Research Article

Received: 24 February 2025 / Accepted: 28 April 2025 / Published: 06 May 2025

Factors Influencing the Sustainability of the Results of Two Management Interventions in the Luki Biosphere Reserve: Kongo-Central Province, D.R. Congo

Taylor Mabula Pongo[1,2*]

Grégoire Ngalamulume Tshiebue[2]

Philippe Lebailly[1]

Fabio Berti[1]

Faivre Arno[1]

Philippe Burny[1]

Bouréma Kone[3]

Kossi Tênon[4]

[1]Laboratory of Economics and Rural Development, Gembloux Agro-Bio Tech, University of Liège, Transport Passage 2, 5030 Gembloux, Belgium
[2]Faculty of Economics and Development, Catholic University of Congo (UCC), 2 Av, BP 1534 Kinshasa, Democratic Republic of the Congo
[3]Institute of Rural Economy (IER) of Bamako, Bamako, Mali
[4]Faculty of Economics and Management (FASEG), University of Lomé, Lomé, Togo

DOI: https://doi.org/10.36941/ajis-2025-0046

Abstract

Two major interventions, PASAGAR and integrated REDD, aimed at promoting the sustainable management and development of the Luki Biosphere Reserve were implemented between 2013 and 2018. Despite their support, local communities living in and around this reserve continue to face poverty and biodiversity loss, which continues to threaten the stability and adaptability of the biosphere in the face of environmental change. The results show that 41% of the influence on sustainability of the REDD pilot results comes from innovations such as "model farms". The sustainability of PASAGAR's results was influenced by the inputs, accounting for up to 94%. The two interventions are complementary, and their sustainability is reinforced by the fencing of land (including savannahs with shrubs), the payment of environmental services, reforestation, and agroforestry, etc. On the sociodemographic level, people over the age of forty-five play a significant role in the sustainability of the results. The Local Development Committees, actors of local governance and direct beneficiaries, facilitated the interaction between PASAGAR, REDD and local communities by promoting the participatory process. As a result, the results of this study indicate zero participation in the design and evaluations, while it is estimated at 83% for the implementation of PASAGAR and 63% for the implementation of the integrated REDD pilot project.

Keywords: *Sustainability, development project and program, local development committees, Biosphere*

1. Introduction

Biosphere reserves are models of sustainable development that reconcile the three complementary functions and classics highlighted by UNESCO (1996; 2018) : conservation, development, and logistical support. Proposed to UNESCO by national governments, these reserves remain under the supervision of the States where they are located. Right now, the world matters 727 biosphere reserves in 131 countries, including 22 transboundary sites (Matters, 2021) and 86 sites in 31 African countries.

Indeed, these reserves are characterized by three specific zones: a central surveillance zone, protected by national legislation; a buffer zone, intended for research, experimentation, education, tourism, and recreation; A transition zone, also dedicated to research, tourism, leisure, local and sustainable development. The latter area is usually made available to local communities for agricultural and other activities. In this context, UNESCO's MAB (Man of Biosphere) program places people at the center of environmental and natural resource management issues, promoting a "systemic" approach, which illustrates the diversity of opinions of local communities, for participatory and integrated management, aimed at ensuring that they benefit from forest resources without degrading the Biosphere Reserve.

Like any protected area, the Luki Biosphere Reserve, which is our field of research, is organized into three classic zones (Mikobi et al., 2023): a core zone of 8,858 ha for integral protection, a buffer zone of 6,430 ha housing the village enclaves, the MAB/INERA station and the forestry intervention sites, and a transition zone of 18,523 ha where the activities of local riparian communities take place. These hectares are distributed in each chiefdom to guarantee the subsistence of the inhabitants, according to their numbers, the productive capacity of the soil and the minimum area required. As a result, an average of two or three hectares goes to each inhabitant (Nyange, 2014). Of the 76 chiefdoms in the Mayombe territory, 41 do not have enough land, exposing their inhabitants to starvation, forcing them to cut timber and firewood and to slash-and-burn farming practices (WWF,2024). These activities constitute a real threat to the biosphere and are opposed to aspects of local governance rules: deforestation, agroforestry, reforestation, etc. In order to mitigate these practices, external development agents (public authorities, donors, technicians, etc.) call on local development committees (LDCs) to raise awareness among local communities.

In the Democratic Republic of the Congo, local development committees were established by the constitution of the Third Republic in the context of decentralization, through the Organic Law of 7 October 2008 on the composition, organization and functioning of decentralized territorial entities and their relations with the State and the provinces (Melmoth, 2007; STANCIU, 2020). In this context, the State is repositioning its role in development and has decided to share certain responsibilities, by involving these LDCs in their approach to promoting development initiatives that better take local needs into account. The Central African Forest Initiative has 745 CLDs in the DRC, located and spread over several provinces for local and participatory land management. The Luki Biosphere has an average of 81 CLDs, constituting a permanent framework for participatory dialogue (WWF, 2024). According to NDAMBO Marie NYANGE (2014), these LDCs generally meet at the invitation of the World-Wide Fund for Nature (WWF-DRC), as part of the implementation of projects. In this context, they function as an interface between local communities and external actors involved in projects (technical managers, public authorities, donors, NGOs, etc.). Their main objective is to promote the active participation of local communities in the stages of rural development projects and programs: programming, identification, formulation, implementation, and evaluation(European Commission, 2001)

Moreover, the population of Luki is poor, living with an average GDP per capita of USD 0.37 over the past ten years (NYANGE, 2014). As a result, the Government of the DRC is collaborating with multilateral and bilateral partners to co-finance interventions aimed at the development and conservation of the biosphere. According to our sources, our focus groups and surveys, this biosphere has benefited from several interventions with similar objectives, claiming to respond to the problems expressed by the grassroots. The underlying problem with this concentration of interventions lies in

the sustainability of their results beyond funding periods. This study focuses on two interventions: PASAGAR and integrated REDD.

Subsidized between 2013 and 2017 by the World-Wide Fund for Nature (WWF), to the tune of 216 million euros from the European Union, PASAGAR aimed to support 10,000 farmers gathered in the Local Development Committees (LDCs) in Luki (Central African Forest Observatory, 2018). In addition, this intervention specifically promised food security for local communities by increasing agricultural production, supporting value chains and actors in agricultural and rural governance, and ensuring adequate quality of nutrition and price regularity. As for the integrated REDD pilot project, it was subsidized between 2013 and 2018 by the Congo Basin Forest Fund (CBFF) in terms of grants, for a total amount of €2.3 million. The beneficiaries were broadly the same as those targeted by PASAGAR: The populations living in and around the Luki Biosphere Reserve (100.000 people in total, 80% of whom were women) and 10.000 farming households benefiting from the project's support through the 50 existing CLDs. The project had provided support for land recognition, the development of agricultural production systems and reforestation/regeneration, including practices such as agroforestry, controlling management of anthropogenic savannahs, wood energy production and the protection of natural forests (ABOU-SABAA et al., 2024).

The choice of these two interventions for this research is motivated by their crucial importance in the context of the Luki Biosphere Reserve: the integrated REDD pilot project focuses on the sustainable preservation of the Luki Biosphere, in coherence with an ecosystem services approach, contributing to the mitigation of deforestation, the destruction of natural forests and the eradication of poverty (Office of Foreign Affairs Assets Control, 2018); while the PASAGAR project works with local communities in a value chain approach, which should in principle be able to highlight agri-environmental services, advocating the implementation by farmers of practices conducive to the conservation and improvement of the environment (HPP-Congo, 2024). These two interventions highlight two distinct trends, with a complementarity to be explored: on the one hand, the conservation of the biosphere, which is a requirement, and on the other hand, the promotion of agricultural and rural development, which proves to be a priority for local communities. As a result, this research consists of addressing the following concerns: (i) what are the factors influencing the sustainability of the results of these two interventions? (ii) to what extent does the value chain approach (in connection with the PASAGAR project) seem to be complementary to the sustainable preservation of the Luki Biosphere (in connection with the integrated REDD project).

2. Materials and Methods

2.1 Conceptual framework of sustainability and development projects

2.1.1 Overview of the sustainability of the results of a development project or program

Sustainability of results refers to the continuation of post-intervention services once development assistance has been discontinued (Peersman, 2014). Where the focus is on external assistance, sustainability of results refers to the ability of key stakeholders to extend the benefits of an intervention after donor funding has stopped, using available local resources. According to the United Nations Development Program (2002), the sustainability of results is considered in three aspects: the sustainability of results, as a principle aimed at maintaining and sustaining results in the long term, or even after official closure; Static sustainability, which aims to maintain the initial benefits of target groups, as well as dynamic sustainability, which seeks to adapt results to distinct contexts or a changing environment. This article analyzes sustainability as the ability to sustain the benefits of an intervention after donor funding has stopped. However, to respond to the challenges of our time (climate, biodiversity, ecology, etc.), it is crucial not to neglect the impact of project and program activities on the sustainability of development in its economic, social, and environmental dimensions.

2.1.2 Theoretical approach to development projects and programs

A development project is defined as a temporary organization, endowed with human, financial and technical resources, whose implementation aims at its own objectives and is supposed to serve as a lever to transform public action on a larger scale (Löfgren et al., 2013). A program refers to a tangle of activities or projects, often varied, pursuing a central objective to promote the production of goods and services by using human, material and financial resources organized in a coherent manner (Organization for Economic Co-operation and Development, 2024). In addition, to verify the impact of a project or development program, it is crucial to highlight all the layers likely to benefit from the promoted benefits. As a result, direct beneficiaries, usually referred to as principal beneficiaries, are individuals who interact directly with the project (in the context of this research, these are the local development committees). As for the indirect beneficiaries, often called secondary beneficiaries, are indirectly involved in the project, but nevertheless benefit from the actions; these individuals are often members of the community or region, or family members of the participants (Caujolle A., et al., 2024).

2.1.3 Local Development Committees (LDCs)

The DRC's policy of decentralization and land use planning has led to the legal recognition of local development committees (LDCs)**.** These CLDs constitute a set of resident members of the village community**,** formally engaging in decisions on land, water, and wildlife use plans (Central African Forest Initiative, 2024). According to WWF (2014), the CLD is a state and institutional structure whose objective is to take charge of the future of the community by itself. The mission of the latter is to draw up the Local Development Plan (LDP) in which the local communities set their development priorities. In addition to this, they promptly ensure the interface and participation of local communities in the implementation of local development initiatives (NYANGE, 2014).

3. Presentation of the Luki Biosphere Reserve

The Luki Biosphere Reserve is in the center of the Mayombe Forest, in the province of Kongo Central. Founded in 1937, this reserve is jointly managed by the National Institute for Agricultural Studies and Research (INERA) and the "Man and the Biosphere" program attached to the Ministry of the Environment and Sustainable Development (MEDD). This reserve is a real natural research laboratory with potential for studies on REDD+ issues and the functions of tropical ecosystems (Desclée et al., 2018). In addition, it is a forest area of the State and one of the two remaining primary forest areas of the province of Kongo Central. Recognized as a protected area by UNESCO in 1979, this reserve covers a total area of 33,811 hectares, and is part of a transnational process, which brings together the DRC, Angola, and the Republic of Congo. Figure 1 provides an overview of the Luki Biosphere, while Figure 2 shows the geospatial evolution of the Luki's landscape, and the sites surveyed.

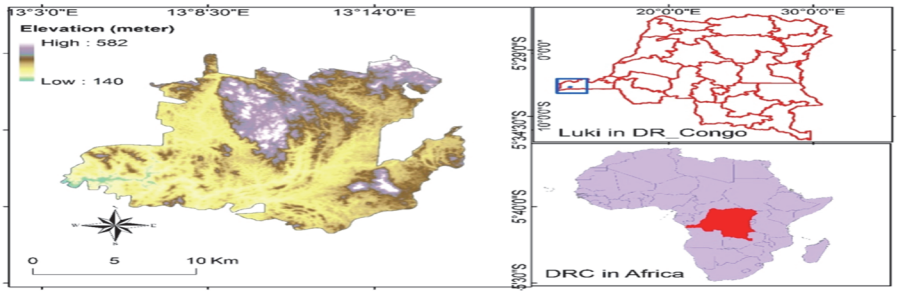

Figure 1. Location of the Luki Biosphere Reserve

4. Methodology for Analyzing the Factors Influencing the Sustainability of PASAGAR and REDD Results

4.1 Selection of survey villages and data collection

The selection of the villages to be surveyed was based on a few criteria: having benefited from the two interventions in this study, having at least one well-structured CLD and a woman on its executive committee, having benefited from several interventions in the past, being accessible and voluntarily agreeing to participate in the investigation. In villages with several CLDs, only one was selected. Because this study highlights the preponderant role of CLDs in the interaction between projects and local communities, and their involvement in the objective of sustainability of interventions, a purposive (non-probabilistic) sampling was conducted. Before this sample was constituted, an exploratory study (with one hundred people) was organized, via focus groups and interviews with local communities gathered in CLDs and various resource persons. This study made it possible to contact different villages in the area to verify the selection criteria, to experiment with the operating and organizational mode of the CLDs and to discover the different traces of the interventions. At the end of this study, a series of structured questionnaires was distributed to forty-seven members of the CLDs (direct beneficiaries of the interventions). As a result, the survey considered 74% of individuals from the executive board of these CLDs and 26% of the subordinate members from the local community (final beneficiaries).

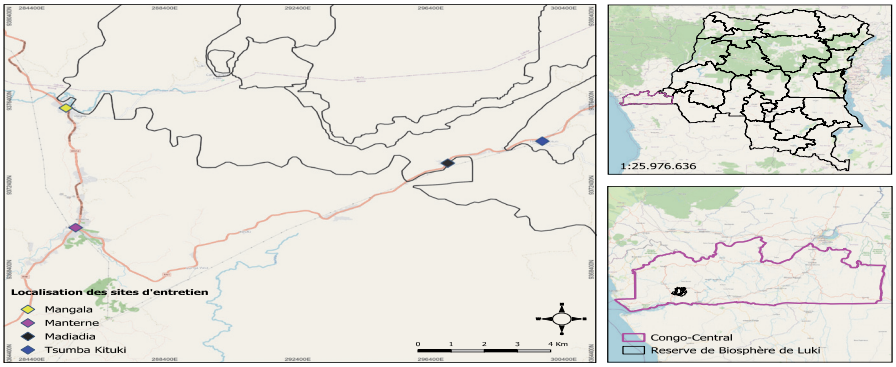

Figure 2. Location of interview sites

Table 1. Distribution of CLD members interviewed according to the selected villages.

Village	Staff	Numbers of respondents
Tshumba-Kituti	938	**12**
Mangala	2.000	**12**
Madiadia	362	**11**
Man	250	**12**
Total	**3.550**	**47**

Source: Prepared by the author, based on documentary information, key informants, area reports, and other statistics

4.2 Data processing and analysis

The data collected was analyzed using SPSS software. Descriptive statistics (mean, median, mode, minimum, maximum frequency) and the chi-square test (or χ^2 test) were used. This independence test was applied to check whether differences observed in the sample correspond to significant differences from the expected frequencies. To do this, two types of verification hypotheses were chosen: (i) the null hypothesis: Ho, the two variables are independent; (ii) the alternative hypothesis: H1, the two variables are related. In addition, if the probability associated with the Pearson chi-square value is less than 5 or 10%, then the null hypothesis is rejected in favor of the alternative hypothesis.

Table 2 describes the choice and description of the variables (dependent and explanatory) used to perform this chi-square independence test. In this context, the variable to be explained is the durability of the results. The explanatory variables for this sustainability are socio-demographic and those relating to the activities of the interventions.

Table 2. Choice and description of variables

Categories	Variables	Abbreviations or notation	Unit	Expected signs	Nature
Demographic	**Sex**	Sex	Dummy	+	Explanatory
	Age	Age	Dummy	-	Explanatory
	Instruction	Instruction	Dummy	+	Explanatory
	Civilian	Civilian	Dummy	+	Explanatory
	Main activity	Activity	Dummy	+	Explanatory
	Professional experience	Experiment	Dummy	+	Explanatory
Activity variables	**Sustainability of results**	**Sustainability**	**Dummy**	+/-	**Dependent**
	Agricultural Input	Inputs	Dummy	-	Explanatory
	Early harvest	Rec_préc	Dummy	-	Explanatory
	Post-harvest equipment	Mill	Dummy	+	Explanatory
	Formation	Formation	Dummy	+	Explanatory
	Reforestation	Reforestation	Dummy	+	Explanatory
	Agroforestry	Agro_for	Dummy	+	Explanatory
	Fencing off degraded savannahs	Mise_défen	Dummy	+	Explanatory
	Apiculture	Apiculture	Dummy	+	Explanatory
	Model farmer	Fer_modèle	Dummy	+	Explanatory
	Payments for Environmental Services (PES)	PES	Dummy	+	Explanatory

5. Presentation of Results

5.1 Characteristics of Local Development Committees (LDCs)

Table 3 highlights the characteristics of the local development committees. The results show that the sample is dominated by people over 45 years old. This situation is explained by the fact that these individuals are often heads of households and are moreover obliged to remain in the villages for long periods to ensure their families' survival. Conversely, young people are poorly represented since many of them are attracted by the rural exodus, seeking better-paid jobs outside their community.

In addition, there is also a low representation of women in the administration of the CLDs, despite articles 25, 26 and 27 of the statutes of these CLDs, which advocate gender equality in the

composition of the administration. This under-representation stems from historical, cultural, and ancestral biases, favoring male domination in society. These results confirm the findings of previous surveys conducted in the same area on agrarian diagnosis, where a low representation of women was observed, accounting for only 15% of the sample (Mikobi et al., 2019). The results also reveal that most of the respondents are full-time farmers (70%), although some of them also have other secondary activities. In addition, a large majority were educated (76%) and married (66%).

Table 3. Characteristics of Local Development Committees

VARIABLE	CHARACTERISTICS	TERMS	SURVEY NUMBER	PERCENTAGE	CUMULATIVE VALID PERCENTAGE
Demographic	Sex	Wife	13	27,7	27,7
		Man	34	72,3	100,0
	Age	Young	11	23,4	23,4
		Over 45 years old	36	76,6	100,0
	Instruction	Uneducated	15	31,9	31,9
		Educated	32	68,1	100,0
	Civilian	Married	31	66,0	100,0
		Other	16	34,0	34,0
	Main activities	Full-time farmers	33	70,2	70,2
		Pluriactive and/or diversified farmers	14	29,8	100,0
	Professional experience	Less than 7 years old	5	10,6	10,6
		More than 7 years old	42	89,4	100,0

Number of observations in the survey = 47; Valid percentage = proportion of observation or sample considered valid or dependable.

This table describes the socio-demographic characteristics of the local development committees (CLDs). To make this data more accessible, the graph below illustrates the distribution of these variables in visual form, providing a clear understanding of trends and comparisons between the different categories.

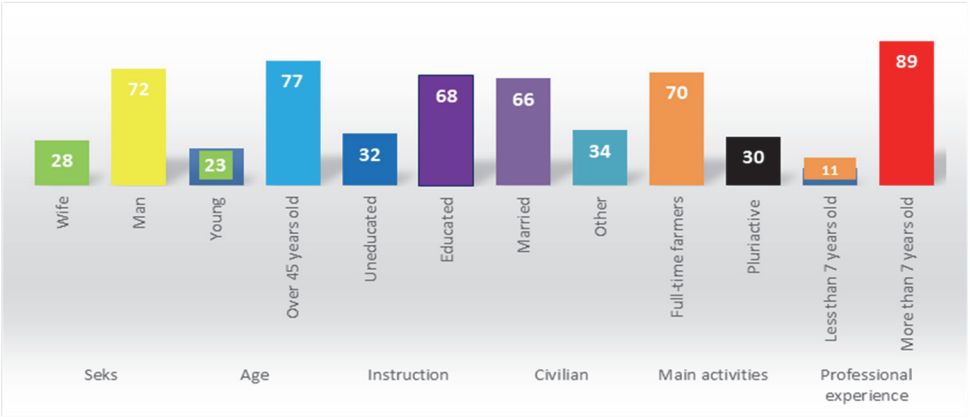

Figure 1. Characteristics of Local Development Committees (CLDs)
Source: Author, based on socio-demographic data from the survey

6. Characteristics of Local Development Committees in Relation to the Sustainability of PASAGAR and Integrated REDD Results

Table 4 highlights the relationship between the characteristics of the local development committees and the sustainability of the results of the two interventions. It is observed that all p-values are above the significance level of 0.05, hence the acceptance of the null hypothesis rather than the alternative hypothesis, which indicates independence between variables. Based on this decision, the socio-demographic factors influencing the sustainability of the results of two interventions will be read using the percentages observed in the distinct categories, which will make it possible to identify certain trends (cf. Figure 2).

As a result, the results indicate that the sustainability of the results of both interventions is ensured by people over 45 years of age. This is because most of them are married and are forced to ensure the sustainability of intervention results to support their households. In addition, the results also show that educated people are more likely to ensure the sustainability of outcomes than uneducated people. This trend is explained by the fact that these people better assimilate capacity-building training, which is given by projects before their implementation. It is also observed that full-time farmers maintain the benefits of interventions better after funding has been discontinued, than pluriactive and/or diversified farmers, who, in addition to agriculture, have other sources of income, which prevents them from fully focusing on the agricultural practices put in place by the interventions. According to WWF (2024), when implementing project activities, agricultural and conservation, the first targets of donors are farmers, due to the pressure they put on the biosphere and their experience in this profession.

On the other hand, given the low representation of women in the sample of this survey, the trend in results also indicates a low involvement of women in the sustainability of the results of the two interventions. This observation could be explained by the intensity of some of the activities promoted by PASAGAR and REDD: beekeeping, wood energy, fish farming, agroforestry, monitoring of antrophic savannahs, etc., usually require a great deal of physical commitment, which does not allow women to adapt easily. It should also be noted that, in the implementation of development interventions in this area, women are the priority of donors. This low trend in women's participation corroborates the finding of a previous survey conducted in the same study area by NDAMBO Marie NYANGE (2014): at the end of this survey aimed at the participation of local communities in sustainable forest management, men represented more than 80% of the sample.

Table 4. Characteristics of Local Development Committees in relation to the sustainability of PASAGAR and integrated REDD results

CHARACTERISTICS	SUSTAINABILITY			X2-TEST (PEARSON)	P-VALUE
AGE	**Yes**	**No**	**TOTAL**	1,212	0,271
Over 45 years old	26 (70,3)	11 (29,7)	37 (100)		
Under 45 years old (Youth)	6 (60)	4 (40)	10 (100)		
TOTAL	**32 (68,1)**	**15 (31,9)**	**47 (100)**		
INSTRUCTION	**Yes**	**No**	**TOTAL**	0,663	0,416
Educated	23(71,9)	9 (28 ,1)	32 (100)		
Uneducated	9(60)	6(40)	15(100)		
TOTAL	**32(68,1)**	**15(31,9)**	**47(100)**		
CIVILIAN	**Yes**	**No**	**TOTAL**	0,020	0,555
Married	22(68,8)	10(31,3)	32(100)		
Unmarried	10(66,7)	5(33,3)	15(100)		
TOTAL	**32(68,1)**	**15(31,9)**	**47(10)**		
ACTIVITIES	**Yes**	**No**	**TOTAL**	2,852	0,091
Full-time farmers	20(60,6)	13(39,4)	33(100)		
Pluriactive and/or diversified farmers	12(85,7)	2(14,3)	14(100)		
TOTAL	**32(68,1)**	**15(31,9)**	**47(100)**		

EXPERIMENT	Yes	No	TOTAL		
More than 7 years (long)	28 (66,7)	14 (33,3)	42(100)	0,366	0,545
Under 7 years old (Short)	4(80)	1(20)	5(100)		
TOTAL	**32(68,1)**	**15(31,9)**	**47(100)**		
SEX	Yes	No	TOTAL		
Man	25 (74)	9(26)	34(100)	1,677	0,195
Wife	7(54)	6(46)	13(100)		
TOTAL	**32(68,1)**	**15(31,9)**	**47(100)**		

Number of survey observations = 47; percentage in parentheses, value of $p(X2)$ = chi-square fit test (one variable), * indicates a 5% significant test; ** indicates a 1% highly significant test; *** indicates a 0.1% very highly significant test.

As noted in the previous paragraph, although these results do not suggest a statistically significant relationship between sociodemographic factors and outcome sustainability (p-value), the observed percentages indicate some interesting trends regarding the explanatory factors for outcome sustainability. The chart below illustrates these trends.

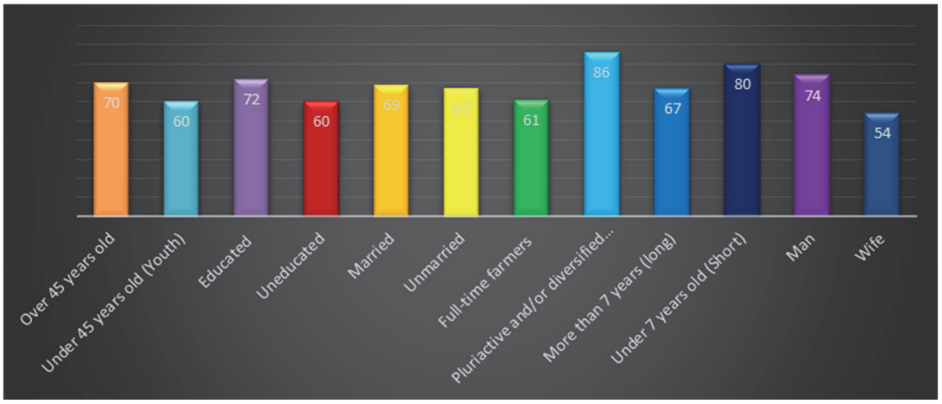

Figure 2. Trend of sociodemographic factors positively influencing the sustainability of PASAGAR and Integrated REDD results
Source: Chi-square test results (see Table.4)

6.1.1 Factors Influencing the Sustainability of PASAGAR and Integrated REDD Results

Table 5 reveals the factors influencing the sustainability of PASAGAR's results. This durability was influenced by the "agricultural input" factor as well as the post-harvest equipment: mill and sheller. The "early harvest" factor also has a significant impact, the variables "input" and "post-harvest equipment" are very highly significant. Regarding the "input" variable, given the improved seeds, chemical fertilizers, pesticides and various hand-held agricultural tools (machetes, hoes, etc.) brought by this program, an early agricultural harvest was observed varying between 6 and 9 months after sowing, compared to 12 months before the arrival of PASAGAR. These seeds were cassava cuttings of the Vama and Rava anti-octa varieties, as well as maize of the yellow Samarou variety, which develop quickly.

Furthermore, PASAGAR also offered post-harvest equipment to local communities with the aim of promoting the processing of agricultural products and supporting the populations living in and around the Luki Biosphere. Among the four villages surveyed, the mill was specifically allocated to the CLD of Tshumba-Kituti, the shellers to the CLDs Materne, Mangala and Madiadia. According to the information gathered in our focus groups, this equipment has improved the efficiency of

processing cereal crops such as maize, rice, ground nuts, etc. By facilitating this transformation, they have reduced post-harvest losses, improved food quality, promoted the dynamics of the local economy and promoted sustainable development for local populations.

Table 5. Factors Influencing the Sustainability of PASAGAR Intervention Results

ACTIVITY VARIABLES	SUSTAINABILITY			X2-TEST (PEARSON)	P-VALUE
REC_PRÉC	**Yes**	**No**	**TOTAL**	5,910	0,015*
Yes	30(93,8)	2(6,3)	32 (100)		
No	10(66,7)	5(33,3)	15 (100)		
TOTAL	**40(85,1)**	**7(14,9)**	**47 (100)**		
INPUTS	**Yes**	**No**	**TOTAL**	8,236	0,004**
Yes	30(93,8)	2(6,3)	32 (100,0)		
No	9(60,0)	6(40,0)	15(100,0)		
TOTAL	**39(83,0)**	**8(17,0)**	**47(100)**		
ÉQ_POST_RÉCOLT	**Yes**	**No**	**TOTAL**	12,204	0,002**
Yes	30(93,8)	2(6,3)	32(100,0)		
No	13(86,7)	2(13,3)	15(100,0)		
TOTAL	**43(91,5)**	**4(8,5)**	**47(100,0)**		

Number of survey observations = 47; percentage in parentheses, value of $p(X2)$ = chi-square fit test (one variable), * indicates a 5% significant test; ** indicates a 1% highly significant test; *** indicates a 0.1% very highly significant test.

The results in Table 6 highlight the factors influencing the sustainability of the results of the integrated REDD pilot project. The "model farm" factor is significant, while the "beekeeping" factor has no impact.

The implementation of model farms had revealed certain activities: reforestation and agroforestry, the very convincing results of which have been evaluated. Through these two activities, other income-generating factors were initiated by the farmers, including beekeeping, which had promoted the production and marketing of honey. According to the focus groups, this beekeeping has been difficult to develop because of the contamination of bees' food resources by pesticides and because of the competition in agricultural production, promoted by PASAGAR. On the other hand, following the promotion of these model farms and reforestation activities, and in terms of impact, the populations say they have felt the reduction in heat waves, the observation of rainfall, etc.

In addition, although overall 70% of respondents expressed dissatisfaction with the integrated REDD project, the chi-square test revealed significant differences in the perception of certain activities implemented, such as "model farms". During the implementation of this project, the local committee managing model farms received not only the benefits in kind, but also in cash (amounting to 1000 US dollars), paid for a single payment during implementation. These funds, received from the beginning of implementation, were aimed at improving and developing farm activities such as agriculture, beekeeping, fish farming, and reforestation.

Table 6: Factors influencing the sustainability of the results of the integrated REDD pilot project

ACTIVITY VARIABLES	SUSTAINABILITY			X2-TEST (PEARSON)	P-VALUE
APICULTURE	**Yes**	**No**	**TOTAL**	2,401	1,121
Yes	11(37,9)	18(62,1)	29 (100,0)		
No	3(16,7)	15(83,3)	18(100,0)		
TOTAL	**14(29,8)**	**33(70,2)**	**47(100)**		
FER_MODEL	**Yes**	**No**	**TOTAL**	4,865	0,027
Yes	12(41,4)	17(58,6)	29 (100,0)		
No	2(11,1))	16(88,9)	18(100,0)		
TOTAL	**14(91,5)**	**33(70,2)**	**47(100,0)**		

Number of survey observations = 47; percentage in parentheses, value of $p(X2)$ = chi-square fit test (one variable), * indicates a 5% significant test; ** indicates a 1% highly significant test; *** indicates a 0.1% very highly significant test.

While PASAGAR and Integrated REDD are quite complementary, the results in Table 7 highlight common factors influencing the sustainability of their results: the enclosure of anthropogenic savanna is highly significant, while payments for environmental services (PES) and training are very highly significant. In Luki, protected enclosure is a tool that can be mobilized to ensure the conservation and restoration of forests and anthropogenic savannahs. In this context, integrated REDD and PASAGAR supported the CLDs with payment for environmental services (PES).

As far as these PES are concerned, among the four villages surveyed, only Madiadia and Materne were beneficiaries, due to the presence of savannahs in their concessions. According to information from focus groups and archives of one-off service contracts relating to this PSE, local conservation actors are paid over a period of three years. At the end of our investigation, the local development committees concerned claim to have received this payment only in the first and second years of implementation, after which these payments were stopped. During these two years, payment was made in two phases: at the beginning of the dry season (between mid-May and the end of June), a period characterized by the accentuation of bush fires, and in November (during the rainy season). On the other hand, the correlation also seems significant between training and the durability of results; Respondents believe that this training is a fundamental tool for continuing activities after the funding of interventions.

Table 7. Common Factors Influencing the Sustainability of Results from Both Interventions

ACTIVITY VARIABLES	SUSTAINABILITY			X2-TEST (PEARSON)	P-VALUE
MIS_DEFENS	**Yes**	**No**	**TOTAL**	6,71	0,010
Yes	17(53,1)	15(46,9)	32 (100)		
No	2(13,3)	13(86,7)	15 (100)		
TOTAL	**19(40,0)**	**28(59,6)**	**47 (100)**		
FORMATION	**Yes**	**No**	**TOTAL**	30,164	0,000 ***
Yes	31(96,9)	1(3,1)	32 (100,0)		
No	3(20,0)	12(80,0)	15(100,0)		
TOTAL	**34(72,3)**	**13(27,7)**	**47(100)**		
REFORESTATION	**Yes**	**No**	**TOTAL**	0,059	0,808
Yes	18(56,3)	14(43,8)	32(100,0)		
No	9(60,0)	6(40,0)	15(100,0)		
TOTAL	**27(57,4)**	**20(42,6)**	**47(100,0)**		
AGRO_FOR	**Yes**	**No**	**TOTAL**	1,502	0,220
Yes	29(90,6)	3(9,4)	32(100,0)		
No	15(100,0)	0(0,0)	15(100,0)		
TOTAL	**44(93,6)**	**3(6,4)**	**47(100,0)**		
PES	**Yes**	**No**	**TOTAL**	34,377	0,000 ***
Yes	32(100,00)	0(0,0)	32(100,0)		
No	3(20,0)	12(80,0)	15(100,0)		
TOTAL	**35(74,5)**	**12(25,5)**	**47(100,0)**		

Number of survey observations = 47; percentage in parentheses, value of $p(X2)$ = chi-square fit test (one variable), * indicates a 5% significant test; ** indicates a 1% highly significant test; *** indicates a 0.1% very highly significant test.

The table below summarizes the factors positively influencing the sustainability of two interventions. These factors include socio-demographic variables and those related to the activities implemented by the two interventions.

Table 8. Summary of factors positively influencing the sustainability of PASAGAR and Integrated REDD

Factors	PASAGR	Integrated REDD	Common factors
Institutional	-	-	Local Development Committees, participation in implementation
Agricultural and environnemental technology	Agricultural Inputs, Post-Harvest Equipment, Early Harvest	Model Farm	Protected enclosure
Socioeconomic	-	-	Payments for Environmental Services (PES), training
Socio-demographic factors	-	-	Persons over 45 years of age, educated persons, Married, Persons with more than 7 years of experience, Male.

7. Discussion

7.1 Factors influencing the sustainability of PASAGAR's results

The results of the independence test illustrate the factors influencing the sustainability of PASAGAR results: agricultural inputs (improved seeds, fertilizers, pesticides, and other hand-held agricultural tools: machetes, hoes, etc.) and post-harvest equipment, such as mills and shellers. Regarding the "input variable", the information collected in our focus groups indicates that with PASAGAR funding, the acquisition of input has been significantly increased agricultural productivity, strengthening food security by improving yields and controlling pests, and facilitating more efficient agricultural practices. These results corroborate those found by Giuseppe Davide Cioffo (2014), in an analysis of smallholder farmers in the face of rural modernization in the Northern Province of Rwanda. The study shows that agricultural modernization aimed at increasing the productivity and sustainability of the country's primary sector activities is a function of, among other things, the distribution of improved inputs (chemical fertilizers and improved seeds); this input distribution program is considered to be one of the central moments in the implementation of the crop intensification program.

In addition, PASAGAR had actively encouraged the local processing of agricultural products by providing local communities with post-harvest equipment (mills and shellers). This equipment has made it possible to enhance the value of agricultural products, creating added value thanks to the integration of the short circuit. In the field and over time, this initiative promotes the processing, storage, and management of agricultural products, helping to improve the overall efficiency and quality of finished products. These results corroborate those of Claude Marouze and Djibril Drame (2004) on the mechanization of post-harvest operations of the FAO-funded Fonio project in Senegal, in the Tambacounda Region. After the implementation of this project, the mechanization of post-harvest operations proved fundamental to promote the fonio sector and reduce the challenges related to women's work.

Considering the set of results, 81% of respondents believe that PASAGAR has met their expectations. However, despite this satisfaction, it should be noted that during consultations between the CLDs, local communities and projects, only 43% of respondents had expressed the need to increase agricultural production. The remaining 57% had expressed other needs, such as the construction of hospitals, roads for agricultural services, schools, etc. Moreover, not all respondents stated that they had been involved in all the evaluations conducted, even though 83% acknowledged that they had participated in the implementation of the programmer's activities.

7.2 Factors influencing the sustainability of the results of the integrated REDD pilot project

The sustainability of the results of this project is influenced by the promotion of "model farms". In this context, REDD initially developed thirty pilot farms during its implementation. After its implementation, another 140 agroforestry farms were developed, without additional funding, but thanks to the training received. While the relative success of these model farms is noteworthy, it does not allow us to conclude the sustainability of the project's other results. As a result, it was therefore necessary to evaluate other aspects of the project to determine their sustainability and get a comprehensive overview.

Indeed, these farms constitute the foundation of a varied agriculture, likely to generate alternative food and financial resources to the exploitation of forest resources (OFAC, 2018). The activities implemented in these model farms, in particular reforestation and agroforestry, had generated some underlying activities: the production of honey and sustainable wood energy, the revitalization of the economic and environmental sustainability of the area. These initiatives have boosted the resilience of local communities to climate change and economic hazards, while protecting biodiversity and sustainably optimizing quality of life. These results are consistent with those found in the MAMPU project, at the Batéké plateaus in the city of Kinshasa. This project had set up an agroforestry dynamic associating acacia with savannah crops to protect forest ecosystems, revitalize savannah soils, improve living conditions, and therefore also reduce the migratory flow to large urban centers. It was also a question of better securing the supply of wood energy and food crops on the markets of large cities (BISIAUX et al., 2009).

Despite the results of the integrated REDD, 70% of respondents believe that this pilot project has not met expectations very well. As in PASAGAR, not all respondents said they participated in all the project's evaluations. These observations indicate that the integrated REDD pilot project was implemented using a top-down approach, which places the poor as non-development actors for whom everything should be done (Nahavandi, 2005). Even though this approach has been criticized for 30 years in favor of community participation and the bottom-up approach, the top-down approach is still observed in the field about the low involvement of local communities from the design phase.

7.3 Complementarity between integrated REDD and PASAGAR

While the two interventions are complementary, a few factors influenced the sustainability of their results. Even though all p-values of the sociodemographic variables exceed the significance level of 0.05, leading to the acceptance of the null hypothesis, it is nevertheless relevant to note that the observed differences could have practical importance or implications that would merit further exploration.

Considering our results, people over the age of 45, the majority of whom are married, contribute more to the sustainability of the benefits of agricultural development interventions than young people. These results corroborate those of Mastaki et al., (2013) who demonstrate a positive correlation between older people and farm sustainability in South Kivu in the Democratic Republic of Congo. In this context, older people have more land and more income than young farmers. In addition, the educated have benefited from the benefits of the interventions and contributed more to the continuity of these benefits than the uneducated. These results contrast with those found in a similar study, where educated farmers maintained their self-esteem and dignity by avoiding traveling long distances to conduct activities that jeopardized the continuity of post-intervention outcomes (Pesa, 2020). Moreover, our results also suggest that women are less influential in maintaining post-intervention benefits than men. These results are consistent with those experienced by the World Bank (2014) in its interventions in six African countries (Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda). Despite the gender approach promoted in its interventions, which allows women to benefit from interventions to the same degree as men, there has been a low performance in the

continuity of activities after the financing of these interventions.

The sustainability of the results of two interventions was also influenced by factors such protected enclosure, agroforestry, PES and reforestation. According to WWF (2024), the promotion of protected enclosure, reforestation and agroforestry had a positive impact on forest cover and the regeneration of anthropogenic savannahs. In the Luki Biosphere Reserve, protected enclosure consists of the total protection of savannah areas degraded by agriculture, to stimulate the restoration of forest cover. To do this, Payments for Environmental Services (PES) finance the populations. These funds are of three types: payment to the rights holders, payment to the CLD and payment for firebreak work (Préroches, 2020). The rights holder is the owner of large tracts of land; the Local Development Committees (LDCs) are the initiators of local development plans and serve as legitimate structures responsible for managing the conservation of these hectares, as well as the contract between the rights holder and the donor. Firebreak construction involves artificial mechanisms designed to limit the spread of wildfire within these protected areas. These operations are conducted by the fire prevention brigade, a sub-unit of the LDCs.

According to interviews and focus groups granted to the heads of beneficiary CLDs (Djo, M et al., 2023) and other various sources, the cost of the PES depended on the number of hectares reforested or put under defence. The distribution of this payment is as follows: 70% to the rights holder, 20% to the CLD and 10% to the fire brigade. Regarding the use of these funds, it should be noted that the rights holder consumes his income with his family, while the CLDs put their income at the service of local communities by helping to meet basic needs. With the PASAGAR PSE and REDD integrated, the CLDs of Materne and Madiadia claim to have contributed to the renovation of classrooms and other needs. According to Venturexpert- Solution Design Team (2021), most of the PES systems that exist today aim to remunerate individually, or even jointly in some cases, the services provided by foresters for carbon sequestration and the preservation of habitats for the maintenance of biodiversity or the beauty of landscapes. Although this analysis briefly addresses the aspects related to PES, it is necessary to emphasize that an in-depth study seems necessary to analyze the fundamentals, implementation mechanisms and potential impacts on the sustainable management of the Luki Biosphere.

8. Limitations of the Research

At the end of the exploration survey, 47 CLD members from 4 villages received structured questionnaires. This sample size seems not to be representative of the entire population of PASAGAR and REDD beneficiary villages. In statistics, the sample size depends on the objectives of the study, the population being studied, and the appropriate statistical requirements to ensure the adequacy of the results. As the objective of this study is to verify the trend of factors influencing the sustainability of integrated REDD and PASAGAR results, we opted for a smaller sample size, composed of direct beneficiaries of these interventions, namely the local development committees (CLDs).

9. Conclusions

This research highlights the sustainability of the results of PASAGAR and REDD, two cases of sustainable management and development intervention of the Luki Biosphere, subsidized between 2013 and 2018. Two main concerns were expressed: to identify the factors influencing the sustainability of these interventions, and to see to what extent the value chain approach (in connection with the PASAGAR project) seemed complementary to the sustainable preservation of the Luki biosphere (in coherence with the Integrated REDD pilot project). Overall, the results suggest that the sustainability of the results of these interventions has been influenced by institutional factors (local development committees, participation in implementation), techno-agricultural and environmental factors (improved seeds, responsible practices of natural resources, including forests, land and water, agroforestry, reforestation, protected enclosure, etc.) and socio-economic factors

(payment for agri-environmental services, training, beekeeping through the marketing of sustainable honeys and wood energies through the sale of charcoal).

Overall, the sustainability of PASAGAR has been influenced by the "agricultural inputs" factor, which has contributed to increasing agricultural production, strengthening value chains, and improving the skills of actors in integrated rural governance. On the other hand, the sustainability of the integrated REDD pilot project has been influenced by the promotion of "model farms", highlighting diversified agricultural practices, capable of providing both food and financial resources, while sustainably exploiting forest resources. While the two interventions proved to be complementary, a few common factors influenced their sustainability: protected enclosure, payment for environmental services, reforestation, and agroforestry. On the socio-demographic level, it is important to remember that people over 45 years of age, educated people and married people play a key role in the sustainability of the results. In addition, the Local Development Committees (LDCs), actors of local governance, direct beneficiaries, and promoters of local participation, have facilitated the interaction between PASAGAR, REDD and local communities by promoting this participatory process. As a result, the results of this study suggest zero participation in design and evaluations, while it is estimated at 83% in the implementation of PASAGAR and 63% in that of the Integrated REDD pilot project.

Indeed, the results of this study seem mixed because some expected variables such as reforestation, agroforestry, beekeeping, participation in design and evaluations, etc., have low sustainability, which implies that the interaction between CLD and the two interventions would have encountered constraints. In this context, we recommend a study on the challenges faced by CLDs and projects in the implementation of activities in the field. This study should be able to highlight the strengths and weaknesses, as well as the opportunities and threats of this interaction.

10. Recommendations

In view of all the results of this study, we recommend the consideration of two models, likely to promote an optimal implementation of future interventions in the Luki Biosphere:

- **The Commons Governance Model, for a New Approach to Natural Resources (Elinor , 2010)** : Elinor Ostrom highlights eight "design principles" that characterize all effective management of common resources: (i) the existence of clearly defined boundaries (both for individuals with access to the resource and regarding the boundaries of the resource itself); (ii) adaptation to local conditions (labour, equipment, money); (iii) the existence of collective choice mechanisms including most of the individuals concerned, such as local communities (gathered in CLDs); (iv) the existence of methods for monitoring the behavior of individuals with access to the resource (reporting to these same individuals); (v) the existence of graduated sanctions against individuals who transgress the rules; (vi) the existence of mechanisms for the resolution of conflicts in a timely and cost-effective manner; (vii) the minimal recognition by external authorities of the right to self-organization; and (viii) the interweaving of local institutions within larger institutions. However, if Elinor Ostrom's model highlights the community governance of natural resources, it seems crucial to complement it with a model that integrates global economic dynamics, such as the green economy model.
- **The Green Economy Model, coupled with agriculture (GEA) (FAO, 2011) :** According to sources, this model has been successfully implemented in several biosphere reserves around the world: the Man Biosphere and the MAB Biosphere (MAB) of Senegal, the Okavango Delta Biosphere Reserve in Botswana, the Cairngorms Biosphere Reserve in Scotland, the Selous Biosphere Reserve in Tanzania... In practice, the green economy, coupled with agriculture, is of crucial importance for the Luki Biosphere, as it (Beaudoin, Nadeau and al., 2018) Guarantees the right to fair food and food security of rural populations, while promoting their livelihoods. This requires sustainable management of natural resources and strengthening equity and resilience throughout the food chain.

References

ABOU-SABAA, D. A., Osan Fregene, D. M., & Ahai, D. (2017). *I Basic data A Report data B Project managers at the* African Development Bank https://www.afdb.org/fr/documents/rdc-projet-pilote-redd-integre-autour-de-la-reserve-de-biosphere-de-luki-dans-la-foret-de-mayombe-rapport-dachevement-de-projet, read and accessed on 24 April 2025.

African Development Bank. (2020). Democratic Republic of Congo - Integrated REDD pilot project around the Luki Biosphere Reserve in the Mayom Forest https://projectsportal.afdb.org/dataportal/VProject/show/P

World Bank. (2014). Improving Prospects for Women Farmers in Africa and Addressing Gender Inequality https://www.banquemondiale.org/fr/region/afr/publication/levelling-the-field-improving Opportunities for Women Farmers in Africa.

Beaudoin Nadeau, M., Hénault-Ethier, L., Rony, F. J., Michel, G., & Monette, M. (2018). Restoration of forest and agroforestry landscapes combined with the recovery of organic waste in Haiti for the sustainable development of a green economy resilient to climate change. In *Haiti Perspectives* (Vol. 6). Www.worldometers.info

Bisiaux F., Peltier R., Muliele J-P. (2009). Industrial plantations and agroforestry at the service of the populations of the Batéké and Mampu plateaus in the Democratic Republic of Congo. *Woods and Forests of the Tropics*, 2009, 301

Office of Foreign Assets Control (OFAC) (2018). Integrated REDD pilot project around the Luki Biosphere Reserve in the Mayombe Forest. https://www.observatoire comifac.net/info/project/171/pdf?lang=en.

CAUJOLLE, A., DUBOIS, M., LIVACHE, N., MOREAU, E; FAUCHIER, M; DURIEUX, R. (2024). Reflection notes on the calculation of the number of beneficiaries and the measurement of the quality of energy access projects. International cooperation. Available at: http://www.reseau-cicle.org/wp-content/uploads/Cicle_Guide_methodo_beneficiaires-1.pdf.

Charlot, M. and Samuel, M. (2024). *CONSULTATION REPORT, LUKI BIOSPHERE RESERVE*. https://www.ulb-cooperation.org/wp-content/uploads/2021/10/rapport-de-consultance-a-luki_2020.pdf

Coméliau, C. (1994). Development of sustainable development, or conceptual blockages? *Third World Review*, 35(137), 61-76. https://doi.org/10.3406/tiers.1994.4850

European Commission. (2001). Project Cycle Management Manual, 49p. https://agridev-expertise.com/wpcontent /uploads/2022/06/manuel_de_gestion_de_cycle_de_projet.pdf

Elinon O. (2010). Observatoire du Management Alternatif Alternative Management Observatory __ Fiche de lecture Governing the Commons-The Evolution of Institutions for Collective Action .

FAO. (2011). Green economy and agriculture. The path to sustainability. https://www.fao.org/4/ar585f/ar585f. pdf

Giuseppe, D. (2014). Smallholder farmers and rural modernization in Rwanda's Northern Province: consolidation of land use, distribution of improved inputs, and food security. The Africa of the Great Lakes. Yearbook 2013-2014.

Humana People to People Congo (HPP-Congo) (2024). Support programme for food security and agricultural and rural governance in the districts of Boma and Bas-Fleuve (PASAGAR). https://www.hpp-

Central African Forest Initiative (2024). For local and participatory land use management: 745 local development committees established in the DRC. Available on https://www.cafi.org/fr/pays-partenaires/democratic-republic-congo/pour-une-gestion-locale-et-participative-de-lusage-des-terres-745-comites-locaux-de-developpement.

Löfgren, K., Godenhjelm, S., Sjöblom, S., Löfgren, K., & Godenhjelm, S. (n.d.). Projectified Politics-Temporary Organisations in a Public Context Introduction to the special issue SJPA 17(2). In *Scandinavian Journal of Public Administration* (Vol. 17, Issue 2).

Marouze, C., & Djibril, D. (2004). Working approach for the mechanization of fonio post-harvest operations, experimentation protocols and design tools. Improvement of post-harvest technologies for fonio; Cl RAD-1 ER-IRAG-IRSAT. https://agritrop.cirad.fr/607532/1/ID607532.pdf.

Mastaki, Jean-Luc., Nfuamba Fabrice., and Rushigira C. (2013). Essay on the sustainability of farms in South Kivu. The Africa of the Great Lakes, 145.

Matters, D. (2021, November 2). *Biosphere reserves: tools for the Sustainable Development Goals*. The importance of development.https://oecd-development-matters.org/2021/11/02/les-reserves-de-biosphere-outils-au-service-des-objectifs-de-developpement-durable/

Mazzorana-Kremer, F. (2018). What management model for temporary organizations? Study of a project to renew gas installations. *Revue française de gestion*, *274*(5), 11-30. https://doi.org/10.3166/rfg.2018.00257

Mayrand, K., Paquin, M. (2004). Payment for environmental services: study and evaluation of current systems. Unisféra International Centre. North American Commission for Environmental Cooperation.

Melmoth, S. (2007). Democratic Republic of the Congo: decentralization and conflict recovery. *Contemporary Africa*, *221*(1), 75-85. https://doi.org/10.3917/afco.221.0075

Mikobi, C. M., Tipi, E. L., Kashiki, B. K. wa N., Makanua, I. D., Kasali, J. L., & Michel, B. (2023). Diversity and uses of macromycetes in the Luki Biosphere Reserve (Kongo Central / Democratic Republic of Congo). *VertigO - the electronic journal in environmental sciences*. https://doi.org/10.4000/vertigo.39434

Nahavandi, F. (2005). From development to globalization. Histoire d'une stigmatisation, 2nd revised and expanded edition, Bruylant, Brussels.

Nyange, N. M. (2014). Participation of local communities and sustainable forest management: the case of the Luki Biosphere Reserve in the Democratic Republic of Congo.

Office of Foreign Assets Control (OFAC) (2018). Integrated REDD Pilot Project around the Luki Biosphere Reserve in the Mayombe Forest. https://www.observatoire comifac.net/info/project/171/pdf?lang=en.

Organisation for Economic Co-operation and Development. (2024). *Development*. https://www.oecd.org/fr/development/

Peersman, G. (2014) Evaluation Criteria - Methodological Notes Impact Evaluation No. 3, UNICEF. Available on: http://cooperation-concept.net/glossary/durabilite/

Préroches, A. (2021). Action training in agrarian diagnosis in the Luki Biosphere Reserve, WWF, ERAIFT, https://www.ulb-cooperation.org/wp-content/uploads/2021/09/20200415_rapport_mission_luki_peroches_vf.pdf.

Pesa, I. (2020). Crops and copper: agriculture and urban planning in the copper belt of Central Africa, 1950-2000. J. S. Afr. Stud, 46, 527-545. [Cross ref]

Stanciu, L. (2020). ; Decentralization in DR Congo: what application? file:///Users/admin/Downloads/la-decentralisation-en-rd-congo-quelle-application.pdf

UNESCO. (1996). Biosphere Reserve: Seville Strategy and Statutory Framework of the World Network, Editions, Unesco, Paris, https://www.mab-france.org/workspace/uploads/intranet/documents/strate-gie-de-se-ville.pdf/

Venturexpert - Solution Design Team (2021). Vertdeep Solution: How to offset the environmental and social services provided by certified forest companies in the Congo Basin French Fund for Global Development.https://www.atibt.org/files/upload/technical-publications/Etude_C_-_Opportunite_mecanisme_remuneration_.

WWF. (2024). For threatened biodiversity. http://legacy.wwf.be/fr/nos-projets/luki/

WWF (2014), Establishment of CLD and Community Structuring, Louvain-la-Neuve Cooperation, Capitalization of SARAGNA's actions in the Three-Year Plan 2 – Period 2011-2013, Food and Economic Security Domain. Available on: https://louvaincooperation.org/sites/default/files/2018-10/17%20Capitalisation%20%20Mise%20en%20place%20CLD%20et%20structuration%20communautaire.pdf.

WWF (2014), Establishment of CLD and Community Structuring, Louvain-la-Neuve Cooperation, Capitalization of SARAGNA's actions in the Three-Year Plan 2 – Period 2011-2013, Food and Economic Security Domain. Available on: https://louvaincooperation.org/sites/default/files/2018-10/17%20Capitalisation%20-%20Mise%20en%20place%20CLD%20et%20structuration%20communautaire.pdf