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Assessment of livelihood vulnerability of indigenous people and local communities face to climate change in a forest conserved landscape: south eastern Cameroon

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DEDICATION

To

My father KAMDEM Rene of late

And

My mother NGUIAM Martine Solange

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LIST OF ABBREVIATIONS

ILO	:	International Labour Organisation
IPLC	:	Indigenous peoples and local communities
IPCC		Intergovernmental Panel on Climate Change
LVICC	:	Livelihood Vulnerability Index to Climate Change
MCA	:	Multiple Correlation Analyses
NTFP	:	Non-Timber Forest Product
PACL	:	Peuples Autochtones et Communautés Local
PCA	:	Principal Component Analysis
PCD	:	Plan Communal de Développement de Ngoyla
SDG	:	Sustainable Development Goal
TEK	:	Traditional Ethnobotanical Knowledge
UNFCCC	:	United Nations Framework Convention on Climate Change
WWF	:	World Wide Fund

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ABSTRACT

The livelihoods of Indigenous people and Local communities are at a critical juncture due to the intensifying effects of climate impact drivers. However, there is still a growing debate on how vulnerability to climate change shapes indigenous people's and local communities' livelihoods in a forest-conserved landscape. This study was carried out to examine the livelihood vulnerability of Indigenous people and local communities to climate change in East Cameroon. Data were collected through a semi structure questionnaire and field observation in five villages of the Ngoyla subdivision with each community containing the Baka and Bantu group.. The result revealed that human, physical, natural, financial and social assets differ significantly between the Baka and Bantu groups. These include education ($p<0.001$) and years of farming experience ($p=0.002$); communication tools ($p<0.001$) and type of house ($p<0.004$); farm size ($p<0.001$), practice of agriculture ($p=0.005$) and fishing ($p=0.039$); access to credit and savings ($p=0.003$); social aids ($p<0.001$) respectively. The Livelihood Vulnerability Index to Climate Change of the IPLC in Ngoyla is high (0.7) with high exposure (0.5) and a low adaptive capacity (0.3). The MCA illustrated three clusters of groups on the study side, first those who are not involved in NTFP domestication, and reforestation activities and do not partake in decision-making. Then a cluster of individuals with access to information and training in natural resources. Lastly, a cluster of individuals highly engaged in ecological practices. There is therefore the need to strengthen environmental management, social inclusion and empowerment in terms of livelihood opportunities.

Keywords: Adaptation responses, Climate change, Forest management, Indigenous people and local communities, Livelihood assets, livelihood vulnerability

RESUME

Les moyens de subsistance des populations autochtones et des communautés locales se trouvent à un stade critique en raison de l'intensification des effets climatiques. Cependant, le débat sur la manière dont la vulnérabilité au changement climatique influe sur les moyens de subsistance des populations autochtones et des communautés locales ne cesse de s'intensifier. Cette étude a été réalisée pour examiner la vulnérabilité des moyens de subsistance des peuples autochtones et des communautés locales face au changement climatique dans l'est du Cameroun. Les données ont été collectées à travers un questionnaire semi structuré et l'observation sur le terrain dans cinq villages dans l'arrondissement Ngoyla, chaque communauté comprenant des Baka et des Bantous. Les résultats ont révélé que les capitaux humains, physiques, naturels, financiers et sociaux diffèrent de manière significative entre les groupes Baka et Bantu. Il s'agit notamment de l'éducation ($p<0,001$) et des années d'expérience agricole ($p=0,002$) ; des outils de communication ($p<0,001$) et du type de maison ($p<0,004$) ; de la taille de l'exploitation ($p<0,001$), de la pratique de l'agriculture ($p=0,005$) et de la pêche ($p=0,039$) ; de l'accès au crédit et à l'épargne ($p=0,003$) ; et des aides sociales ($p<0,001$), respectivement. L'indice de vulnérabilité des moyens de subsistance au changement climatique de PACL de Ngoyla est élevé (0,7) avec une forte exposition (0,5) et une faible capacité d'adaptation (0,3). L'ACM a mis en évidence trois groupes du côté de l'étude, d'abord ceux qui ne sont pas impliqués dans la domestication des PFNL et les activités de reboisement et qui ne participent pas à la prise de décision. Ensuite, un groupe d'individus ayant accès à l'information et à la formation sur les ressources naturelles. Enfin, un groupe d'individus très engagés dans les pratiques écologiques. Il est donc nécessaire de renforcer la gestion de l'environnement, l'inclusion sociale et l'autonomisation en termes de moyens de subsistance.

Mots-clés : Réponses d'adaptation, changement climatique, gestion forestière, peuples autochtones et communautés locales, moyens de subsistance, vulnérabilité des moyens de subsistance.

CHAPTER I. GENERALITIES

I.1. Introduction

I.1.1. Background

Cameroon's forest constitutes a substantial component of the Congo basin forests, which is the world's second biggest block of continuous tropical forests after the Amazon. The forest is vital to the rural livelihoods of more than 60 million people (Lhoest et *al.,* 2020). The East region of Cameroon is one of the country's largest regions, representing two-thirds of Cameroon's total forest cover (Nsoh, 2012). This area, known for its ecological and cultural significance, is increasingly threatened by climate change, exacerbating the vulnerabilities of Indigenous People and Local Communities (IPLCs) who depend on forests for subsistence, cultural identity, and income (Anonymous 2015 a).

The sedentarization policy promoted by the government since the 1950s has pushed the nomadic Baka hunter-gatherers to settle near the farmers' villages interacting with local communities (Shiho, 2014; Fa et *al*., 2021). Moreover, the practice of activities highly climate dependent, such as hunting, fishing, farming, and gathering makes their rural livelihood greatly vulnerable to climate change (Jouni et *al*., 2018; Girma et *al.*, 2023). Although climate change is a global problem, its impacts differ across regions, countries, sectors, and communities (Huong et.*al.,* 2018). According to the IPCC Fifth Assessment Report, climate change introduces grave implications for rural areas through a direct toll on rural livelihoods (Quaisrani et *al.*, 2018). Climate change is altering rainfall patterns, increasing temperatures, and driving extreme weather events, which directly impact forest ecosystems and the communities reliant on them (Vosa et *al.*, 2012; Dasgupta et *al.*, 2014; Innocent *et al.*, 2015; Mavhura et *al.*, 2021).

The compounded effects of environmental and socio-economic pressures make it imperative to assess IPLCs' exposure, sensitivity, and adaptive capacity (Kolawole et *al*., 2016; Anonymous, 2022; Ruane et *al.*, 2022). Although the Government of Cameroon and international conservation initiatives have implemented policies such as the REDD+ program to protect the Congo Basin forests, the livelihood sustainability of IPLCs remains a major concern couple to climate change (Egoh et *al.*, 2012; Legese et *al.*, 2016; Lhoest et *al*., 2020; Kumar et *al*., 2021). A comprehensive assessment of livelihood vulnerabilities is essential to bridge this gap, ensuring that conservation efforts are inclusive and enhance the resilience of IPLCs.

I.1.2. Problem statement

Indigenous peoples and local communities (IPLCs) play a vital role in the management and conservation of forest landscapes in the Congo Basin. For centuries, they have been preserving the forest through their traditional practices, which are deeply rooted in their understanding of the forest (Sada et *al.*, 2019). They are among the most vulnerable to climate change as their livelihood activities such as hunting, fishing, gathering and farming are highly climate-dependent (Bauer et *al.*, 2022). These activities are being increasingly threatened by climate impact drivers such as prolonged dryness, erratic rainfall patterns, floods, and increased temperature (Anonymous, 2015 b; Khan et *al*., 2022; Ruane et *al*., 2022). These climate impact drivers have a considerable influence on IPLC livelihood and forest conservation aims in forest management.

However, there is still a growing debate on the extent to which vulnerability to climate change shapes the livelihood of indigenous people and local communities in a forest-conserved landscape in East Cameroon. There is therefore a need to assess the livelihood vulnerability of forest-dependent people to enable practitioners to identify the risks posed by climate change on livelihood and conservation aims and to develop adaptation options targeted at the most vulnerable areas and people. The main question of this study is: What is the livelihood vulnerability to climate change in the forest conservation landscape? Specific research questions include:

- How are livelihood assets and forest management practices interlinked within the IPLC community?
- What is the vulnerability index of forest-based livelihood assets to climate change within the IPLC community?
- What are the existing coping mechanisms used by communities to deal with climate variability?

I.1.3 Objectives

The main objective of the study is to examine the extent of livelihood vulnerability of IPLC to climate change impacts in a forest-conserved landscape of south eastern Cameroon.
To meet this main objective, the study focused on the following specific objectives, to:

- Characterised the livelihood assets and forest management profile of IPLC in the study site;
- Analyse the livelihood vulnerabilities to which their well-being is exposed;

- Identify the adaptation responses among IPLC communities to mitigate climate vulnerability

I.2. Literature review

I.2.1. Definition of key terms

I.2.1.1. Adaptation

Adaptation is the process of adjustment to actual or expected climate and its effects, to moderate harm or exploit beneficial opportunities (Anonymous, 2022). According to the UN, climate change refers to long-term shifts in temperature and weather patterns (Anonymous, 2022).

I.2.1.2. Climate Impact Drivers (CID)

Climatic impact drivers are physical climate system conditions (e.g., means, events, extremes) that affect an element of society or ecosystems. Depending on system tolerance, CIDs and their changes can be detrimental, beneficial, neutral, or a mixture of each across interacting system elements and regions (Anonymous, 2022).

I.2.1.3. Exposure

Exposure is the presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected (Anonymous, 2022).

I.2.1.4. Sensitivity

Sensitivity is the degree or magnitude or extent to which climate variability or climate impact drivers affect a system or species, either negatively or positively (Anonymous, 2022).

I.2.1.5. Vulnerability

Vulnerability is the propensity or predisposition to be adversely affected (Anonymous, 2022). Vulnerability to climate change is also a measure of a system's sensitivity or incapacity to cope with the negative consequences of climatic variability and climate hazards. Thus, vulnerability assessment is a systematic method of determining who and what is being affected by climate change and how/to what extern /in what way (Anonymous, 2021). In order words, it is the process of recognizing, analysing and ranking vulnerabilities in a system (Tiani et *al*., 2015). Meanwhile, vulnerability index is a metric characterising the vulnerability of a system. A climate vulnerability index is typically derived by combining, with or without weighting, several indicators assumed to represent vulnerability (Etwire et *al.*, 2013; Anonymous, 2022).

I.2.1.6. Livelihood

Livelihood: refers to the resources used and the activities undertaken in order for people to live and improve their wellbeing. The entitlements and resources to which individuals have access typically define their livelihoods. Such assets can be categorised as human, social, natural, physical or financial (Anonymous, 2022). Livelihood diversification is the process by which rural families construct a diverse portfolio of activities and social support capabilities to survive and improve their standard of living.

I.2.1.7. Wellbeing

Wellbeing is a state of existence that fulfils various human needs, including material living conditions and quality of life, as well as the ability to pursue one's goals, to thrive and to feel satisfied with one's life (Anonymous, 2022). An Indigenous perspective on well-being is broad and typically incorporates a healthy relationship with the natural world (Sangha et *al*., 2018).

I.2.1.8. Forest conservation

Forest conservation refers to the practice of planting and maintaining forested areas for the benefit and sustainability of future generations (Girma et *al*., 2023). Forest-conserved landscapes are areas of forest that are protected for their biodiversity and other values. These landscapes often provide important livelihood opportunities for IPLCs (Anonymous, 2021).

I.2.1.9. Indigenous People

According to the ILO Convention No169 (Anonymous, 2015 a), IPs are defined based on the description of their historical continuity; territorial connection; and distinct social, economic, cultural and political institutions. Also known as pygmies are hunter-gatherers living in the South eastern equatorial rainforest of Cameroon. Indigenous people are descendants sharing an ancestral tie to the lands and natural resources where they live. United Nations asserted that indigenous people are recognised as being connected to a particular geographical region and having ancestral ties to the original land inhabitants before the development of modern states and borders (Anonymous, 2013). The IP are divided into 02groups namely the Mbororo nomadic pastoralists and the forest peoples. The forest people are subdivided into: the Baka found in the eastern and southern regions of Cameroon which formed the majority with a population estimated between 70 000- 100 000persons; the Bagyéli or Bakola live in south Cameroon particularly in the district of Akam II, Bipindi, Kribi, Campo, Ma'an and Lolodorf with a population estimated between 10 000 and 30 000-persons and lastly, the Bedzang group

with a population less than a thousand found in the central region to the northwest of Mbam in the Ngambe Tikar division (Nsoh, 2012).

The South East region of Cameroon is one of the largest regions of the country representing two-thirds of Cameroon's total forest cover, representing a significant portion of the Congo Forest which has played an important role in defining the history of Indigenous people of the region and their statue (Oishi & Fongnzossie, 2013). Moreover Njounan et *al*. 2012, study reveals that Baka are among one of the Pygmy hunter-gatherer groups who are assumed to be the first people of the Congo Basin tropical forest. That said, of this area, 17 million hectare (approximately 75%) is a dense, closed semi-deciduous tropical rainforest (Anonymous, 2013) very rich in natural resources and biodiversity. Hence Baka people are traditionally nomadic, living from hunting and gathering (Shiho, 2014).), having values that differ from the dominant society in which they live.

I.2.2. Livelihood assets and forest management for forest-dependent people

I.2.2.1. Livelihood assets framework for IPLC

The concept of livelihood assets is central to understanding how communities sustain themselves and respond to external pressures. The Sustainable Livelihoods Framework (SLF) categorises livelihood assets into five types that are human, physical, social, natural and financial capital (Buauer et *al.*, 2022). Studies show that IPLC rely heavily on a combination of these assets particularly natural and social capital due to their deep connection to natural resources and strong community bonds (Zhang et *al.*, 2018).

Livelihood characteristics, such as productive activities and assets, are important factors determining how vulnerable livelihoods are to extreme weather events (Anonymous, 2014). Natural resources provide essential support for forest-dependent communities. For instance, IP as a hunter-gatherer community engages primarily in activities like hunting, gathering and fishing which are deeply intertwined with their cultural identity and knowledge of the forest (Nkembi et *al.*, 2022). In contrast, the local communities are often more into agricultural activities.

According to research by Shiho (2014), the IP share a mutually dependent relationship with the local community about lifestyle and culture while holding ambivalent attitudes about one another characterized by discrimination and respect, as well as loving-kindness and hate. This is because the sedentarisation policy promoted by the government since the 1950s has made the nomadic Baka hunter-gatherers settle near the farmers' village. Also, the Baka people

are more dependent on the farmer's group economically and politically due to the introduction of outside agencies such as logging companies, tourism businesses, and conservation agencies in the forest creating conflicts of interest between them concerning forest resources.

Most of the benefits issued by these outside agencies have gone to the farmers' group. He thus suggested that the future sustainability of the Baka way of life is influenced by the outside agencies that is they play a decisive role. However, he found the following changes occurring with indigenous people such as: increased sedentarization, changes in livelihood activities; and decreased use of homemade commodities, the use of manufactured household commodities obtained from farmers and merchants had increased, adoption of a cash economy. These changes in the lifestyle of IP are linked to the presence of other ethnic groups, outside agencies and governmental policy (Anonymous, 2015 a).

I.2.2.2. Forest management and IPLC involvement

Forest preservation and conservation provide an essential mitigation measure towards addressing climate variability and change. The importance of forests to the well-being of a large number of poor people especially in tropical developing countries is indisputable and well-recorded (Mohd et *al.,* 2023). In addition, tropical forests are a natural resource pool indispensable to the national development plans and poverty reduction strategies of many developing countries (Nkem et *al.,* 2013). Therefore, managing forest resources is very important for the survival of indigenous people who dwell in or depend on forests (Abas et *al.*, 2022).

The contribution of Indigenous peoples and local communities (IPLCs) to effective biodiversity conservation has gained recognition, particularly since the 2003 World Parks Congress in Durban, South Africa (Dawson et *al*. 2021). Moreover, Kumar et *al.* (2021) work revealed that out of the 17 Sustainable development goals (SDGs), at least 7 goals are associated with traditional ethnobotanical knowledge (TEK) revealing the importance of Indigenous people and the local community in forest management. This is because they possess great knowledge of the usage of plants for various purposes known as traditional ethnobotanical knowledge which is not well documented but transmitted from one generation to another orally and vertically (Mohd et *al.*, 2023). These 7 goals include:

- SDG 1: End poverty;
- SDG 2: Achieve zero hunger and improve the nutritional status of the public;
- SDG 3: Ensure healthy lives and promote well-being for all at all ages;

- SDG 12: Ensure sustainable consumption and production patterns;
- SDG 13: Take urgent action to combat climate change and its impacts;
- SDG 15: Protect, restore, and promote sustainable use of terrestrial ecosystems; sustainably manage forests; combat desertification; and halt and reverse land degradation and halt biodiversity loss;
- SDG 17: Revitalize the global partnership for sustainable development

Involving IPLCs is perceived as important not only because it makes conservation more equitable, but also because it has the potential to produce better biodiversity outcomes or more effective conservation when upheld in wider law and policy (Pemunta, 2018; Dawson et *al.*, 2021; Kumar et *al.*, 2021).

I.2.3. Vulnerability to climate change

Climate change and its impacts add another dimension by introducing risks that further complicate livelihood activities (Salik et *al.*, 2015; Dendir &Simane, 2019). These impacts may be presented through either a slow onset of climate/environmental changes affecting rural livelihoods, or through extreme events such as (amongst others) droughts, floods, and heat waves (Dasgupta et *al*., 2014; Elum et *al*., 2017). Firstly, studies carried out by Innocent et *al.* (2015) in the Bamenda highlands reveal a decreased rainfall and water supply, upward change and movement of certain plant species and a rise in the incidence of diseases on crops are major issues faced by farmers due to climate change.

Secondly, increases in temperature, changes in precipitation, higher atmospheric concentrations of carbon dioxide (CO2), and higher nitrogen (N) deposition may change ecosystem structure and function, the most rapidly visible and most significant short-term effects on forest ecosystems will be caused by altered disturbance regimes. For example, wildfires, insect infestations, pulses of erosion and flooding, and drought-induced tree mortality are all expected to increase during the 21st century (Vosa et *al.* 2012).

Thirdly, other direct impacts are largely expressed through the interaction of infectious and vector-borne diseases with temperature and precipitation. Malaria, dengue and cholera, for example, are all highly affected by changes in the seasonal distribution of precipitation, including changes in flood and drought patterns (Vosa et *al.*, 2012; Philip et *al.*, 2014). Although changes in malaria vectors will occur due to the gradual increase in temperature, the incidence of disease is also quite sensitive to changes in precipitation (Philip et *al.*, 2014).

Indirectly, the adverse impacts of climate change on farm-based livelihoods are manifested through shifts in cropping seasons and a loss in agricultural productivity (Anonymous, 2014). This not only translates into loss of income but also exacerbates food insecurity among the rural population. Especially vulnerable are those households who are engaged in subsistence farming. Furthermore, climate extremes resulting in widespread destruction have livelihood consequences that may resonate long after the event has passed. Through loss of lives, property and livelihoods, people lose their human, physical, natural and financial capital which has long-lasting repercussions on income and income-generating means (Gray & Mueller, 2012; Ngwa et *al*., 2015**).** The threats associated with climate change impacts may lock the already marginalised rural population in poverty traps as their livelihoods are exposed to additional risks, thereby perpetuating poverty, deprivation and livelihood insecurity (Anonymous, 2014). In contrast, Vosa et *al.,* (2012) and Luedeling et *al.,* (2013) suggested that climate change effects may well be beneficial in certain ecosystems in others but that climate effects are predominantly negative.

I.2.4. Adaptation responses in forest landscapes

Adaptation strategies among IPLCs are grounded in traditional knowledge and local practices (Sonwa et *al.*, 2012; Billong et *al*., 2020). They use diverse adaptation approaches to cope with environmental changes such as altering hunting and gathering patterns, shifting agricultural practices, involving in decision-making, forest and diversifying income sources (Azumah et *al.*, 2020; Gregorio et *al.*, 2020). For instance, studies have revealed that local communities depend on Indigenous Local knowledge practices, which are maintained through various traditional resource management systems regulated by cultural values and are used as adaptation responses to enhanced livelihood (Ndalio et *al.*, 2020; Schmidt et *al.*, 2021). These include the domestication of wild food and medicinal plants, the use of bio-pesticides, crop rotation and crop diversification (Sharma et *al.*, 2022).

Training and access to information are critical components of adaptation responses in forest landscapes. Training initiatives aim to enhance local knowledge and skills, empowering communities to respond effectively to environmental changes (Vinceti et *al.*, 2020). According to Standurf (2021), training contributes to long-term adaptation as communities are more likely to adopt climate-resilient crops and methods. Access to timely and relevant information is critical for informed decision-making and effective adaptation strategies. Shaibu et *al.*, 2020 highlighted some practices that decrease households' livelihood vulnerabilities to climate change such as refilling, strip cropping, mulching, and land rotation among which he

encouraged the practice of strip cropping on farms and that row planting and use of early maturing varieties had positive significant effects on vulnerability. In addition, some recommended the assistance of the government in providing credit opportunities to farmers in farm-based organisations thus encouraging farmers to join associations and provide backward practices in the treatment of diseases (Huong et *al.*, 2018; Shaibu et *al.*, 2020).

Furthermore, they advised that they should modify their agricultural calendar, make flexible use of all kinds of livelihood capital and diversify their farming systems to better meet current and future risks from climate variability and change (Zhang. et *al.*, 2018; Mavhura et *al.*, 2021).

I.2.5. Description of research area

I.1.1.2. Physical geography

Climate

The sub-division of Ngoyla is influenced by an equatorial climate of the Guinean type, with four seasons of unequal duration that is: long dry season (mid-November to mid-March); short rainy season (mid-March to mid-June); short dry season (mid-June to mid-August); long rainy season (mid-August to mid-November). This climate supports two cropping seasons each year (mid-March to mid-June and mid-August to mid-November) and has an average annual rainfall of 1,577 mm (Anonymous, 2012).

Topography

Due to its proximity to the Dja and Mié rivers, the relief of the Commune of Ngoyla is relatively flat and varied (plains, hills and valleys), with slopes of between 0 and 5%, indicating a low susceptibility to erosion. The average altitude is 625 m (Anonymous, 2012).

Hydrography

The Commune of Ngoyla is watered by the Dja and the Mié, both of which are rich in fish and have a permanent flow. In addition to these rivers, there are several small rivers with permanent or seasonal flow (Anonymous, 2012).

Vegetation Type

The vegetation of Ngoyla is characterised by dense rainforests and swamp forests. This vegetation is rich in commercial species and non-timber forest products (NTFPs). The dominant herbaceous species in the savannah zones are *Pennisetum purpureum, Hyparhénya rufa, Chromolaena odorata*, *Mimosa* sp and numerous grasses. The marshy grasslands are mainly colonised by the *Maranthaceae* and *Zynziberaceae*. To these plant species must be added the

varied range of food crops and perennial crops. Fallow land is colonised mainly by *Musanga cercropiodes*, *Eupatorium* sp and *Chromolaen* (Anonymous, 2012).

II.1.1.3. Human geography

Population

The Ngoyla community has a surface area of 4382 Km^2, with a population of 6000 inhabitants, essentially made up of the Ndjem but equally, we found a high population density of Maka, Nzimbe, Baka, and Bamoun. They have a homogeneous linguistic language. Each village is made up of many lineages, arising from the fusion of many villages. The vulnerable population is made up of orphans, immigrants, handicapped and octogenarians (Anonymous, 2012).

Religion

Three religious groups are identified in the Ngoyla community, which is Presbyterian, Catholic and Muslim. The Muslims are the minority group whereas the majority group consist of Catholics and Presbyterians (Anonymous, 2012).

Socio-economic activities

Table I. Human Activities

Descriptions / Human activity	Characteristics
Agriculture	- It is the main subsistence activity practice via slash and burn. It contributes 80% of the potential economy. - It is practised by almost all men and women, in which 60% of the product goes for consumption and the rest 40% for sales. - It covers cash crops such as cocoa, coffee and palm oil. The food crops include plantain, cassava, groundnut, yam, and maize.
Livestock farming and Fishing	- Livestock is an extensive form and it's very underdeveloped. Characterised by reduced yields with animals roaming freely (goats, sheep, and poultry). It's mainly for self-consumption and operates on a very small scale (goat). - It's the second lucrative activity carried along the Dja and Mbi rivers between May and October. It is a form of artisanal fishing, making use of nets, traps and hooks.
Hunting	It is a traditional activity and a major source of income for households. Hunting products are mainly destined for commercial purposes (70%) as they are sold on-site, either fresh or smoked, by neighbourhood.

Gathering	These non-timber products are mostly sold to middlemen who resell them in major markets. These harvested products include Gnetum leaves, bitter kola, mobali, wild mangoes, djansang, and nuts from the African walnut tree which are important both nutritionally and economically.
Forest exploitation	It is centred on the exploitation of the community forest of Nkondong and the communal forest of the commune. The wood harvested is mainly used for energy (firewood) and construction wood.
Commerce	Small trade is supported by several shops, the largest of which are run by Bamoun and Nordistes selling essential goods. There are about five small liquor stores in the commune and a bus station.
Industry	The agro-industrial sector remains underdeveloped in the commune of Ngoyla and is limited to artisanal processing of agricultural products such as cassava into cassava sticks or couscous.

Source: Anonymous, 2012.

I.2.6. Conceptual framework

The concept of livelihood vulnerability to climate change examines what livelihood assets are exposed, to what extent they are sensitive to climate impact drivers and what are the coping strategies of those exposed to these changes (Anonymous, 2021). Understanding the vulnerability context of IPLC livelihood to climate change is a core aspect when planning forest management and livelihood sustainability. Vulnerability assessment is a function of exposure, sensitivity and adaptive capacity (Anonymous, 2014). Each dimension of vulnerability consists of major components. Thus, the major component for exposure is the presence of social, financial natural, physical, and human assets. Meanwhile the major component of sensitivity is the frequency of climate impact drivers and the level of loss and damages caused to livelihood. The major component for adaptive capacity is the copping strategies as well as skills and knowledge developed by IPLCs.

Each major component is quantified through a set of indicators such as age, gender, trainings, savings, climate impact drivers (irregular rainfall, strong winds, pest and disease incidence), crop protection, knowledge and skill in forest resources management, conflict resolution, forms of trades, income diversification, access to information, trainings in resource management, domestication of NTFP. Hence, leading to adaptation responses such as in decision making and ecological practices.

Decision-making processes are integral to the ability of IPLCs to adapt effectively to climate change. In forest landscapes, decision-making is influenced by a combination of

traditional knowledge, external interventions, and community governance systems (Bele et *al.*, 2014; Sangha et *al.*, 2018). Traditional Knowledge Systems provide locally tailored insights into climate adaptation, such as crop diversification or rotational farming, which have evolved over generations (Cisse et *al.*, 2022). Access to Information and Capacity Building plays a critical role in decision-making (Vinceti et *al.*, 2020). Training programs and awareness campaigns enable IPLCs to understand climate risks and explore sustainable alternatives (Stanturf, 2021). Ecological practices adopted by IPLCs are pivotal to building resilience against climate change. In forest areas, IPLCs engage in practices such as: mixed farming, sustainable harvesting, forest restoration and conservation.

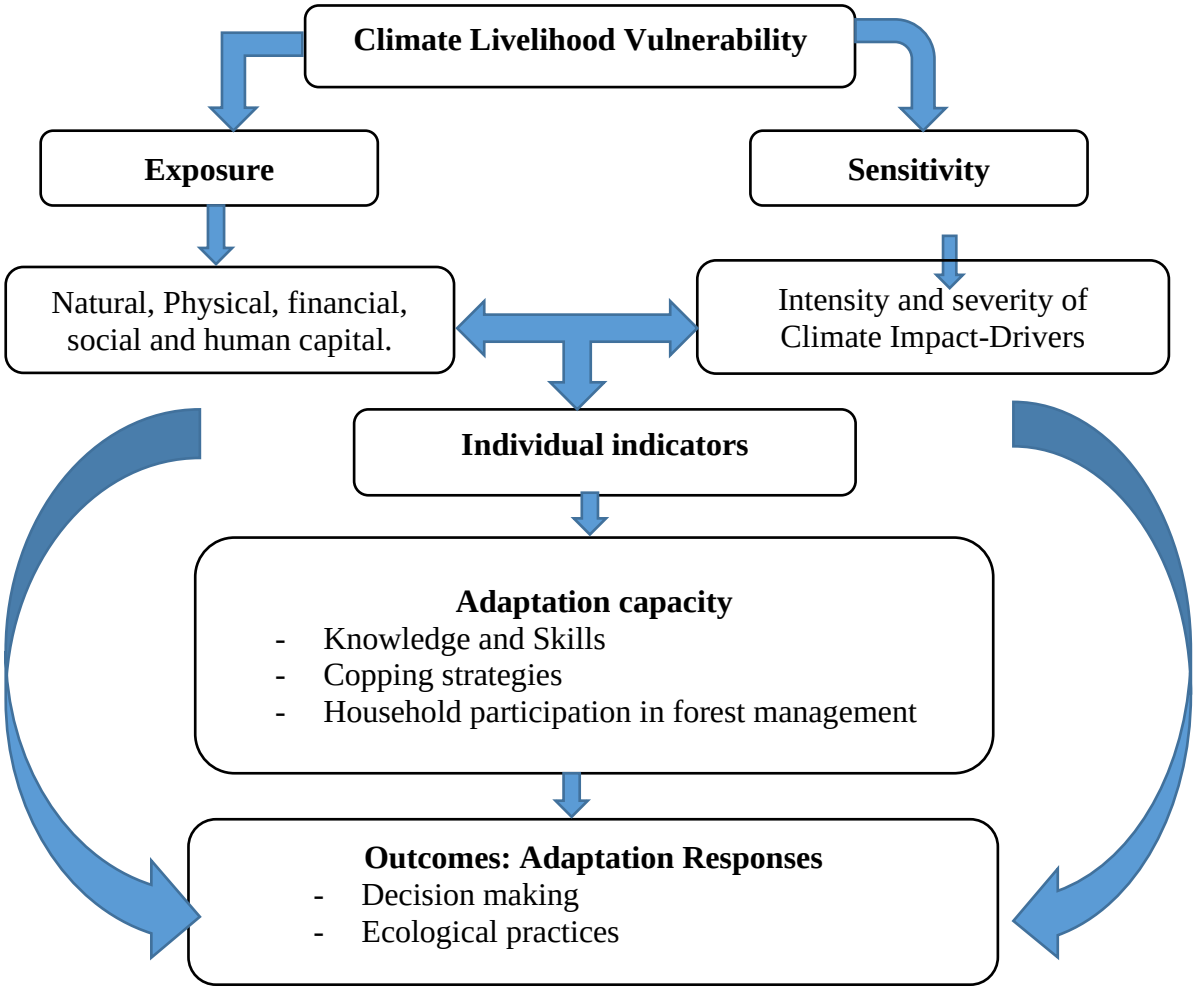

Fig. 1. Conceptual framework flow chat adapted from Sustainable Livelihood Framework (Anonymous, 2000).

CHAPTER II. MATERIAL AND METHODS

II.1. Material

II.1.1. Location of research area

This study was conducted in the Ngoyla subdivision found in the Upper-Nyong Division of the East region of Cameroun (Fig. 2).

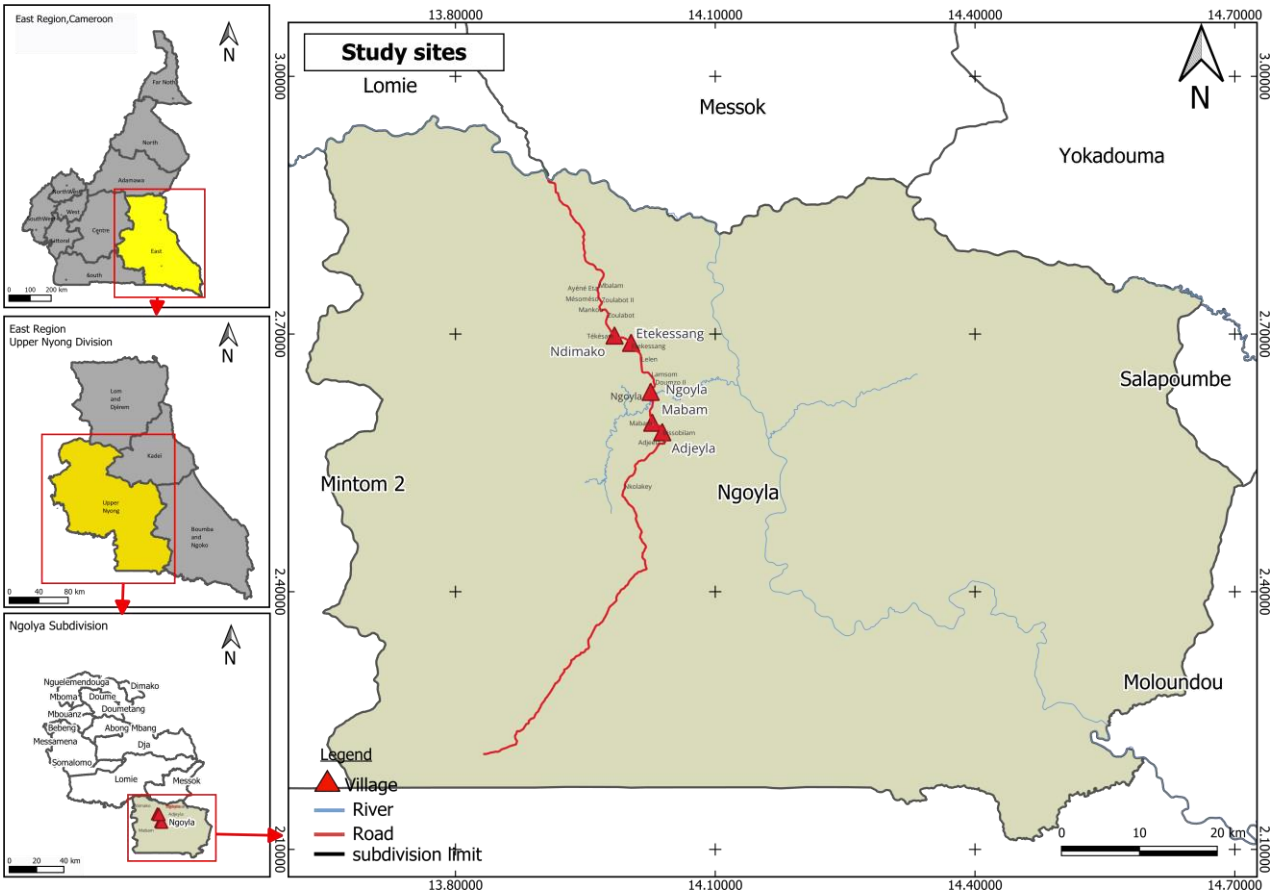

Fig. 2. Map of the study site (PCD, 2012)

II.1.2. Tools

To effectively carry out this study, the following tools were used:

- Questionnaires were used to collect information from the sampled population;
- a GPS (Global Positioning System) was used to record the coordinates of surveyed villages using a Garmin x64 GPS;
- photographs were shot to illustrate the study with the help of a Sony photo camera;
- a notebook was used to collect extra information from discussions.

II.2. Methods

II.2.1. Data collection

II.2.2.1. Secondary data collection

Secondary data was collected from publications, theses, articles, scientific journals and research reports from institutions.

II.2.2.2. Primary data collection

Primary data was collected using key informant interviews, household surveys and direct observation. Key informant interviews were focused on topics such as climate change, challenges faced by livelihood assets and the percentage of forest management budget allocated to IPLC-led activities. Key informants were selected from government and non-governmental organizations, local communities, and administrative bodies. They comprise local chiefs, development agents, and forestry and natural resources management experts (WWF).

Household surveys were collected through semi-structured questionnaires to capture both qualitative and quantitative information from IPLC communities. Open and closed-ended questions were collected and subdivided into 4 sections: (i) Characteristics of livelihood assets attributes used by IPLC that are natural, physical, financial, social and human. Assets (L'Roe et *al*, 2023), (ii) Forest management performance attributes, (iii) Intensity of climate impact drivers and severity in terms of losses per livelihood assets, (iv) Adaptation responses and level of wellbeing to perceive household decision-making (Jouni et *al*., 2018). The household surveys were conducted in February and March 2024 because the dry season facilitates movements to the different villages. Moreover, most households are at home during this period due to a slowdown in seasonal activities. Direct observation was made for house types and the presence of solar panels or not.

Fig. 3. Photo of Household survey in Etekessang village.

II.2.2. Sampling design

Three-stage random sampling techniques were employed to select respondents that is, at the village, population and household levels.

II.2.2.1. Criteria for selecting the villages

A total of five villages were randomly selected namely, Etekessang, Ndimako, Ngoyla village, Mabam and Adjela. Villages were selected based on their population size ≥ 20 inhabitants (Anonymous 2012) and the proximity of the Bantu villages to those of Baka community both in the north and south canton of Ngoyla to enable comparison among them. For the Baka communities, two villages were selected because of their low population density and for statistical representation validity.

II.2.2.2. Choice of population

The studied population were those whose economic activities are directly climate sensitive such as agriculture, hunting, fishing, and gathering (L'Roe et *al*, 2023). Hence this study excluded exogen population residents in the area such as traders and white-collar jobs such as teachers. The PCD 2012 of Ngoyla reveals that agriculture is highly practised by men and women, hunting and fishing are more between men and youth, and gathering of NTFP is highly carried out by the Baka.

II.2.2.3. Criteria for Selecting Household

A systematic random sampling approach was adopted wherein all the households in the different villages had an equal chance of being selected. This probabilistic sampling method was adopted in order to avoid bias and allow for a more robust statistical analysis.

II.2.2.4. Population sampling size

A total of 60 households were interviewed from villages having a population size ranging from ≥ 20 inhabitants and bigger ones with ≥ 200 inhabitants.

Table II. Population sample size.

Number / Villages	Household size	Total
Etekessang	17	60 household
Ndimako	8	
Ngoyla village	12	
Mabam	17	
Adjela	6	

II.2.3. Data analysis

Data collected was analysed using Excel, SPSS 27.0, and Jamovi software

II.2.3.1. Characterised the livelihood assets and forest management involvement

To characterise the livelihood assets between the Baka and Bantu, descriptive statistics were employed to reveal the percentage distribution, means, standard deviation, minimum, and maximum. In addition, independent sample χ^2 Tests, the z-test difference in 2 proportions, and Welch's test were used to see the statistical difference between the Baka and Bantu groups. The set of variables consisted of Human assets such as age, gender, education, household size, and labour availability (Yego et *al*, 2021); Natural assets such as the practice of agriculture, hunting, fishing, collection of NTFPs, and farm size (Senganimalunje et *al*., 2020). Physical assets among which working equipment, type of house, communication tool, and energy source, (Awazi et *al*., 2022); Financial assets such as access to credit, number of wage-earning activities, and savings (Khan et *al*., 2022). Social assets include membership in any local association, tontine member and social aids, and involvement in forest management committees (Girma et *al*., 2023). Moreover, binary logistic regression was used to predict the likelihood of the involvement of IPLC in forest management (binary dependent variable) based on livelihood assets (predictor variables). These statistics provide a foundational understanding of the data, allowing us to identify patterns and trends for further exploration.

II.2.3.2. Livelihood Vulnerability Assessment

This study developed a Livelihood Vulnerability Index to Climate Change (LVICC) to achieve specific objective 2. The choice to design the LVICC was based on studies that have used similar methods to measure livelihood vulnerability in different systems (Zhang et *al*., 2018; Bauer et *al*., 2022). The following steps were used in the construction of this index (i) Selection of indicators, (ii) Data Normalisation, (iii) Aggregation (iv) Multivariate analysis (v) Presentation and visualisation

(i) Selection of indicators

Forest-based livelihood assets (Bauer et *al*., 2022; L'Roe et *al*., 2023), Climate impact drivers (Ngwa et *al*., 2015; Dechassa et *al*., 2016; Mavhura et *al*., 2021; Ruane et *al*., 2022) and adaptive responses frameworks for assessment constituted the bases for the selection of indicators (Salik et *al*., 2015; Girma et *al*., 2023). These indicators were sub-grouped and classified under the vulnerability dimension that is: exposure which reflects what or who is exposed; sensitivity which is the frequency and severity of climate impact drivers and adaptive

capacities which is the adjustments made by IPLC to minimise or reduce the harm of these climate impact drivers (Table III).

Table III. Selection of indicators.

Major Components \ **Indicators**		**Link with Vulnerability dimension**	**Appreciation**
Vulnerability Dimension: Exposure			
Human capital	Gender	Females are more exposed than male	Dummy variable; 0=Male, 1= Female
	Ethnic group	The ethnic group that solely depends on forest resources has higher exposure	Dummy variable 0=Bantu 1=Baka,
	Education	Exposure decreases with a higher education level	1=Tertiary, 2=secondary, 3=Primary, 4= Non formal
	Training	Exposure decreases with training	Dummy variable; 1=No, 0= Yes
	Family size	Exposure increases with family size	Number
	Labour availability	Exposure decreases with an increased number of farm labour	Number
	Health state	Exposure increases with a poor health state	Likert scale
	Farming experience	Exposure decreases with increased years of farming experience	Numbers
Physical assets	Communication tools	Exposure decreases with effective communication tools	1=Internet, 2=telephone, 3=radio, 4=mouth to mouth
	Type of house	Exposure decreases with adapted house	1=Concrete block, 2=Earth brick, 3=Woodplanck, 4=Clay
	Energy source	Exposure decreases with the availability of electricity	1=Electricity, 2=Solar lamps 3=Kerosene 4=Firewood
	State of farming tools	Exposure decreases with good farming tools	1=Good, 2=Average, 3=Bad
	State of roads	Exposure increases with the bad state of roads	Likert scale
Natural assets	Soil quality	Exposure increases with poor soil quality	Likert scale
	Farm size	Exposure increases with small farm size	Hectares
	Distance to water	Exposure increases with far water distances	Kilometre
	Water quality	Exposure increases with poor water qu*al*ity	1=Good, 2=Average, 3=Bad

Major Components \ Indicators		Link with Vulnerability dimension	Appreciation
	Hunting practices	An individual practicing hunting is less expose	Dummy variable; 1=No, 0= Yes
	Fishing practices	An individual practicing fishing is less expose	Dummy variable; 1=No, 0= Yes
Financial assets	Access to credits	Exposure increases with a low access to credit	1=High, 2=Medium 3=Low
	Saving	Exposure increases with no savings	Dummy variable; 1=No, 0= Yes
Social assets	Member of a group	Exposure decreases when you are a member of a group	Dummy variable; 1=No, 0= Yes
	Social aids	Exposure decreases with high social aids	1=High, 2=Medium 3=Low
	Saving groups	Exposure decreases when you are a member of a group	Dummy variable; 1=No, 0= Yes
Vulnerability Dimension: Sensitivity			
Frequency of climate impact drivers	Irregular rainfall	Sensitivity increase with increased frequency of irregular rainfall	Likert scale
	Prolonged dry spells	Sensitivity increase with increased frequency of prolonged dry spell	Likert scale
	Pest and disease incident	Sensitivity increase with increased frequency of	Likert scale
	Strong winds	Sensitivity increase with increased frequency of strong winds	Likert scale
Level of loss and damages as a result of Climate Impact drivers	Flood	Individuals with a high level of damages due to flood are highly sensitive	1= None 2=Negligible 3= Significant
	Prolonged dry spells	Individuals whose livelihood suffers from damages as a result of prolonged dry spell are highly sensitive	
	Pest and disease incident	Increase in damages and loss of livelihood as a result of pest and disease increases an individual sensitivity.	
	Strong winds	Increase in damages and loss as a result of strong winds increases sensitivity	
Vulnerability Dimension: Adaptive capacity			
Knowledge and Skills (Thi et *al*., 2023)	Forest resources	Individuals with knowledge of forest resources have higher adaptability	Likert scale
	Forms of trade	Individuals with different forms of trade have higher adaptability	Likert scale
	Conflict resolution	Individuals with skills in conflict resolution have high adaptability	Likert scale
	Forest law	Individuals with knowledge of forest law have higher adaptability	Likert scale
	Income diversification	Farmers with numerous sources of income have high adaptability	Likert scale
	Crop protection	Individuals with knowledge of crop protection have high adaptability	Likert scale

Major Components \ Indicators		Link with Vulnerability dimension	Appreciation
	Adaptation to climate change	Individuals with knowledge of adaptation to climate variability techniques have higher adaptability	Likert scale
	Access to information	Adaptability increases with access to information	Dummy variable; 0=No, 1= Yes
Coping strategies	Reforestation	Individuals who are involved in reforestation have a higher adaptability	Dummy variable; 0=No, 1= Yes
	Domestication of NTFPs	Individuals who practice NTFP domestication have a higher adaptability	Dummy variable; 0=No, 1= Yes
	Training in natural resource management	Individuals who are trained to manage natural resources have a higher adaptability	Dummy variable; 0=No, 1= Yes

(ii) Normalisation

After the selection of indicators, data normalisation was done by Min-Max normalization to develop an Indicator score (I_{score}). The score value ranges between 0 (least vulnerable) to 1 (most vulnerable).

$$\text{Iscore} = \frac{Ii - Imin}{\text{Imax} - \text{Imin}}$$

The quantification of the variables is useful because it makes it possible to analyse information collected using methods which is useful for the identification of patterns and potential contributing factors behind them.

(iii) Aggregation

The formula of Hahn et *al*. (2009) was used to obtain a forest-based livelihood index of the contributing factors. For calculating the value of each major component, Equation (1) was used:

$$Mi = \frac{\sum_{i=1}^{n} Iscore}{n}$$

Where M_i is the major component, n is the number of indicators, I_{score} is the indicators score

Once the average values were determined for each of the 9 major components, Equation (2) was used for calculating the vulnerability dimension index:

$$Dv = \frac{\sum_{i=1}^{n} Mi}{n}$$

where D_v is the IPCC-defined dimensions of vulnerability (exposure, sensitivity and adaptive capacity), M_i is the major component; n is the number of major components under each dimension. These three dimensions were finally merged to generate the Livelihood Vulnerability Index to Climate Change (LVICC) by using equation 3 developed by Gehendra (2012) as follows:

$$LVICC = (E \times S)/AC$$

Where LVICC is the vulnerability index, E is the exposure index, S is the sensitivity index and AC is the adaptive capacity index.

(iv) Multivariate analysis

Principal component Analysis (PCA) was used to reduce the dimensionality of data and identify key underlying factors driving vulnerability.

(v) Visualisation

The LVICC interval will be ranked as seen in Table III below as adopted from Fongnzossie et *al*. (2018). A radar diagram will equally be used for data visualisation.

Table IV. Livelihood Vulnerability Index to Climate Change (LVICC) rank.

Index value	**Vulnerability Level**
0.3<	Low vulnerability
0.3-0.6	Medium vulnerability
>0.6	High vulnerability

II.2.3.3. Identify the adaptation responses employed by IPLC communities

Multiple Correspondent Analysis (MCA) biplot was used to identify patterns of level of adaptation strategies among variables such as practice reforestation, training in natural resources, access to information, domestication of NTFPs, crop protection practices and decision making.

CHAPTER III. RESULTS AND DISCUSSION

III.1. Results

III.1.1. Characteristics of livelihood of survey respondents

III.1.1.1. Human assets

III.1.1.1.1. Gender

The result indicates that the majority of respondents in the study for both Bantu and Baka communities were men 59 % and 57 % respectively (Fig. 4). Revealing no statistical differences between the two communities in terms of gender composition.

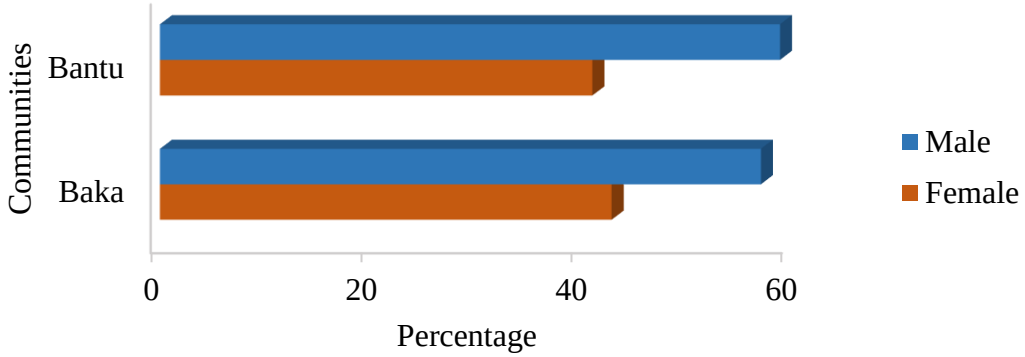

Fig. 4. Gender per community.

III.1.1.1.2. Age

In general, both ethnic groups have a similar age mean of 44±14 years. The violin plot indicates that the Bantu group shows greater variability in age compared to the Baka group which might indicate differences in the age distribution of the population between the two groups (Fig. 5).

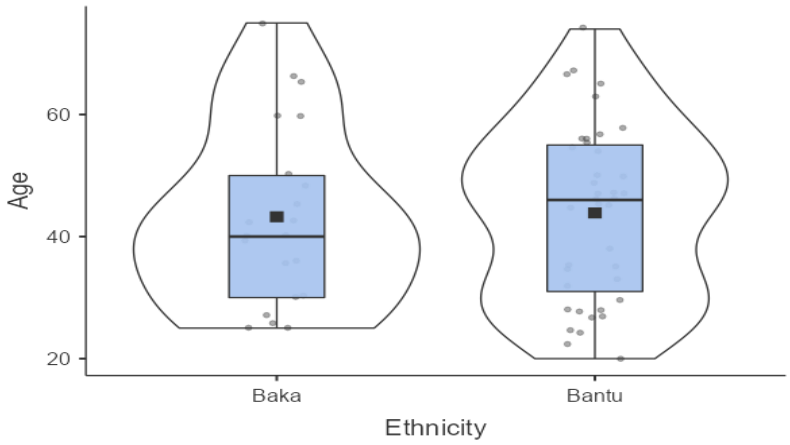

Fig. 5. Age distribution between the Baka and Bantu ethnic groups.

III.1.1.1.3. Education

The percentages show that a large proportion of Baka individuals have non-formal education (76 %) while Bantu individuals are more represented in secondary education (49 %) and some have attained University education (5 %). The p-value (<0.001) indicates that there is a statistically significant difference in education levels between Baka and Bantu ethnic groups (Table V).

Table V. Education level.

Ethnicity / Education	Baka	Bantu	χ^2 Tests			
Non formal (%)	76	23		Value	df	**P**
Primary (%)	24	23	χ^2	20.6	3	**< .001**
Secondary (%)	0	49				
University (%)	0	5				
Total (%)	100	100				

III.1.1.1.4. Family size

The descriptive statistics reveal that the mean family size of Baka is 5.9±2.1 meanwhile the mean family size of Bantu is 8.5±4.9 showing greater variability (Table VI).

Table VI. Family size distribution among Baka and Bantu groups.

Family size / Ethnicity	Mean	Standard deviation	Minimum	Maximum
Baka	5.9	2.1	3	10
Bantu	8.5	4.9	2	24

III.1.1.1.5. Years of farming

The results show that the Baka group has a mean farming experience of 3.7±1.9 years compared to the Bantu group with 12.1±10.9 years. The p-value of 0.002 indicates a statistically significant difference in farming years between the Baka and Bantu groups, with the Bantu group having significantly more years of farming experience than the Baka (Table VII).

Table VII. Farming experience

Farming years / Ethnicity	Mean	Standard deviation	Minimum	Maximum	Statistic		df	**P**
Baka	3.65	1.9	1	8	Student's t	-3.18[a]	54	**0.002**
Bantu	12.1	10.9	2	50				

III.1.1.1.6. Health state

The result shows that a higher percentage of the Baka group consider their health state good (90 %) compared to the Bantu group. Since the p-value is 0.008, this indicates a statistically significant difference in health state percentages between these two groups (Table VIII).

Table VIII. Perception of state of health.

Ethnicity / Health state	Baka	Bantu	χ^2 Tests			
Bad (%)	0	18		Value	df	P
Good (%)	90	51	χ^2	9.64	2	0.008
Worst (%)	10	31				

III.1.1.2. Physical assets

III.1.1.2.1. Communication tools

The result shows that the Bantu used telephones (51 %) followed by 21 % mouth to mouth, whereas the Baka relied more on the traditional communication tool, which is mouth-to-mouth, with 71 % and 24 % using radio. Moreover, the p-value (<0.001) indicates statistical differences between the Baka and Bantu groups regarding the use of communication tools (Table IX).

Table IX. Type of communication tools used.

Ethnicity / Communication tool	Baka	Bantu	χ^2 Tests			
Mouth to mouth (%)	71	21		Value	df	**P**
Internet (%)	0	8	χ^2	23.1	4	**< .001**
Radio (%)	24	10				
Telephone (%)	5	51				
Television (%)	0	10				

III.1.1.2.2. Energy sources

The result shows that solar lamps are the most common energy source across both ethnic groups used by approximately 71 % of users in each group. Firewood usage is higher among Baka (29 %) than Bantu (18 %) whereas solar panel usage is only recorded among the Bantu (10 %). This data suggests that while both groups use solar lamps predominantly, the Baka have limited access to solar panels compared to the Bantu (Fig. 6).

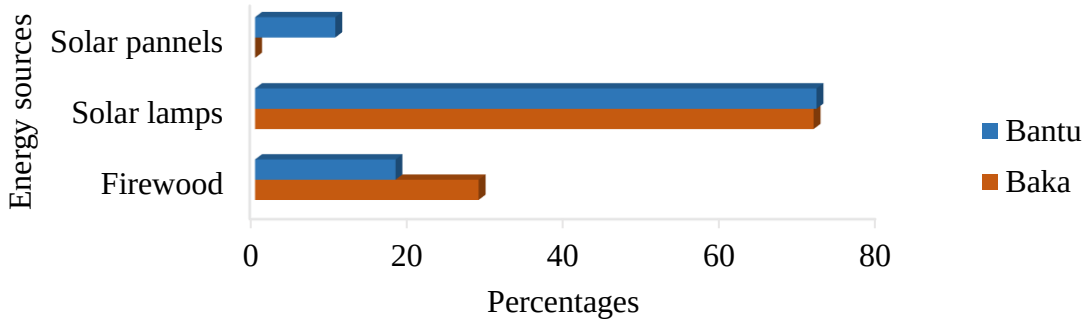

Fig. 6. Use of energy among the IPLC.

III.1.1.2.3. Type of houses

The findings reveal that clay house is the dominant form of housing for both the Baka (52 %) and the Bantu (69 %) meanwhile earth brick house is high for the Baka (48 %) compared to the Bantu (10 %). However, concrete block and wood plank houses were only recorded among the Bantu with 8 % and 13 % respectively. The p-value ($p<0.004$) reveals that the distribution of housing types differs significantly between the Baka and Bantu ethnic groups (Table X). This may suggest cultural, socio-economic or environmental factors influencing the type of houses within each community.

Table X. Percentage distribution of housing type among the IPLC.

Ethnicity / Type of house	Baka	Bantu	χ^2 Tests			
Clay (%)	52	69		Value	df	**p**
Concrete block (%)	0	8	χ^2	13.1	3	< **0.004**
Earth brick (%)	48	10				
Woodplanck (%)	0	13				

III.1.1.2.4. State of working equipment

In general, most of the respondents reply that their working equipment is averagely good (54 %) with 25 % saying that it is bad (Fig. 7). This data suggests that the potential for optimal productivity is average.

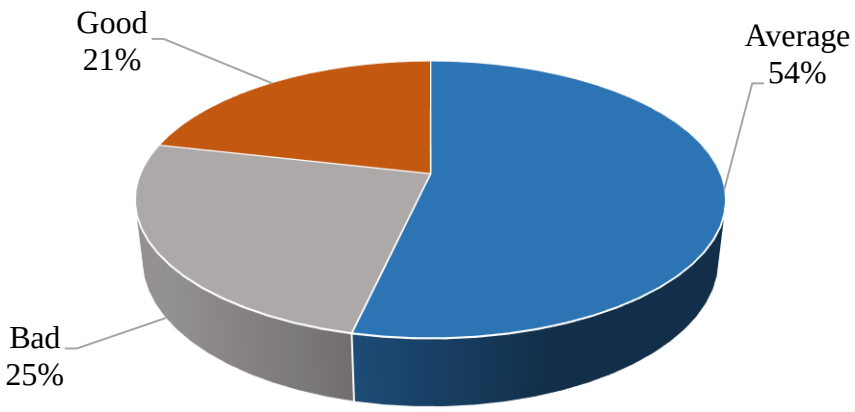

Fig. 7. State of working equipment.

III.1.1.3. Natural assets

III.1.1.3.1. Practice of agriculture

The Bantu group has a higher participation rate, reaching 100 % involvement compared to the Baka group. The p-value of 0.005 indicates a statistically significant difference in the percentage of Baka and Bantu individuals involved in agriculture (Table XI).

Table XI. Percentages of those practising agriculture.

Ethnicity / Agriculture	Baka	Bantu	z test difference in 2 proportions		
No (%)	19	0	Value	df	p
Yes (%)	81	100	2.82		0.005

III.1.1.3.2. Farm size

The result shows that the Baka group has a smaller mean farm size (0.024±0.60 ha) compared to the Bantu group (2.58±2.86 ha). The Welch's t-test ($p<0.001$) indicates a statistically significant difference in farm size between the two groups (Table XII).

Table XII. Farm size.

Farm size / Ethnicity	Mean	Standard deviation	Welch's t		
Baka	0.024	0.060	Statistic	df	p
Bantu	2.58	2.86	-5.6	38.1	<.001

III.1.1.3.3. Soil quality

Soil quality ratings vary significantly between the two groups with the Bantu group showing higher percentages for good soil quality (56 %) and fewer cases of very good (38 %) than the Baka group with 18 % and 82 % respectively. The Mantel-Haenszel tests (p-value of 0.003) indicate statistical differences in how Baka and Bantu groups rate soil quality (Table XIII).

Table XIII. Percentage perception of soil quality.

Ethnicity / Soil quality	Baka	Bantu	Mantel-Haenszel Test for Trend		
Fairly good (%)	0	5	χ^2	df	p
Good (%)	18	56	8.7	1	0.003
Very good (%)	82	38			

III.1.1.3.4. Practice of hunting

The result indicates high participation in hunting within the Baka group with a majority (70 %) involved in hunting activities compared to the Bantu group (51 %). This data shows that hunting may be more integral to the lifestyle or cultural practices of the Baka group, while it appears to be less dominant but still significant among the Bantu (Fig. 8).

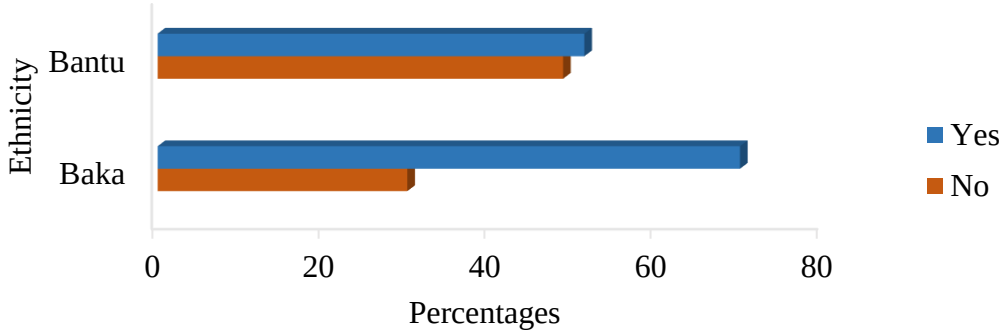

Fig. 8. Participation in hunting activities.

III.1.1.3.5. Practice of fishing

This result shows that all Baka individuals practice fishing (100 %) compared to the Bantu group with 82 % also engaging in fishing. The statistical differences (p=0.039) among these ethnic groups reflect cultural, environmental and economic differences in reliance on fishing activities (Table XIV).

Table XIV. Percentage of those practising fishing.

Ethnicity / Fishing	Baka	Bantu	χ^2 Tests			
No (%)	0	18		Value	Df	P
Yes (%)	100	82	χ^2	4.27	1	0.039

III.1.1.4. Financial assets

III.1.1.4.1. Access to credit

The Baka group has significantly lower access to credits (100 %) compared to the Bantu (59 %) who have more access at a medium level (38 %) The test (p-value=0.003) indicates a significant disparity in access to credit between the Baka and Bantu groups (Table XV).

Table XV. Level of access to credit.

Ethnicity / Access to credit	Baka	Bantu	χ^2 Tests			
Low (%)	100	59		Value	df	p
Medium (%)	0	38	χ^2	11.7	2	0.003
High (%)	0	3				

III.1.1.4.2. Savings

The result shows that among the Baka group, only 29 % claim to practice saving but 71 % don't have savings compared to the Bantu group where 69 % have savings. The p-value (0.003) indicates that the likelihood of saving differs significantly between the Baka and Bantu groups (Table XVI).

Table XVI. Percentage of those practising saving.

Ethnicity / Savings	Baka	Bantu	χ^2 Tests			
No (%)	71	31		Value	df	p
Yes (%)	29	69	χ^2	9.12	1	0.003

III.1.1.5. Social assets

III.1.1.5.1. Tontine members

The results show that both ethnic groups are involved in tontine however, it is more common in the Bantu group with 72 % compared to the Baka group with 53 % (Fig. 9).

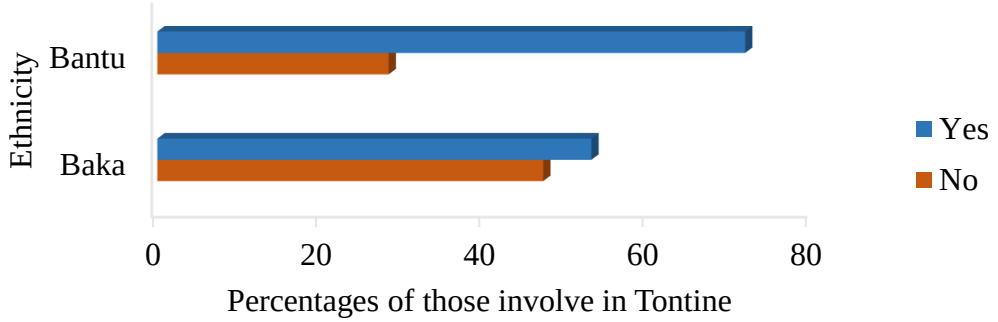

Fig. 9. Percentage of those involve in tontine.

III.1.1.5.2. Level of social aid

The result reveals that the level of social aid is high for the Baka group (52 %) compared to the Bantu (3 %). The p-value (<0.001) indicates that there is a statistical difference between the Baka and Bantu regarding the level of social aid (Table XVII).

Table XVII. Level of social aid

Ethnicity / Social aids	Baka	Bantu	χ^2 Tests			
High (%)	52	3		Value	df	p
Low (%)	38	44	χ^2	24	2	<.001
Medium (%)	10	54				

III.1.1.5.3. Member of an association

The findings show that for the Bantu and Baka groups, respondents involved in associations are higher with 51 % and 59 % respectively (Fig. 10).

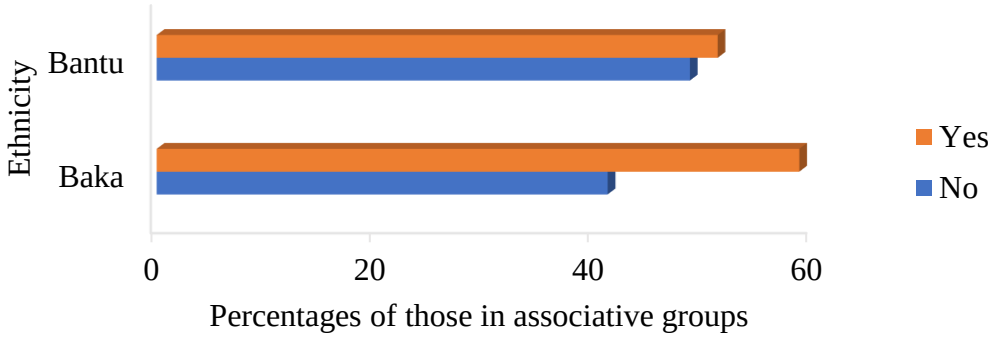

Fig. 10. Member of an association.

III.1.1.6. Involvement in forest management committees

For both ethnic groups, the percentage of individuals involved in forest management is higher than those not involved. However, there is a slightly higher level of involvement among the Bantu (56 %) compared to the Baka (52 %) (Fig. 11).

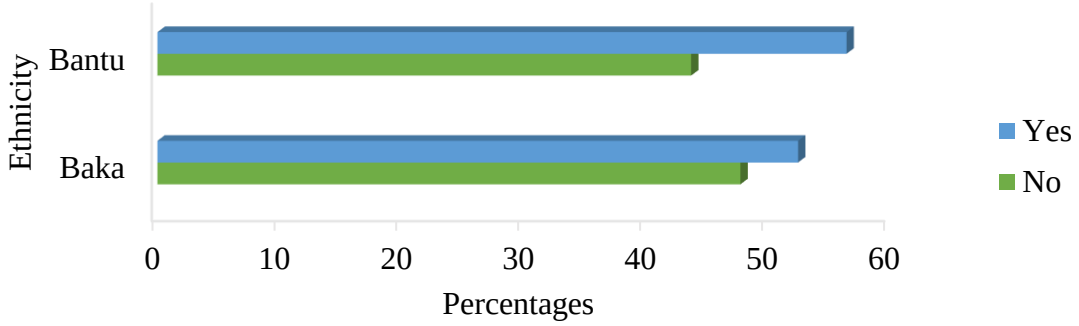

Fig. 11. Involvement in forest management committees.

III.1.1.7. Relationship between livelihood assets and involvement in forest management

The logistic regression reveals that ethnicity ($p=0.001$), education ($p<0.001$), access to credit ($p<0.001$), type of house ($p<0.001$), energy sources ($p<0.001$), training ($p<0.001$), social aids ($p<0.001$), hunting ($p<0.001$), fishing ($p<0.001$) and member of association ($p=0.004$) contribute significantly to predicting the outcome of forest management involvement among the IPLC. In contrast, variables like Gender, communication tools and tontine members are not significant predictors (Table XVIII).

Table XVIII. Binary logistic regression between livelihood assets (predictors) and involvement in forest

Predictor	Omnibus Likelihood Ratio Tests		
	χ^2	df	p
Gender	-6.73e−9	1	1
Ethnicity	10.8	1	0.001
Education	17.9	3	<.001
Communication tool	8.04E-09	4	1
Access to credit	21.8	1	<.001
Type of house	21.8	3	<.001
Energy source	21.9	2	<.001
Training	20.8	1	<.001
Social aids	20.1	1	<.001
Tontine member	3.81E-10	1	1
Hunting	16.5	1	<.001
Fishing	16.5	1	<.001
Member of an association	8.32	1	0.004

III.1.2. Vulnerability of livelihood to climate change

III.1.2.1. Exposure

The result shows that the physical (0.6) and financial assets (0.6) of the Baka group are more exposed to climate change contrary to the Bantu group whose natural (0.7) and social assets (0.5) are more exposed. However, both groups show similar exposure at the level of their human assets (0.4) to climate change (Fig. 12).

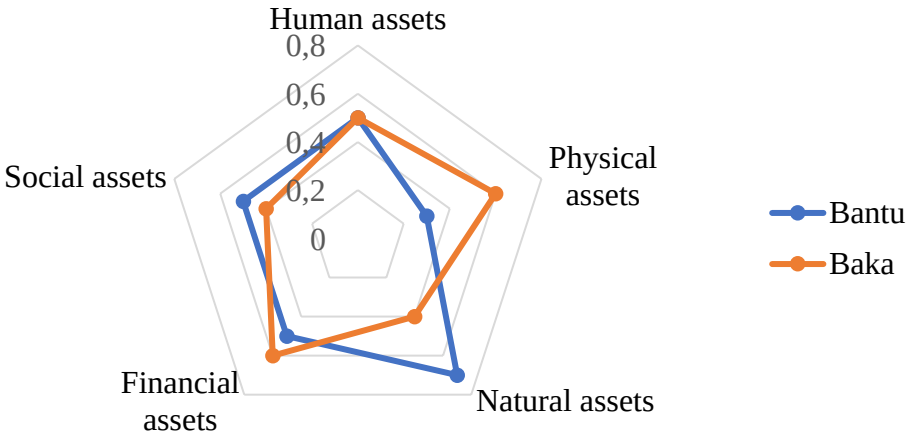

Fig. 12. Score of Exposure's major component.

III.1.2.2. Sensitivity

The result highlights a slight difference in climate change sensitivity between the Baka and Bantu groups. The Baka slightly perceive a higher frequency of climate-impact drivers (0.5) compared to the Bantu group (0.4). Likewise, the Baka experience greater loss and damages (0.6) from climate events compared to the Bantu with a score of 0.5 (Fig. 13).

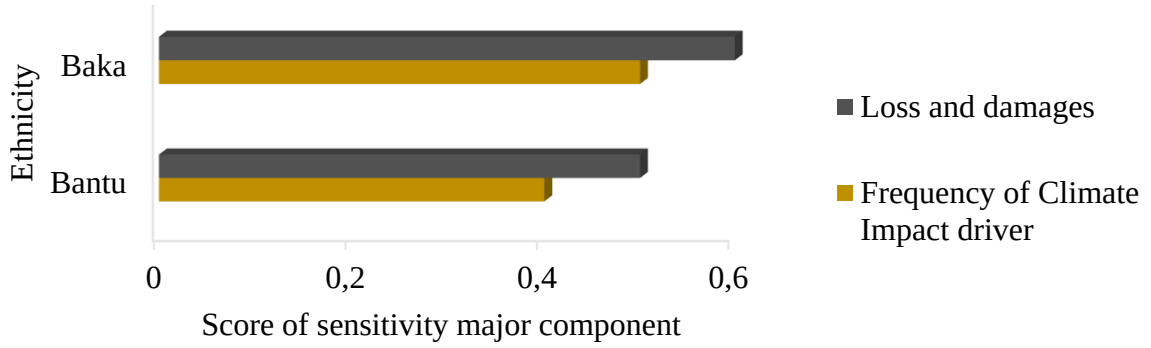

Fig. 13. Scores of sensitivity major component.

III.1.2.3. Adaptive Capacity

The result shows that both the Baka and Bantu groups have similar coping strategies scores (0.4) to climate change impacts. However, the Bantu group has a slightly higher score in knowledge and skill (0.3) compared to the Baka group (0.2). This indicates that the Bantu may possess better technical skills or education levels that can aid in adjusting to climate impacts (Fig. 14).

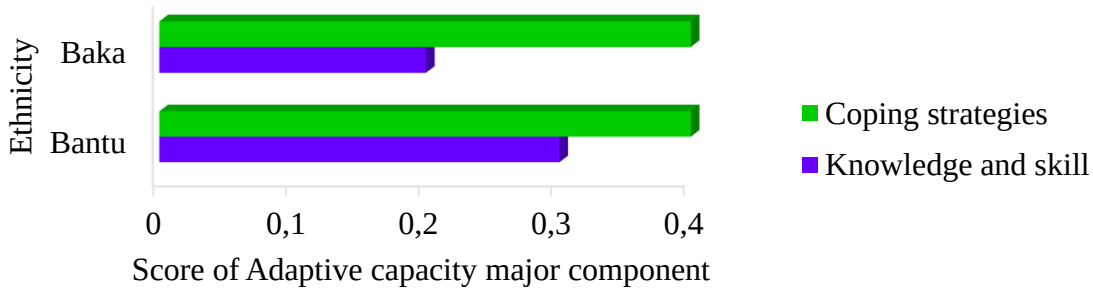

Fig. 14. Score of Adaptive Capacity major component.

III.1.2.5. Livelihood Vulnerability Index to Climate Change

The result indicates that the overall vulnerability of the IPLC in Ngoyla is high (0.7) with high exposure (0.5) and a low adaptive capacity (0.3) (Table XIX).

Table XIX. Livelihood Vulnerability Index to Climate Change.

Index / Vulnerability dimension	Index
Exposure	0.5
Sensitivity	0.4
Adaptive capacity	0.3
Overall Vulnerability in Ngoyla	0.7

III.1.2.4. Key Factors Influencing Vulnerability

The principal component analysis (PCA) reveals that component 1 has high loadings for variables like forest law (0.762), conflict resolution (0.752), practice reforestation (0.726), and domestication of NTFPs (0.845). This component seems to capture factors related to environmental management and conservation practices. This suggests that communities relying heavily on forest resources are more vulnerable if these resources are poorly managed and if they lack sustainable practices to mitigate climate change. Component 2 shows strong loadings for gender (0.780), type of house (0.533), form of trade (0.506), saving (0.664), hunting practices (0.724). This component appears to represent socio-economic factors contributing to vulnerability. However, component 3 is strongly associated with communication tools (0.776), education (0.690), farm size (0.698) and traditional knowledge of forest and its resources (0.451). Component 3 focuses on access to resources, information and traditional knowledge (Table XX).

Table XX. Principal Component Analysis

Component / Indicators	1	2	3
Gender	-0.014	0.78	0.324
Education	0.176	0.19	0.69
Type of house	-0.128	0.533	-0.177
Forest laws	0.762	-0.052	0.161
Conflicts resolution	0.752	0.193	0.078
Forms of trade	0.281	0.506	-0.433
Communication tools	0.126	0.153	0.776
Access to credit	-0.623	-0.358	-0.347
Social aids	-0.642	-0.439	-0.294
Practice reforestation	0.726	0.064	0.051
Farm size in hectares	-0.102	0.002	0.698
Years of agricultural experienced	-0.064	0.155	-0.636
Saving groups	-0.105	-0.657	0.403

Savings	-0.11	-0.664	0.392
Lost as a result of prolonged dryness	0.539	-0.144	-0.169
Lost due to pests and diseases	0.144	0.556	0.074
Hunting practice	-0.076	0.724	0.229
Domestication of NTFPs	0.845	0.02	0.038
Traditional knowledge of forest and its resources	0.451	-0.257	0.565
Extraction Method: Principal Component Analysis.			
Rotation Method: Varimax with Kaiser Normalization.			

III.1.3. Adaption Responses

MCA biplot illustrates clusters highlighting different adaptation strategies and levels of engagement. The red group contains domestication of NTFPs-no, reforestation-no, decision-making-no and adaptation strategies-very low, suggesting that individuals in this area are associated with a lack of decision-making and low engagement in ecological practices. The blue group contains adaptation strategies-average, access to information-yes and training in natural resources-yes. This suggests that individuals in this area have good access to information and it is contributing positively to their adaptation responses. The green group contains categories such as crop protection-average, domestication of NTFPs-yes and reforestation-yes. This indicates individuals who are highly engaged in ecological practices (Fig. 15).

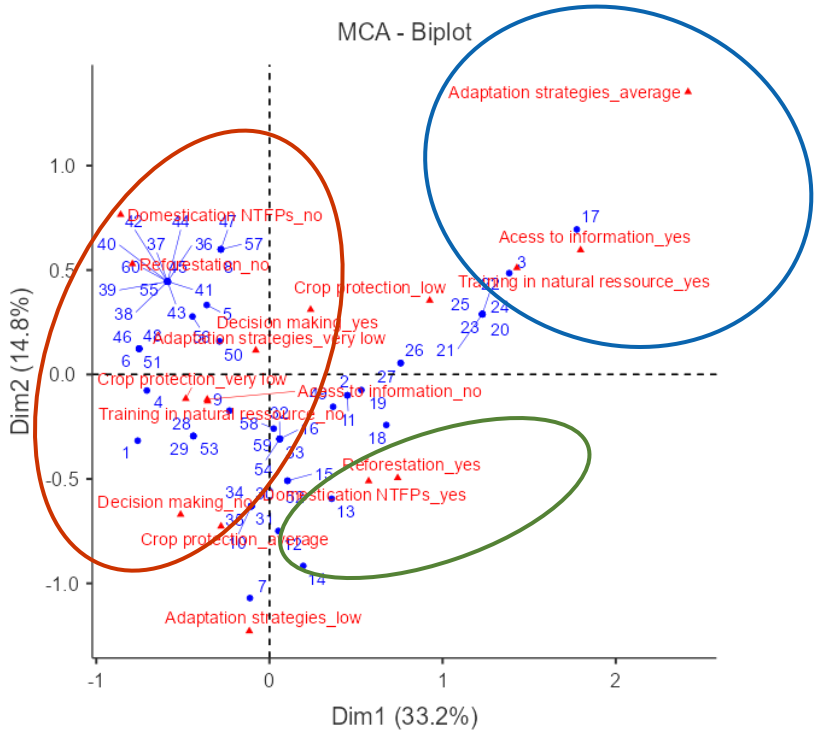

Fig. 15. Multiple Correspondent Analysis.

III.2. Discussion

III.2.1. Livelihood assets and forest management

The study reveals significant disparities in livelihood assets between the Baka and Bantu communities in south eastern Cameroon, highlighting the complex interplay between cultural practices, socio-economic factors, and environmental management (Shiho, 2014; Zhang et *al.*, 2018). Human assets such as education, family size, years of farming and health state differ significantly between the two groups. The reliance on non-formal education within the Baka community suggests a need for culturally sensitive educational programs that integrate traditional knowledge. Larger family sizes among Bantu households can lead to increased labour resources for agricultural activities. Conversely, the Baka, who traditionally engage in a forest dependent life style based on hunting and gathering, had smaller family sizes. Their communal resource-sharing system and reliance on subsistence economies reduce dependence on farming (Nkembi et *al.*, 2022). Regarding access to information and communication, technological tools like mobile phones were more common among the Bantu, enabling better connectivity, access to information and opportunities for market engagement. In contrast, the Baka with limited access to this tool will turn to limit their social mobility and reduce opportunities for economic engagement.

The findings also reveal that the larger farm size within the Bantu group reflects their historical engagement in agriculture as their primary livelihood activity. In contrast, the Baka who traditionally rely on hunting, fishing and gathering, tend to have small farm sizes (Shiho, 2014). Financially, the Bantu have greater access to credit due to their deeper integration into formal economic systems whereas the Baka face barriers to financial services. Moreover, the Bantu exhibit higher savings rates, while the Baka perceive saving as culturally less relevant (Yego et *al.*, 2021). This limited financial resilience makes the Baka more vulnerable to shocks like health emergencies, crop failure and climate variability. Socially, there is an improvement in the social network of the Baka particularly with the increasing participation of Baka-led associations in NTFPs collection. This growing involvement contributes to their socio-economic stability, albeit at a slower pace compared to the Bantu (Ndalio et *al.*, 2020). Overall, the observed differences in livelihood assets between the Baka and Bantu communities underscores their distinct livelihood strategies, socio-economic structure and varying degrees of integration into mainstream economic systems.

The finding showed that ethnicity, education, access to credit, type of house, energy sources, training, social aids, hunting, fishing and member of association contributed

significantly to predicting the outcome of forest management involvement among the IPLC. This suggests that ethnic identity can enhance resource conservation, as cultural ties foster a sense of responsibility toward the forest in Ngoyla. Similar studies showed that Indigenous groups often maintain strong stewardship practices rooted in culture (Yego et *al.,* 2021; Awazi et *al.,* 2022; L'Roe et *al.,* 2023). Conversely, Senganimalunje et *al.* (2020), reported that ethnicity is less influential compared to economic factors that override cultural values.

Moreover, education creates awareness regarding the benefits of sustainable practices and enhances participation in conservation efforts. This is broadly supported by Yego et *al.* (2021), Awazi et *al.* (2022) and L'Roe et *al.* (2023). confirming that education fosters sustainable practices. However, Senganimalunje et *al.* (2020) suggest that the practical impact of education may depend on financial resources, which influence the capacity to act on knowledge gained. Access to credits and membership associations equally emerged as important predictors of forest management involvement among IPLC. This finding suggests that financial resources and community associations are instrumental in empowering communities to diversify livelihood and mobilizing collective conservation efforts, enabling resource sharing and enhancing knowledge dissemination (Yego et *al.,* 2021; Awazi et *al.,* 2022; L'Roe et *al.,* 2023; Mohd et *al.,*2023). However, Senganimalunje et *al.* (2020) suggest that association impact can be limited without robust support, highlighting the need for strong institutional and financial backing.

III.2.2. Vulnerability to climate change

The exposure score showed that most assets exposed to climate change were the physical and financial assets belonging mostly to the Baka group. This is because, the Baka are traditionally hunter-gatherers with a deep reliance on natural sources and have a marginalized position (Shiho, 2014). This finding is in keeping with that of Kumar et *al.,* 2021; Khan et *al.,* 2022 indicating resource dependency is a primary factor in determining exposure factors. The data indicate high exposure levels, implying that without interventions, the well-being of these communities will deteriorate.

Also, the findings in Ngoyla revealed that the Baka group experiences a higher frequency of climate impacts and greater losses, suggesting greater sensitivity. Meanwhile, the Bantu group, with access to agricultural activities, appears less sensitive due to their ability to adopt different food production strategies. These impacts limit agricultural productivity and consequently food security. Similarly, Bauer et *al.* (2022) and L'Roe et *al.* (2023) findings align, indicating that dependency on climate-sensitive resources without alternatives heightens

sensitivity. This high sensitivity in the Baka group is explain by their high practiced of climate sensitive activities (fishing, hunting), limited access to credits and poor state of equipment.

Furthermore, the slightly higher score in coping strategies of adaptive strategies of the Bantu is due to better social integration, and diversified livelihoods, allowing them to better cope with climate challenges. This finding supports Poudel et *al.* (2019) and Zhang et *al.* (2018) who emphasize that limited adaptive capacity is often tied to economic constraints, restricted access to information and resources, and that diversified income sources act as a buffer against climate shocks. The overall high vulnerability indicates that Ngoyla's socio-economic and environmental systems are likely to be significantly impacted by climate change (L'Roe et *al.*, 2023). High vulnerability implies that climate impacts can lead to severe livelihood insecurity and push the households deeper into poverty making it harder for them to invest in resilience or recover from losses.

Moreover, the Principal Component Analyses (PCA) suggest that addressing climate vulnerability in Ngoyla may require strengthening environmental management, enhancing socio-economic support, and improving access to information and agricultural resources. These factors align with Poudel et *al.*, 2019; Khan et *al.*, 2022 who found that economic stability, access to financial services, and educational opportunities are essential for reducing vulnerability. Each of these components provides insights into different ways the community might be vulnerable to climate change impacts, pointing to areas where targeted interventions could reduce vulnerability and improve resilience. Here vulnerability may stem from limited access to modern communication tools, which can restrict access to climate information and adaptive practices. Farm size could reflect the scale of agricultural activities, with smaller farms potentially more vulnerable to extreme weather events. Traditional knowledge about forest resources is critical in climate adaptation but may be insufficient without access to modern resources or information channels.

III.2.3. Adaptation responses

The Multiple Correspondent Analysis results highlighted three adaptation response groups at our study site. Firstly, there is a group of individuals who fall within very low adaptation strategies, these individuals do not domesticate NTFPs, are not involved in reforestation activities and do not partake in decision-making. This result suggests that community members in forest regions are less likely to participate actively in sustainable practices without proper empowerment and decision-making involvement (Thu et *al.*, 2021).

This result can be linked to environmental stewardship in socio-ecological systems where community involvement is essential for effective conservation efforts (Folk et *al.*, 2016).

Secondly, there is a cluster of individuals with access to information and training in natural resources. This finding indicates that individuals with good access to information tend to have positive adaptation responses. Studies have reported that training improves understanding of ecological practices, enabling participants to make informed decisions and adopt sustainable behaviours (Vinceti et *al.*, 2020; Stanturf, 2021). Despite the benefits of training and access to information, socio-cultural barriers such as traditional beliefs and practices may affect the uptake of new knowledge and information (Savari et *al.*, 2020; Oduniyi, 2022). Thus, addressing these barriers is crucial for maximising these benefits and supporting sustainable forest management. However, the content of training programs is crucial to address socio-ecological challenges as it requires a holistic approach to foster sustainable behaviours in diverse community settings.

Thirdly, individuals who are highly engaged in ecological practices such as domestication of NTFPs, reforestation and crop protection turn to increase their adaptation strategies. Likewise, studies reveal that the domestication of medicinal plants and wild food is widely used as a practice of Indigenous and Local Knowledge (Ndalilo et *al.*2020; Stanturf, 2021; Sharma et *al.*, 2022). There is a need to integrate such practices and innovations into relevant policies and climate change adaptation strategies at the local, national and international levels, as a means of enhancing livelihoods (Schmidt et *al.*, 2021). However, Gregorio et *al.* (2020) emphasise that improved human and social capital is crucial for long-term commitment to managing trees.

Hence, groups with low adaptation strategies tend to lack access to information, have low decision-making power and are less involved in ecological practices making them more vulnerable to environmental challenges. Meanwhile, groups with high adaptation strategies have better access to information and engage in practices like NTFP domestication and reforestation.

CHAPTER IV. CONCLUSION AND RECOMMENDATION

IV.1. Conclusion

In conclusion, the study aimed to examine the livelihood vulnerability of IPLC to climate change. To achieve this goal, the livelihood assets and the forest management involvement of IPLC were characterised. The result indicates that there is an overall statistical difference between the Baka and Bantu groups in terms of their livelihood assets. These statistical differences in livelihood between Baka and Bantu highlight the need for differentiated support strategies and enable the development of inclusive policies and programs that build on each community's strength, address disparities and promote sustainable, culturally respectful development. Moreover, Forest management involvement was influenced by education, access to credits, members of association, ethnicity, and energy sources. Regarding livelihood vulnerability, the Livelihood Vulnerability Index to climate change in Ngoyla was high (0.7) with high exposure (0.5) and low adaptive capacity (0.3) showing the financial and physical assets exposed to climate change for Baka and natural and social assets for the Bantu group.

Lastly, results indicated that groups with low adaptation strategies tend to lack access to information, have low decision-making power and are less involved in ecological practices making them more vulnerable to environmental challenges. Meanwhile, groups with high adaptation strategies have better access to information and engage in practices like NTFP domestication and reforestation. There is therefore a need to enhance their socio-economic and environmental system for the wellbeing of the society as a whole.

IV.2. Recommendation

Arising from the findings, the following recommendations could be made at the 04 level:

- At the household level there should be enhancement of diversification and access to microfinance;
- At the research level, more research should be conducted on local adaptation practices and publish case studies on vulnerability and adaptation strategies;
- At the community level, there is a need to organise Climate Education and skill-building workshops and build community savings and insurance groups;
- At the policy level, there is a need to promote the integration of IPLC concerns into National Adaptation Plans

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APPENDIXES

Appendix 1. Authorisation obtained from Divisional Officer of Ngoyla.

REPUBLIQUE DU CAMEROUN
PAIX – TRAVAIL-PATRIE
REGION DE L'EST
DEPARTEMENT DU HAUT-NYONG
ARRONDISSEMENT DE NGOYLA
SOUS-PREFECTURE DE NGOYLA
SECRETARIAT PARTICULIER
N° 02 /AR/B13.07/SP

REPUBLIC OF CAMEROON
PEACE – WORK - FATHERLAND
EAST REGION
UPPER NYONG DIVISION
NGOYLA SUB-DIVISION
SUB-DIDVISION OFFICE
PRIVATE SECRETARIAT

AUTORISATION DE RECHERCHE

Le Sous-prefet de l'Arrondissement de Ngoyla

Soussigné autorise l'étudiante **MAFFOUO KAMDEM Mystere**, étudiante en cycle Master option Botanique-écologie matricule 17J249 à l'université de Yaoundé, CNI N°000673216, à effectuer des réalisations de recherche pour son mémoire sous le thème **« Evaluation de la vulnérabilité des moyens de subsistance des peuples autochtones et des communautés locales face au changement climatique dans la paysage de conservation »** dans les villages de Ngoyla pour un durée d'un mois à compter de la date de signature de la présente autorisation.

En foi de quoi la présente le présente autorisation a été établie et délivrée à l'intéressée pour servir et valoir ce que de droit./-

Ngoyla le 29 FEV 2024
LE SOUS-PREFET

Le Sous-Préfet
Guy Amba Amba
Administrateur Civil

AMPLIATIONS :
-PREFET HN/ABG-MBG (ATCR)
-MAIRE NGOYLA(P.INFO)
-CHEF DEPARTEMENT DBPV/UNI.YDE I(P.INFO)
-CHEFS VILLAGES NGOYLA(P.ACCOMPAGNEMENT)

Appendix 2. Questionnaire

UNIVERSITE DE YAOUNDE I
THE UNIVERSITY OF YAOUNDE I

FACULTE DES SCIENCES
FACULTY OF SCIENCE

DEPARTEMENT DE BIOLOGIE ET PHYSIOLOGIE VEGETALES

DEPARTMENT OF PLANT BIOLOGY

Etude : Evaluation de la vulnérabilité des moyens de subsistance des peoples autochtones et des communautés locales face au changement climatique dans le paysage de conservation : Est Cameroun

Ce questionnaire est utilisé pour collecter des informations à des fins académiques en vue de la préparation d'un mémoire en master à l'Université de Yaoundé 1. Nous vous prions de donner les informations justes. **Nous vous remercions pour votre temps consacrez pour ce travail**.

Identification et validation du questionnaire

Département : _____ Arrondissement : _____

Village : _____ Fiche N° : _____

SECTION A : Caractérisation des moyens de subsistance et de l'attribut de la forêt

A.1. Profile Socioéconomique

1. Sexe du chef de ménage : ☐Homme ☐ Femme
2. Age_____
3. Quelle est votre groupe ethnique : ☐Baka ☐Bantu (précise) _____
4. Niveau de scolarisation : ☐ Non-formel ☐ Primaire ☐ Secondaire ☐ Universitaire
5. Statut matrimonial : ☐Veuve ☐Célibataire ☐ Marié
6. Combien de personnes vivent dans ce ménage ? _____ Enfants moins de 15ans ___
7. Nombre de personnes impliquées dans des activités non agricoles (moto, commerce)_____
8. Type de maison : ☐ En terre battue ☐ Briques de terres ☐ Parpaings ☐ Paille
9. Quelle est la distance entre votre maison et le point d'eau le plus proche et votre domicile ?_____
10. Quels sont vos outils de communication : ☐ Téléphone ☐ Radio ☐ TV ☐ Internet
11. Quelles sont vos sources d'énergie ? Électricité__ Pétrole__ Bois de chauffe__ Plaque soleil__
12. Quels types d'infrastructures physiques sont essentiels pour assurer vos moyens de subsistances ? ☐ Voie d'accès ☐Equipements ☐ Installations électriques
13. avez-vous de la facilité à contracter un prêt d'argent chez les autres membres du village? ☐Elevée ☐Moyenne ☐ Faible
14. Aptitude à recevoir de l'aide en cas de besoin ou d'un problème? ☐Elevée ☐ ☐ Moyenne Faible
15. Mode d'acquisition de terre : ☐ Héritage ☐ Location ☐ Achat

16. Quelle est la qualité de l'eau que vous buvez ? ☐ Bonne ☐ Moyenne ☐ Mauvaise
17. Comment évalueriez-vous votre état de santé généralement ? ☐ Excellent ☐ Très bon ☐ ☐ Bon Moyen ☐ Mauvaise
    Raisons : pas de problème particulier ; mange bien, trop de maladie, etc
18. Au cours des 12 derniers mois, avez-vous eu accès à des services de soins de santé lorsque vous en aviez besoin ? ___Oui ___Non
    Si non, pourquoi ?

A.2. Niveau de participation à la gestion de l'aire protégée

19. Avez-vous remarqué des changements dans la disponibilité ou la qualité des ressources naturelles au cours des denieres annees ? ___Oui ___Non
20. Etes-vous impliqué dans la gestion ou le partage des décisions concernant la gestion de l'aire protégée : ☐ Oui Non
21. Si oui, comment cette participation se manifeste-t-elle :_Participation à la planification de gestion __Participation à l'exécution des activités de conservation __Participation à la surveillance environnementale __Engagement dans le processus de prise de décision __Autres formes de participation (préciser) _____
22. Comment évaluer vous le niveau de cette participation ? ___Très satisfaisant ___Satisfaisant ____Insatisfaisant
23. Etes-vous implique dans des pratiques de reboisement ou de conservation ? ___Oui ___Non
24. Si Oui, les quelles _____
25. Quels défis rencontre-vous dans la participation à la gestion de l'aire protégée ?_____
26. Dans quelle mesure ces défis affectent-ils vous moyen de subsistance ? _____

SECTION B : Evaluation de la vulnérabilité des moyens de subsistances (capit*al*es physique, naturel, humain financière et social)

B.1. Agriculture

27. Pratiquez vous l'agriculture ? ☐ Oui ☐ Non
28. Citer les types d'équipement que vous utilise pour l'agriculture ? _____
29. Combien d'équipement avez-vous pour pratique l'agriculture ? 1 2 3 4 5
30. État des outils et des équipements : ☐ Bon ☐ Moyen ☐ Mauvaise
31. Etat de la route du champ au marché : Très mauvais__ Mauvais__ Passable___ Bon__ Excellent___
32. De quelle superficie dispose votre ménage pour l'agriculture ? _____

Cultures	**Superficie**	**Quantité récolté**	**Quantité vendue**	**Combien ?**
Cacaoyer				
Manioc				
Plantain				
Arachide				
Champ mixte				
Concombre				

Autres				

33. Qualité de la fertilité du sol : Très mauvais__ Mauvaise__ Passable___ Bon__ Excellent___
34. Diversité des cultures au champ :___ Oui ___Non
35. D'où provient l'eau utiliser en champs : ☐ Eau de pluie ☐ Irrigation Autre _____
36. Nombre d'années d'expérience agricole : _____
37. Avez-vous subi une formation pour améliorer vos pratiques agricoles ces 12 derniers ☐mois: ☐ Oui Non
38. Nombre de personnes actives dans les activités champêtres :_____
39. Disponibilité de la main-d'œuvre : ___Rare ___Moyennement ___Abondante ___Très abondant
40. Etes-vous membre d'une tontine ? ☐ Oui ☐Non
41. Faites-vous des épargnes dans cette tontine ? ☐Oui ☐ Non
42. Avez-vous la possibilité d'emprunter de l'argent dans la tontine pour relancer vous activité agricole ? ☐Oui Non
43. Taux d'intérêt des prêts :
44. Appartenez-vous à un groupe d'agriculteurs (coopératives et/ou associations) : ☐Oui ☐ Non
45. Si Oui, Que ce que ce groupe vous apport comme bénéfice ? ___Formation/conseille ___Aide en intrants ___ Prêt
46. Accès à l'assistance technique (services de vulgarisation) : ☐ Oui ☐Non
47. À quelle fréquence et intensité les changements climatiques affectent-ils vos activités agricoles :

Facteur climatiques	**Fréquence**	**Perte**	**Niveau de perte**
Pluies tardives			
Pluies irrégulières			
Sècheresse prolongée			
Augmentation des maladies et ravageurs des cultures			
Vents violents			
Erosion du sol			
Augmentation de la température			

***Frequence** : 1. Jamais ; 2. Occasionnellement 3. Parfois ; 4. Souvent ; 5.- Toujours

***Niveau de perte**: 1. Aucun ; 2. Négligeable ; 3. Importante

48. Avez-vous été contraint(e) de modifier vos activités agricoles en raison du changement climatique ? ☐Oui ☐Non
49. Si oui, veuillez décrire les changements apportés_____

B.2. Chasse

50. Pratiquezes-vous la chasse ? ___Oui ____Non
51. Si, oui, État des outils de chasse: ___Bon ___Moyen ___Mauvaise
52. Abri et campement : ___Bon ___Moyen ___Mauvaise
53. Espèces animales chassées :_____

54. Abondance des animaux sauvages : Rare ___Moyennement ___Abondante ___Très abondant
55. Avez-vous accès aux zones de chasse ? ___Oui ___Non
56. Menaces sur l'habitat de chasse ? ___Oui ___Non
57. Avez-vous des compétences et connaissances traditionnelles sur la technique de chasse ? ___Oui ___Non
58. Appartenez-vous à une association de chasseurs ? ___ Oui ___ Non
59. Vente de la viande et des produits de la chasse : ___Oui ___ Non
60. À quelle fréquence les changements climatiques suivantes affectent-ils la chasse ? **(Cocher**)

Facteur climatique	**Jamais**	**Parfois**	**Souvent**	**Toujours**
L'irrégularité des pluies				
La sècheresse prolongée				
L'augmentation des m*al*adies et ravageurs				
Les vents violents				
L'augmentation de la température				

61. Avez-vous subi des formations pour améliorer vos techniques de chasse ? ___Oui ___Non
62. Respect des règles et coutumes de la chasse : ____Oui ____Non

B.3. Pêche

63. Pratiquez -vous la pêche ? ____Oui ___Non
64. Type de pêche pratiqué (pêche artisanale) _____
65. Abondance des poissons : Rare ___Moyennement ___Abondante ___Très abondant
66. Différentes espèces de poissons récolté_____
67. État des outils et des équipements : ___Bon ___Moyen ___Mauvaise
68. Appartenance à des associations de pêcheurs : ___Oui ___Non
69. Vente du poisson et des produits de la pêche : ___Oui ___Non
70. À quelle fréquence les changements climatiques suivantes affectent-ils la pêche (**Cocher**) ?

Facteur climatique	**Jamais**	**Parfois**	**Souvent**	**Toujours**
L'irrégularité des pluies				
La sècheresse prolongée				
L'augmentation des maladies et ravageurs				
Les vents violents				
L'augmentation de la température				

B.4. Collecte des PFNLs

71. Disponibilité des PFNLs ? ___Rare ___Moyennement ___Abondante ___Très abondant
72. État des outils et des équipements : ___Bon ___Moyen ___Mauvaise
73. Combien de fois collectez-vous les PFNLs par semaine ? _____
74. Quantité de PFNL collectée et quantité de PFNL vendue et à combien ?

Nom d'especes PFNL	Provenance	Quantité récolté	Quantité vendue	Combien ?
Njansan				
Moabi				
Mango				

Provenance : Cacaoyer (C), Jacheres (J), Forets secondaires (FS), Champs Vivrier (CV), Foret Primaire (FP)

75. À quelle fréquence les changements climatiques suivantes affectent-ils le collecte des PFNLs ?

Facteur climatique	Jamais	Parfois	Souvent	Toujours
Irrégularité des pluies				
Sècheresse prolongée				
Augmentation des maladies et ravageurs				
Vents violents				
Augmentation de la température				

76. Etes-vous implique dans des activites de transformation des PFNLs ? ___Oui ___Non
77. Si Oui, les quelles ? _____
78. Pensez-vous déjà avoir domestiqué certaines espèce des PFNL ? ___Oui ___Non

SECTION C : ADAPTATION ET PERCEPTION DU NIVEAU DU BIEN-ETRE

79. Dans quelle mesure pensez-vous que le bien-être de votre ménage a changé au cours des dernières années ? ___s'est amélioré ___s'est détérioré ___est resté stable
80. Veuillez expliquer les raisons principales de ce changement _____
81. Quel est votre apport dans ce changement ?
82. Etes-vous satisfait par la disponibilité des ressources naturelles ? (i) Pas du tout satisfait ; (ii) Assez satisfait ; (iii) Satisfait ; (iv) Très satisfait ; (v) Extrêmement satisfait
83. Avez-vous déjà reçu une formation en gestion des ressources naturelles et adaptation au changement climatiques ? ___Oui ____Non
84. Si oui, sur une échelle de 1(très bas) a 5(Eleve), comment évalueriez-vous votre niveau de :
85. Compétences et connaissances traditionnelles liées à la forêt et à ses ressources ? 1 2 3 4 5
86. Connaissance et compétence sur les activités alternatives génératrices de revenus : 1 2 3 4 5
87. Connaissances et compétences en matière de commercialisation : 1 2 3 4 5
88. Connaissances et compétences en matière de résolution des conflits : 1 2 3 4 5
89. Connaissance des réglementations et des lois forestières : 1 2 3 4 5
90. Connaissances et compétences en matière de production et de protection des cultures : 1 2 3 4 5

91. Connaissances et compétences en matière d'adaptation au changement climatique : 1 2 3 4 5
92. Avez-vous accès à des informations et des services de soutien pour vous aidez à adapter vos moyens de subsistance au changement climatique ? ___Oui ___Non
93. Si oui, précisez les sources d'information et les services de soutien disponibles_____

_____

94. Quelles sont les mesures que vous souhaiteriez voir mises en place pour vous aider à mieux s'adapter face au changement climatique ?

    _____

_____

Appendix 3. Pictures from the field observations

Image of Baka campment in Mabam village

Image of Ndimako village

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