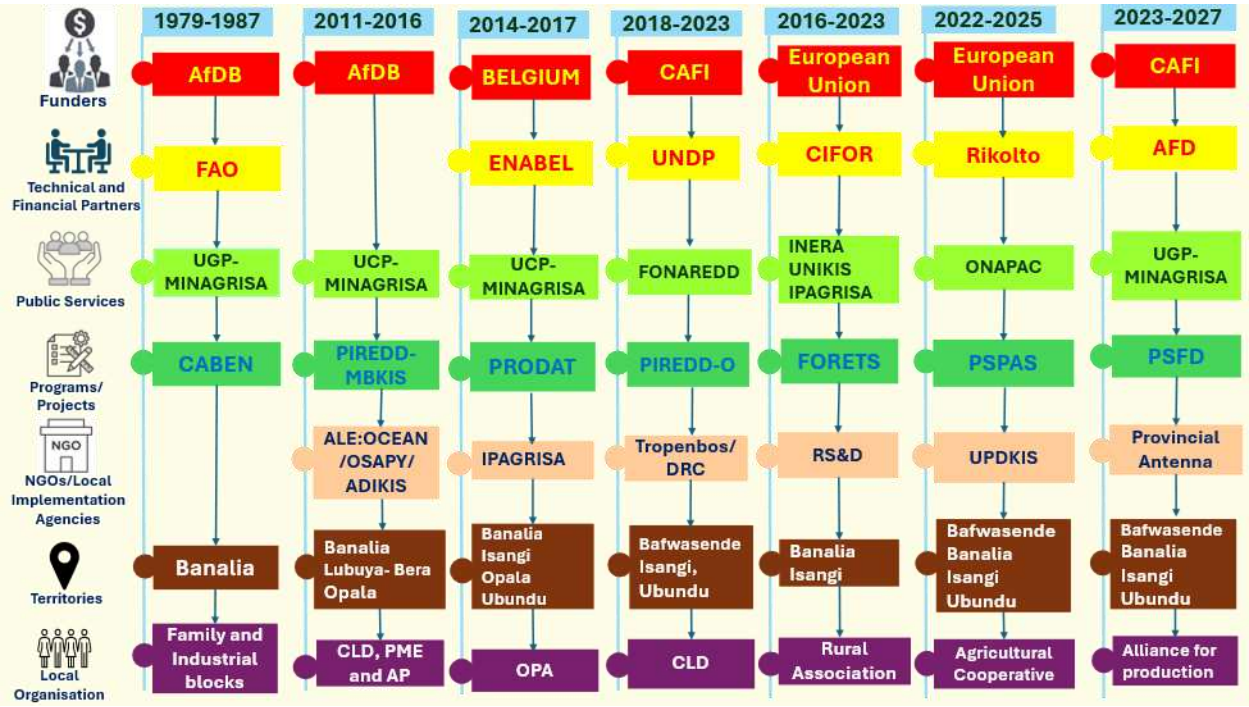


Figure 3. Complexity of the governance of the CVC in Tshopo province (R&SD : Resources and Synergies Development, OPA : Organisation des Producteurs Agricoles, PME : Petite et Moyennes Entreprises, AP : Association Paysanne.)

The CVC involves a wide range of funders, development agencies, NGOs, public services, private actors, as well as local organizations. Nevertheless, it is marked by poor horizontal coordination (Table 2), which results in ineffective governance. Each of these projects follows its own intervention logic, as established by its donors or technical and financial partners, rather than being harmonized at the national or provincial level. Ideally, intervention should be guided by a provincial action plan (directives for cocoa production and commercialization as well as a governance model), which unfortunately does not exist. For instance, each project had created its own structure at the local level, i.e., "*comité local de développement* (CLD)", "*organisation des producteurs agricoles* (OPA)", "*association villageoise* (AV)", "*alliance productive* (AP)*"* and "Cooperative", which disappear after the project cycle ends. In some villages, it is possible to find these organizations all together, using the same facilitators and pursuing similar objectives, reflecting the overlap of activities and the lack of collaboration up front (Table 2). However, the ongoing sensitisation campaigns focusing on the CVC risk becoming "illusions of happiness" if the actors involved continue to ignore governance issues. Indeed, these projects had sensitised farmers to adopt the CVC to reduce their poverty and to preserve ecosystem services, without long-term prospects or the transfer of necessary skills needed to tackle the challenges of this sector. Some cocoa producers involved in these projects do not register real changes after their implementation.

Table 2. Functional and contextual analysis of parameters and indicators of the CVC governance in Tshopo landscape

Parameters	***Indicators***	***Assessment of indicators in Tshopo landscape***
Coordination	Decision Makers	No central actor (public or private) in the CVC for making decisions
	Participation of actors	Limited participation of private actors (wholesalers, retailers and producers) in the decision-making process
	Transparency	Low transparency in cocoa price fixation, tax system and data recording
	Coordination Framework	No interprofessional organisation to federate actors to harmonise different interests
Regulation	Formal rulers	Exploitation permits for big producers (more than 3 ha in mature or secondary forest) Buyer licence (A for exporting beans from Tshopo province and B

		for commercialising beans only in Tshopo province) Registration of cocoa producer association as well as cooperatives Complexity of tax system
	Informal rules	Deal between wholesalers and retailers who are buying directly from cocoa producers at cheap price Use unconventional selling units (other than kg) through the cocoa basin Use of association or cooperative membership to escape tax harassment Sharecropping of plantations with retailers to minimise the risk of cocoa theft
	Market organisation	No location of official cocoa market in Tshopo landscape (wholesalers are at their private addresses, sometimes unknown to the producers) Wholesalers include the transport fees in the price of beans as the RN4 and RN3 are deteriorated No official warehouse for cocoa beans in Tshopo Derisory price of beans for producers due to their limited access to information Lack of market organisation (less involvement of public services)
Public policies	National policies	No official agricultural policy in general or related to the CVC The national strategy of REDD and PRODOCs are often the main reference for various related cocoa programs without clear vision and directives for the CVC
	Provincial policies	Absence of provincial directives regarding the vision and objectives for this value chain
	Legal framework	Existence of agricultural law without specific disposition related on cocoa value chain, as well as the seed supply chain
	Structuration of the cocoa value chain	3 new cooperatives which are not fully operationalised Less structured cocoa producers marked by big cooperatives without legal documents or partnership for
Type of Governance	Roles of actors	No barriers to entering this value chain due to its liberalisation Each actor plays many roles (production, export, transportation) Validation of roles without fixed criteria, as well as poor follow-up of actors by public services
	Relational partnership	Some private-private partnerships between wholesalers and big producers are rising to maximise their flows Otherwise, partnerships between wholesalers and retailers have also been reported An annual public-private partnership between CABEN and wholesalers can be mentioned
	Implication of public service	Low implications of public services (ONAPAC, INERA, CABEN) in the conception and implementation of cocoa-related programs
Market governance	Price fixation	ONAPAC, together with other services, sets the cocoa price per grade every week Prices are not displayed or known by producers

Official buyers	Four official wholesalers: SCAK, VOLCANO, BAHARI and CFB
Retailers	Many retailers (more than 50 people) in the Tshopo landscape
Transporters	Five operators: Palos, Dissa, Glodi, TMK and Ngolu Coach
Information	Poor information flow, especially for the price of cocoa beans

Source: Our surveys in the Tshopo landscape

3.3 Cartography of the CVC in Tshopo, DRC

A cartography of actors (Figure 6) represents the interaction between actors who benefit from the added value of the CVC. This cartography does not consider public services, NGOs, and development agencies as actors due to their non-profit status.

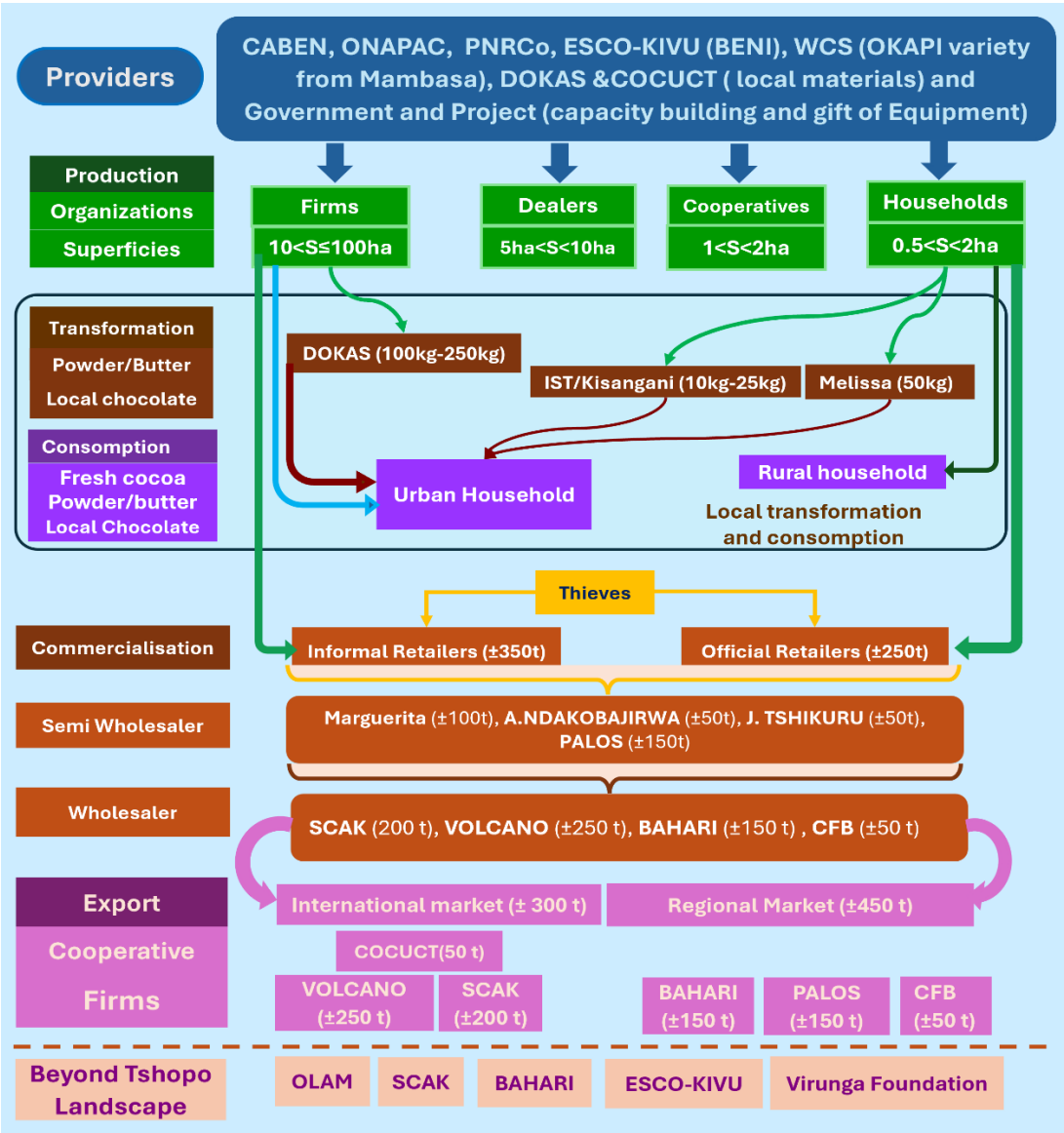


Figure 4. Cartography of involved actors of the CVC in Tshopo Province with 6 layers: providers, production, transformation, consumption, commercialisation, and export

The configuration of the CVC changed significantly over the last two decades due to the expansion of the cocoa market in eastern DRC. Previously, CABEN had a monopoly in this sector, distributed inputs and strengthened the skills of producers. In return, they exclusively sold their entire production to this program, which shipped beans to Kinshasa via the Congo River for exportation. In 1988, CABEN went bankrupt due to the cancellation of program funding linked to the fall in cocoa prices caused by the CVC liberalization. So, farmers were demotivated to invest in the CVC through the Tshopo landscape without a definite market. In 2007, the trend of the CVC started to change due to the arrival of people escaping the war in Eastern DRC with developed skills for this cash crop. Their investment in this sector enabled the relaunch of the CVC by changing local perceptions and dynamizing the cocoa market in the Tshopo landscape.

Currently, this value chain includes 6 segments: providers, production, transformation, consumption, commercialization and export. The main input suppliers are PNRCo, CABEN, DOKAS, and ONAPAC, which provide producers with seeds (seedlings or fresh pods). Production is undertaken by large-scale producers (private and public companies), medium-scale (concessioners) and small producers (households). Interviews with producers have revealed that, in this landscape, they generally don't use chemical fertilisers or pesticides; as a result, the cocoa produced in this region is typically organic, even though producers are not informed about possible cocoa certification in this landscape. However, there is often a problem accessing high-quality seeds, so many producers use uncertified cocoa seeds (without traceability). The largest cocoa producers in the Tshopo province include CABEN (a state-owned company with 443 has remained from 1750 has installed), DOKAS, TERRA GROUP, PALOS and KAVIRA; whilst small and medium-sized producers are diverse, ranging from independent concessionaires to cooperatives (COCUCT created in 2021 with 1833 members; COPAPROCA created in 2023 with 185 members and Cacao-Tshopo created in 2023 with 235 members) comprising hundreds of farming households (with less than 5 hectares). Furthermore, ONAPAC reported 867 cocoa producers in 2024, while the statistics of cooperatives are different (2253 producers). Indeed, ONAPAC is more focused on marketing (purchase permits) and export (export permits) activities than on recording basic data.

This mapping enabled the identification of a local sub-sector: local processing (cocoa powder and butter done by DOKAS and chocolate mass from IST-Kisangani and Melissa) and consumption of these derived products, including the non-food uses of the beans (such as eating fresh beans and consuming dried raw beans for their presumed aphrodisiac properties). Moreover, interviews with CABEN revealed that this program received cocoa processing equipment, which was never used before it disappeared. Furthermore, the use of cocoa husks to produce local salts should be mentioned in this landscape, although this remains limited to domestic needs. Finally, cocoa provides a wide range of derivative products across multiple sectors: food (tea from cocoa shells, fish feed from the placenta, juice and liqueur from the mucilage); cosmetics (soap, skin and hair pomade, lotion); and pharmaceuticals (aphrodisiacs and cardiovascular treatments) (Nascimento et al., 2025). This highlights the potential to generate economic benefits through better-structured local micro-processing and enhance the limited technical knowledge of local communities.

Compared to other provinces, Tshopo currently stands out due to the arrival of large buyers: SCAK, BAHARI, CFB (who ship their lots to Beni, where their headquarters are located) and Volcano (which exports cocoa directly from Tshopo to the Netherlands and Singapore). They provide a new boost to the marketing of cocoa by purchasing at relatively high prices compared to intermediaries in the past. Nevertheless, the marketing of cocoa remains a challenge, not only because of increased robberies, but also due to low prices (< USD 1 kg^{-1}) in the villages further away from Kisangani, where producers don't have access to ONAPAC's price forecasts. Additionally, these buyers face a wide range of taxes (OCC, ONAPAC, DGRPT, DGDA). As a result, they prefer to export via Mambasa or Beni, where taxes are relatively affordable, rather than Kisangani.

4 SWOT Analysis of the CVC in Tshopo, DRC

This analysis presents the strengths and weaknesses (internal factors), opportunities and threats (external factors) of the CVC in the Tshopo landscape. This SWOT analysis is presented through Table 2, completing the VCA4D results to serve as a baseline for this sector in Tshopo province, as well as to guide future cocoa-related programs to ensure equity of shared incomes of involved actors.

415 *Table 3. SWOT analysis of the CVC in Tshopo province (DRC)*

Strengths	**Weakness**
✓ *Presence of INERA-Yangambi within PNRCo for providing high-quality seedlings or seeds* ✓ *Availability of arable land (affordable price)* ✓ *Suitable ecology and climate for cocoa production* ✓ *Large size of the beans (less than 100 seeds per 100 grams)* ✓ *Cooperative structures begin to emerge among producers (COCUCT, COPAPROCA and Cacao Tshopo)* ✓ *Growing production (>500 t), which could enable the export of batches from Kisangani* ✓ *Attractive market undergoing restructuring* ✓ *Business skills and adoption of the CVC by investors, especially the Nande* ✓ *Rising prices for producers following the arrival of major buyers (Volcano, SCAK, and Bahari)* ✓ *Presence of workforce (young people from different communities)* ✓ *Progressive rehabilitation of old plantations (CABEN, especially the family branch)*	o *Poor traceability of the seed supply chain due to various origins of cocoa seedlings and seeds* o *Nocturnal theft in fields (cocoa pods) and homes (cocoa beans)* o *Low productivity due to poor pruning, poor maintenance, gaps in fields and poor productive cultivars* o *Limited expertise in technical itineraries due to a lack of adequate capacity-building for producers* o *Dominance of informal activities in this value chain* o *Insufficient phytosanitary monitoring in cacao production basins (ineffectiveness of quarantine and plant protection services)* o *Limited involvement of public services in different projects* o *Financial participation of the local community in the cocoa project, which led to less appropriation* o *Opportunism of local communities in response to international cocoa market trends* o *Lack of transformation units near Kisangani* o *Low expertise for cocoa post-harvest processing by cocoa producers* o *Too high expectations of cocoa farmers for projects* o *Short cycles of projects to support producers effectively for the market aspects* o *Lack of agricultural credit to encourage young people (especially when setting up plantations)* o *Misunderstanding of certification procedures by producers* o *Exorbitant export tax system for companies based in Kisangani* o *Lack of transparency in the local cocoa market* o *Severe degradation of roads (RN3 and RN4)* o *Lack of a provincial consultation framework and clear strategies for cocoa value chain (ineffective governance)*

Opportunities	Threats
❖ *Various partners present in the Tshopo region (ENABEL, EU-CIFOR, CAFI-AFD, CAFI-UNDP)* ❖ *Existence of four access ways: over land (RN3, RN4), Congo river and Bangkoka international airport* ❖ *Presence of research institutions (INERA, IFA, ISEA and UNIKIS) in the landscape* ❖ *Expansion of the cocoa market in Eastern DRC, including Kisangani* ❖ *Cocoa promotion under the national REDD strategy to balance livelihoods and biodiversity conservation as well as carbon market* ❖ *Geostrategic position of Tshopo Province, a key link between the North-East and North-West regions within the Green Corridor program* ❖ *Flash of cocoa prices on the international market influencing local prices positively* ❖ *Public awareness campaign and distribution of cocoa seedlings by the national and provincial governments* ❖ *Growing investment (several new and large plantations since 2023)*	• *Risk of land conflict between native and allochthonous populations due to large concessions for perennial crops* • *Insecurity in production areas due to the spread of nocturnal thefts* • *Large-scale deforestation due to the cocoa cultivation in mature forest* • *Danger of disease spread due to the use of unsafe materials (failure of the quarantine service)* • *Unhomogenized quality of cocoa beans on the regional market due to inappropriate post-harvesting treatment* • *Difficult access to (global) cocoa market and demotivation of producers* • *Fall of international market prices could discourage cocoa producers* • *Risk of food insecurity if farmers switch to this labour-intensive crop rather than growing food crops* • *Climate change, especially drought periods and severe temperatures*

Even though this analysis is limited to the province of Tshopo alone, it could also provide an overview of the realities of this value chain across the DRC. This calls upon all stakeholders to take more structured action, not only to address weaknesses but, above all, to capitalize opportunities and leverage strengths and anticipate threats. Far from being exhaustive, the various components of this analysis highlight the gaps in the multi-level governance of this value chain, for changing the paradigm from a disorganised sector to an efficient and strategic one. This decision-making tool bridges the gap between the diagnostic and value chain analysis for development (VCA4D) approaches (Lescuyer et al., 2019). In fact, mapping of actors provides only a snapshot of the stakeholders involved in this sector, while the SWOT analysis serves as a baseline for decision-makers to improve policies for this value chain (Safaruddin et al., 2023).

5 Critical analysis of cocoa research in Yangambi

5.1 Historic cocoa research in Yangambi

Before the creation of INERA (until 1960 INEAC) in 1933, cocoa research in the DRC started in 1895 when Emile Laurent studied the feasibility of growing cocoa in the DRC and recommended cocoa cultivation under shade in the Eala botanical garden located in Equateur province (Limba et al., 2017). Literature reports that biological material collected in the Amazon basin (São Tomé, Brazil, Ecuador and Trinidad) was quarantined in the Phyto-technical laboratory of the Catholic University of Louvain and then introduced in the DRC (Tollens, 2004). From 1895 to 1915, the *Régie des Plantations du Congo* (REPCO) implemented varietal selection based on the productivity of the best cocoa materials to boost production. In 1915, a large collection was set up in Barumbu with 123.500 cocoa seedlings from different varieties and regions, i.e., Eala and Lukolela (Equateur), Ngazi (Tshopo), as well as Mayombe (Kongo Central), to select the most adapted and productive cocoa varieties for industrial plantations (Limba et al., 2017; Rottiers et al., 2018). This experiment emphasized that the hybrids Amelonado and Nacional were most productive and adapted to the local environment (Van Himme, 1973). In 1925, an experiment was conducted to test the adaptation of the Criollo variety to Eala, but this was not properly followed up on or documented following the death of the expert, E. Laurent. It should be noted that the cocoa selection was carried out in the plantations of the REPCO, which had a purely commercial focus across various sectors (oil palm, coffee, rubber and cocoa) and did not have the status of a research institution.

In 1932, a pilot scientific cocoa experiment was conducted in Ngazi, where Amelonado (from Barumbu, Lukolela, and Mayumbe) was crossed with Trinitario (from Eala, Likimi, and Mobwasa (material with white cotyledon)) to constitute the national cocoa collection. Then, INEAC was created in 1933 by royal decree to lead in-depth agronomic research. Previously, INEAC's head office was based in Yangambi and had a coffee-cocoa department, which was split in1975 into two research programs: cocoa and coffee. So, the coffee-cocoa department started experiments in 1934, in Ngazi, which is located far from the Congo River and makes cocoa bean shipment difficult, as well as being more prone to animal attacks (i.e., monkeys and squirrels). Hence cocoa activities were set up in Yangambi, which is near the Congo River, in 1948. Meanwhile, the selection of the best cultivars began in 1937 in a pilot scientific

experiment. These materials were also tested in Bongabo and Luki stations of INEAC, before being introduced into REPCO's industrial plantations. In 1959, the PNRCo selected for the first time, 10 "*candidats abres meres"* (CAM, or parent trees) based on the report of Bongabo, Luki and Yangambi. The criteria applied were the average dried bean mass (≥ 1g), the ratio between the average mass of merchant to fresh cocoa (≥ 0.3) and the amount of fresh beans per pod (≥ 30 seeds).

Table 3. List of the first 10 CAM selected in the Yangambi station in 1959

Codes		***Average bean yield (kg ha^{-1})***	***Average bean mass (g)***	
Ancient	**New**		**Inbred line**	**Parent tree**
F996 Y2	*F12*	828	1.18	1.21
E460 Y1	*E18*	803	1.39	1.65
F10 Y2	*F1*	761	1.12	1.12
F2519 Y4	*F24*	757	1.02	1.19
E1553 Y1	*E24*	752	1.45	1.78
Li30 Y1	*Li18*	676	1.18	1.19
E256 Y1	*E10*	658	1.20	1.13
F996 Y10	*F15*	622	1.28	1.40
Li8 Y1	*Li7*	609	1.33	1.67
M40 Y414	*M1*	604	1.26	1.34

Source: Van Himme, 1973 (E: Eala, Li: Likimi, M: Mobwasa, Y: Yangambi and F: Forastero from Barumbu and Ngazi)

These parent trees were disseminated through vegetative propagation in Mayumbe, Bongabo Ngazi, Lokolela, Eala and Barumbu in partnership with REPCO (Ndunzi, 1986). Given that Yangambi is the headquarters of INEAC's PNRCo, several other studies have been conducted using these materials, such as their resistance to lethal *Sahlbergella* and *Helopeltis,* phenology, cocoa soil assessment and shade management with *Ficus mucuso*, *Alstonia congensis, Croton mubango* and *Hevea brasiliensis* (INEAC, 1944; Neirinckx and Struelens, 1952; Rottier et al.,

2018). Unfortunately, these trials were not followed up due to the Second World War (1940-1945).

However, the need to improve cocoa productivity and reach a desired yield of about 1 t ha^{-1} motivated PNRCo to introduce 199 cocoa accessions (most productive, disease-resistant, and high-quality) between 1956 and 1959. These materials were: "Upper Amazone" (UPA, Brazil), "Tafo" (T, Ghana), "Impérial Collège Sélection" (ICS, Trinidad), "Selection of Nkoemvoen" (SNK, Cameroon), "Djati Roenggo" (DR, Java), "Scavina" (SCA, Brazil), "Parinari" (PA, Peru), "Aburi" (ACU, Ghana) and "Iquitos Mixed Calabacillo" (IMC, Trinidad). They were collected from the "Laboratoire de Phytotechnie tropicale" of Louvain Catholic University (Belgium) or directly from these countries (Van Himme, 1973; Ndunga, 1986). Except for the UPA, which was directly crossbred through a trial of illegitimate descendants, all other cultivars were evaluated in polyclonal trials to select the most productive and best adapted to local ecological conditions. Table 4 below presents the selected clones from the ones introduced between 1956 and 1959.

Table 4. Selected clones from various introductions in Yangambi station in 1972

Selection ID	**Plants Introduced**	**Plants Selected**	**Selected descendent**	
			Codes	Yield kg ha^{-1} yr^{-1}
T 63	12	2	I 2/137	2 417
			I 2/151	2 751
T 65	15	1	I 3/158	2 171
T 72	14	2	I 4/177	2 650
			I 4/196	2 705
T 73	8	1	I 5/211	2 780
T 76	13	7	I 6/231	2 019
			I 6/233	2 478
			I 6/235	3 706
			I 6/238	2 153
			I 6/240	3 354
			I 6/955	2 070
			I 6/957	2 220
T 79	9	3	I 7/252	2 112
			I 7/254	2 540
			I 7/255	2 106
T 82	7	4	I 8/261	2 704
			I 8/277	2 496
			I 8/278	2 056

			I 8/979	2 608
T 85	13	2	I 9/323	2 097
			I 9/1011	2 049
T87	7	2	I 10/1623	2 507
			I 10/282	2 189
IMC 67	21	8	I 29/667	2 295
			I 29/673	2 896
			I 29/685	2 574
			I 29/688	3 135
			I 29/693	2 176
			I 29/1405	2 505
			I 29/1413	2 476
			I 29/1626	2 287
ACU 85	3	1	I 11/1638	2 244
SNK 115	2	2	I 20/458	3 077
			I 20/485	2 806
SNK 142	5	1	I 21/1177	2 738
SCA	25	2	I 30/752	2 127
			I 30/1450	2 333
PA 169	16	5	I 33/823	2 185
			I 33/1535	3 296
			I 33/1537	3 519
			I 33/1553	3 017
			I 33/1558	2 665
UPA	29	13	I29/1752	2 744
			I511/1598	2 076
			I19/1534	3 036
			I3/22	2 450
			I7/273	2 510
			I3/50	2 057
			I4/66	3 851
			I4/66	2 851
			I9/83	2 110
			I9/253	2 511
			I2/207	2 187
			I505/159	2 876
			I8/354	2 053

Source: SOCFINCO, 1987

This critical analysis reveals a lack of pre-selection, given that only 56 cultivars were selected based on the vegetative method (plagiotropic cuttings) (in 1972) from 199 introduced varieties, representing 28.1% of the introductions. Meanwhile, significant investment was made in

research to conduct the bi-clonal experiment in Yangambi, over nearly 12 years and covering 6 ha within 68 plots. However, some of these materials were simultaneously studied in their origin countries, i.e. Ghana and Côte d'Ivoire, and the results were satisfying and published in 1969 (Ndunga, 1986). So, Van Himme decided in 1969, based on these findings, to adopt the generative method as an alternative to the high costs of the vegetative method. He decided to proceed first with hybridization between the selected UPA (Table 4) and CAM (Table 3) to obtain vigorous and more productive materials, which resulted in 245 combinations. Finally, a selection of 11 elite hybrids was realised among these combinations in 1979 (Table 5). The criteria applied were precocity, productivity (> 1 t ha^{-1} of cocoa beans) and bean size (bean weight ≥ 1g).

Table 5. The elite cocoa hybrids (F1) from crossbreeding between UPA and CAM in Yangambi station (1979)

	Hybrids		**Potential yield (kg ha^{-1})**	**Yield increase based on local variety (%)**	**MC/FC ratio (%)**	**Bean mass (g)**
♂ Id	(Local Amelonado)	♀ (UPA)				
1	E 24	T 73/201	1 414	155.7	39	1.27±0.08
2	E 18	T 72/189	1 244	125.0	39	1.16±0.08
3	F 1	IMC 67/691	1 229	122.2	37	1.06±0.04
4	E 18	T 63/135	1 143	106.7	38	1.20±0.10
5	E 12	IMC 67/1427	1 137	105.6	36	1.08±0.05
6	F 12	T 72/178	1 089	96.9	39	1.08±0.03
7	F 12	T 85/1014	1 054	90.6	38	1.04±0.06
8	E 24	T 65/158	1 054	90.6	36	1.17±0.05
9	F 1	T 79/966	1 033	86.8	38	1.13±0.04
10	F12	IMC 67/673	1 021	84.6	39	1.19±0.09
11	F12	T 85/94	962	74.0	37	1,04 ±0.07
	Controls					
	Local (Amelonado)		553	0	35	1.25±0.04
	UPA		1 028	-	35	1.13±0.08

Source: Ndunga, 1986. MC: Merchant cocoa (after fermentation and drying); FC: Fresh cocoa

Despite achieving the target yield of 1 t ha^{-1} yr^{-1}, literature indicates that during the period between 1966 and 1967, the estimated yields in the research station in Côte d'Ivoire and Trinidad were more than double (2.5 t ha^{-1} yr^{-1}) (SOCFINCO, 1987). Several studies have been conducted on these hybrids, including a bi-clonal trial assessing legitimate (controlled fecundation) and illegitimate (uncontrolled fecundation) descendants. Meanwhile, a seed production plot (4.5 ha) was established to distribute improved seeds to producers for boosting cocoa production in the Eastern Province. Subsequently, PNRCo introduced new cocoa materials from Western Africa (Côte d'Ivoire and Trinidad) to enhance cocoa productivity over 1 t ha^{-1}. As these materials were already tested in Western Africa, they had first crossed two by two (only the materials of this lot) to select the performant and adapted materials. In 1979, these materials were crossed with the 11 elite hybrids (Table 5) to produce performant cocoa varieties in Yangambi. The criteria used were a potential yield of 2 t ha^{-1}, bean mass (≥ 1.10 g), as well as the organoleptic properties. Hence, 15 new hybrids were selected among 285 combinations in 1986 (Table 6).

Table 6. The 15 elite hybrids (F2) from the first 11 hybrids and the best hybrids selected from the crossbreeding of second cocoa materials introduced in Yangambi (in 1986)

Id	***Males*** ♂	***Females*** ♀	**Codes**	***Number of Trees***	**Estimated yield (kg ha^{-1})**
1	I9/94	SNK115	120/485	2	2806
2	I4/149	T 73	15/211	8	2780
3	I9/1011	SNK142	121/1117	5	2758
4	I2/885	T 63	12/137	12	2751
5	I3/158	T 72	14/196	14	2705
6	I29/1427	PA169	133/1558	16	2665
7	I5/201	T 82	18/979	7	2608
8	I29/691	SCA	130/1450	25	2333
9	I7/966	IMC 67	129/1626	21	2287
10	I7/978	ACU85	111/1638	3	2244
11	I4/903	T 76	16/957	13	2220
12	I7/254	T 87	110/282	7	2189
13	I3/158	T 65	13/158	16	2171

14	I5/201	T 79	17/255	9	2106
15	I6/229	T 85	19/1011	13	2049

Source: Limba, 2017

These 15 elite hybrids were then crossed through a bi-clonal design of 10 ha within 32 plots to continue cocoa selection in Yangambi. Unfortunately, this experiment was not followed up due to the lack of funding as well as partnership. So, there is no result reported directly from these materials, which were abandoned in the forest. In 1998, a random selection of seedlings was taken from this abandoned experiment to establish an unshaded experiment, which is currently the only cocoa germplasm collection in Yangambi. This historical overview shows that cocoa selection in Yangambi is less documented, with a complex research agenda requiring a substantial budget to improve cocoa accessions. For instance, the PNRCo used various selection methods (generative: legitimate and illegitimate descendants; vegetative: plagiotropic and orthotropic; grafting) and diverse materials. However, the downside of this selection process is the limited precision, with the risk of excluding other better cultivars in the process. Furthermore, the centralisation of research at Yangambi has made it more difficult not only to supervise activities at other stations but also, above all, to deal with logistical issues (transport of seedlings).

Although this selection process has generated a variety of materials in Yangambi, it remained laborious and relied on trial and error. Additionally, the complexity of the selection process results in the dissemination of various cocoa varieties (grafting introduced in 1975, cuttings (plagiotropic and orthotropic) and generative reproduction (legitimate and illegitimate descendants) which makes it more difficult to trace cocoa varieties. Finally, the implementation of a supply chain for high-quality cocoa seedlings continues to pose a problem and remains unresolved to date.

5.2 Current cocoa research experiments at INERA- Yangambi

Table 7 emphasises the current cocoa experiments which are still maintained at INERA-Yangambi, including the name of the experiments, installation year, aims, experiment design and observations.

Table 8. Overview of current cocoa experiments in INERA Yangambi station

Experiments	***Installation Year***	***Aims***	***Experiment design***	***Observations***
Cocoa collection	*1958*	Maintenance of UPA materials (13 clones)	Covering 0.5 ha with 2 repetitions of 50m × 50m	Too old a collection (68 years) and more dead trees Few clones exist but are unlabelled Feasibility of reproducing some ancient material
Comparative crossbreeding experiment	*1975-1985*	Evaluation of individual trees (F2, Table 6): yield, organoleptic properties and resistance to diseases	An experiment of 10 ha within 32 plots (50 x 100 m) with 285 combinations	Interesting cocoa experiment but abandoned. Resulted in a lack of data related to this experiment
Unshaded experiment (ESO, Current cocoa germplasm)	1998	Preserve germplasm from crossbreeding of 15 elite hybrids (F2) Yield assessment of hybrids under unshaded conditions	A trial of 0.6 ha without repetition 57 cocoa cultivars planted in a sinuous row pattern	Currently, there is one parent per hybrid Around 5% died without replacement Sensitivity to radiation during the short dry season
Production field (Illegitimate trial)	2005	Assessing the yield of the 10 most productive cocoa cultivars among 57 hybrids (1998 trial), without controlling the fecundation in shade conditions	Implemented over 3 ha in 6 blocks, and each line constitutes a repetition	Limited data availability, challenges in maintenance, and technical monitoring Death caused by excessive shade and fungal diseases Loss of certain materials due to bushfires
Pilot field	2006	Assessment of cocoa yield in agroforestry: intercropping of cocoa with plantains, cassava and useful woody plants	One plot of 1 ha with 4 repetitions using 10 most productive cocoa cultivars	Experiment abandoned due to lack of resources (no data recorded) Collapse of some cocoa trees due to shallow planting holes (made with a machete)
Graft experiment in unshaded conditions	2009	Vegetative multiplication of the 10 most productive cocoa cultivars to maintain the parents' character	One plot of 39 ares without repetition 13 lines within 10 trees per cultivar)	Most productive cocoa experiment used as a seed production plot in Yangambi
Field for complete	2014	Assessment of the yield	Trial of 1 ha with	Funded by the government

evaluation (legitimate trial)		of 10 cocoa varieties by controlling pollination	4 blocks (each has 17 lines, which are repetitions) and 20 trees per line	Low rate of pollination to assess legitimate varieties Limited supervision to fight theft
Government field (production field within cuttings)	2014	Assessment of the cocoa yield of 10 cultivars in real conditions without controlling the fecundation	A plot of 1 ha without repetition or randomization	Funded by the government Low production due to cocoa bean thievery and disease attack
Fertilization trial	2022	Assessment of cocoa productivity by using compost from cocoa pods	A plot of 20 ares without repetition	Trail damaged by bush fire (twice) Lack of research funding

Source: Interviews with Gaston Limba, Melchior Tshongo and Victor Boyaemo (PNRCo, INERA Yangambi)

Despite limited resources, research continues within this program, which remains a key player in revitalizing the value chain across the DRC. Indeed, the various studies mentioned above should be more effectively monitored, not only to continue with varietal improvement, but above all to supply producers with high-performance materials in line with national demand trends. This program needs to be restructured by establishing satellite stations in other production basins (Mambasa and Beni) and by building the capacity of researchers to guarantee the future of this value chain. Interviews with PNRCo staff highlighted low attention to research in cocoa-related projects despite its important role in the sustainability of the value chain. In fact, more projects (PRODAT, PIREDD-O, PSFD) have targeted cocoa production by providing cocoa seeds to farmers without verification of the selection or hybridization process. For instance, the cocoa collection of introduced cocoa materials (UPA) has been in place since 1958 and exceeds the productive cycle of 45 years (de Almeida and Valle, 2007). In addition, the cocoa germplasm (28 years) contains only one specimen per cultivar, for the 57 genetically identified by Rottiers et al. (2018). Thus, urgent actions are needed to mobilize resources for the rehabilitation of both the cocoa collection and germplasm in line with standards, to ensure the sustainability of this value chain.

Conclusion

This study found that CVC governance in the Tshopo landscape has been ineffective over the last half century, despite the involvement of various actors. This ineffectiveness is demonstrated by the lack of an interprofessional framework to federate actors around a clear vision, as well as poor planning (strategic and operational) either to increase cocoa production and quality or to align projects with national policies. Currently, the governance of the CVC is characterised by overlapping roles of actors, e.g., The cocoa seed supply chain involves numerous actors, which increases the risk of disseminating uncertified accessions which could spread diseases and pests in this landscape. So, this underpins the hypothesis of ineffective governance not only due to the limited involvement of public actors and the poor coordination of different cocoa-related projects, but most importantly due to the lack of restructuring of this sector.

Besides, the SWOT analysis emphasized the comparative advantages and the bottlenecks of the CVC in the Tshopo landscape to serve as a baseline assessment for guiding decision makers to take concrete action for upgrading this sector. For instance, several taxes, especially for wholesalers, affect the cocoa bean price of local producers and could make the formalisation of the CVC uncertain in this landscape. The limited skills of producers for post-harvest treatment of beans can compromise the future CVC due to poor quality. Furthermore, the theft of cocoa beans from plantations is currently a huge security risk, which demands special attention for the welfare of the producers. Hence, upcoming cocoa-related projects in this landscape could use this SWOT analysis as a roadmap for increasing the inclusivity of young and local people, improving the quality of Congolese beans and involving public actors to improve their tax system as well as the business environment.

Regarding cocoa research, this paper highlights the trajectory of various materials selected since 1933. Despite the willingness to improve cocoa yield and performance against diseases and pests, our critical analysis emphasises the lack of a dedicated research plan, as research continues to proceed haphazardly. There is an urgent need to mobilize resources for restructuring this program and rehabilitating the various collections according to international standards. Hence, the revitalisation of the CVC requires synergistic efforts between development projects, the national and provincial government, administrative services and scientific institutions. This synergy will allow for improved governance for greater inclusivity and upgrade the CVC sustainably in this landscape.

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Conflict of interest

Not applicable

Ethics approval

Not applicable

Availability of data and material

Not applicable

Authors contribution

Conceptualisation: Alain L. Katayi and Pascal Boeckx; Data collection: Alain L. Katayi, Gaston Limba, Muller Lofinda; Supervision: John Edem Kongor, Koen Dewettinck, Baudouin Michel and Pascal Boeckx; Writing: Alain L. Katayi, John Edem Kongor, Muller Lofinda, Alain Ofio, Pascal Boeckx; Data analysis: Alain L. Katayi, John Edem Kongor, Pascal Boeckx; Validation: Alain Ofio, Baudouin Michel, Pascal Boeckx and Koen Dewettinck.

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