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**A subnational assessment of restoration
opportunities for degraded ecosystem services of
the Sanaga and Kadéy watersheds, East-
Cameroon**

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DEDICATION

To my late parents

Samuel MBANDO BESINGI

and

Agnes NWEYA MBILE BESINGI

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ACRONYMS

AFR100	: African Restoration Initiation
ANAFOR	: National Forestry Development Support Agency
CCO	: Cameroon Country Office
CLIP	: Free, Informed and Prior Consent
CMCI	: International Christian Missionary Community
DFNP	: Non-permanent forest estate
DFP	: Permanent Forest Estate
DRC	: Danish Refugee Council
FC	: Community forest
FMU	: Forest Management Unit
FMU	: Forest Management Unit
FSC	: Forest Stewardship Council
GFW	: Global Forest Watch
GIC	: Common Initiative Group
GIZ	: Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
IMFC	: Christian Missionary Fellowship International
IPCC	: The Intergovernmental Panel on Climate Change
IUCN	: International Union for the Conservation of Nature
MEOR	: Restoration Opportunity Assessment Methodology.
MINEPDED	: Ministry of the Environment Protection of Nature and Sustainable Development
MINFOF	: Ministry of Forests and Wildlife
MoU	: Memorandum of Understanding
NTFP	: Non-Timber Forest Products
PMA	: Multi-Actor Platform
RPF	: Forest Landscape Restoration
RPF HQ	: High Quality Forest Landscape Restoration
STBK	: Société de Transformation de Bois de la Kadey
TACS	: Time Averaged Carbon Stocks
tCO ₂ eq	: Tons of Carbon Dioxide Equivalent
TNS	: Tri National Sangha
TNS	: Tri National Sangha
TRIDOM	: Trinational Dja Odzala Minkebe
USA	: United State of America
WITH	: Village Savings and Credit Association
WRI	: World Resources Institute
WWF	: World Wildlife Fund

ABSTRACT

The Kadey and Sanaga watersheds in the East Region of Cameroon face severe degradation of ecosystem services caused by unsustainable practices such as deforestation, mining, overgrazing, and wildfires. This degradation threatens biodiversity, reduces productivity, and compromises the livelihoods of local communities, necessitating urgent restoration efforts. The study applies the Restoration Opportunities Assessment Methodology (ROAM) to identify and prioritize potential restoration interventions for these degraded landscapes. The research highlights the importance of restoring ecosystem services to improve forest productivity, enhance water quality, and secure local livelihoods. By identifying the drivers and extent of degradation, the study provides critical data for sustainable forest landscape restoration. The findings are essential for policymakers, conservationists, and local stakeholders to address land-use challenges effectively. The assessment used a combination of primary data collection methods, including GPS mapping, stakeholder interviews, and community surveys, and secondary data from satellite imagery and government reports. Multiple Correspondence Analysis (MCA) was employed to establish links between land-use types, administrative units, and degradation drivers, while spatial tools mapped restoration opportunities across the watersheds. The study revealed five key degradation drivers notably, deforestation for agriculture, wildfires, unsustainable harvesting of timber and fuelwood, mining activities, and overgrazing, contributing to significant landscape degradation. Restoration opportunities were identified over a total surface area of 426,913 hectares across agroforestry systems, communal forests, gallery forests lands, gold panning and micro-zoning zones. Restoration options include agroforestry practices, enrichment planting, soil stabilization, and community-driven reforestation activities, integrated with sustainable land-use management. The results highlight the need for integrated restoration strategies targeting both ecological and socio-economic objectives. Agroforestry interventions and reforestation in degraded areas, alongside sustainable agricultural practices and stakeholder collaboration, are recommended to rehabilitate the watersheds. These measures ensure ecosystem recovery, improved livelihoods and long-term landscape resilience.

Keywords: ecosystem services, landscape degradation, restoration opportunities, watershed

RESUME

Les bassins versants de la Kadey et de la Sanaga, situés dans la région de l'Est du Cameroun, subissent une dégradation importante des services écosystémiques en raison de pratiques non-durables telles que la déforestation, l'exploitation minière, le surpâturage et les feux de brousse. Ces dégradations ont des conséquences graves sur la biodiversité, réduisent la productivité des terres et menacent les moyens de subsistance des populations locales, rendant les efforts de restauration indispensables. Cette étude s'appuie sur la Méthodologie d'Évaluation des Opportunités de Restauration (ROAM) pour identifier et prioriser les interventions nécessaires à la restauration de ces paysages dégradés. Elle met en lumière l'importance de la restauration des services écosystémiques afin d'améliorer la productivité des forêts, la qualité de l'eau et de renforcer la résilience des moyens de subsistance des communautés. En déterminant les principaux facteurs et l'étendue de la dégradation, l'étude fournit des données essentielles pour une gestion durable et intégrée des paysages forestiers. Ces résultats s'adressent particulièrement aux décideurs, aux acteurs de la conservation et aux parties prenantes locales afin de mieux relever les défis liés à l'utilisation des terres. Les résultats révèlent cinq principaux facteurs de dégradation: la déforestation pour l'agriculture, les feux de brousse, l'exploitation non-durable des bois d'œuvre et de chauffage, les activités minières et le surpâturage. Ces pressions ont entraîné une dégradation significative, et des opportunités de restauration ont été identifiées sur une superficie totale de 426,913 hectares, couvrant des systèmes agroforestiers, des forêts communales et des zones de micro-zonage. Les approches de restauration proposées incluent l'introduction de pratiques agroforestières, des plantations d'enrichissement, la stabilisation des sols, ainsi que des programmes de reboisement participatif, intégrés à une gestion durable des terres. Cette étude souligne l'urgence de mettre en œuvre des stratégies de restauration intégrées, visant à la fois des objectifs écologiques et socio-économiques. Des interventions telles que le reboisement, l'agroforesterie et des pratiques agricoles durables, combinées à une collaboration étroite avec les parties prenantes, sont indispensables pour réhabiliter les bassins versants. Ces efforts permettront de restaurer les écosystèmes, d'améliorer les conditions de vie des populations et de renforcer la résilience à long terme des paysages.

Mots clés : bassin versant, dégradation du paysage, , opportunité de restauration, services écosystémique.

CHAPTER I. GENERALITIES

I.1. Introduction

I.1.1. Background and context

Catchments play a fundamental role in maintaining ecosystem services that are essential to human life and environmental health. They contribute to the regulation of hydrological cycles, carbon storage, soil fertility and biodiversity conservation (Anonym, 2005). However, throughout the world, and particularly in tropical regions, these ecosystems are coming under increasing pressure from agricultural expansion, logging, mining activities and climate change, leading to their gradual degradation (Anonym, 2020). The Sanaga and Kadey watersheds in the East Region of Cameroon are no exception to this dynamic.

The Sanaga and Kadey water catchment areas are of vital ecological and socio-economic importance. They provide drinking water, support agriculture and fishing, and a natural habitat for the rich biodiversity. However, these catchments are facing alarming degradation caused by deforestation, soil erosion, river pollution and unsustainable exploitation of natural resources (MINFOF, 2018). This situation compromises not only the provision of essential ecosystem services but also the resilience of local communities that depend on these ecosystems for their livelihoods. In this context, the restoration of degraded ecosystem services is emerging as a strategic solution for reversing the effects of degradation, while contributing to national and international biodiversity conservation, climate change and sustainable development goals (CBD, 2010; UNCCD, 2022). It is therefore crucial to carry out a thorough assessment of restoration opportunities in these catchments. This assessment will help to target priority areas, identify appropriate restoration opportunities and interventions and maximise ecological, social and economic benefits.

However, to ensure the success of such initiatives, Cameroon has signed and ratified several major multilateral environmental agreements relating to forests, biodiversity and climate change, including the African Forest Landscape Restoration Initiative (AFR100): a continental initiative launched in 2015 to restore 100 million hectares of degraded landscapes across Africa by 2030, to which it committed in 2017 to restore 12,062,768 hectares and which is proving particularly relevant to restoring the country's degraded and degrading forests. Cameroon has also drawn up a national development strategy for 2030 (SND30), which includes the restoration and sustainable management of the country's forests.

I.1.2. Problem Statement

The fact that the Sanaga-Kadey watershed in the East Region of Cameroon is a transition between humid savannahs and dense forests, it is exposed to significant degradation of ecosystem services due to drivers of landscape deforestation and degradation. These drivers have led to biodiversity loss, soil erosion, reduced water quality, and declining forest productivity, which directly impact local livelihoods and environmental stability. Despite the critical need for restoration, the lack of comprehensive data on the extent of degradation and potential restoration opportunities hinders effective intervention. Addressing this issue requires a systematic assessment to guide sustainable restoration and management strategies tailored to the region's socio-ecological context.

1.1.3. Research questions

The main question of this study is, what has led to the decline of the ecological functions and its associated services in the Sanaga and Kadey watersheds and what restoration opportunities can be derived from them for these functions to be restored? The secondary questions to this would include:

- what are the principal drivers of degradation and deforestation in the Sanaga-Kadey watershed?
- what restoration opportunities can be available?
- what are the possible intervention options for these watersheds?

1.1.4. Objective

The main objective of this study is to assess the priorities and opportunities for restoration within the Sanaga-Kadey watershed to propose sustainable strategies to restore ecological functions.

More specifically, it is to:

- identify the existing drivers of deforestation and landscape degradation;
- identify and quantify restoration opportunities;
- propose restoration options and interventions.

I.2. Literature review

I.2.1. Definition of key concepts

Forest landscape restoration (sometimes referred to as (“forest and landscape restoration”) is the process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes (Maginnis *et al.*, 2005). It is about “forests” because it involves increasing the number and/or health of trees or woody plants in an area to a level appropriate for the native ecosystem. It is about “landscapes” because it involves going beyond restoring individual sites to restoring entire watersheds, jurisdictions, or even countries in which many land uses interact and where people live and work. It is about “restoration” because it involves bringing back the ecological functions of an area in order to achieve a wide range of benefits for people and the planet (Anonym, 2004). Restoration opportunities refer to favourable conditions or circumstances for achieving a goal that enable conservation and restoration efforts (Anonym, 2019).

A sub-national assessment refers to an assessment carried out in administrative levels below the national levels such as province, region or states (Anonym, 2016) while assessment refers to the process of evaluating the state of biodiversity and ecosystem services (anonym, 2019). Forest landscape refers to a spatially heterogeneous forest area with diverse ecosystems, land uses, and cultural features (Landscape Ecology, 2013). In this study, the forest landscape to be brought under restoration includes the Sanaga and Kadey watersheds. These are critical ecosystems supporting biodiversity and human livelihoods (Anonym, 2015). Finally, it is about a “process” because it typically takes a long time for a forest landscape to recover, although some of the ecological functions and human benefits provided by restoration may appear early on.

Forest Landscape Restoration is provided for in Cameroon’s Forest Law of 2024. It identifies reforestation and artificial regeneration as some of the operations that must be conducted in the permanent forest estate and recognizes individual and group efforts in establishing forests (Eba'a *et al.*, 2014). Future Terrains defines Landscape Restoration as the improvement of degraded landscape and on a wide scale that rebuilds ecological integrity and enhances people’s lives. The International Union for the Conservation of Nature – IUCN defines Forest landscape restoration (FLR) as an ongoing process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes. The Global Partnership on Forest Landscape Restoration - GPFLR co-launched in 2003 by the IUCN, defines Forest Landscape Restoration as a process that aims to regain ecological functionality and enhance human well-being in deforested or degraded landscapes.

There is an emphasis on “forests” in the IUCN definition, whereas the GPFLR definition does not mention “forest” in the latter part. The Terrains definition focuses on Landscapes in general, not just forested ones. However, rebuilding ecological health and addressing livelihoods – two key elements in restoration are covered in all definitions.

I.2.1.1. Watershed Degradation and Deforestation

Watershed degradation and deforestation are significant environmental concerns, particularly in tropical regions (Lambin *et al.*, 2001; Geist & Lambin, 2002). The Kadey and Sanaga watersheds are no exception, facing severe deforestation and land degradation due to agricultural expansion, urbanization, and logging (Kotto-Same *et al.*, 2005; Ndoye & Kellman, 2007). Deforestation leads to soil erosion, reduced water quality, and loss of biodiversity (Bruijnzeel, 2004; Chomitz & Gray, 1996).

Additionally, watershed degradation can have devastating impacts on local communities, including decreased water availability and reduced livelihood opportunities (Sutton *et al.*, 2016). Remote sensing data on forest loss, underlines the significance of monitoring systems in detecting degradation and restoration outcomes over time (Achard *et al.*, 2002).

I.2.1.2. Landscape degradation in the East Region from Secondary data

Data presented by the Global Forest Watch and assessed in August 2023, revealed that for the past two decades that is, from 2002 to 2022, the total surface area of the humid primary forest of the East Region of Cameroon has decreased by 2.6%. Within this monitoring period, the highest peak was registered in the years 2017, 2020 and 2021 (Fig.2).

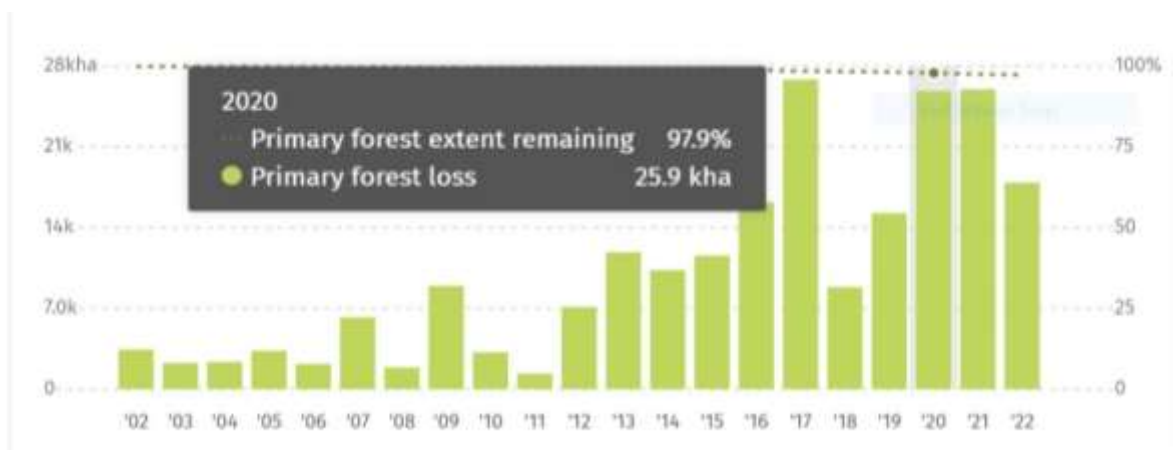


Fig. 1. Primary forest loss in East Cameroon (Anonym, 2023).

From this secondary data, the East Region lost 399 thousand hectares (kha) of tree cover, representing a 3.8% decrease in tree cover since 2000. This loss corresponds to the release of

257 million tons (Mt) of CO₂, emissions. There has been a drastic tree cover loss in the East Region equivalent to 3.8% decrease from 2001 to 2022 and amounted to 257 Mt of CO₂ emissions. In 2019, over 45kha of forest cover was lost representing 0.29% of the total tree cover loss for that same period of time (Fig.3). there is therefore a steady and alarming increase in tree cover loss over the years, posing significant threats to the stability of ecosystems in the region.

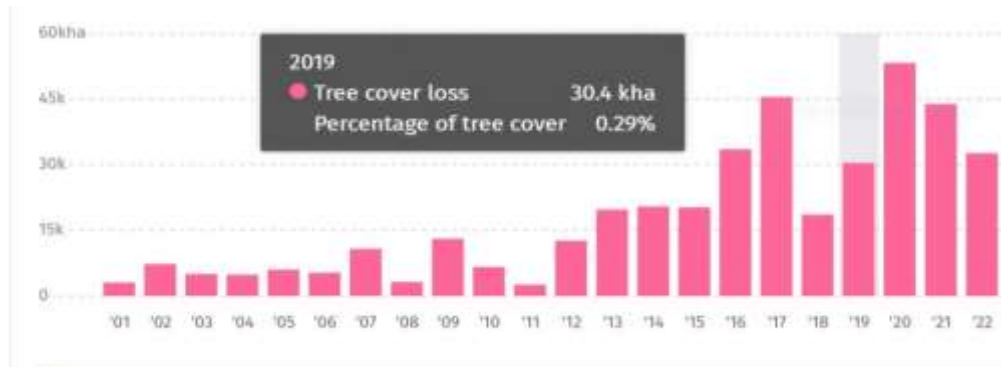


Fig. 2. Tree cover loss in East Cameroon (Anonym, 2023).

I.2.1.3. Restoration Opportunities and Strategies

Forest landscape restoration (FLR) offers a promising solution to address watershed degradation (Lamb *et al.*, 2005; Chazdon, 2008). Ecological restoration techniques, such as reforestation and agroforestry, can enhance ecosystem services and promote sustainable land use (Cairns, 2007; Holl & Crone, 2004). Successful restoration initiatives require community engagement and participation (Kellman & Tackaberry, 2017; Mansourian, 2017). Furthermore, restoration efforts can be enhanced through the integration of traditional ecological knowledge (TEK) and modern restoration practices (Berkes, 2009).

Achieving success in restoration initiatives requires consideration of short- and long-term economic and social outcomes for local communities, through their active engagement in the process (Kang and Kim 2015). To be successful in the long term, restoration initiatives must address the underlying causes of deforestation and degradation; they also need to be proactive, with the participation of multiple stakeholders, and long-term planning horizons (Nawir *et al.*, 2007; Le *et al.*, 2012). Restoration initiatives need to move beyond time- and space-bound project-based activities to foster real change in the management and governance of forest landscapes. Forest restoration is strongly aligned with policy objectives embodied by the UN's Sustainable Development Goals, including increasing food security, reducing poverty, enhancing water supplies, protecting biodiversity, disaster mitigation and climate-change adaptation (Mansourian & Vallauri, 2014; Stanturf *et al.* 2015).

Stanturf *et al.* (2017) break down the FLR process into four distinct phases. The first phase is a visioning phase, where FLR is placed within a specific context in a country, region, or landscape. Visioning requires knowing where degradation or forest loss has occurred, and what actions and interventions constitute FLR. The second is a conceptualizing phase, where priority landscapes and specific ecological and social goals are identified. This phase requires assessments of restoration opportunities, using biophysical and social criteria. Multiple stakeholder groups participate in these assessments, based on specific objectives for different FLR interventions (Mansourian and Vallauri 2014).

The third phase involves designing the FLR project, based on the objectives selected in the second phase, with clearly identified start and end points for restoring specific landscape elements. The fourth is the implementation phase, where detailed plans for interventions are put into place to meet the objectives for FLR. Monitoring is a critical element of implementation. Implementation decisions involve selecting specific sites for applying restoration interventions, selecting species for planting, planting designs and genetic provenances. Under favorable social and ecological conditions, interventions can take the form of spontaneous, assisted or farmer-managed natural regeneration (Chazdon & Guariguata 2016).

I.2.1.3. Hydrological and Water Resource Management

Watershed hydrology plays a crucial role in maintaining water resources and quality (Burt & Pinay, 2005; Calder, 2005). Land-use changes significantly impact water cycling and quality (Bruijnzeel, 2004; Bonell & Balek, 1993). Effective water management strategies, such as watershed-based approaches, can mitigate these impacts (Folliott & Brock, 2007; Olivera & Deletic, 2016). Moreover, integrating hydrological and ecological principles can enhance restoration outcomes (Covich *et al.*, 2004).

I.2.1.4. Biodiversity Conservation and Ecosystem Services

Restoration efforts can maintain ecosystem resilience and promote biodiversity conservation (Chapin *et al.*, 2000; Holl *et al.*, 2014). Ecosystem services provided by restored watersheds include carbon sequestration, soil conservation, and water regulation (Daily *et al.*, 2009; Millennium Ecosystem Assessment, 2005). Additionally, restored watersheds can support a range of biodiversity, including threatened and endangered species (Lawton *et al.*, 2010).

Natural regeneration processes and farmer-managed reforestation in FLR is important in that it leads to spontaneous recovery in favourable conditions (Mansourian & Vallauri, 2014). Aligning Forest Landscape Restoration with climate mitigation goals, considering that restored landscapes improve carbon sequestration and enhance biodiversity resilience is a sensible

approach (Chazdon *et al.*, 2017).

I.2.1.5. Socio-Economic and Community Aspects

Community engagement and participation are essential for successful restoration initiatives (Kellman & Tackaberry, 2017; Mansourian *et al.*, 2017). Restoration can generate livelihood benefits, such as ecotourism and sustainable forest products (Cairns, 2007; Kotto-Same *et al.*, 2005). However, restoration efforts must address potential livelihood trade-offs and conflicts (Ndoye & Kellman, 2007). Furthermore, involving local communities in restoration decision-making can enhance project outcomes and sustainability (Borrini-Feyerabend *et al.*, 2004).

In the socio-economic dimension of restoration, active community participation and livelihood enhancement are critical to achieving sustainable results (Kang & Kim, 2015). Governance challenges in wide-scale restoration, the need for collaborative management frameworks that integrate stakeholders at all levels, from governments to local communities has been identified (Mansourian, 2017). This implies the role in the stakeholders at all level of the forest landscape restoration process is highly and effectively important. The local population has the background history and knows the evolution of the degraded landscape. Participatory restoration, through multi-stakeholder platforms is necessary to negotiate trade-offs between different land uses while maintaining ecosystem functionality (Sabogal *et al.*, 2015).

I.2.1.6. Policy and Governance Frameworks

National and international policies support watershed restoration efforts (Anonym, 2011; CBD, 2010). Effective governance frameworks require institutional arrangements and stakeholder engagement (Kellman & Tackaberry, 2017; Mansourian *et al.*, 2017). Policy and governance challenges can hinder restoration success (Lambin *et al.*, 2001). Moreover, integrating restoration into existing policy frameworks can enhance implementation (Sayer *et al.*, 2016).

Underlying the Bonn Challenge is the forest landscape restoration (FLR) approach, which aims to restore ecological integrity and improve human well-being. FLR balances both biophysical and socioeconomic outcomes and promotes a triple-win scenario in terms of biodiversity conservation, ecosystem service (ES) supply and livelihood improvement. While FLR offers a promising future for environmental sustainability, the path towards achieving the ambitious targets of wide-scale FLR remains unclear due to a poor understanding of the biophysical, socioeconomic and governance obstacles and the complexity of integrating multiple benefits, scales, competing interests and priorities in balancing biodiversity, Ecosystem Services and livelihoods.

Full achievement of the Sustainable Development Goals (SDGs) is only possible through urgent, concerted and effective action to avoid and reduce land degradation and promote restoration, bringing positive impacts across all dimensions of development.

The UN has declared 2021-2030 the Decade on Ecosystem restoration. In Africa 32 countries have so far pledged to bring 128 million hectares under restoration by 2030 as part of the African Forest Landscape Initiative (AFR100 initiative). This country-led effort, AFR100 aims to accelerate restoration to enhance food security, increase climate change resilience and mitigation, and combat rural poverty.

Successful FLR is forward-looking and dynamic, focusing on strengthening the resilience of landscapes and creating future options to enhance and further optimize ecosystem goods and services as societal needs change or new challenges arise. Restoring forests and landscapes is more than just planting trees – a restored landscape could include naturally regenerated areas, agroforestry, on-farm trees, mangroves, protected areas, plantings of trees and other non woody plants like bamboos, and more (Craig *et al.*, 2019). Restoration takes place through an active process that allows the integration of various sectors, plans, and programs, bringing local communities and other stakeholders together to identify and implement appropriate restoration activities. At the national level, the process of achieving restoration begins long before implementation.

Recognizing both the need and potential for restoration is the first step to motivate action, followed by a formal commitment to implement restoration interventions. To this end, multiple international and global initiatives have arisen to encourage national-scale commitments to undertake restoration (Craig *et al.*, 2019). Although these commitments signal the first steps of a complex and long-term restoration trajectory, the next steps of planning, prioritizing and implementing restoration interventions require overcoming many obstacles and knowledge gaps (Chazdon *et al.*, 2017; Mansourian *et al.*, 2017). Although REDD+ has required each participating country to define “forest”, a definition for restoration that goes beyond forest seems more appropriate for the Kadey watershed area and its surrounding. It must be acknowledged that the Ministry of Forestry and Wildlife has initiated and implemented several measures, some of which include: strengthening the legal framework and forestry governance, as well as institutional, strategic, programming and budgetary reforms in the forestry and wildlife subsector.

The implementation of these measures has resulted over the years in considerable progress towards sustainable forest management (establishment of the permanent forest estate, which currently spans 15,689,586 hectares, representing approximately 33% of the national

territory (Anonym, 2015). However, much still has to be done, especially in addressing the issue as to whether timber production from natural forests will be able to definitely satisfy the needs of the people and industries.

I.2.1.7. Case studies and lessons learned

Successful restoration initiatives in similar tropical watersheds provide valuable lessons (Lamb *et al.*, 2005; Chazdon, 2008). Case studies from Africa and Asia highlight the importance of community engagement, sustainable land use, and ecosystem-based approaches (Kotto-Same *et al.*, 2005; Ndoye & Kellman, 2007). Additionally, lessons from failed restoration projects can inform future initiatives (Mansourian *et al.*, 2017). Over 2 billion hectares globally have been identified as having restoration potential, and this highlights opportunities for wide-scale FLR in tropical regions, particularly through agroforestry and mixed-use landscapes (Laestadius *et al.*, 2012).

I.2.1.8. Knowledge gaps and research needs

Research gaps persist in understanding the complex relationships between watershed degradation, restoration, and ecosystem services (Chapin *et al.*, 2000). Future research should prioritize the development of effective restoration strategies, community engagement, and policy frameworks (Lambin *et al.*, 2016). A phased FLR model involving visioning, planning, implementing, and monitoring stages is a form of adaptive management meant to sustain long-term outcomes (Stanturf *et al.*, 2017).

Combining the various works of these authors, there is therefore the need for methodological advances with regards to Sub-National ROAM assessment in the in the East Region of Cameroon. The Restoration Opportunities Assessment Methodology (ROAM) developed by Anonym (2014) offers a practical framework for identifying and prioritizing restoration areas. It integrates ecological, social, and economic analyses, providing actionable insights into restoration opportunities. The ROAM framework was the preferred tool or approach used for this work in view of the fact that it has been tested and implemented in many countries across the globe and the results have been so astonishing. To better understand this framework, it will be necessary to look at the ROAM review.

In summary, the literature underscores that landscape restoration is a multi-faceted process requiring ecological restoration, community involvement, adaptive management, and effective governance. The integration of advanced tools like ROAM and GIS-based monitoring systems ensures restoration initiatives are both science-based and inclusive, supporting long-term environmental and socio-economic outcomes.

I.2.2. Restoration Opportunities Assessment Methodology (ROAM) Overview

For a full understanding of ROAM or Restoration Opportunities Assessment Methodology as conceived by the founding experts, to support landscape restoration, it is otherwise referred to as the ROAM Manual (Anonym, 2014). Essentially, ROAM is a methodology that can be described in the eight (08), consecutive steps, outlined below;

I.2.2.1. Stakeholders analyses

Stakeholder analysis is a method for identifying and analysing the stakeholders who have a stake in a particular issue or decision (Reed *et al.*, 2009). These are generally all internal and external parties, actors and those affected by degradation or who stand to benefit from restoration. From communities, State Ministries to Technical and Financial partners interested in, supporting the restoration process or affected by the degradation process. A stakeholder is any group or individual who can affect or is affected by the achievement of the organization's objectives. (Freeman, 1984). These are the people whose knowledge needs to be used, interest served, and commitment secured, respectively. In the study area, efforts were made to maximize the implication of all the stakeholders encountered. It ranged from local knowledge to scientific based knowledge.

I.2.2.2. Identifying priorities for restoration in the regions

The priorities refer to the full measurable extent; including perception of all conceivable dimensions of degradation (often in millions of Ha). Priorities can be mapped using resource persons with the best local knowledge (e.g., through participatory mapping), and best available technology and data (e.g. from Satellite imagery, aerial photos, etc.).

Restoration priorities should be based on ecological criteria, such as the degree of degradation, biodiversity value, and ecosystem services (Holl and Hayes, 2006).

Priorities are often expressed in restoration pledges. The government of Cameroon has pledged to the Bonn Challenge to restore over twelve (12) million hectares of degraded forest landscape by 2030. On its part, WWF CCO has committed itself as contribution to the NDC to restore about three million hectares of degraded landscape in the country. Prioritization of restoration actions should consider multiple ecosystem services and stakeholder benefits (Palmer *et al.*, 2016).

I.2.2.3. Identifying opportunities for restoration in the regions

The opportunities on the other hand, refer to what can, be restored given the extent and dimensions of the degradation; available resources, competing interests on the degraded

resources; including other constraints of feasibility and or relevance. Restoration opportunities exist where ecosystems have been degraded, damaged, or destroyed (Anonym, 2004).

Uncertain tenure, very high cost versus uncertain benefits; possibility for undesirable outcomes like conflicts etc., can all combine to render addressing a priority impractical and not feasible. As such it does not present an “opportunity” for restoration. Restoration opportunity is therefore, what can be achieved; “within the limits of feasibility”; costs, relevance. Restoration opportunities can be identified through assessments of ecosystem condition, biodiversity, and ecosystem services (Mansourian *et al.*, 2014).

I.2.2.4. Identifying the most relevant and feasible restoration options

Restoration options include reintroduction of native species, habitat reconstruction, and removal of invasive species (Clewell *et al.*, 2005). This refers to the range of restoration investments or actions that are both biophysically, economically and socially possible given the opportunities identified. For a given piece of watershed, both a monoculture Teak Plantation and or a mixed fruit tree-crops system may be options for restoration. What is eventually selected after considering costs, appropriateness (local acceptability, policy, etc.) or even markets, etc., becomes the intervention option. Restoration options should consider ecological processes, biodiversity, and ecosystem services (Temperton, 2016).

I.2.2.5. Costs and benefits analyses of restoration options

It is essential for the options to be costed both in financial, social (gender) and environmental cost terms; from identification of degradation drivers, to recommendation/choice of restoration options and interventions. Cost-benefit analysis involves comparing the costs of restoration with the benefits, including ecosystem services and biodiversity (Boardman *et al.*, 2011). A chosen intervention may be prejudicial to a local social group, just as it may lead to the disappearance of indigenous species and therefore, no longer a viable option.

Economic analysis of restoration options should consider non-market benefits, such as recreation and tourism (Hanley *et al.*, 2017).

I.2.2.6. Analysing ecosystems (carbon) benefits of restoration

Given its origins (partly a product of accumulated knowledge from the outset of REDD+ science 2008 - 2011), it is expected that landscape restoration will contribute towards enhancing carbon stocks under the countries NDC. Ecosystem restoration can enhance biodiversity, ecosystem services, and human well-being (Anonym, 2005). Restoration can improve ecosystem services, including pollination, pest control, and climate regulation (Anonym, 2019).

I.2.2.7. Analysing finance and investment opportunities and constraints

This is an essential element of the landscape restoration process and can often be considered as a powerful determinant of opportunity – therefore, depending on the objective, is likely to be an important consideration of a ROAM exercise. With the growing interest by the Private Sector in Environmental Management this is a potential growth and opportunity area for the region. Green finance mechanisms, such as grants and loans, can support restoration efforts (Anonym, 2018).

Restoration is a long-term investment. For this reason, we are increasingly seeing interest from Financial Institutions and from Private Capital through Public Private Partnerships. Restoration investments can generate returns through ecosystem services and sustainable land use (World Bank, 2019).

I.2.2.8. Identifying policy and institutional bottlenecks and or enablers for restoration

Institutional analysis can identify policy and regulatory barriers to restoration (Kozar *et al.*, 2015). These often goes beyond policies, although actions like pledges are important enablers of restoration. Important bottlenecks can include contested areas where either tenure is unclear or where prospecting for minerals or wood products may be planned or ongoing.

Generally, a national Pledge tends to provide excellent policy and institutional coverage for both national and sub national ROAM exercises. Enabling policies, such as land tenure reform, can support forest landscape restoration (Anonym, 2019). Based on the Political and strategic context WWF CCO and FACET POWER Inc. USA, signed a Memorandum of Understanding on April 15, 2023, to collaborate on the restoration of degraded landscapes and contribute to sustainable land and forest management in Cameroon.

This MoU supports a higher-level WWF commitment on September 29, 2021 with MINFOF (MoU) to support the sustainable management of forests and wildlife resources in Cameroon. These MoUs and policy commitments also align with WWF's national CCO 2021 - 2025 strategy for forest management and landscape restoration, and contribute to its model of delivering high-quality conservation outcomes through multi-stakeholder partnerships.

Recently, as part of CCO's deployment of its partnership with the private sector under the WWF FLR in Africa Initiative, a prioritization of intervention sites with FACET POWER identified the Kadey watershed as a strategic landscape for landscape restoration interventions involving the use of Biochar. The Kadey watershed (a landscape) also has the advantage of being a buffer and transition zone between the more degraded and densely populated northern

regions of Cameroon, and the densely forested and humid landscapes of the TNS and TRIDOM, which are densely forested, sparsely populated, rich in biodiversity and fragile.

The selection of the Kadey watershed as a priority site for a private sector partnership for landscape restoration will therefore support landscapes such as TNS and TRIDOM, contribute to MINFOF's sustainable management of land, forests and wildlife, Cameroon's National Development Strategy 2030 and the AFR100 platform's goal of improving livelihoods and protecting nature by restoring over 12 million hectares of degraded landscapes by 2030. The World-Wide Fund for Nature (WWF) is committed to High Quality Forest Landscape Restoration (HQ FLR).

I.2.3. ROAM alignment with national and international restoration goals

The prime purpose of a ROAM is to prepare the ground for the best possible landscape restoration outcomes for nature and for people. However, establishing clear objectives beforehand is important to the process. Nevertheless, the roll-out of a restoration process; sub national (not considering the entire country) or national, are rarely identical from country to country. They are often linked to some short term, medium- and or long-term outcomes and or deliverables. In the present context, ROAM is designed primarily to provide relevant analytical input to subnational policy and operational processes, such as the development of programmes of work related to a national REDD+ strategy, a national adaptation programme of action, a national biodiversity strategy and action plan, or requests for development assistance. In addition, ROAM will often be able to fill in missing information relevant to other national policy priorities, such as rural development, food security or energy supply. Many of these types of policies tend to ignore the potential of degraded or sub-optimally managed land.

Essentially, ROAM involves a stepwise and iterative application of a series of analyses to identify the best set of FLR opportunities applicable to the area in question. A good deal of information will need to come from local experts and other stakeholders with first-hand knowledge of the landscapes and livelihoods in the areas being assessed. So, while carrying out the FLR assessment there is the use of a combination of 'best science' and 'best knowledge' to obtain accurate, realistic answers. In addition, many of the questions will necessitate discussion, debate and negotiation among the different stakeholders. The multi-stakeholder approach of FLR offers a mechanism to identify and address any trade-offs between different, sometimes competing, land uses.

The social returns of taking action on restoration at a global level are estimated at US\$ 5 for every \$ 1 invested in restoring degraded land. These facts represent both an excellent investment opportunity for both developed and developing countries. Reversing land

degradation and halting deforestation through restoration is possible. The annual deforested area for the humid tropics is estimated at 5.8 ± 1.4 million hectares with a further 2.3 ± 0.7 million hectares of forest where degradation can be visually inferred from satellite imagery (Achard, F. 2002.). This figure highlights the extensive loss of tropical rainforests which are critical for biodiversity, carbon storage and climate regulation.

The range ± 1.4 million hectares reflects variability due to factors like data sources, measurement techniques, and regional difference in restoration drivers. This high deforestation rate underscores the urgent need for global restoration initiatives like the Bonn Challenge and methodologies such as ROAM, aimed at reversing forest degradation and restoring ecosystem services. About 30% of global forest cover has been cleared and a further 20% degraded to date. Deforestation is the second leading cause and currently accounts for 24% of total greenhouse gas emissions. Landscape degradation through human activities negatively impacts the well-being of at least 3.2 billion people, and costs more than 10% of annual global gross product in loss of biodiversity and ecosystem services. Forest and land degradation also increases competition for scarce resources and contributes to human migration, both of which can lead to increased conflict (Anonym, 2019).

More recently, the Global Partnership on Forest Landscape Restoration has defined FLR as an active process that brings people together to identify, negotiate and implement practices that restore an agreed optimal balance of the ecological, social and economic benefits of forests and trees within a broader pattern of land uses” (Sabogal *et al.*, 2015). Across the tropics, most opportunities for restoration in forest biomes lie within mixed-use landscapes. One influential global assessment showed that over 2 billion ha of deforested and degraded landscapes could be considered as opportunities for restoration interventions (Laestadius *et al.*, 2012).

- principle 1: focus on landscapes

FLR takes place within and across entire landscapes, not just individual sites; representing mosaics of interacting land uses and management practices, under diverse systems of ownership and governance. It is at this scale that ecological, social and economic priorities can be balanced. FLR interventions must intentionally follow, align with or seek to remedy ecosystem service degradation in the downstream direction of the service or product flow. This means that ecosystem services are provided according to the configuration of the landscape, ecoregion or biome, which must be highlighted in the diagnosis of FLR opportunities.

- principle 2: engage stakeholders and support participative governance

FLR actively involves stakeholders, including vulnerable groups, in planning and decision-making concerning land use, restoration objectives and strategies, implementation

methods, benefit sharing, monitoring and evaluation processes. One way in which WWF can capitalize on its particularity is by promoting multi-stakeholder platforms (MSPs) to support FLR.

- principle 3: restoring multiple functions for multiple benefits

FLR interventions aim to restore multiple ecological, social and economic functions that contribute to landscape vitality and the provision of a range of ecosystem goods and services that benefit multiple stakeholder groups. To achieve this, it is necessary to understand the different priorities sought by different stakeholder groups and to negotiate compromises.

- principle 4: maintain and enhance natural ecosystems within landscapes

FLR reinforces ecological integrity, i.e., the diversity, function and organization of ecosystems in the landscape. It supports the conservation, restoration and sustainable management of forests and other ecosystems. This is a very important criterion, and under WWF's core business, natural ecosystems that provide fundamental downstream services (gallery forests, national parks, mangroves, wetlands, mountain forests, sacred forests, etc.) have unique but interdependent values that support other wildlife services.

- principle 5: adapt to the local context using a variety of approaches

FLR seeks to improve the resilience of the landscape and its stakeholders over the medium and long term. Restoration approaches must strengthen the characteristics (e.g., species and genetic diversity) that enable forest ecosystems and human uses of the landscape to adapt over time, to reflect climate and other environmental changes. As restoration progresses, information from monitoring activities, research and stakeholder guidance should be integrated into existing management plans.

- principle 6: adaptive management for long-term resilience

In the specific case of WWF conservation landscapes, this principle is particularly important as this is where WWF can effectively ensure the real-time integration of activities, risk management and safeguards, as part of the operationalization of the MSP (human networks/institutions - where most of the risks originate), through the continuous and systematic collection of information on the progress of activities for monitoring and evaluation purposes and for adaptive management.

I.2.4. Presentation of the study area

This assessment area is located in the East Region of Cameroon, specifically in two divisions, the Kadey and the Lom and Djerem.

I.2.4.1. Localisation of the study area

The larger of these is the Kadey, with its multifaceted anthropogenic pressures and diverse ethnic composition. The Kadey Division is located in the region of East Cameroon between 4°12' and 4° 36' north latitude and 14°29' and 14°45' east longitude (Fig. 1). It covers a total area of 2571 km² and its bordered on the north by the Lom and Djerem Division, on the East by the Central African Republic, on the south by the Bomba and Ngoko Division and on the west by the Haut-Nyong Division (Sigha Nkamdjou, 1994; Mvondo Ondoua, 2009; Vishiti *et al.*, 2015; Kouassy Kalédjé *et al.*, 2016). The Kadey is 552 km long and covers an area of 41,000 km² (4,100,000 ha)

I.2.4.2. Biophysical characteristics of the study area

I.2.4.2.1. Climate

The localities of the Kadey Division notably, Garoua-Boulai, Betare-Oya and Ngoura are situated at the boundary between the equatorial forest and the Sahelian zone influenced by a Guinean equatorial climate with four seasons of unequal lengths. The annual rainfall is around 1,400 mm with average temperature approximately 25°C. The climate supports two agricultural season: mid-June to mid-August and mid-August to mid-November. Kette, Batouri and Kentzou council areas are dominated by a classical Guinean equatorial climate with four seasons of unequal lengths: a small rainy season from March – June, a small dry season from June to mid-August. The temperature and average thematic amplitude vary according to reports from the sub division delegation of agriculture and rural development from between 23.8°C to 29°C. The average annual precipitation height stands at 1600mm. This climate is very favourable for many production activities notably, agriculture and livestock.

I.2.4.2.2. Relief and hydrography

The area lies in a transitional zone between the southeastern plains and the Adamaoua plateau. The relief is mostly gentle undulating consisting of plateau dissected by deep valleys and depressions forming lowlands. In the south, the highlands dominate much of the landscapes. In Betare-Oya, the relief is relatively rugged, with an average altitude of 680 m above sea level. The soil types are predominantly ferrallitic and lateritic soils, with some more or less brown soils caused by leaching. These soils are generally differentiated by horizons, with the surface horizon being black. The hydrographic network is quite dense and consists of non-navigable watercourses, including the Kadey, Bali, Nguli, Bah, Meloumba, and Lom rivers, the latter being one of the tributaries of the Sanaga River. Additionally, there exists a vast network of

seasonal waterways, most of which dry up during the dry season. Betare-Oya council area is watered by two main rivers, Lom and Pangar including several smaller rivers.

I.2.4.2.3. Fauna and flora

For Lom and Djerem Division, the vegetation in Garoua-Boulai exhibits a mix of grasslands, savannas, and forests, including gallery forests and marshy areas. Notably, numerous gallery forests are identified, primarily along rivers, streams, and marshy areas. The dominant herbaceous species include *Pennisetum purpureum*, *Hyparrhenia rufa*, *Chromolaena odorata* (Bocassa), *Mimosa* sp., and various grass species. The main vegetation formations encountered in this area are herbaceous plains dotted with shrubs, marshy forests (periodically flooded areas near watercourses, low-lying areas, and valleys), raphia marshes (zones dominated by raphia palms), fallow lands surrounding houses and gallery forests. Interestingly, pockets of forest with ligneous species (e.g., *Milicia excelsa*) are also present in some patches of forest. The principal dominant tree species include among others, iroko, fraké (*Terminalia superba*) and padouk (*Ptérocarpus soyauxii*) Anonym (2017). Bétare-Oya is characterised by a peri-forest savanna, with 90% of its territory covered, and 10% primary equatorial forest.

The area has a variety of animal species, but they are not very abundant. There are some areas with plenty of game, and some species of mammals, birds, and fish have been spotted. Some of the rare wildlife species include, green mamba (*Rendroaspis janesoni*), sharp-shinned hawk (*Accipiter erythropus*), turtle (*Chelonidae*), Nile monitor (*Varanus niloticus*), Gabon viper (*Bitis gabonica*), pangolin (*Manis tricuspis*), crested porcupine (*Hystrix cristata*), while species like chimpanzee (*Pan troglodytes*), Peter's duiker (*Cephalophus callipygus*) and elephants (*Loxodonta africana*) have disappeared. Betare-Oya is rich in fauna, with common animal species like antelopes, monkeys, elephants, and 196 bird species identified.

I.2.4.2.4. Human environment

The area of Garoua-Boulai has rich gold deposits, which are mined artisanally. However, this has led to a decline in education and agriculture in the community. Historically, the area experienced significant population movement in the late 19th and early 20th centuries, driven by factors such as clan disputes, search for better living conditions, and access to infrastructure. The community eventually settled in its current location, encouraged by colonial administrators who saw the area's potential as a trade hub. Garoua-Boulai got the name from its hospitality. Bétare-Oya was founded by the Baya people, who settled there after leaving the Central African Republic. The commune has a population of approximately 63,882 inhabitants, distributed across various villages.

CHAPTER II. MATERIAL AND METHODS

II.1. Material

II.1.1. Study site

The study took place in three (3) councils of the Kadey Division notably in Batouri, Kentzou and Kette and in seven (7) councils of the Lom and Djerem, notably in Bertoua I, Belabo, Mandjou, Diang, Garoua-Boulai, Betare-Oya and Ngoura. Most particularly, for Kadey Division the following villages: Kambele and Pater (Batouri Council); Lolo and Mbile (Kenzou); Mama I and Ndongdare (Kette); For the Lom and Djerem Division, the following villages were visited: Mbaki and Koundi (Belabo); Koume (Bertoua); Dongo (Diang); Dokto and Mbelle (Betare-Oya); Ndounbe and Wantamo (Ngoura); Bazzama and Touki (Mandjou); Bindiba and Nandoungué (Garoua-Boulai) (Fig.3).

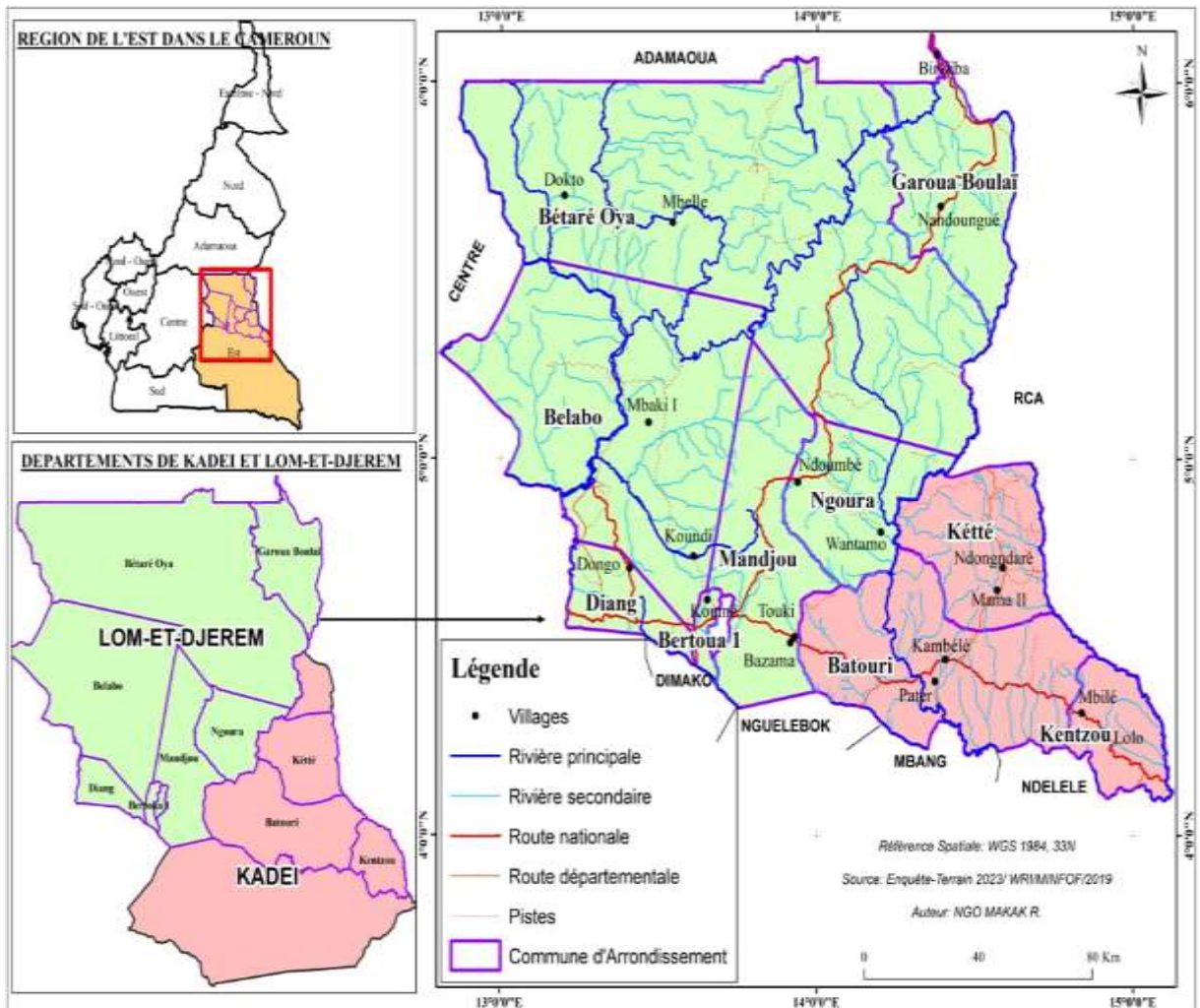


Fig. 3. Study site map adapted from Anonym (2019).

II.1.2. Tools

To obtain the objective of this study, materials and tools that are appropriate to the ROAM approach were used. These materials were used to ensure scientific rigour and context-specificity in identifying and prioritizing restoration opportunities. These materials align with the ROAM framework allowing for accurate data collection, spatial mapping, stakeholder input and cost-benefit analysis. The following materials were used;

- GPS Garmin 64S: used to accurately record the geographic coordinates of degraded and restoration sites
- SW Maps: utilised for mapping land-use patterns and analyzing spatial data.
- Camera: employed to capture visual evidence of landscape degradation and restoration potential.
- Notebooks: were used for recording observations, field notes, and important data during site visits.
- Stakeholder interview guides: facilitated structured discussions to gather expert and local knowledge about degradation and restoration opportunities.
- Community survey questionnaires: collected quantitative and qualitative data on community perspectives and land-use practices.

II.2. Methods

II.2.1. Sampling design

II.2.1.1. Choice of study site

The Sanaga–Kadey watershed was identified as a high-level hotspot for restoration at the national level. The selection of gallery forests as focus areas within the watershed was based on local NGO and community preferences such as the emergency community forest along the “pater stream” and the gallery forest in Yassa along the “mbal stream”.

II.2.1.2. Choice of respondents

Participants for the various groups of discussions and surveys were purposively selected to ensure representation of key community groups and stakeholders. The selection criteria included: (i). Key stakeholders, that is representatives of farmers, women’s groups, youth associations and community elders based on their knowledge and perspectives on degradation and restoration needs for their community: (ii). Diversity, each group was expected to include individuals with varying socio-economic statuses to capture a broad range of experience and also (iii). Availability, that is based on willingness and the availability to engage in the discussions. During village meetings and focus group discussions, at least thirty (30)

respondents were targeted per community during village meetings and focused group discussions. Although desegregation by gender was desired the meetings were dominated by men and boys with women sitting in the background.

II.2.2. Data collection

Restoration Opportunities Assessment Methodology (ROAM) data collection involves a combination of participatory and technical approaches tailored to assess restoration opportunities in specific landscapes. This approach ensures that local knowledge and priorities are incorporated, increasing the relevance and acceptability of the assessment. This combined approach ensures that the data collected under ROAM is comprehensive, blending scientific rigour with local stakeholder inputs to provide actionable recommendations for restoration planning. The ROAM principle fits data collection methods by emphasising participatory approaches, spatial analysis, and the use of field data to identify restoration opportunities Anonym. (2014) and Chazdon., *et al.* (2016). These principles ensure that ecological, social, and economic factors are integrated into restoration planning and decision-making.

II.2.2.1. Secondary data collection

The objective of reviewing the secondary data was to gather baseline data on forest systems and historical degradation trends. In this method, existing literature, government reports, base maps, and national restoration strategy and mandates were reviewed and related literature and information on past land-use changes, existing species biodiversity, and characterisation of degradation drivers were equally reviewed.

II.2.3.2. Primary data collection

II.2.3.2.1. Drivers of deforestation and landscape degradation

A participatory survey was carried out in the communities bordering the catchment areas, covering nine (9) councils, in order to understand local perceptions of functional degradation in their respective areas. The survey was based on semi-structured interviews with 68 community chiefs, 9 mayors, 9 forestry and wildlife chiefs of post, 9 heads of communal forestry units, 1 ANAFOR representative, 3 members of the regional council, 8 local associations and a forestry manager from the Dino et Fils company. In addition, 18 focus groups were organised to explore local perceptions of the causes of landscape degradation (CIFOR, 2014). Analysis of satellite images, particularly those from Landsat 8, was used due to its high-resolution imagery to measure changes in forest cover and characterised landscape types in the two catchments (Hansen *et al.*, 2013).

Furthermore, focus group discussions were also conducted in these communities with the local population. The objective of conducting FGDs in the communities visited was to capture community perceptions, knowledge and perspectives on deforestation and the degradation drivers associated to them. Field observation carried out geared towards the validation of spatial data and observed physical indicators of functional degradation. Geospatial tools like GPS and Site Web Maps (SW Maps) were used to document field conditions. Observations included discussions with communities on their perceptions of soil fertility changes, water quality and vegetation cover changes, especially in gallery forests (Fig.2). These combined methodological approaches provided an in-depth, multidimensional understanding of the factors behind deforestation and landscape degradation in the Sanaga and Kadey catchments.



Fig. 4. FGD with local communities to assess ecosystems degradation and restoration options
(a) Koundi village community, (b) Koundi village community

II.2.3.2.2. Quantifying restoration opportunities

The specific methods used to quantify restoration opportunities in the Kadey and Lom-et-Djerem watersheds include:

- field surveys with GPS and SW Maps were used to locate and map degraded sites, while observations and measurements were conducted on the ground for the 9 council areas,
- community survey questionnaires and interview guides helped gather information on local perceptions, land use practices, and restoration needs,
- Landsat 8 imagery was analysed to assess land cover changes and degradation patterns,

- notebooks documented field observations, while cameras captured visual evidence of site conditions.

II.2.3.2.3. Restoration options and interventions

Restoration activities already being implemented by government agencies (MINFOF, MINEPDED, and ANAFOR), private sectors (e.g. Dino et Fils timber company) and plans to carry out restoration activities in some communities were also the focus of the stakeholder interviews. The objective of conducting focus group discussions and stakeholder interviews in the communities visited was to capture community perceptions, knowledge and perspectives on restoration needs and for the watershed. Field observation methods of data collection was also conducted. Potential FLR options were first identified. It general started with a longer – and quite detailed – list of locally appropriate interventions and during the assessment several of these options were combined and some had to be discarded. By the end of the process a concrete list of between five and fifteen interventions were established. At this early stage of the process the best way to produce the list of possible interventions was to classify ongoing restoration activities in the country by: (i) those that take place primarily on forest land; (ii) those that take place primarily on agricultural land; and (iii) those that take place primarily to protect slopes, rivers, wetlands or coastal areas. The approach was focused on conducting rapid observation of land use/land cover, water source and quality, soil degradation and biodiversity. The objective of using this method was to understand local perceptions and gather qualitative insights into restoration needs and priorities.

II.2.3. Data analysis

II.2.3.1. Drivers of deforestation and landscape degradation

The purpose of analysing the drivers of degradation was to identify anthropogenic factors contributing to landscape degradation, with a focus on gallery forests. Data from interviews, FGDs, and spatial mapping were analysed. Descriptive analysis was used to assess the frequency of specific responses regarding degradation causes and restoration priorities. Meanwhile, content analysis was used to identify key phrases and sentiments within focus group discussions and stakeholder interviews to extract major viewpoints. Spatial data was analysed using Geographic Information System (GIS).

II.2.3.2. Restoration and options

The objective of analysing the restoration opportunities was to identify feasible forest landscape restoration (FLR) options. The activities carried out in order to analyse these opportunities were as follows:

- a list of restoration options was developed based on existing perceptions of functional degradation and preferences of communities and,
- possible interventions were classified into landscape mosaic types and wide-scale; where mosaic interventions applied to agroforestry zones near community areas, and wide-scale to degraded tree plantations or degraded forest estates in more remote areas.

During focus group discussions, participants were asked to confirm whether their responses and insights were accurately captured and interpreted. Local leaders and key informants also reviewed the findings and provided feedback to ensure that the data aligned with their knowledge and observations. As the expert conducting the study, internal validation was conducted by cross-checking the data with existing literature and reports (e.g., local environmental assessments, and government statistics). ArcGIS 3.6 was used to map and analyse spatial data collected from field observations and remote sensing. This was done through an overlay analysis by superimposing degradation maps over community land-use data to identify high-priority restoration areas. Microsoft Excel 2016 was used for the descriptive analyses.

CHAPTER III. RESULTS AND DISCUSSION

III.1. Results

III.1.1. Drivers of degradation

III.1.1.1. Drivers by land use type

The results present the identified drivers of landscape degradation across different land use categories in the Sanaga and Kadey watersheds. The categories include agroforestry land, communal forest, forest galleries, gold panning zones, and micro-zoning zones. Each driver contributes to varying extents of degradation based on the specific land use type.

Deforestation for agriculture expansion is the leading driver in agroforestry land use category (174 responses) and gallery forests (70 responses), a total of 244 responses, reflecting the pressure from agricultural expansion to meet food production demands in both land use categories. Unsustainable harvesting of service wood and logging is the second largest driver, with a total impact of 190 responses distributed across land use types with communal forests recording the most impacted (105 responses) followed by gallery forests (75 responses). Wildfires significantly impact agroforestry areas (35 responses), forest galleries (20 responses), and communal forests (10 responses). This underscores the need for fire management strategies.

104 responses revealed that mining activities are reported as a significant driver of degradation in gold panning zones (69 responses) and gallery forests (35 responses). This highlights the localized impact of artisanal and small-scale mining, which leads to deforestation, soil erosion, and contamination of water sources within these land use categories. Unlike other land use categories, mining is specific to areas where mineral resources are exploited, emphasizing its concentrated but severe environmental impact. Overgrazing and conflicts between land users are widespread, especially in micro-zoning areas (82 responses), reflecting competing demands for land (Table I).

Table I. Degradation drivers per land use category

Degradation Drivers Local land use	Deforestation for agriculture	Wildfires and uncontrolled burning	Unsustainable harvesting of service wood and logging	Mining activities	Overgrazing and land use conflict	Total
Agro-forestry land	174	35	10	-	-	219
Communal forest		10	105	-	-	115
Gallery forests	70	20	75	35	-	200
Gold panning	-	-	-	69		69
Micro-zoning	-	-	-	-	82	82
Total response	244	65	190	104	82	685

III.1.1.2. Drivers of deforestation by council areas

Finding from the study revealed that the perception of the local knowledge about the drivers of deforestation and degradation varies from one council area (Sub-Division) to another around the Sanaga-Kadey watershed. The table presents data on the drivers of deforestation and degradation across the different selected council areas in the in the Kaddey and Lom and Djerem Divisions of the Est Region of Cameroon. In these findings, the council areas around the watershed have varying deforestation and degradation profiles, with Betare Oya (107 responses) and Garoua boulai (106 responses) appearing to be the most severely impacted across multiple driver categories (Table II). A comparative analysis of landscape deforestation and degradation drivers by Council area shows that the councils most impacted by deforestation for agriculture are Garoua boulai (39), Batouri (26), and Mandjou (26). Ngoura and Kette show relatively lower impacts from agricultural deforestation with 10 responses each. Garoua-Boulai (21), Batouri (18) and Mandjou (15) have the highest levels of deforestation from wild fires and uncontrolled burning. Kentzou, Ngoura and Belabo (9,10 and 10 respectively) experience the lowest impacts from this driver. Betare Oya (50), Bélabo (33), Mandjou and Batouri (both at 23) have the highest deforestation from unsustainable wood harvesting and logging. Kambélé (13) and Garoua-Boulai (9) council areas have the lowest degradation levels. Kambele (27) and Betare Oya (17) have the most significant mining-related deforestation impacts. Garoua boulai (14) also experiences some significant mining-driven degradation. Garoua-Boulai, Mandjou and Batouri and to a lesser

extend the Betare-Oya council areas have reported overgrazing and land use conflict as a major degradation driver.

Table II. Degradation and deforestation drivers by council areas

Degradation drivers Councils	Deforestation for agriculture	Wildfires and uncontrolled burning	Unsustainable harvesting of service wood and logging	Mining activities	Overgrazing and land use conflict	Total
Batouri	26	18	23	9	15	91
Bélabo	24	10	33			67
Bertoua	12	12				24
Betaré Oya	22	13	50	17	5	107
Garoua boulaï	39	21	9	14	23	106
Kambélé	13	16	13	27		69
Kentzou	18	9	20			47
Ketté	10	12	19	9		50
Mandjou	26	15	23		16	80
Ngoura	10	10	17	7		44
Total	200	136	207	85	57	685

III.1.2. Restoration opportunity

III.1.2.1. Restoration opportunities for degraded ecosystem service

The results from the study carried in the Sanaga-Kadey watershed show huge restoration opportunities in the 10 selected council sites around the catchment areas. The table presents the five (5) categories of land use systems in the watershed and the surface area (hectare) of restoration opportunities found for each council area per land use type. The total surface area of restoration opportunities across all land use types is 426,913 ha for the ten (10) selected councils. The numerical data shows the specific area (in ha) for each land use type within the council area. The table indicates that there are 145,835 ha (the highest) of restoration opportunities for agro-forestry land use type, followed by gallery forests land use type with 107,001 ha of forests, and communal forests land having 98,942 ha of opportunities. The gold panning land use provides the least opportunities in terms of surface area but also very crucial due to its huge devastation and impact on functional degradation. The table provides a detailed breakdown of the different land use types and their associated restoration potential (Table III).

Belabo is the council with the highest restoration potential providing over one hundred and twenty-seven (127,000 ha) hectares of restoration opportunities, mostly from agro-forestry, communal forests and gallery forests land use systems and it is closely followed by Betare-Oya that shows close to ninety thousand hectares (90,000 ha) of landscape restoration opportunities. Kentzou and Kambele show the smallest opportunities in terms of surface area mostly affected by agro-forestry and gold panning land use systems. Opportunities to restore gallery forests and agro-forestry land use systems are represented in eight (8) of the ten (10) selected councils within the watersheds.

Table III. Restoration opportunities in the Sanaga-Kadey watershed

Council areas(ha)											
Land use type	Batouri	Bélabo	Bertoua	Betaré-Oya	Garoua -boulai	Kambélé	Kentzou	Ketté	Mandjou	Ngoura	Total
Agro-forestry land	11185	88226		33454	1565	-	2211	-	9194		145835
Communal forest	25001	31000	-	-	-	-	-	-	9441	33500	98942
Gallery forests	22537	8532	4415	26182	11700	-	-	15846	11163	6626	107001
Gold panning	-	-	-	3763	13	2775	-	2144	-	1375	10070
Micro-zoning zones	-	-	-	26404	27345	-	-	-	11316	-	65065
Total surface of restoration opportunities	33722	127758	4415	89803	40623	2775	2211	17990	41115	41501	426913

III.1.2.2. Percentage distribution of the restoration opportunity

This quantitative analysis illustrates the severity of degradation in different land-use categories. Agroforestry and gallery forests, which represent the largest areas of degradation, offer the highest potential for intervention through restoration efforts (Fig. 6).

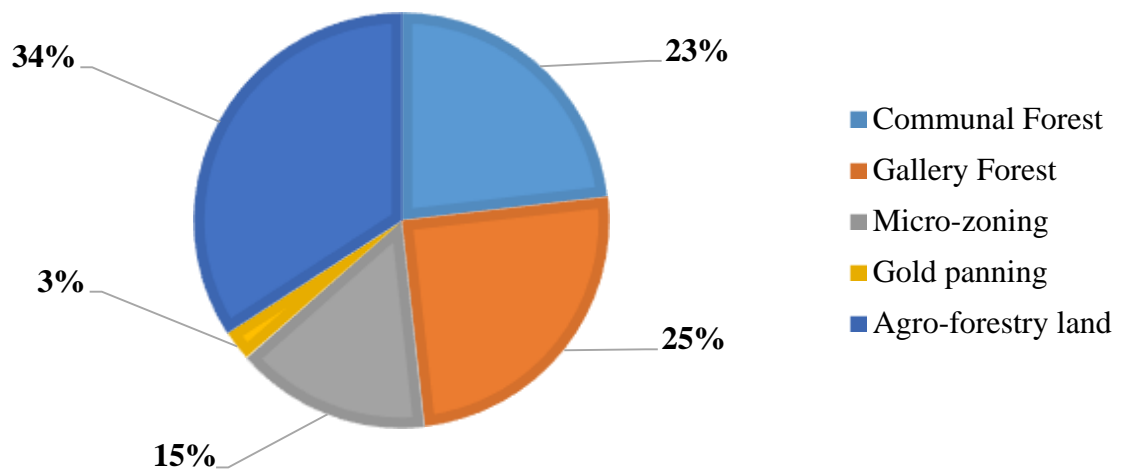


Fig. 5. Distribution of restoration opportunities in Sanaga-Kadey watersheds

III.1.2.3. Spatial distribution of the restoration opportunity zones

The opportunity zones in the landscape context for the Sanaga-Kadey watershed were mapped using satellite data and Geographic Information System (GIS) tools and based on the areas identified as degraded (intervention priorities), restoration opportunities were identified according to the main degradation factors per plot. Despite vague or approximate boundaries, these areas are currently considered the best opportunities for restoration on a landscape scale. These results highlight the boundaries of both the Sanaga and the Kadey watersheds, showcasing their ecological significance in the studied landscape.

The Sanaga community forests are delineated in green on the map representing areas managed by the local communities for forest-related activities. Meanwhile, the kadey community forests marked distinctly as light brown, also represented the community-managed forests specific to the Kadey watershed. Protected areas (shown in specific colour, deep green, on the map), signified zones designated for conservation. These areas likely have minimal degradation but can benefit from supportive restoration activities. The areas marked as opportunities for restoration (yellow) is the focus of these results and highlight zones identified as degraded or underutilised landscapes. These areas are prioritised for restoration interventions (Fig.3).

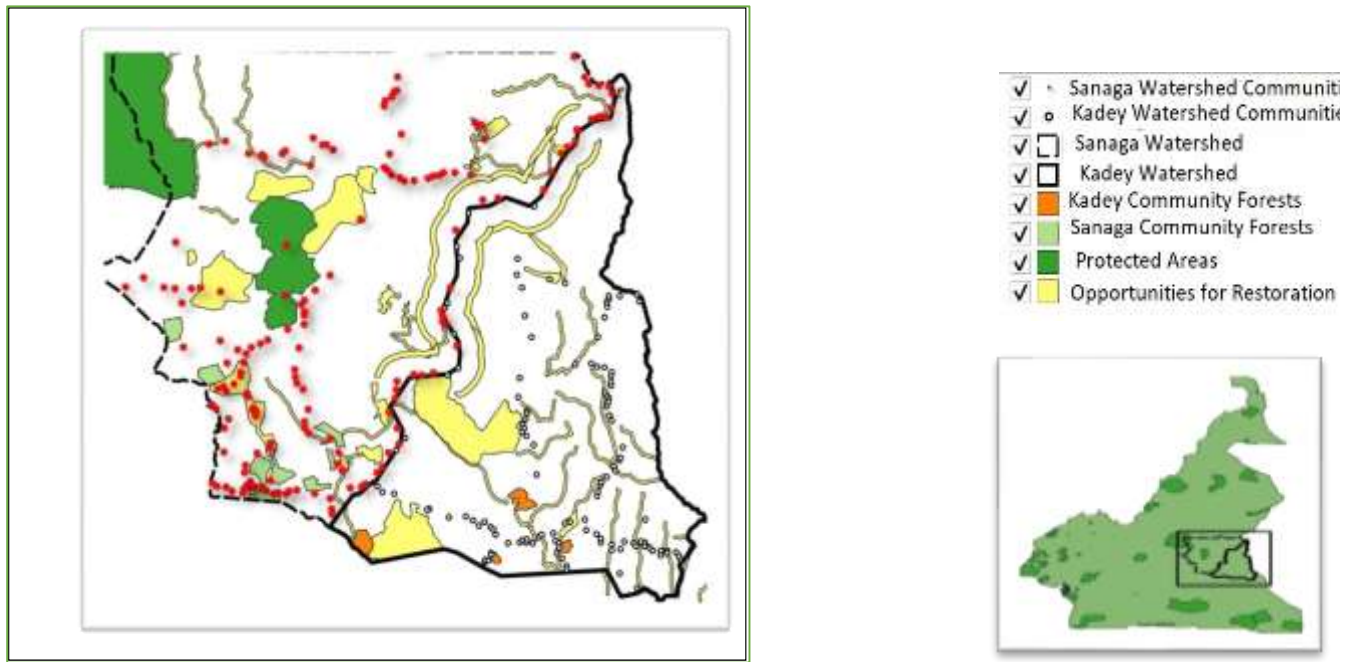


Fig. 6. The spatial characterisation of restoration opportunity zones in the studied landscape.

III.1.3. Restoration options and intervention

III.1.3.1. Variation of restoration options in relation to land use type

Based on the opportunity assessment, several restoration options and interventions were identified for the Sanaga-Kadey watershed. The results reveal the most appropriate strategies for addressing land degradation and restoring ecological functions in the region. Detailed restoration options were proposed and their subsequent interventions were designed in a participatory manner with stakeholders involved and consolidated as such illustrated (Table IV). The specific restoration options identified for the agroforestry land use system include biochar application of over 43,000 ha in mosaic landscape pattern, over 100,000 ha of approaches to agroforestry and reforestation in wide-scale.

Enforcement of local and state forest management and conservation rules, statutory protection, local regulations and assisted natural regeneration were proposed interventions to restore the close to 99,000 ha of identified degraded communal forests. For the degraded gallery forests, defending against bushfires and assisted natural regeneration were identified as options to bring approximately the 107,000 ha of degraded landscape under restoration in mosaic and wide-scale landscape restoration pattern. ReviTech®, biochar application, reforestation and assisted

natural regeneration at wide-scale were identified as restoration options to restore the over 10,000 ha of deforested and abandoned gold exploitation sites (Table IV).

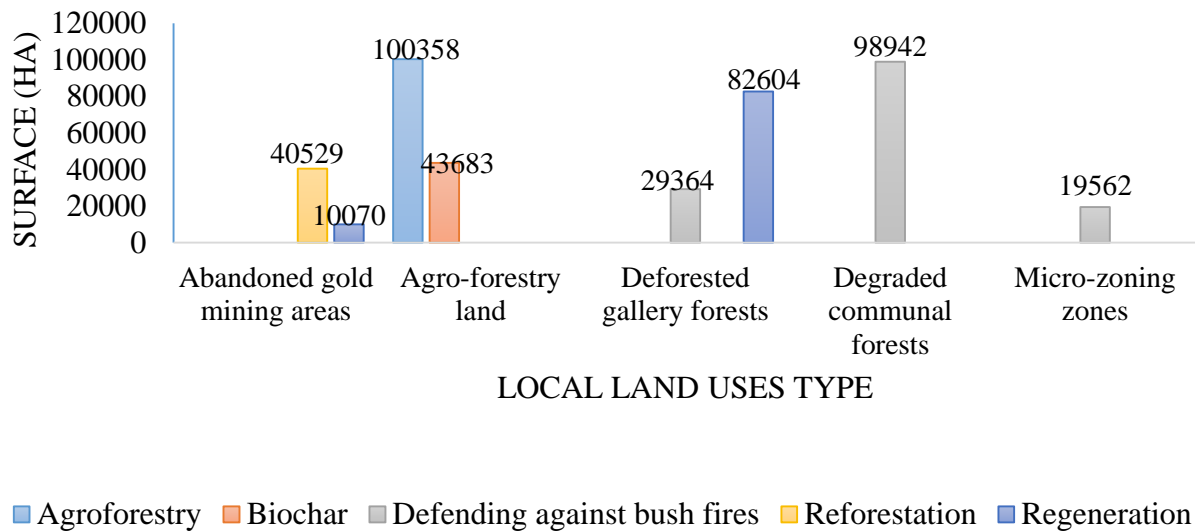


Fig. 7. Restoration options by land use type.

III.1.3.2. Correlation between restoration options, land use types, degradation drivers and the selected administrative units

A multiple correspondence analysis (MCA) of the components and results obtained from this study, can be established between the different land use systems, the identified drivers of landscape deforestation and degradation, the administrative units where these elements were identified and consequently the restoration and intervention options. The MCA shows clear linkages between land systems, administrative units, and their specific degradation drivers, emphasizing the tailored restoration strategies needed for each combination. It presents a visual statistical link between all the principal components of assessing degraded landscape. Agroforestry land use type found predominantly in the Kadey division, shows a strong link to deforestation for agriculture. Kadey west and east contribute to 32.7% of responses for agroforestry degradation due to agriculture. These administrative units support farming activities, leading to high rates of deforestation. Communal forests concentrated in Batouri, Belabo and Ngoura councils are highly linked to unsustainable wood harvesting, accounting for 16.8% of the total degradation drivers in the area. This reflects local livelihoods that depend on forest resources.

Gallery forests and Micro-zoning zones are present across both divisions but especially in Lom-et-Djerem, these systems are associated with wildfires and overgrazing, constituting 37.6% of total drivers in these areas. Deforestation for agriculture is the most significant in agroforestry

land (63.9%), primarily in Kadey subdivisions, where agriculture expands into forested areas. Unsustainable harvesting and logging dominates communal forests (91.3%) in Ngoura Batouri, and Belabo with significant effects on forest health and biodiversity. Overgrazing and land-use conflict is strongly correlated with forest galleries and micro-zoning zones (12% of total degradation drivers), especially in Lom-et-Djerem division, where both cattle grazing and agriculture compete for land.

Wildfires and uncontrolled burning is a recurring issue in agroforestry land, communal and gallery forests and micro-zoning zones, constituting 10.9% of the degradation responses across both divisions. Mining activities in gold panning zones are entirely degraded by mining, showing an exclusive link to Betaré-Oya in Lom-et-Djerem and Kambele. Each degradation driver is linked to specific administrative units, agriculture (Kadey), mining (Betaré-Oya), and overgrazing (micro-zoning zones in Lom-et-Djerem). These links highlight the importance of designing region-specific restoration strategies that account for the unique interplay between land-use types, administrative boundaries, and degradation drivers (Fig.8).

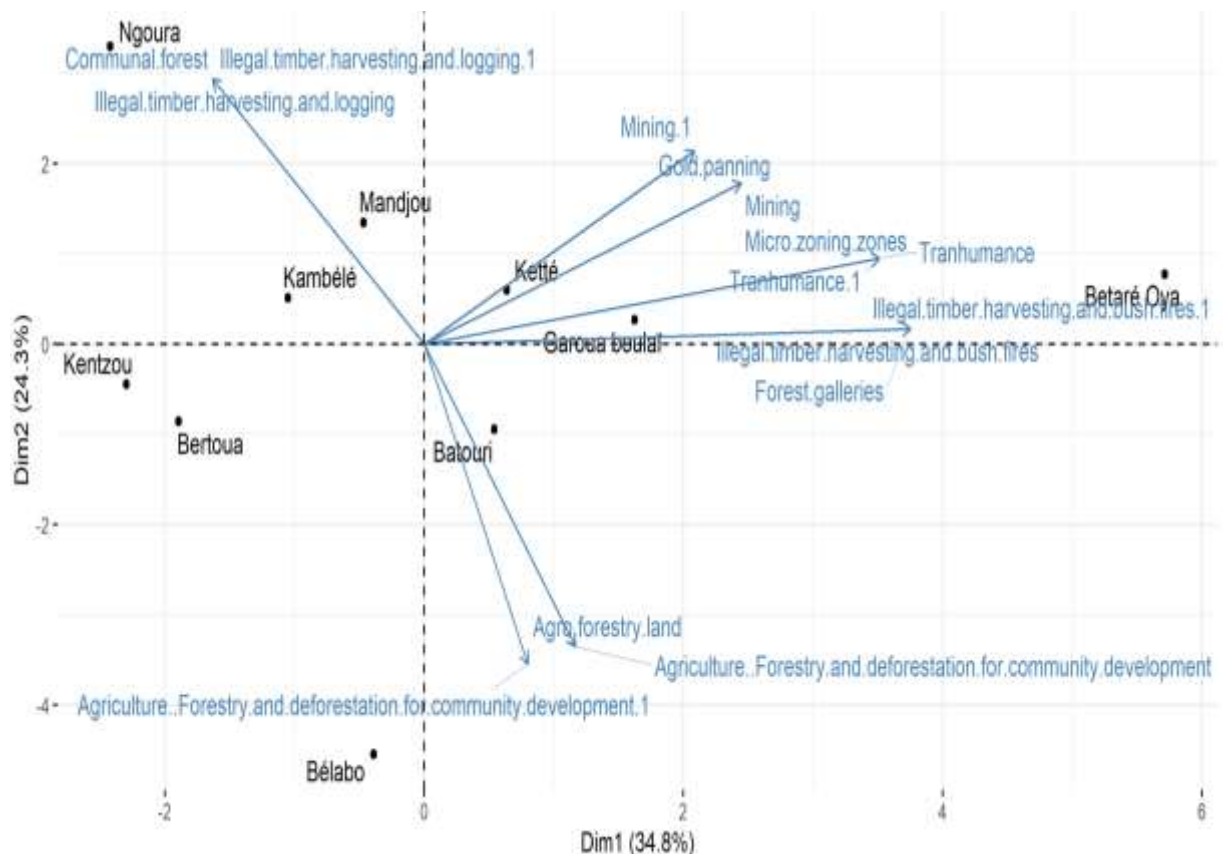


Fig. 8. Multiple correspondence analysis for land use systems, administrative units and degradation drivers

III.2. Discussion

Results from this study underscore that landscape degradation is driven by a combination of anthropogenic activities. Addressing these drivers requires integrated restoration approaches tailored to each land use type. For instance, agroforestry systems require strategies to balance agriculture with conservation, while forest galleries demand interventions for fire and wood extraction management. This study highlighted that gallery forests, agroforestry zones, and communal forests form the backbone of the Sanaga-Kadey watershed's ecosystems. However, these systems are under severe pressure due to agricultural expansion, harvesting of timber and fuelwood, and mining. Unmanaged agricultural activities, particularly slash-and-burn farming, were identified as the primary drivers of deforestation, contributing to over 65% of functional degradation in some areas. This aligns with global trends, where agricultural expansion is the leading cause of deforestation in tropical regions.

From secondary data analyses, there have been increased rates of land cover change (forest and tree loss) in the East region corresponding to the period 2016 - 2022. This is the period during which large numbers of refugees crossed into Cameroon, fleeing the effects of civil war in the Central African Republic. The northeastern landscape of the East Cameroon region and the assessment area in particular, shows a level of degradation visible on satellite images. Detection and associated data (Anonym, 2023) show a strong change in vegetation cover, with forest areas destroyed and/or replaced by grassy savannah (Anonym, 2015).

The observed fragmentation of gallery forests, with severe reduction in total area and a decrease in average patch size, emphasizes the ecological vulnerability of these habitats. Fragmentation reduces biodiversity and weakens ecosystem services such as water regulation and carbon sequestration. Restoration efforts must prioritize these areas to halt further degradation. There is the loss of ground cover through the exploitation of high value timber though the creation of communal forests is primarily intended for the sustainable harvesting of timber. The timber harvested is mainly; Frake, Ayous (*Triplochiron scleroxylon*), Moabi (*Baillonella Toxisperma*), *Enantia chlorantha*, *Azelia bipindensis*, and many more others for export and domestic use. This often-unmanaged harvesting of timber leads to a significant reduction in wood biomass and vegetation cover, which in turn promotes erosion. It also exposes the affected areas to strong winds, leading to overheating and drying out of watercourses and surface waters, encouraging bush fires, loss of soil carbon, instability of riverbanks, and much more.

Mining activities, principally gold mining, emerged as another critical driver. The deforestation and degradation around mining areas highlights the need for stricter enforcement of environmental regulations. These findings corroborate studies in similar regions, where unregulated mining has led to significant habitat destruction and soil erosion. Mining causes radical transformation of the immediate environment to the point where vegetation covers and wildlife (biodiversity) are almost completely lost. During the extraction, cleaning and treatment of the mining products, the physical, chemical and biological structure of the soil is denatured. In addition to the contamination of watercourses by increased siltation, some watercourses are disappearing (siltation of watercourse beds). This is the case of the watercourse in the Kambele village in Batouri and the mbal stream in Yassa village of the Bindiba canton.

Concerning agroforestry land use, several technical factors accounted for its relatively highest rate of landscape degradation. This include degradation from intensive agricultural land use leading to progressive decline in soil fertility in areas of continuous farming and limited soil conservation. The 244 responses from the 685 overall respondents account for the highest degradation level among the other land use systems which also corresponds to 35.6% of the total response. This degradation reduces crop yields and compromises ecosystem health, creating a strong need for restoration. As the population grows and demand for agricultural land increases, agroforestry lands are put under pressure. This can also lead to increased vulnerability to climate change. Degraded agroforestry systems lose resilience to extreme weather events. Agricultural expansion is a major driver of landscape degradation, leading to habitat destruction, soil erosion and water pollution (Tilman *et al.*, 2001). Poor agricultural practices like slash and burn constitute a significant driver of degradation to ecosystem services. Agricultural expansion constitutes a significant impact on landscape degradation including deforestation, soil degradation and biodiversity loss (Foley *et al.*, 2005).

Gallery forests, known for high biodiversity, lose native species due to deforestation and habitat fragmentation, which diminishes their ecological value. The survey results highlight the various factors contributing to the degradation of gallery forests. Gallery forests are unique ecosystems that thrive along watercourses and are crucial for maintaining biodiversity and ecosystem services. The local perceptions of the main causes of gallery forest degradation from the study show that 70 respondents believe that it is due to deforestation for agriculture. The conversion of gallery forests to agricultural land is a significant driver of degradation. Agricultural expansion in gallery forests leads to habitat loss, soil erosion, and

changes in hydrological processes, ultimately threatening the integrity of these ecosystems. 75 respondents maintain that over-exploitation of gallery forests for timber and other forest products has led to the degradation of the gallery forests. Selective logging and the removal of key species can disrupt ecosystem processes and reduce biodiversity. Mining can have devastating impacts on gallery forests, including habitat destruction, soil pollution, and changes to hydrological processes. The high number of respondents (200), citing degradation as a major impact on gallery forests suggests that these ecosystems are facing significant threats.

The survey results highlight the complex and multifaceted nature of gallery forest degradation. Addressing these threats will require a comprehensive approach that involves sustainable land-use planning, responsible resource management, and conservation efforts. Both watersheds have extensive gallery forests, perhaps the most important micro-ecosystem requiring some form of protection. Severely degraded gallery forests have a negative impact on the Kadey, the Sanaga and other downstream river basins. Many of the isolated gallery forests face degradation rates at least four times higher than those of gallery forests close to communities. In these circumstances, the protection and restoration of these sensitive but isolated gallery forests would require state protection through some form of targeted legislation, supported by local by-laws, and perhaps managed by local non-governmental organizations and the use of landscape platforms as governance mechanisms to support Wide-Scale (WS) restoration interventions.

Communal forests face heavy degradation from fuelwood harvesting, illegal logging, and unsustainable agriculture. These activities reduce tree density and soil health, disrupting ecological functions and local livelihoods. The results of the survey indicate that communal forests are significantly impacted by degradation drivers, with 115 responses out of 685 identifying this land use type as the third most affected. Unsustainable harvesting of wood biomass and logging emerged as the predominant driver, with 105 responses citing this factor. Unsustainable harvesting of wood biomass and logging can have severe impacts on communal forests, including loss of biodiversity. Over-exploitation of timber and other forest products can lead to the decline or extinction of native species (Lamb *et al.*, 2005). Logging and wood harvesting can cause soil erosion, nutrient depletion, and increased sedimentation in waterways (Bruijnzeel, 2004). Most of the communal forests land use type have undergone severe reduction of the vegetation cover due to unsustainable having of timber for service

wood. Selective logging and the removal of key species can disrupt ecosystem processes, such as nutrient cycling and hydrological processes (Putz *et al.*, 2012).

Wildfire and uncontrolled burning, cited by 10 respondents, can also have significant impacts on communal forests, including. Wildfires can cause widespread damage to vegetation, leading to soil erosion and increased sedimentation in waterways (Cerdeira & Robichaud, 2009). Wildfires can alter ecosystem processes, such as nutrient cycling and hydrological processes, and can lead to changes in soil chemistry and structure (DeBano *et al.*, 199). The degradation of communal forests can have significant impacts on the Sanaga-Kadey watershed, include soil erosion and increased sedimentation in waterways can lead to changes in water quality and quantity, affecting aquatic ecosystems and human settlements (Bruijnruptzeel, 2004). The unsustainable harvesting of service wood and logging in communal forests depletes biomass and disrupt the forest structure, causing biodiversity loss and reducing ecosystem service provisioning. Encroachment by farming leads to habitat destruction and soil degradation. Wildfire and uncontrolled burning do not only destroy vegetation but also disrupt the ecological balance, impacting services such as carbon sequestration. Degradation of communal forests can alter hydrological processes, leading to changes in water flow and quality, and affecting the overall health of the watershed (Putz *et al.*, 2012).

Gold mining activities has led to severe degradation through soil removal and contamination, resulting in barren landscapes and toxic soils. Restoration is essential to rehabilitate these areas for safe ecological function and prevent further environmental damage. The over 10,000 hectares of abandoned gold mining zones detected in this study is of increasing trend since the artisanal exploitation and industrial gold panning is still in progress. Abandoned gold mining operations have left behind significant landscape disturbances, such as open pits, trenches, and piles of excavated soil and rock. These features have drastically altered the natural topography and disrupt the local ecosystem. It also involved clearing and removing vegetation to access the mineral deposits which has led to widespread deforestation and loss of natural habitats, impacting the local flora and fauna.

Approximately 34% of the total restoration opportunities was found to be in the agroforestry zones; these are areas, primarily targeting degraded agricultural lands. Gallery Forests accounted for over 25% of the total restoration opportunities focusing on reforestation to improve biodiversity and water regulation. More than 23% was found as opportunity for restoration in the communal forest land use system. Abandoned mining sites that accounted

for about 3%, requires soil stabilisation and reforestation. Agro-pastoral zones with over 10%, requires integrating trees into grazing systems to improve soil quality and reduce erosion.

The identification of the almost 427,000 hectares of potential restoration zones across the watershed presents a significant opportunity. Agroforestry zones, have been prioritized due to their dual benefits of ecological restoration and socio-economic upliftment. This aligns with the Bonn Challenge's principles of forest landscape restoration, which advocate for integrating ecological restoration with community livelihoods.

Gallery forests requires targeted reforestation interventions to address water quality issues and biodiversity loss. The preference for native species in reforestation efforts ensures ecological compatibility and long-term sustainability. Gallery forests in East Cameroon, which historically played a critical role in regulating water cycles and supporting biodiversity, have experienced significant degradation over the past two decades. Focusing on gallery forests in this study is critical due to their ecological, socio-economic, and hydrological importance. The ecological significance of the gallery forests highlights the biodiversity hotspots that serve as critical habitats for diverse plant and animal species, many of which are endemic or threatened. Their degradation could lead to a loss of biodiversity. They play a regulatory role in ecosystem services. These forests act as carbon sinks, playing a significant role in sequestering carbon and mitigating climate change.

Gallery forests are important to maintain ecological balance by supporting adjacent ecosystems, including agroforestry systems. They also have an ecological importance in that they serve in watershed protection. These forests are often located along rivers and streams, acting as natural buffers that prevent soil erosion, reduce sedimentation, and maintain water quality in watersheds. They support groundwater recharge and help stabilise river flows, essential for both agriculture and local water supply. These forests provide essential resources like fuelwood, timber, medicinal plants, and non-timber forest products for local communities.

One other major reason for focusing this study on gallery forest is due to their vulnerability to degradation. Gallery forests are particularly vulnerable due to their proximity to human settlements and agricultural activities, leading to biomass harvesting, deforestation, and conversion to farmlands. This type of degradation would have irreversible impacts if nothing is done to address the situation. Also, degraded gallery forests are harder to restore compared to other ecosystems due to their unique microclimates and dependency on water

bodies. Restoring gallery forests can create ecological corridors, linking fragmented habitats and promoting species movement.

Restoration efforts in gallery forests align with national and global priorities. Through the country's commitment to international goals. Protecting gallery forests aligns with commitments under the Bonn Challenge, AFR100, and the United Nations Decade on Ecosystem Restoration. Furthermore, Cameroon's focus on watershed protection and sustainable land management highlights the need to prioritise gallery forests in restoration efforts. Successful restoration of gallery forests can serve as a replicable model for addressing degradation in other critical ecosystems, ensuring sustainable landscape management.

For Agroforestry land use category, the recommended options and appropriate intervention technology packages would include the application of high-quality biochar to regenerate degraded soils, the application of agroforestry techniques using priority indigenous fruit trees in farmer-managed landscape mosaics, reforestation through planting and enrichment of mixed tree stands in heavily degraded parts of community forests.

Recreational forests can be created along the national highway, such as Bertoua - Garoua Boulai, and Bertoua – Batouri using fast growing tree species and hardwood. During the maintenance period, local residents will be able to benefit from firewood. This will ensure the sustainability and effectiveness of restoration work in these severely degraded landscapes. The choice of ornamental species such as *Tectonia grandis* will be pleasant and useful for the reforestation of recreation forests.

In the case of communal forests, restoration of degraded areas would be more direct. These are state-owned forests which can benefit from the application of existing laws on sustainable management. Where this is not appropriate, for example to avoid evicting people, which is contrary to WWF "best practice", regulations or community management guidelines can be used to make existing texts more flexible and locally acceptable.

Interventions in gallery forests will invariably consist of a mix of fast-growing species that rapidly develop appropriate micro-environments, favouring assisted natural regeneration and rapid colonisation of planted native trees and other plant species. Protection and enforcement, with the support of the local population, would also play an important role. The fruits of *X. aethiopica*, *B. anacardioides* and *B. jacques-felixii* are particularly important in technological packages adapted to forest galleries. The marketing chain for these products extends beyond the Deng Deng and Mbam & Djerem national park landscapes. *X. aethiopica* fruit is sold to foreign wholesalers from Chad, Sudan, Nigeria and even Libya. *B. anacardioides*

and *B. jacques-felixii* fruits are sold to semi-wholesalers living in the villages and to wholesalers from other countries.

For the abandoned gold mining areas, biochar application, reforestation and assisted natural regeneration using application techniques like ReviTech® are recommended. For example, in the abandoned gold mining areas of Kambélé (Batouri), Yassa village (Bindiba), Betare Oya and all the other sites in the area, the creation of community nature reserves is recommended through assisted natural regeneration and reforestation. Conservation areas can be created on the basis of species richness and biological potential. These areas would require a certain level of protection from the state, local council or using regulations when such investments are to be made by communities.

For the Micro-zoning zones in the Garoua Boulai district, to resolve the problem between farmers and livestock owners, the boundaries of micro-zoning area can be marked out by planting fast-growing trees in the form of hedges. The choice of species (species with thorns, providing firewood and protective black bamboo, *Phyllostachys heteroclada*) is crucial to the success of this intervention technology. The delimitation of the micro-zoning validated by the Garoua-Boulai communal council could solve the problems of agro-pastoral conflicts, but also reduce the spread of agricultural clearances.

Restoration of landscapes can bring socio-economic benefits. The use of high-quality biochar for carbon capture and storage can help maintain soil fertility and generate additional income through voluntary carbon markets. These additional revenues will serve as bargaining points for zero deforestation and as a means of increasing production volumes.

The choice of the Kadey & Sanaga watersheds for restoration interventions is precisely aimed at gaining a better understanding of upstream-downstream relationships; the impacts of degradation and the potential benefits of restoration on water quantity and quality. While taking into account the recommendations of the communities, special mention should be made of the role of biochar in promoting biodiversity. Restoring high-quality landscapes seeks at least four types of support for biodiversity: conserving biodiversity in protected areas by encouraging activities that reduce pressure on biodiversity in protected areas, improving all growing environments (especially soils) to ensure that living things (including microscopic organisms such as certain mycelia and mycorrhiza thrive, increasing the absolute abundance of species (including sub-species) and promoting balance (evenness) between individual species or groups between different populations within the landscape.

One of the main limitations in the assessment of opportunities for restoration in the Sanaga-Kadey landscape and the envisaged action plan was potentially the risk of insufficient involvement of concerned communities who may be interested, but unable or unavailable to accompany the process. This limitation is particularly relevant to the potentially low involvement of young people, refugees and non-natives in the intervention zone.

Consequently, to take account of these expected limitations in the assessment process, and to ensure that the impact on the action plan would be minimal, the assessment adopted a more in-depth thematic approach rather than seeking exhaustiveness on a geographical scale. The aim was to ensure that sensitive ecosystems such as gallery forests, where social groups are inaccessible, were sufficiently involved, and very well assessed. The assessment also looked at indigenous cultural practices to ensure that the areas of conflict envisaged could be better understood, and that good hypotheses could be developed for scaling up at a later date.

CHAPTER IV. CONCLUSION, PERSPECTIVES AND RECOMMENDATIONS

IV.1. Conclusion

To conclude, the restoration of degraded ecosystem services in the Sanaga-Kadey watersheds in East Cameroon, as evaluated in this study, demonstrates the critical importance of adopting a holistic and participatory approach to landscape restoration. The research, which utilised the Restoration Opportunities Assessment Methodology (ROAM), highlighted key drivers of degradation-such as agricultural expansion, mining, timber exploitation, and deforestation-and mapped priority intervention areas covering 426,904 hectares.

The study's findings underscore that successful restoration hinges on a multi-dimensional approach integrating ecological, socio-economic, and governance considerations. Notably, agroforestry practices, biochar applications, reforestation efforts, and sustainable land management strategies were identified as the most viable restoration options of intervention. Importantly, the continuous and active involvement of local communities, participatory governance, and adaptive management are essential to ensure the long-term sustainability and resilience of restored ecosystems.

Finally, this sub-national assessment of restoration opportunities aligns with WWF pledged support of three million hectares to be brought under restoration by 2027 to the state of Cameroon, as well as the Country's commitment under the Bonn Challenge and the AFR100 initiative to restore over 12 million hectares of degraded land by 2030. It also emphasizes the significance of integrating restoration efforts with national development priorities and community needs to enhance biodiversity, improve livelihoods, and support ecosystem functions.

The insights from this study serve as a model for similar restoration projects in the region, offering practical recommendations to strengthen ecosystem resilience and ensure sustainable land use practices. Ultimately, this work contributes not only to landscape restoration but also to broader objectives such as poverty alleviation, food security, and climate change mitigation, which are essential for achieving the Sustainable Development Goals.

IV.2. Perspectives

For the long-term sustainability of the restoration efforts in the Sanaga and Kadey watersheds, the solutions envisaged by the population and in relation to the objective of this assessment can only be reached according to the following perspectives:

Restoration efforts in degraded forest landscapes can be strengthened through participatory governance, community involvement as well as organised community-based restoration committees.

IV.3. recommendations

Key recommendations would include:

- the introduction of restrictive regulations by raising awareness and communicating the impact of biodiversity loss and the rigorous application of existing legislation;
- collaborative governance frameworks should prioritize community-led restoration initiatives by engaging local stakeholders in restoration planning and implementation to ensure ownership, accountability, and long-term success;
- the creation of nature reserves on abandoned gold mining sites after soil revitalisation and the training and support for local residents in restoring disappearing habitats;

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ANNEX

Annex 1. Representatives of local associations contacted

Organization	Contact person	Functions	Telephones	Comments
GIC Emergence		Chairman, GIC Emergence		Scattered members, however, will be able to contribute to the production of seedlings for reforestation, given that the community forest is poor in timber and multiple-use species.
GIC DOH	Wan Miché	GIC President	698 262 484	Scattered members of the GIC, however, their contribution to restoring degraded landscapes and producing seedlings for reforestation of the community forest has been confirmed by local residents.
GIC ZOCK Mo Citi	Baba Alim Francois		696 444 421	Community forest already managed by members.
CMFI	Name	Head of Planning Unit	696 565 977	
MONEESE	Harap Doka Angelle	Vice-President of the MONEESE association	671 025 183	A group of women whose main socio-economic activity is farming. They work with the Danish Refugee Council as part of AVEC. As part of the restoration of degraded landscapes, this association can be supported in the creation of nurseries that will help them solve the problem of declining fertility in their agricultural plots.
APCRE	Koguem	Chairman of APCRE	699 021 685	The Bertoua-based NGO involved in the MEOR project will support community groups in producing seedlings and transplanting them to target sites.
REFACOF	Elomo Christiane Lylliane	Member of REFACOF	674 663 828	REFACOF, a women's network, took part in the realization of the MEOR and will support women's groups in the production of seedlings for the implementation of restoration options.

Annex. 1. Example of the restoration opportunities linked to human networks.

Land use category/ Restoration opportunity zones	Main degradation factors as perceived by local players	Resource person /Village	Telephone no.
Agro-forestry land	<ul style="list-style-type: none"> Biomass harvesting for service wood and small-scale agriculture 	Ms Harap Doka /Bindima,	671 025 183
	<ul style="list-style-type: none"> Declining fertility of agricultural land; 	Mr Achille Adamou / Gbabio ; Mrs. Mama Madeleine / Nandoungue	695 960 897
	<ul style="list-style-type: none"> Biomass reduction in the GIC ZOCK community forest 	Mr Baba Alim Francois	696 444 421
	<ul style="list-style-type: none"> Biomass reduction in DOOH community forest 	Mr Wan Michele	698 262 484
	<ul style="list-style-type: none"> Decrease in biomass and soil fertility in the emerging community forest 	Village Pater	
Gallery forest	<ul style="list-style-type: none"> Decrease in vegetation cover in the gallery forest from the source to Bindiba ; 	Mr Tchindje Eric / Bindima	672 510 241
	<ul style="list-style-type: none"> Decrease in Bindiki stream gallery forest Decrease in plant biomass in the gallery forest of the Kadey spring Loss of gallery forest cover Decline in soil fertility Reduced vegetation cover in gallery forests 	Mr Achille Adamou /Garoua boulai Mbile/Kentzou	695 960 897
Gold panning	<ul style="list-style-type: none"> Complete removal of topsoil and toxicity Reduced vegetation cover on the mine site 	Kambele/ Batouri	
Communal forest	<ul style="list-style-type: none"> Biomass harvesting for service wood; Reduced vegetation cover in the Belabo communal forest 	Mr Stephane Yende/ Koundi	
Micro-zoning	Agropastoral conflicts based on small-scale subsistence, market gardening and extensive livestock grazing.	Mr Achille/ Adamou/ Gbabio,	695 960 897
	Destruction of crops in agricultural plots	Mr Sadou Ousmane / Garoua boulai	672 177 531

Annex 3. Restoration options and intervention designs

No.	Land use category/ Restoration opportunity zones	Nature of degradation; classic and based on local perception	Details of restoration options and design of intervention technology packages	Estimated surface area (ha)/ Landscape approach
1	Agro-forestry land use	Total or partial loss of soil fertility (low nutrient retention capacity, poor water retention, loss of soil micro-organisms, etc.) leading to a significant drop in crop productivity and the spread of invasive species.	<p>Biochar application; (Mosaic)</p> <ul style="list-style-type: none"> - Agricultural areas only. - The biochar resulting from the high-temperature carbonization of organic matter will be buried in farmland to optimize water and mineral retention. 	<p>43 683 (In mosaic)</p>
		Selective overharvesting of high-value species in community forests and roadsides; loss of standing value of tree species ;	<p>Approaches to agroforestry; (Mosaïque)</p> <ul style="list-style-type: none"> - Planting of fruit trees (avocado, <i>Irvingia gabonensis.</i>, <i>Dacryodes edulis</i>, <i>Garcinia spp.</i> etc) and, where appropriate, fast-growing legumes in association with food crops such as cassava, maize, etc. in the same agricultural plot. - Enriching agricultural plots with native, off-season tree species such as the safoutier, <i>Irvingia wombulu</i>, will also help manage periods of drought. 	<p>Large 100 358</p>
			<p>Reforestation in community forests (Wide-scale)</p> <ul style="list-style-type: none"> - Defending - Planting timber trees such as Frake, Ayous, Bubinga, Iroko, Sapelli, Doucier and also local fruit trees in degraded areas. Planting trees like the <i>Tectonia spp.</i> to improve and maintain the ecosystem potentials of the landscape and limit the spreading of barren, arid land 	
2	Degraded communal forests	Selective over-harvesting and sometimes illegal use of valuable species in communal forests	<p>Law enforcement and reforestation (Wide-scale)</p> <ul style="list-style-type: none"> - Defending against bush fires (fire breaks etc) - Assisted regeneration - Reforestation will mainly concern timber species; 	

			- Future trees in communal forests are maintained and maintenance techniques are applied.	
3	Deforested gallery forests	Biomass harvesting for service wood; small-scale agriculture	Statutory protection, local regulations; assisted natural regeneration and reforestation; (Wide-scale and Mosaic) - Defending against bush fires - The choice of species depends on their suitability for the gallery forest. - Techniques such as pruning (and even the opportunistic use of fast-growing species), will be put to good use for the growth of future stems.	29 364 (In mosaic)
				82 604 (Wide-scale)
4	Abandoned gold mining areas	Complete removal of topsoil and soil toxicity	ReviTech®, biochar application, reforestation and assisted natural regeneration (Wide-scale) - The sites are completely abandoned, which can encourage their restoration under the watchful eye of local laws and regulations.	10 070 (Wide-scale)
5	Micro-zoning zones	Agro-pastoral conflict, both sides of the demarcation zone	Creation of protective hedges, reforestation, development of grazing and application of Biochar (Mosaic and Wide-scale). - Spiny legumes and protective black bamboo (<i>Phyllostachys nigra</i>) will be planted in three rows, each 50 cm apart, to create a watertight barrier between the agricultural and livestock plots.	40 529 (In mosaic)
				19 562 (On a Wide-scale)

Annex 4. Example of economic impact from restoration of ecosystem services

	Opportunity zones	Restoration and intervention options	Estimated surface area (ha)	Envisaged economic impact
1	Agro-forestry land	Biochar application; (Mosaic) Agricultural areas only.	43 683 (In mosaic form)	Significant increase in crop yields and net revenues from peanuts, corn and cassava
		Approaches to agroforestry; (Mosaïque) Growing local fruit trees in agricultural areas		Diversification of native fruit trees, for home consumption and markets; cashew nut development opportunities on restored soils.
		Reforestation in community forests (Wide-scale)	100 358 (Wide-scale)	Provides direct employment, wages for workers and their families during forest development and in the long term, through maintenance, harvesting and sale of timber locally; and contributes to GDP through taxes. Diversification of plantations with indigenous fruit trees provides additional income from NTFPs.
		Reforestation of degraded roadsides; (Wide-scale)		
3	Deforested gallery forests	Statutory protection, local regulations; assisted natural regeneration and reforestation; (Wide-scale and Mosaic)	29 364 (En Mosaïque) <hr/> 82 604 (Wide-scale)	Healthy gallery forests guarantee good water quality for the health of people and livestock in the immediate vicinity and downstream. They promote controlled market gardening without deforestation. The most important economic value is that of the services

	Opportunity zones	Restoration and intervention options	Estimated surface area (ha)	Envisaged economic impact
4	Abandoned gold mining areas	The ReviTech biochar application, reforestation and assisted natural regeneration (Wide-scale)	10 070 (on a Wide-scale)	provided by healthy gallery forest ecosystems. The fruits of <i>X. aethiopica</i> , <i>B. anacardioides</i> and <i>B. jacques-felixii</i> are collected in forest galleries and the forest-savanna mosaic by local people on the outskirts of the Mbam and Djerem and Deng Deng national parks
5	Micro-zoning zones	Creation of protective hedges, reforestation, development of grazing and application of Biochar (Mosaic and Wide-scale).	40 529 (In mosaic) <hr/> 19 562 (On a Wide-scale)	The initial aim of agro-pastoral conflict management in micro-zoning is to unlock the economic potential of livestock and arable crops. It would involve firstly a fast-growing permanent biomass barrier, then a combination of soil fertility treatment to support both productive arable land and intensive livestock grazing. There is the potential for massive application of Biochar for carbon storage and capture, with crops and forage benefiting.

Annex 5. Questionnaire for Local Community Members

Section 1: Demographic Information

1. Name of the respondent (optional): _____

2. Age: 15-30 31-45 46-60 61 and above

3. Gender: F M

4. Occupation: _____

5. Length of time lived in this community: 0-5 6-10 11-15 16-20 21 and more

Section 2: Perceptions of Degradation and Restoration

6. What changes have you noticed in the local forests or landscape over the years?

- a) Deforestation: Yes No
- b) Decrease in water sources: Yes No
- c) Soil degradation: Yes No
- d) Biodiversity loss: Yes No

7. What do you believe are the main causes of these changes?

- a) Agriculture expansion: Yes No
- b) Mining activities: Yes No
- c) Logging: Yes No
- d) Climate changes: Yes No
- e) Other (please specify): _____

8. Are you aware of any local or government-led efforts to restore the forests?

Yes No

If yes, please describe briefly. _____

Section 3: Community Involvement in Restoration

9. Are you or your community involved in forest restoration activities?

Yes No

10. If yes, what type of activities are you involved in?

- a) Tree planting: Yes
- b) Soil conservation techniques: Yes
- c) Agroforestry: Yes
- d) Others (please specify): _____

Section 4: Knowledge of Restoration Benefits

12. What benefits do you think forest restoration could bring to your community?

- a) Improved water quality: Yes
- b) Increased soil fertility: Yes
- c) Employment opportunities: Yes
- d) Better biodiversity: Yes

Other

(please

specify):

Annex 2. Questionnaire for Local Authorities

Section 1: Awareness of Environmental Degradation

1. In your opinion, what is/are the primary drivers of forest and landscape degradation in your area?

- a) Agriculture
- b) Mining
- c) Fuelwood collection
- d) Other (please specify): _____

2. What measures are currently being taken to address these issues?

Section 2: Policies and Community Involvement

3. What policies or regulations are in place to support forest landscape restoration (FLR)?

4. How do you ensure that local communities are involved in restoration initiatives?

5. What are the main challenges in implementing these policies?

Section 3: Restoration Methods and Support

6. Are there specific techniques promoted for restoration in this area (e.g., biochar, agroforestry)?

Section 1: General Perceptions of FLR in the Region

1. What are the main environmental challenges impacting the Kadey and Sanaga watersheds?
2. What restoration techniques are you currently employing, and why?

Section 2: Specific Techniques and Impact

3. What has been your experience with using biochar, agroforestry, or other sustainable land practices?
4. How do you measure the effectiveness of these restoration interventions?
5. What results or successes have you observed in the restoration areas?

Section 3: Community and Policy Challenges

6. How would you rate the community's involvement and interest in FLR projects?

Annex 4. Questionnaire pour les Membres de la Communauté

Section 1: Informations Démographiques

1. Nom du répondant (optionnel): _____

2. Âge: 15-30 31-45 46-60 61 and above

3. Sexe: F M

4. Profession: _____

5. Depuis combien de temps vivez-vous dans cette communauté ? _____

Section 2: Perceptions de la Dégradation et de la Restauration

6. Quels changements avez-vous observés dans les forêts ou les paysages locaux au fil des années?

- a) Déforestation
- b) Diminution des sources d'eau
- c) Dégradation des sols
- d) Perte de biodiversité

7. Selon vous, quelles sont les principales causes de ces changements ?

- a) Expansion agricole
- b) Activités minières
- c) Exploitation forestière
- d) Changements climatiques
- e) Autre (veuillez préciser)

8. Connaissez-vous des efforts locaux ou gouvernementaux pour restaurer les forêts?

Oui Non

Si oui, veuillez décrire brièvement: _____

9. Êtes-vous ou votre communauté impliqués dans des activités de restauration des forêts?

Oui Non

10. Si oui, dans quel type d'activités êtes-vous impliqués?

a) Plantation d'arbres

Section 4: Connaissance des Bénéfices de la Restauration

12. Quels bénéfices pensez-vous que la restauration des forêts pourrait apporter à votre communauté?

- a) Amélioration de la qualité de l'eau:
- b) Augmentation de la fertilité des sols:
- c) Opportunités d'emploi:
- d) Meilleure biodiversité:
- e) Autre (veuillez préciser):

Section 1: Perceptions de la Dégradation Environnementale

1. Selon vous, quelles sont les principales causes de la dégradation des forêts et des paysages dans votre région?

- a) Agriculture
- b) Exploitation minière
- c) Collecte de bois de chauffe
- d) Autre (veuillez préciser)

2. Quelles mesures sont actuellement prises pour traiter ces problèmes ?

Section 2: Politiques et Implication Communautaire

3. Quelles politiques ou réglementations soutiennent la restauration des paysages forestiers (FLR)?

4. Comment assurez-vous l'implication des communautés locales dans les initiatives de restauration?

5. Quels sont les principaux défis dans la mise en œuvre de ces politiques?

Section 3: Méthodes de Restauration et Soutien

6. Y a-t-il des techniques spécifiques promues pour la restauration dans cette

Annex 5. Questionnaire pour les Spécialistes Environnementaux/ONG

Section 1: Perceptions Générales de la Restauration des Paysages (FLR) dans la Région

1. Quels sont les principaux défis environnementaux qui impactent les bassins versants de la Kadey et de la Sanaga?

2. Quelles techniques de restauration utilisez-vous actuellement et pourquoi?

Section 2: Techniques Spécifiques et Impact

3. Quelle est votre expérience avec l'utilisation du biochar, de l'agroforesterie ou d'autres pratiques durables?

4. Comment mesurez-vous l'efficacité de ces interventions de restauration?

5. Quels résultats ou succès avez-vous observés dans les zones de restauration?

Section 3: Défis Communautaires et Politiques

6. Comment évaluez-vous l'implication et l'intérêt de la communauté dans les projets de restauration?

7. Rencontrez-vous des défis liés aux politiques ou aux réglementations pour la mise en



a). Effect of landscape degradation in Garoua-Boulai

Annex 6. Photos of Degradation effects

Abandoned gold mining sites for example in Kambele, exhibited significant environmental degradation, including landscape alterations, loss of vegetation, water pollution, and soil deterioration and siltation. These impacts can have long-lasting effects on the local ecosystem and the overall sustainability of the Kadey watershed.

