CONTRIBUTION OF PARTICIPATORY FOREST MANAGEMENT TO FOREST CONSERVATION IN BENIN

BY

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ABBREVIATIONS

AGM	Annual General Meeting
CCUA	Coordinating Council of Management Units (Conseil de Coordination des Unités d'Aménagement)
CGUA	Managing Council of Planning Units (Conseil de Gestion des Unités d'Aménagement)
CVGF	Village Forest Management Council (Conseil Villageois de Gestion de la Forêt)
CTAF	Technical Forestry Management Unit (Cellule Technique d'Aménagement Forestier)
CTEP	Head of Participative Management Works (Chef Travaux Encadrement Participatif)
CUEP	Head of Participatory Management Unit (Chef Unité Encadrement Participatif)
COGEPAF	Comité de Gestion Participatif des Forêts
DBH	Diameter at Breast Height
DFM	Decentralised Forest Management
DGEFC	Directorate General of Water, Forests, and Hunting (Direction Générale des Eaux Forêt et Chasse)
ES	Ecosystem Service
FDG	Focus Group Discussion
FUG	Forest User Group
GPS	Global Positioning System
IFC	Informant Consensus Factor
KII	Key Informant Interview
MEA	Millenium Ecosystem Assessment
NGO	Non-Governmental Organisation
NTFP	Non-Timber Forest Product
PFM	Participatory Forest Management
RFC	Relative Frequency of Citation
SES	Socio-Ecological System
SONAB	National Wood Company (Société Nationale du Bois)

UAC	University of Abomey-Calavi
UTG	University of The Gambia
UV	Use Value
VPMO	Village Participatory Management Organisation
WASCAL	West African Science Centre on Climate Change and Adapted Land Use

ABSTRACT

Forests are reported as an important means to adapt and mitigate climate change. Unfortunately, forest management remain challenging in developing countries in general and particularly in West Africa, despite the advent of Participatory Forest Management (PFM) concept to slow down deforestation. PFM was introduced to meet simultaneously the needs of local people and the conservation of forest resources. The current study sought to explore the contribution of PFM on the sustainable management of the resources of three different forests in Benin. Multi-stage sampling techniques was applied for achieving this study. In the first stage of the sampling procedure, three forest reserves in Lama, Penessoulou and Sota forest were purposively selected based on experience on PFM and actively participating local community. Both qualitative and quantitative data were collected from through questionnaires, focus group discussions (FGDs) and key informant interviews. A total of 436, 458, and 211 respondents were questioned for forest ecosystem services evaluation, ethnobotanical knowledge assessment and forest governance assessment, respectively. Moreover, 8 FGDs and 8 key informant interviews were held per study objective. The results revealed that the considered forest reserves are under deconcentration and delegation management with a low to acceptable level of governance. The current way of implementing of PFM approach with low involvement of local people in decision-making process negatively affected the perception and availability of provisioning services as well as the community knowledge of forest plant species used for food and cultural purpose. Furthermore, the implementation failed to enhance the awareness on regulating and supporting services and lessen the community knowledge on forest plant species used for firewood and timber services purpose in order to favour the sustainable use of forest resources. In consequence, the forest experiencing a free access to resources presented a more degraded state of the population stand of the useful

plant species than the one experiencing controlled access to forest resources. More involvement of local management committee members in decision-making process added to more sensitization on indirect ecosystem services and a share of forest direct benefits would improve the forest governance to achieve the sustainable management of the forest resources.

Keywords: Participatory Forest Management, Forest ecosystem services, Forest plant species, Forest governance, Village Participatory Management Organisation

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

Sustainable forest management has gained huge attention in recent decades due to the crucial role forests play in addressing climate change challenges through carbon sequestration and reduction of climate hazards. Unfortunately, many forests are subjected to degradation, threatening the livelihoods of the population at local and worldwide levels. Accordingly, forest management policies have been reviewed by shifting from the traditional government-led management schemes which have been largely rated as having failed to ensure the conservation of forest resources (Díaz et al., 2011; Lund et al., 2018; Masozera et al., 2006; Ribot et al., 2006) to an inclusive management approach. Decentralized Forest Management (DFM) adopted about half a century ago (FAO, 2016) represents a partnership between the state and local community for managing the forests. Indeed, DFM is a mean of managing forest resources by involving surrounding communities for achieving the protection of the forest and improving the community livelihoods (Pokharel & Nurse, 2004). Recent reports on world forests state have showed that developing country forests were prone to deforestation due to the high dependence of local population on forest resources as inputs of their subsistence farming and livelihood systems (FAO, 2016, 2018). Thus, involving local population in forest management was though as a way of lessening the pressure on forest resources. Such approach has been implemented in almost one third of the world's forests particularly in tropical forests including 35 African countries (Arnold, 2001; FAO, 2016) with positive returns mainly in Asia (Adhikari et al., 2014; Devkota et al., 2017; Diansyah et al., 2021). To date, DFM is used in many countries under various labels such as Participatory Forest Management (PFM),

Collaborative Forest Management (CoFM), Community Forest Management (CFM), Forest Co-management (FCM), Joint Forest Management (JFM), and Community-Based Forest Management (CBFM) (Bhattacharya & Basnyat, 2005; Magessa et al., 2020), depending on the level of involvement of the local communities in the management of the forest resources (Duguma et al., 2018).

In African countries, DFM started in the 1990s with a pilot phase (FAO, 2016; Odera, 2009). The concept was introduced in most African forest management plan in the early 2002 (Wily, 2003) mainly to face the issue of deforestation and forest degradation (Kassa et al., 2017; Le Saout et al., 2013; Lund et al., 2014; Mugambi et al., 2020; Ndulinga & Mwitwa, 2017; Zewdu & Beyene, 2018) by strengthening forest security with the help of the local population. Years after, the level of its adoption is unlike from within African regions with variations in the degree of granting decision power to local communities. While stakeholders, particularly local communities were well organised and get high right and advantage from forest through DFM in most East African countries, their involvement remains still challenging in Central and West Africa. For instance, local populations in East Africa were organised in associations like community forest association (CFA) in Kenya, forest cooperatives (FCs) and forest user groups (FUGs) in Ethiopia (Ameha et al., 2014), communal land associations (CLAs) in Uganda (Mawa et al., 2021) with partial or full power on the forest resources management. On the other side, the situation seemed alike in most West African countries with local population organised in cooperatives, helping forest officers in the protection of the forests (Arnold, 2001).

1.2. Problem statement

DFM has been introduced in Benin under the "Participatory Forest Management (PFM)" concept in the early 1990s to slow down forest degradation and deforestation (Direction Générale des Forêts et des Ressources Naturelles (DGFRN) et al., 2012). After the adoption of the approach in 1994, it has been implemented in the gazetted forests of Tchaourou – Toui – Kilibo in the 1996 followed by 14 other forests (Direction Générale des Forêts et des Ressources Naturelles (DGFRN) et al., 2012) with hope of reducing the pressure on forest resources. Unfortunately, the implementation resulted in conflicts between local communities and forests officers at the end of the project. It is the case in Agoua forest caused by the respect of former agreements between stakeholders and Ouémé Supérieur and N'Dali forests due to the exclusion of local population from decision-making process (Idrissou et al., 2011a; Idrissou et al., 2011b). Subsequently, many forest areas continued to decrease and be converted into croplands as mentioned in the reports of on land-use land-cover (da Silva et al., 2020; FAO, 2015; Kakpo & Akpona, 2015; Toko Imorou et al., 2019). However, few forests have successfully implemented the approach with good results such as Lama forest that observed an increase of the different vegetation areas and a decrease of croplands (Toyi et al., 2018).

Unfortunately, PFM in this forest is exclusively implemented on plantations (Agbodossindji et al., 2023; Mehou-Loko et al., 2013) limiting local community interaction with natural forest. Consequently, such management may impact the value of forest ecosystem services of the local community that varies with the interactions between forest beneficiaries and ecosystem services and the characteristics of the beneficiaries Scholte et al. (2015).

Moreover, forests represent a major asset for surrounding population in most developing counties (FAO, 2018). Thus, forests' protection requires the involvement of all the people living

in and around the forests to avoid the development of illegal activities leading to forest degradation (Mvondo, 2005; Oyono & Efoua, 2006). Nevertheless, the rights granted to local people to manage forest resources varies depending to the PFM approach implemented. Classification of different management models revealed that state structures can hold full, partial or no control over forest resources to local community structures (Duguma et al., 2018). The level of management rights holds by local population directly or indirectly impact their livelihoods (Ngeze et al., 2017) and can therefore impact their knowledge of the forest plant species available and their usage.

Furthermore, studies related that the reluctance by state to release power over resources to local communities to the lost of commercial value or revenue rather than the concern that the forest could be destroyed (Chomba et al., 2015; Mogoi et al., 2012). Therefore, it urges to investigate on the impact of PFM to useful forest species even though the approach has been recognized to increase of the forest cover (Mugambi et al., 2020) or the ecological endowment of the forests (Alemayhu & Tesfaye, 2019; Chinangwa et al., 2017; Mawa et al., 2020).

Finally, the governance scheme highly contributes to success or the failure of PFM. The ideal PFM consider community participation to decision making and power devolution to local community as key to success. Nevertheless, this participation is mostly limited to implementation of decisions taken by policy makers, using the community members as workers (Magessa et al., 2020), depriving them of accountability right and favouring the elite capture issue in most cases (Chomba et al., 2015; Meshack et al., 2006). Such conditions raised conflicts which resulted in failure in the implementation of the approach as in some forest in Benin. Less is currently known about the governance status in forest under PFM implementation in Benin. This study seeks to assess how PFM implementation affect forest management and community livelihood in Benin. The identified research gaps drive to the research questions.

1.3. Research questions

The current study seeks to address following research questions:

1. What are the perception and attitudes of local communities towards the forest ecosystem services under different management types?
2. How does the implementation of PFM approach influence the knowledge and use of forest plants by local communities?
3. What is the impact of the participatory forest management on the population structure of the most useful forest plant species?
4. How do the local stakeholders appreciate the way of governance applied in the forest under participatory forest management?

1.4. Objectives of the study

The current work seeks to examine the contribution of the PFM to the sustainable management of the resources of Lama forest, Penessoulou forest and Sota forest in Benin.

The following specific objectives were set to achieve this aim;

1. Explore the perception and attitudes of local communities towards the forest ecosystem services under different management types.
2. Assess the influence of the implementation of PFM approach on the knowledge and use of forest plants by local community.
3. Evaluate the impact of the participatory forest management on the population structure of the most useful forest plant species.

4. Assess the perception of the local stakeholders of the state governance of forest under DFM approach in Benin.

1.5. Scope of the study

The study was conducted in three gazetted forests, under PFM approach, located in the three biogeographical zones of Benin namely Lama forest in the Guinean zone, Penessoulou forest in the Guineo-Sudanian zone and Sota forest in the Sudanian zone. The work was carried out on forest dwellers and forest resources to assess the sustainability of the management approach applied in the different forests. Thus, household heads staying since ten (10) years and more in villages surrounding the different forest reserves were covered for the study. The data related to the perception of forest ecosystem services, useful forest plant species and forest governance were collected from forest local communities using questionnaires, focus group discussion key informant interviews around the three forest reserves. Moreover, dendrometric data were collected onplate useful plant species through forest inventory in each forest.

1.6. Significance of the study

Forests represent a direct an important asset for rural people in Benin. They are a direct source of food and cash income representing a key asset food security and poverty alleviation. Forested areas are used for fuelwood for fuelwood and provides 46 percent of the energy consumed in the country (World Bank, 2020). Even though statistics on uses NFTPs are lacking, studies have demonstrated the high importance of these forest products for food, medicinal and cultural purposes (Dossou-Yovo et al., 2020; Ganglo et al., 2023; Hounsou-Dindin et al., 2022; Yèïnou et al., 2017).

Unfortunately, the management of forests is still challenging with the deforestation in progress despite the implementation of PFM. Three decades after the inception of PFM in Benin, it is important to understand the strengths and the weaknesses of its implementation.

Most of the works on PFM were done after the project phase (the withdrawal of the donors) and dealt with the conflicts that arose, the functioning of the structure of PFM neglecting aspects like perception of ecosystem services provided by forests and the suitability of governance scheme implemented. The current study aims to fill this knowledge gap by enhancing the understanding of local communities' perceptions on forest ecosystem services and the sustainability of the forest resources management, and the quality of the forest governance applied. The outputs from this research will be beneficial to the researchers, policy and decision-makers for a sustainable management of forest resources in Benin.

This work will mainly contribute to an in-depth understanding of the current practice of PFM in Benin. It will enlighten decision-makers on the effectiveness and efficiency of the regulatory and policy framework on achieving the pursued goals: community involvement, forest conservation and community livelihoods improvement.

1.7. Definition of key terms

Some key terms were used throughout this thesis and need to be defined. The following definition have been adopted from the previous literature.

Decentralized Forest Management: According to Agrawal & Ribot, (1999), "Decentralization refers to any act in which a central government formally cedes powers to actors and institutions at lower levels in a political-administrative and territorial hierarchy". Consequently DFM can be

defined as a management design which intimately involves local people in a forestry activity (FAO, 2016). DFM programmes relocate decision-making authority on forest use in the direction of the forest communities, rather than the central government actors. FAO originally adopted the term "community forestry" as an umbrella term (FAO, 1978 see Gilmour 2016). In this study we adopted the term DFM as an umbrella term as community forestry is used in some study as a type of DFM design.

Forest Ecosystem Services: Millenium Ecosystem Assessment (MEA) defines Ecosystem services as the benefits, grouped in provisioning, regulating, cultural and supporting services, people obtain from ecosystem (Millennium Ecosystem Assessment, 2005). When the benefits are derived from forests, it is called forest ecosystem services.

Traditional Ethnobotanical Knowledge (TEK): A myriad of definitions has been given to TEK due to the huge attention it gained since the 1990s. For the purpose of this study, we will use the following definition "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about relationship of living beings (including humans) with one another and with their environment" (Berkes et al., 2000a).

Forest governance: the term governance can be defined as the different way through which public and private actors from state, market and/or civil society govern public issues, autonomously or in interaction (Arts & Visseren-hamakers, 2012). Thus, forest governance comprises a) all formal and informal, public and private regulatory structures (i.e. institutions consisting of rules, norms, principles, decision procedures, concerning forests, their utilisation and their conservation); b) the interactions between public and private actors therein and c) the effects of either on forests (Giessen & Buttoud, 2014).

CHAPTER TWO

LITERATURE REVIEW

2.1. Conceptual Review

Decentralisation can be defined as the process of transferring the authority from the state level to the local level. In the forestry sector, decentralisation occurred through the transfer of authority over forest resources decision-making and its related benefits from the central governments to local communities and institutions (Shackleton et al., 2002). Decentralised Forest Management (DFM) main goal is to ensure sustainable forest management and community livelihoods by involving the local community in the management of the forest resources. To achieve this goal, DFM entailed several concepts such as forest conservation, sustainable livelihoods, community participation and, forest governance.

2.1.1. Forest conservation

The condition of a particular forest is described through vegetation ecology using a variety of techniques and methods (Mueller-Dombois & Ellenberg, 1974) either qualitative (phytosociological and remote-sensing method) or quantitative (dendrometric method). The latter is the most used in DFM research based on key biophysical indicators including, among other, the density of trees, diameter at breast height (DBH), basal area, species richness and canopy density (Bettinger et al., 2017; Pfliegner, 2010). By comparing the forest condition at two different moments, conclusion on improvement or degradation of the forest state can be made. Forests provide useful services for the human livelihoods known under the concept of ecosystem services. These services are highly correlated with the forest condition and are recognized as an analytical tool in policy agenda for reaching the sustainable livelihoods of the local community (Fisher et al.,

2009; Gómez-Baggethun et al., 2010). Three value-domains composed of the ecological, economic and the socio-cultural aspects are associated with ecosystem values (MEA, 2005).

2.1.2. Community participation

Community participation is the key feature of DFM, and this opposed DFM to the authoritarian approach also labelled a 'fines and fences' approach (Hughes & Flintan, 2001) or 'fortress conservation' (Hulme & Murphree, 1999), because of restricted rights of access and use, accompanied by sanctions for non-compliance applied to the communities surrounding the forests. Participation entails involving local actors in decision making, creating new rules or modifying old ones, formulating alternative planning activities and allocation of rights, responsibilities and resources the forest management actors (Agrawal & Ribot, 1999; Tadesse et al., 2017b). Participation allows the dynamic nature of stakeholder needs, priorities and interests to be captured and integrated throughout project implementation (Reed et al., 2009). This implies the involvement of local communities around and in forests in the management of forest resources. The participation of local community is assessed through the number of local people involved in forest activities and the level of their involvement.

2.1.3. Community livelihoods

Livelihood depends on various resources and means that individual and communities use for their survival. Livelihood is comprised of the capabilities, assets and activities required for survival and is considered to be sustainable when it can cope with, and recover from stress and shocks, maintain or enhance its capabilities and assets, and meet present needs without undermining its abilities to supply the need of the future generation (Chambers & Conway, 1992). According to Ellis (2000), livelihoods can encompass three income categories: off-farm, which are related to forest resources

in the case of forest dweller communities, farm income and non-farm income. A community with sustainable livelihoods is expected to be the clue for the conservation of forest resources. Sustainable livelihoods derive from the whole concept of sustainable development which requires increasing the capacity of rural people to influence and control their future on a long-term basis. DFM appears then as a package of sustainable development approach in the sense that it targets the forest resource management as well as the community livelihoods for its success.

2.1.4. Forest governance

Governance has no single, universally accepted definition. Governance is generally defined as the process of decision making by which decisions are made and implemented or not and is much broader than what governments do (Kozová et al., 2018; Pokharel & Tiwari, 2013). In the context of DFM, governance entails policies, institutions, actors, processes, procedures and power and how they interact to determine conservation outcomes (Macura, 2015). World bank stated forest sector governance as the ways in which people, stakeholder groups and institutions (both formal and informal) acquire and exercise authority in the management of forest resources of the sector to sustain and improve the welfare and quality of life for those whose livelihoods depend on the sector (World Bank, 2009). Forest governance includes the norms, processes, instruments, people and organisations that control how people interact with forests (Kishor & Rosenbaum, 2012). According to Shrestha & Shrestha (2017), forest governance is related to rules and policies that define forest use and management, decision making processes and the process of selecting actors who make decisions. It is an important part of DFM because it determines how organisations administer the forests and the associated power and decision-making arrangement. It addresses who makes decisions for the managed areas and management and how the decisions are made. The

term governance is relevant to forest because of its economic, ecological and social value. The concept of governance particularly "good governance" has become an important agenda international development and conservation discourse since the late 1980s, including forests (Kishor & Rosenbaum, 2012; Larson & Petkova, 2011).

2.2. Empirical Review

2.2.1. Forest conservation

Forests are known to be biodiversity hotspots, especially in the tropics. Tropical forests have a rich biodiversity that is affected by several factors, including human and climatic factors, leading to their degradation. Authors have demonstrated that DFM contributed to forest conservation spatially and ecologically. For example, satellite images used in land use and land cover change studies revealed how the DFM approach contributed to forest restoration by increasing the coverage of vegetation types (Mugambi et al., 2020; Ota et al., 2020; Putraditama et al., 2019). Furthermore, studies comparing management approaches have shown that forests under DFM have higher ecological endowment (i.e., species richness, trees density and basal area) than state or non-DFM forests (Alemayhu & Tesfaye, 2019; Chinangwa et al., 2017; Mawa, Babweteera, Tumusiime, et al., 2020). These differences are mainly attributed to the appropriate monitoring mechanism jointly developed by forest officers and forest user groups (Chinangwa et al., 2017; Lund et al., 2014; Tadesse et al., 2016). By carrying out regular patrols, user groups impose efficient management interventions to limit forest disturbance from human activities like fire occurrences, grazing and tree cutting (Tadesse et al., 2016). Nevertheless, DFM performance in forest conservation varies when different forests that are subject to the approach are compared. Factors such as the forest history (Mbwambo et al., 2012), management objectives (Lund et al., 2014), lack of power

allocation to forest user committee (Mawa, Babweteera, Tumusiime, et al., 2020; Mbwambo et al., 2012), lack of incentives and accountability (Mawa, Babweteera, Tumusiime, et al., 2020; Mbwambo et al., 2012), development of infrastructure surrounding the forest (Lund et al., 2014), and size of the user group (Lund et al., 2014; Mbwambo et al., 2012; Mugambi et al., 2020) can hinder the DFM approach by increasing access to and pressure on forest resources. However, the short period of implementation of the DFM before its evaluation, which was generally done a decade after the beginning of the implementation (Mbwambo et al., 2012; Tadesse et al., 2016), and the lack of baseline data (data at the DFM introduction) for comparison purposes (Chinangwa et al., 2017) make the authors doubtful about the outputs of the DFM on forest conservation.

2.2.2. Community participation

A key feature of DFM is the involvement of local community in the management of forest resources. Community participation in DFM is influenced by several factors, which can be grouped under socio-demographic, biophysical, socio-economic, accessibility and institutional factors (Gashu & Aminu, 2019; Kazungu et al., 2021).

Socio-demographic factors include four common indicators: gender, household size, education level and household head age. Most of these indicators have a positive influence on participation to DFM (Musyoki et al., 2013). For instance, male household heads are more represented in DFM due to the unavailability of the women. Indeed, women's productive and reproductive tasks mostly constrain them from participating in DFM activities that are highly time demanding (Engida & Mengistu, 2013; Mbeche et al., 2021). However, the low participation rate of women could be challenging for forest conservation since women are the most users of forest resources in rural areas (Ngang et al., 2018). This calls for more attention on gender inclusiveness for the

sustainability of DFM. Moreover, participation to DFM increases with households' size as large households hold available free labour for off-farm works (Bakala et al., 2021; Danano, 2020; Zewdu & Beyene, 2018). Similarly, participation increases with the age of the household head (Mbeche et al., 2021; Zone et al., 2017). Previous studies reported that older people of Ontukigo and Ngare community forest association in Kenya were more interested in joining forest management than younger people who have various commitments that they value more (Musyoki et al., 2013). These findings contrast with the general opinion that peoples' cooperation behaviour for collective activities decreases with age (Girma & Beyene, 2012). Finally, participation in DFM decreases with the level of education as better-educated households have broader livelihood opportunities making them less interested in forest-related issues (Kazungu et al., 2021; Mbeche et al., 2021). However, when wage employment opportunities are scarce like the case of Chilimaro in Malawi, people with formal education are more interested in DFM mostly to hold key positions in block committees as they understand more the importance of conserving forests (Jumbe & Angelsen, 2007).

Four common indicators are used to represent the socio-economic factors: forest income, annual income, size of land holding and land ownership. Most of these indicators are positively correlated with participation in DFM. Previous studies reported that participation in forest activities mostly increases with forest income (Bakala et al., 2021; Girma & Beyene, 2012) and size of land holding (Bakala et al., 2021; Musyoki et al., 2016), since the members of community forest associations mostly gain more from the forests than non-members. However, studies in Zambia revealed that where dependence on forest resources is linked to the lack of access to other livelihood sources, large agricultural landowners were not interested in forest activities (Kazungu et al., 2021). Annual income mostly impedes community participation in DFM as rich people who have surplus income

that could be diversified in other investments with quick return (Danano, 2020; Mpokigwa et al., 2011), making forest management activities perceived as poor people activity.

Accessibility relates to two main indicators including the distance from forest to house and the distance from house to market, which negatively influence forest participation. Participation in forest management activities decreases with increasing distances to the forests and markets (Danano, 2020; Kazungu et al., 2021).

Biophysical factors encompass two common indicators (livestock support and forest importance) with a positive impact on participation in DFM. Studies in Ethiopia (Danano, 2020; Zewdu & Beyene, 2018), and Kenya (Musyoki et al., 2013, 2016) revealed that households with large livestock are more willing to participate in forest management activities to get their animals easily fed.

Institutional arrangement factors include experience in forest organisation, household awareness and extension services, which positively influence the participation in DFM. Studies revealed that experience in CFM organisation (Girma & Beyene, 2012; Zewdu & Beyene, 2018), household awareness of new forest management practices (Bakala et al., 2021; Danano, 2020), and access to extension services that provide technical assistance on forest and land management (Bakala et al., 2021; Mbeche et al., 2021) enhanced community participation in forest activities. Nevertheless, Coulibaly-Lingani et al. (2011) reported a negative effect of extension services on forest activities in Southern Burkina Faso because respondents did not conceive that training programmes related to forestry would enhance their managerial capacity and their livelihood. This observation indicates that forests do not profit much to community in this region, and extension services should also extend their interventions to other activities of interest to the community.

2.2.3. Community livelihoods

DFM is set in developing countries for a dual goal: conservation of forest biodiversity and improvement of rural livelihoods (Angelsen et al., 2014). Overall, DFM improved the five capital assets of community livelihoods when members of community-managed forest associations are compared to non-members. For instance, physical capital asset improved under DFM through access to quality house, access to educational school (Akamani & Hall, 2019; Francis et al., 2015; Ngeze et al., 2017), and access to quality roads and construction materials (Francis et al., 2015; Ngeze et al., 2017). Moreover, DFM improved human wellbeing by providing a better environmental education and a better access to food, thereby enhancing health quality (Akamani & Hall, 2019; Difabachew et al., 2021). Similarly, DFM enhanced social capitals by facilitating the participation in common development activities and forest conservation activities (Akamani & Hall, 2019; Tadesse et al., 2017a). Financial capital assets were also improved under DFM implementation mainly through a better access to forest products, forest-related employment opportunities, and increased income from agricultural products (Akamani & Hall, 2019; Ngeze et al., 2017; Tadesse et al., 2017a). For instance, DFM favoured the development of income generating activities like butterfly farming, bee farming, tourism and/or on-farm tree planting, which enhanced community income (Ming'ate et al., 2014b). Nevertheless, the mean by which the income from agricultural products is improved remained unclear and need further investigations.

The institutional arrangements supporting the forest decentralisation greatly impact the community benefits. For example, Ngeze et al. (2017) noticed in Tanzania that only human capital assets were partially improved under Joint Forest Management (JFM) compared to Community-Based Forest Management (CBFM) which improved all capital assets of the community

livelihoods. Similar investigations are needed to identify the best type of DFM that is profitable to the community and the reasons underlining this profitability, while not ignoring the remaining goals of DFM. Moreover, elite capture issues are very frequent and deprive poor from benefits. For instance, the upper wealthy class represents the major beneficiaries of DFM schemes, while the poor bear the large cost of the forest management activities in Tanzania (Meshack et al., 2006) and Kenya (Chomba et al., 2015). Thus, the formulation of policy for DFM implementation should focus more on the poor (Gashu & Aminu, 2019). Most studies also highlighted the unsustainability of certain DFM activities like seedling production, beekeeping, mushroom farming, and butterfly farming, which are fully dependent on the availability of funding and are abandoned after the project phases out in most cases (Matiku et al., 2013; Mutune et al., 2017). Further research on DFM governance is needed to shed light on the weaknesses of the enforcement of the rules established on accountability, involvement, and transparency.

2.2.4. Forest governance

Institutional arrangements, often referred to as the "rules of the game" or "how things are and should be done" (Regmi et al., 2008), can greatly contribute to the continuation of a co-management business when well-designed (Ming'ate et al., 2014). The degree of power devolution as well as the clarity in governance determine the success of decentralisation. Decentralization is implemented in different ways such as deconcentration, delegation, and devolution following the level of power transfer (Yilmaz et al., 2010). Decision power can be redistributed to government representatives within geographic units (Mohammed & Inoue, 2013) or be transferred to semi-autonomous organisations (Rene & Oyono, 2004), community organisations (Larson & Soto, 2008), and appointed leaders (Tacconi, 2007). Studies on institutional arrangements were mainly

conducted in east Africa (66.7%) where policies on forest management match the three types of decentralization. The analysis of decentralisation policies in east African countries showed that the forest policies in Ethiopia, Kenya, and Uganda have the potential to achieve only delegation because they allowed committee members to be elected and be accountable to a small group of people in the community (Magessa et al., 2020). In contrast, the same authors reported that forest policies in Tanzania and Malawi may have great potential to achieve devolution since committee members come from a democratic expression of their constituents and representatives of all groups in the community to whom they are accountable. For instance, (Mohammed & Inoue, 2013) reported that local people were empowered to protect and manage resources in Chilimo forest (forest under devolution in Ethiopia), while district offices restricted the power of local people to use forest products for income generation. In Tanzania, the Village Land Forest Reserve is the only forest management which devolved full power to local communities (Duguma et al., 2018). The forest in this type of management belongs to the village which exerts full right. In contrast, the forest belongs to the state which possesses decision right over resources management in Tanzania (e.g. case of JFM), Uganda and Cameroon (Magessa et al., 2020). Reticence by state to unleash power over the forest resources to local communities is attributable to its fear of losing commercial value or revenues rather than that of forest degradation by local people (Duguma et al., 2018). Finally, the details and specifics on incentives and disincentives associated with DFM schemes were less explicit and relied on financial incentive from NGOs and other donors (Duguma et al., 2018). The topic remains under-addressed in the rest of West Africa. The few studies that briefly addressed the topic in Burkina Faso (Bouda et al., 2009) and Ghana (Teye, 2011) did not provide clear definition of the role of each stakeholder.

2.3. Theoretical Review

2.3.1. Forest conservation

Common pool resources are natural resources with size or characteristics that make it costly or difficult to exclude potential beneficiaries from obtaining benefits from their use, and one person's use of them subtracts from its use by others (Ostrom, 1990; Ostrom et al., 2002). Forests represent an example of common pool resources through their wideness and their importance for the livelihoods of the surrounding people. The perception of forest condition varies with the type of the stakeholder. It may entail the features relative to provisioning and cultural services for the local forest user while other stakeholders may focus on more like feature relative to regulating and supporting services.

2.3.2. Community participation

The use of forest resource is based on common pool theory developed by (Ostrom, 1990) . The theory states that common pool resources users are unable to self-organise to preserve their resources but they can act rationally if certain conditions are met. If the natural resources are not carefully managed, there is risk of people exploiting them unsustainably causing tragedy of commons (Hardin, 1968). To avoid the tragedy of commons and achieve better outcome, natural resources must be governed according to the rule of law for public good. Moreover, Ostrom (2002) stated that community must be involved in management of their resources to avoid its over exploitation. Besides, findings suggested that strong local knowledge, practices and institutions are key factors that can favour a sustainable common pool resources management (Berkes et al., 2000b; Dietz et al., 2003; Pretty, 2003). The right to use the resource called property rights is then

acknowledged as playing a core role in the successful governance of a common pool resources (Agarwal, 2001; Laerhoven & Ostrom, 2007; Ostrom, 1990). Feeny et al. (1990) have identified the following four categories of property right regimes: State property, private property, communal property and open access where ownership and management of a resource are held respectively by the State (Feeny et al., 1990), individuals or corporations (Blomley, 1991) and, specific group of resources users (Blomley, 1991). With regards to property rights, three categories of forest management can be identified encompassing many subtype of management: state forest management, participatory forest management (including joint forest management and community forest management) and private forest management (Duguma et al., 2018).

2.3.3. Community livelihoods

The livelihoods of rural people are strongly linked to ecosystem services. Forest based poverty alleviation can be achieved, among others, by ensuring access to the forest resources and protecting the existing forest benefits to rural people by redistributing access to and benefits from forest resources, or by making transfer payments to villagers protecting forest functions (Sunderlin et al., 2005). Livelihoods framework provides a means of understanding how people are vulnerable to shocks and drivers of change. It focuses on outcomes of people's efforts to have satisfactory livelihood like their material wealth, their extent of vulnerability, or the impact of their livelihood activities on environmental resources. A sustainable livelihood is one "that can cope with stress and shocks, and displays resilience when faced with adverse effects" (Ellis, 2000). Sunderlin et al.(2005) stress that forest-based poverty alleviation is never a stand-alone process, but arises from a fusion of livelihood activities, such as forest resource use, non-farm employment, agriculture, pastoralism and so on.

2.3.4. Forest governance

Governance is the keystone of sound forest resources management. Forest governance has evolved similarly to governance in general. This progress resulted from the failure of the orthodox regimes of state forest management models that held all powers of governance over state administrations. Indeed, for long time forest were managed by state administrations through the traditional forest governance in which state exerts its central and sovereign authority to regulate the behaviour of other actors (Tricallotis, 2023). Common pool resources management requires the involvement of all stakeholders using the resource for its sustainable management. Due to multiples limitations of the state centred governance such as being sensitive to political manipulation, too costly in regulation application, inability to address global and complex environmental problems on their own, limited resources available for regulatory agencies (Tricallotis, 2023), the governance style failed to sustainably manage forest resources. An alternative form of forest governance was designed to come over the limitation mentioned above. The new form of forest governance focuses on more flexible and voluntary regulatory strategies and allows private actors to influence rule setting and enforcement (Carrigan & Coglianese, 2011). Parker (2008) demonstrated that the new governance approach is inclusive by allowing the multi-party collaboration of both states and non-state, non-hierarchical and multi-centric by giving authority rule making and enforcement to multiple parties and, post-territorial by opening the spatial boundaries of governing over the conventional political-territorial boundaries of nation-states and extend environmental cooperation worldwide.

2.4. Existing Gap in Literature

Many studies have focused on decentralised forest management (DFM) to assess its effectiveness. In Africa, most of the studies has assessed the ecological, economics and social aspects (forest conservation, community livelihoods, community participation, institutional arrangement) without looking at the interaction between the different aspect on the assessment. Since human and nature are interrelated and the approach aims to sustainably improve forest dwellers livelihoods while safeguarding the forest conditions, it is compulsory to consider forest users' needs at all the stages of the implementation of the approach. This requires therefore the use of the social-ecological method study to analyse the performance of DFM in Africa. Scant works have been recently done on ecosystem services (Tessema & Nayak, 2022) and forest governance (Bodonirina et al., 2018) to link up the ecological or the institutional aspect with the social aspect in DFM assessment even though the well understanding of the functional relationship between the social economy and the ecological environment is the key to achieve the sustainable development of land (Wu et al., 2023). The current study fills this gap by assessing the DFM approach through the analysis of the social-ecological model.

2.5. Theoretical Framework

To explore the interaction between forest dwellers, forests resources, and the management policy, this study integrates ideas from literature on Socio-Ecological System (SES). The SES-based approach takes a holistic approach by integrating social and biophysical factors related to ecosystem services and human well-being, including non-linear feedbacks, trade-offs, and interactions associated with service provision. The model relies on the idea that interactions among resources and governance systems involve institutions that control actors' behaviour as they

participate in the management of natural resources (Hinkel et al., 2014; McGinnis & Ostrom, 2014; Ostrom, 2009). The participatory forest management (PFM) through its aims represents an example of SES. Figure 2.1 provides the overview of the conceptual framework used in this study.

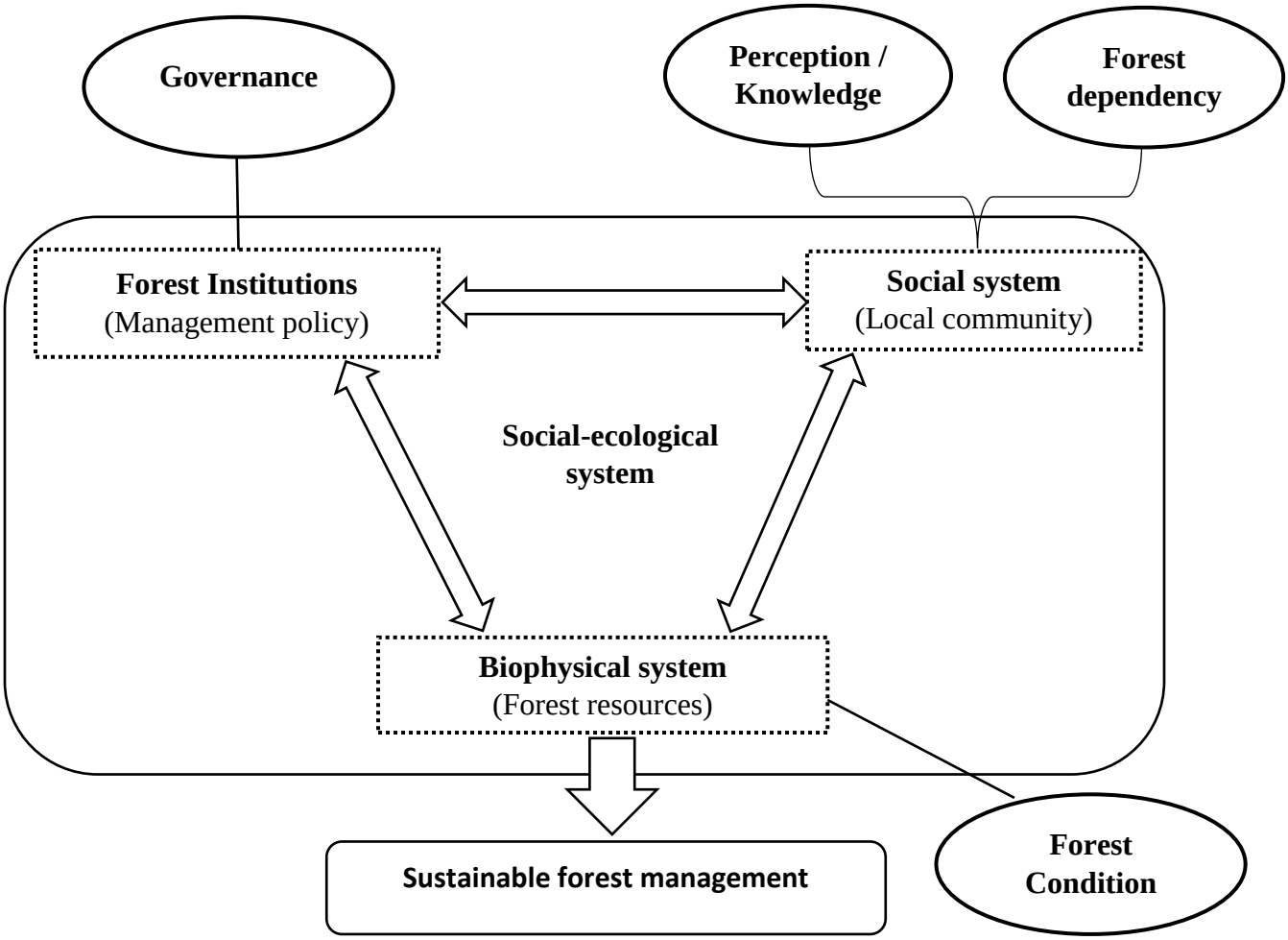


Figure 2.1: Conceptual framework of the study (adapted from Faggin et al. (2017) and (Puri, 2020))

2.5.1. Social system

The social system is defined by the user group characteristics that determine the priorities, the motivations, capacity and dependency of local communities to forests. Forest user groups are social

entities with inherent differentiation based on the gender, caste, education and wealth status. The differentiation is linked to the capacity of households to access and use forest resources (Lund et al., 2014). Previous studies reported that women and poor are less involved in forestry activities and they have no voice in decision-making process (Kairu et al., 2021; Nkengla et al., 2017; Saguye, 2018). In this study, social system is represented by the perception and knowledge, and the forest dependency of local community.

2.5.1.1. Perception and knowledge

Local community's behaviour in relation the forest management is affected by their perception and knowledge. The willingness of people to participate to forest management is shaped by the perceived utility of incentives and benefits derived from forest management (Bakala et al., 2021; Girma & Beyene, 2012). Such perception and knowledge represent therefore a clue for the performance of forest management strategy development.

2.5.1.2. Forest dependency

Studies have shown that forest resources represented an important asset for rural communities in developing countries (FAO, 2014, 2018; van Vliet et al., 2017; Vinceti et al., 2013). Consequently, forest dependency is an important factor motivating local communities' participation to forest management. Local communities generally rely on forest for fuelwood, timber, fodder, wild food and other non-timber forest products (NTFP) that support their livelihoods (FAO, 2014, 2018). Knowing forest resources and using them to satisfy their needs are important factors contributing to community participation to forest management.

2.5.2. Biophysical systems

The biophysical systems are associated with the structure of the forest and the trees, the topography, and other locational factors that establish the context for forest management at the local level (Puri, 2020). In the current study, biophysical system is described by the forest conditions.

The forest conditions determine the state, stock and flow of various goods and services from forest (Hart, 1995). A number of studies have demonstrated that collective action is more likely to occur when the resource in question is sufficiently predictable, easily recognisable by local communities and can be managed in a way that is beneficial to all parties (Mutune et al., 2017; Saguye, 2017; Zewdu & Beyene, 2018). The perceived quality of forests and the benefits derived from them inform the manner in which forests are managed and utilised by local communities. Therefore, the condition of the forest is an important factor in determining the strategies used to enhance community interest to forest management.

2.5.3. Forest Institutions

Forest institutions regulate the management and use of forests, linking biophysical and social systems. These systems determine the objectives, priorities and strategies of forest management. In general, these objectives are shaped by people's aspirations (or needs) and the productive capacity of forest resources. PFM institutions are shaped by the prevailing environment of national policies, guidelines, plans and local practices for managing and using forests (Puri, 2020). Operational plans serve to institutionalise national policies and local forest management practices, thereby regulating the supply of goods and services to forest user groups (Puri, 2020). The

implementation of the operation plans is completed through a process of decision-making called governance. The effectiveness of operational plans is therefore a function of the way in which they are prepared and the governance was done.

CHAPTER THREE

METHODOLOGY

3.1. Research Design

A mixed-methods research design is used to generate quantitative and qualitative data to answer the research questions. The research employed a systematic literature review, a survey, and a field-work. The literature review was performed on participatory forest management in Africa using five online databases, including Web of Science (www.webofknowledge.com), ScienceDirect (www.sciencedirect.com), PubMed (www.pubmed.ncbi.nlm.nih.gov), Google Scholar (www.scholar.google.com), and African Journals Online (www.ajol.info). Papers were collected using the combination of the following keywords: ["decentralized forest management" OR "participatory forest management" OR "forest co-management" OR "joint forest management"] AND ["community livelihoods" OR "rural livelihoods" OR "adjacent land-use"] AND ["Africa"]. The systematic literature review helped to bring out the gap to fill and search on the important aspects to address and the methodology to follow. The survey was done through the administration of questionnaires, the organisation of focus group discussion and semi-structured interviews, and the field observation to collect useful information respectively from local communities, forest user groups and the represent of state represents managing the forests (forest officers and members of the National Wood Company (**SONAB**: Société Nationale du Bois). Finally, the field-work was performed to collect information on the forest plant species most used by the local community.

3.2. Area of study

The study was carried out in Benin, a West African country located between 6°25'N-12°30' and 0°45'E - 4°E (Gbedomon, 2016; Salako, 2016). The country covers 115,762 km^2 and is bordered

by Nigeria at the east, Togo at the west, Niger and Burkina Faso respectively at the north-east and the north-west, and the Atlantic Ocean at the south.

Benin is characterized by three contrasting agro-ecological zones (Jahnke, 1982) ranging from humid to semi-arid. There is the Guinean zone from the latitude 6°25'N to 7°30'N (DGEFC, 2019) having a tropical humid climate with two rainy seasons in the south, the Soudanian zone between the latitudes 10°30'N and 12°N 30' having a semi-arid climate with one rainy season in the North and the Soudano-Guinean zone from the latitude 7°30'N to 10°30'N which is a transition zone with one or two rainy seasons (DGEFC, 2019). The country has 46 gazetted forests of which 39 are managed by the Directorate General of Water, Forests, and Hunting (**DGEFC**: Direction Générale des Eaux Forêt et Chasse) and 7 are managed by the National Wood Company (**SONAB**: Société Nationale du Bois) (World Bank, 2020). 27 out of the 46 gazetted forests are benefitting from a participatory management plan (DGEFC, 2019).

The study location stretches from South to North Benin. The forests were selected based on three criteria: (i) the forest is a gazetted natural forest stand, (ii) the forest is implementing effective participatory forest management approach, (iii) the forest has efficient local committee and forest association. These forest were selected based on previous study from Djogbénou et al. (2011) on participatory forest management assessment in Benin and based on forest status analysis (DGEFC, 2019). Forests reserves included in the study belong to all the three agroecological zones: Lama forest reserve in the Guinean zone, Penessolou forest and in the Soudano-Guinean zone and Sota forest in the Soudanian zone (Figure 3.1).

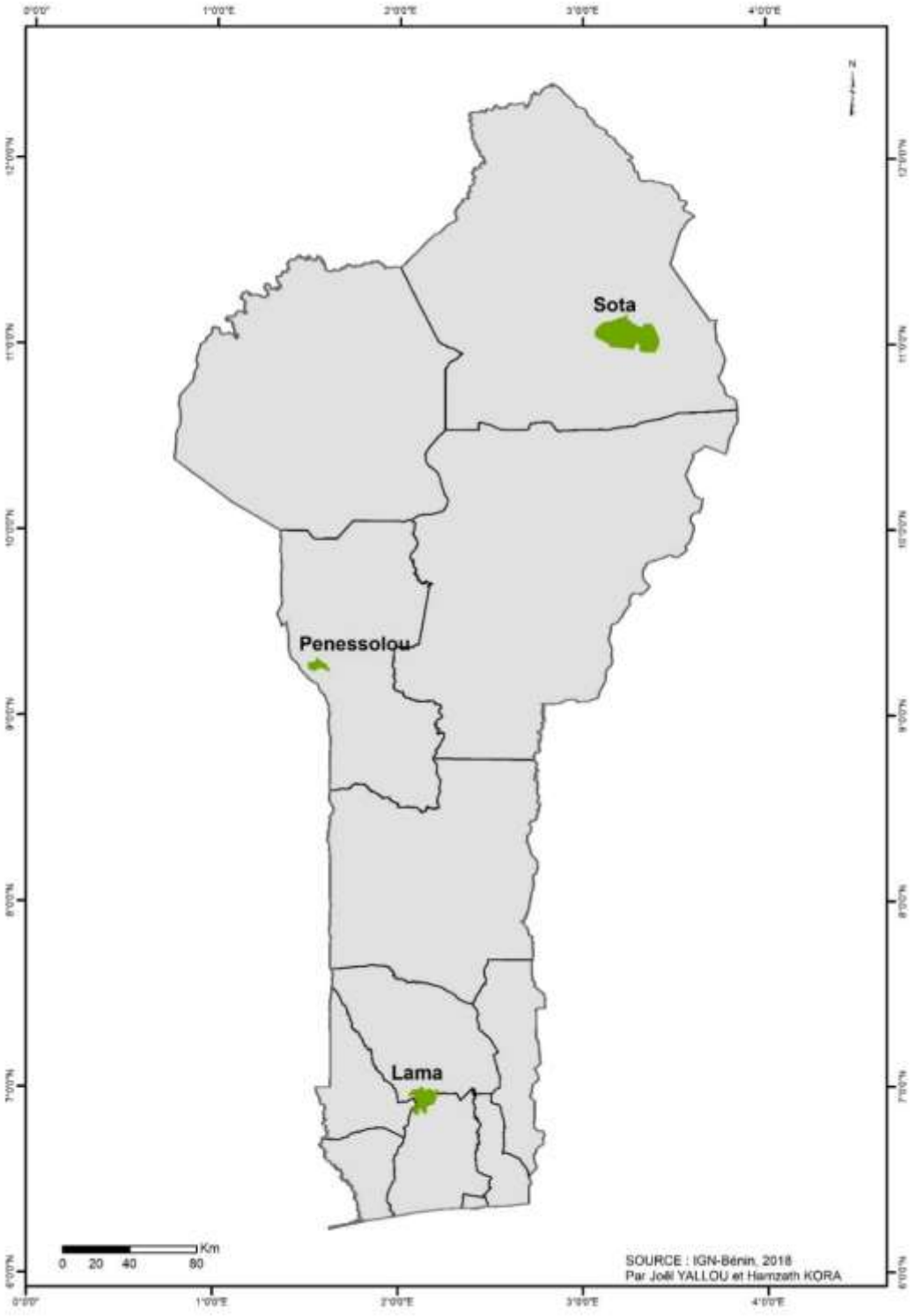


Figure 3.1: Study area location

3.2.1. Lama forest reserve

Natural forest of Lama is a semi-deciduous forest (Nagel et al., 2004), located between 6°55'- 7°00' N and 2°04'-2°12' E, situated in the Centre and South Benin and straddling the communes of Toffo and Zogbodomey (Djego & Sinsin, 2007). The forest covers an area of 16,250 ha, including 4,777 ha of natural forest called "Noyau central", entirely protected (Goussanou et al., 2016) surrounded by plantations, secondary forest, fallow and farms (Toyi et al., 2018). It is influenced by a subequatorial climate with two dry seasons and two wet seasons. The long rainy season extends from March to June and the short rainy season lasts from September to November (ONAB, 2011). The mean annual precipitation is 1,200 mm with monthly precipitations exceeding 100 mm in all months except for December, January and February. The yearly average temperature varies between 25°C and 29°C, with maximum temperatures recorded during the dry season (February to March) which can reach 40°C, and minimum temperatures recorded during the Harmattan period (December). The relative humidity is constantly high given that the forest is located in a depression (depression of Lama). Lama forest is surrounded by 20 villages (Kassa et al., 2003). The population of these villages are occupied mainly by agriculture, livestock, fishing, logging and handicraft (Akouehou et al., 2011).

The participatory forest management reforms started in 1985 with expulsion of population from the forest area. The village committee for participatory forest management was constituted in 1996 and progressively spread in all the villages surrounding the forest (Mehou-Loko et al., 2013). The forest is currently managed by the SONAB together with fifteen (15) surrounding villages (Figure 3.2) organised into Village Participatory Management Organisations (VPMO). Each VPMO is led by a committee of 13 persons except two villages (Tovlamè and Agonli) led by a committee of 5 persons.

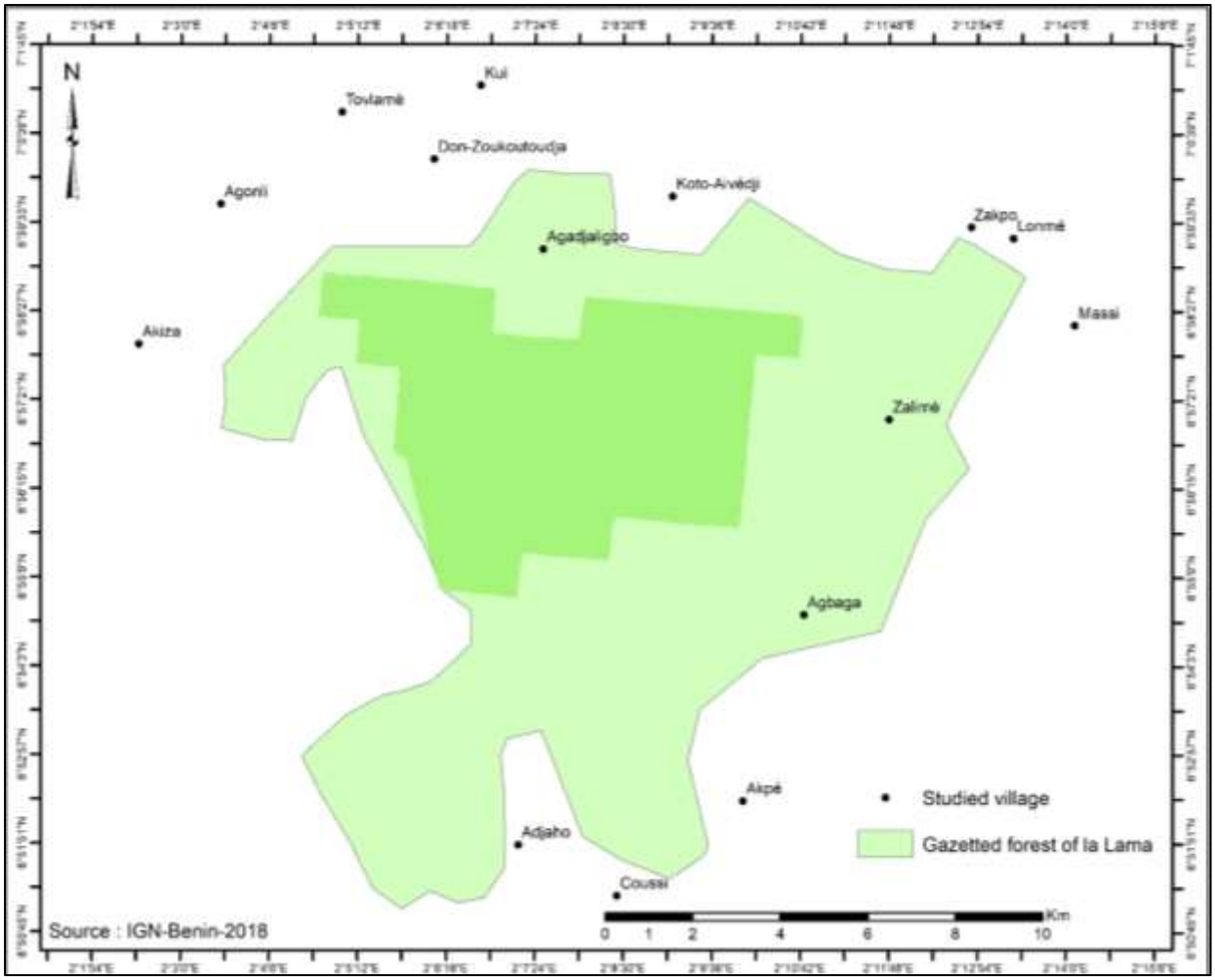


Figure 3.2: Location of villages involved in PFM of the Lama Forest

3.2.2. Gazetted forest of Penessoulou

The gazetted forest of Penessoulou is situated in the commune of Bassila, in the transition guineo-soudanian zone. It is located between the latitude 9°14’ and 9°18’ N and the longitude 1°30’ and 1°37’ E in the centre of Benin (ONAB, 2014). The forest covers an area of 5,575.50 ha occupied by a gallery forest, a dense dry forest, a woodland, a wooded savannah, a shrubby savannah and plantations of teak and cashew (Moussilimi et al., 2022). GFP is characterized by two seasons: the rainy season from April to October and the dry season from November to March (ONAB, 2014).

The mean rainfall recorded from 1980 to 2010 varied between 1200 and 1300 mm. The mean temperature of the area was 26 °C with the highest value (40 °C) recorded in March and the lowest value (15 °C) recorded in December (ONAB, 2014). The hygrometry varied between 19% in January and 99% in August and September. November to February is marked by the harmattan. The forest is surrounded by four villages: Pénéssoulou, Pénélan, Nioro and Nagayilé (Djogbénou et al., 2011). The villages are inhabited by the Anii, the Nagot, the Kotokoli, the Peulh, the Otammari and the Lokpa, with extensive cultivation of yams and cotton as their main activity (Dossa et al., 2021).

The participatory forest management approach was introduced in the forest through the Forest Resources Restoration Project (PRRF: Projet de Restoration des Ressources Forestières) which supported implementation from 1990 to 1998 (Djogbénou et al., 2011). After a period of 13 years (1998-2011) of degradation, the forest management is handed over to the National Wood Company (**SONAB**: Société Nationale du Bois) for the implementation of the new framework of participatory forest management approach from 2013 to 2032. This framework searches to protect forest resources and improve local community livelihoods by involving the later on creation and management of plantation for wood production (ONAB, 2014). The forest is currently managed by the SONAB together with four (04) (Figure 3.3) surrounding villages organised in Village Participatory Management Organisations (VPMO). Each VPMO is led by a committee of 13 persons.

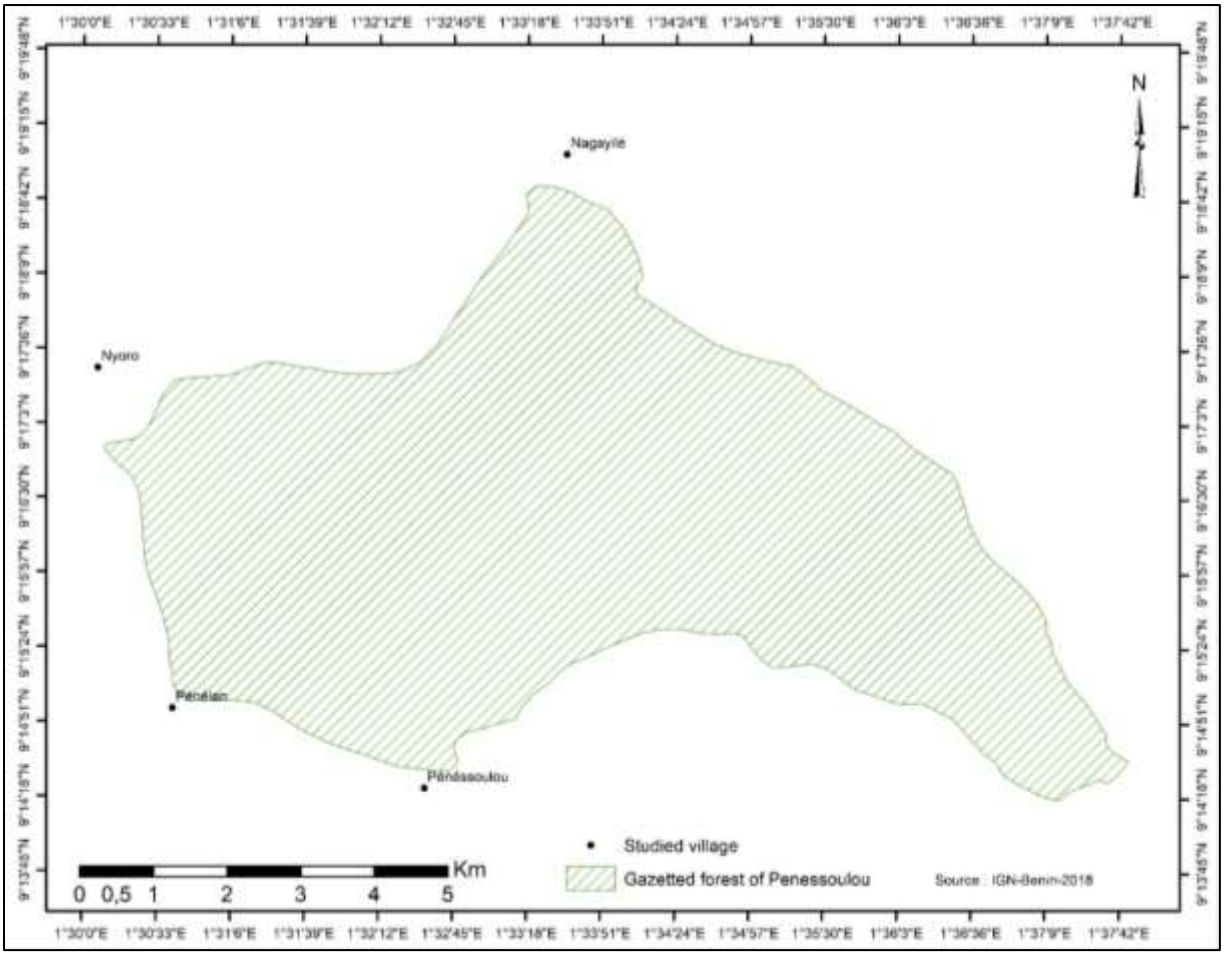


Figure 3.3: Location of villages involved in PFM in Penessoulou forest

3.2.3. The gazetted forest of Sota

The gazetted forest of Sota is located between the latitudes 10°58’ N and 11°11’ N and the longitudes 3°03’ E and 3°25’ E of Benin and covers 53,000 ha (Akouehou et al., 2017). Its climate is the Sudanian type (Djogbénou et al., 2011a), alternating between a rainy season from mid-May to mid-October and a dry season from mid-October to mid-May. Sota forest vegetation is composed of dense dry forest, gallery forest, woodland, wooded savannah, shrubby savannah and plantations of teak, Gmelina and Cassia (DGFRN, 2014). The mean rainfall of the area from 1981 to1990 was

897 mm. The mean temperature was 27 °C with the highest value of 40 °C recorded in March-April and the lowest value of 20 °C recorded during the harmattan in December (Bah Bani Orou & Sanibi, 2019). Sota forest is surrounded by 11 villages inhabited by Boko, Peulh, Bariba, Dendi, Mokole, Gando, Djema and Yoruba, with agriculture, livestock, fishing, hunting and wood exploitation, as their main activities (DGFRN, 2014; C. P. Djogbenou et al., 2008).

Participatory forest management was introduced in Sota forest through the participatory Management of Natural Forest and village reforestation for Carbon Reduction Project (Projet BEN-93-G13) known as UNSO project (Djogbénou et al., 2011a). The project lasted 4 years (1993 to 1997) and included two others; Goungoun and Goroubi forests (Djogbénou et al., 2011b). The approach is currently implemented by the DGEFC under the project "Programme de Gestion des Forêts et Terroirs Riverains (PGFTR) since 2018. The forest is currently managed by the DGEFC together with seven (07) surrounding villages (Figure 3.4) organised in Village Participatory Management Organisations (VPMO). Each VPMO is led by a committee of 7 persons.

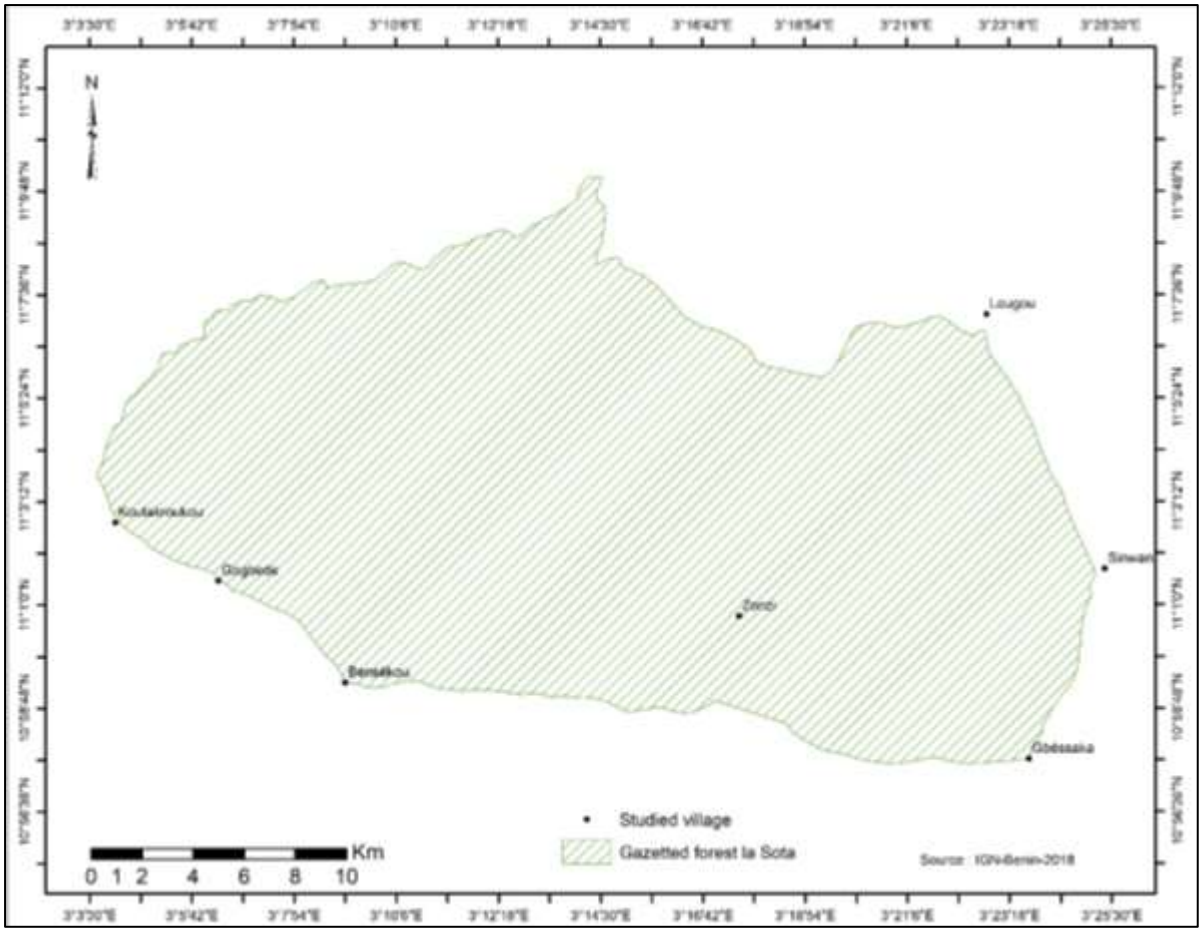


Figure 3.4: Location of the villages involved in the PFM in Sota forest

3.3. Population of the Study

The study was done on two types of population. Firstly, the survey was done the communities living around the different forest reserves and secondly, useful plant species were considered for the forest inventory field work.

The target population for the survey is the household head with a minimal stay of 10 years in the village for assessing the perception of forest ecosystem services and traditional knowledge on useful forest plat species on one side and the member of the village participatory management organisation (VPMO) committee for assessing the forest governance. We targeted household heads

with more than 10 years of stay because such people would have experienced the changes of the forest and forest management and will fit well for the questionnaire of the current study. The characterization of the structure of the forest plant species were done on useful plant species listed during the study on traditional knowledge of useful forest plant species. The individuals of the most used forest plant species with Diameter at Breast Height (DBH) equal or more than 5 cm in order to consider a part of the regeneration. Consequently, herbaceous and liana plants species were excluded from this study.

3.4. Sampling Technique and Sample Size

A multi-stage sampling technic was applied for the achievement of the work. The different stages of sampling are subsequently discussed.

3.4.1. Selection of different forest reserves

One forest was purposively chosen in each of the three agroecological zone among the forests fitting with the three criteria: having a forest management plan, engaged in implementing participatory approach, and having efficient local committee and forest association.

3.4.2. Sample size determination

3.4.2.1. Perceived forest ecosystem services

A pre-survey was done within the population surrounding each forest to determine the proportion of household head knowing the forest ecosystem services. Afterwards, the sample size around the forest was determined using the normal approximation of the distribution (Dagnelie, 1998).

$$n = \frac{P_i\ (1 - P_i)\ U^2_{1-\alpha/2}}{d^2}$$

With n = sample size of the study

Pi: the proportion of household head in the villages surrounding the forest having knowledge on forest ecosystem services. From the preliminary survey, P*i* is 93.33%, 90% and 89% respectively around Lama forest, Penessoulou forest and Sota forest.

$U_{1-\alpha/2}$: it is determined based on the level of confidence. With a confidence level of 95%, the $U_{1-\alpha/2}$ was 1.96 (standard normal distribution table)

d: the margin error of the estimation. With a confidence level of 95%, margin error will be 5%.

3.4.2.2. Traditional knowledge of useful forest plant species

A pre-survey was done within the population surrounding each forest to determine the proportion of household head knowing and/or using the forest plant species. Afterwards, the sample size around the forest was determined using the normal approximation of the distribution (Dagnelie, 1998).

$$n = \frac{P_i\ (1 - P_i)\ U^2_{1-\alpha/2}}{d^2}$$

With n = sample size of the study

P*i* the proportion of household head in the villages surrounding the forest having knowledge on forest plant species. From the preliminary survey, P*i* is 51.11%, 25% and 56.67% respectively around Lama forest, Penessoulou forest and Sota forest.

$U_{1-\alpha/2}$: it is determined based on the level of confidence. With a confidence level of 95%, the $U_{1-\alpha/2}$ was 1.96 (standard normal distribution table)

d: the margin error of the estimation. With a confidence level of 95%, margin error will be 5%.

To determine the number of interviewees in each village, the sample size was redistributed proportionally to the number of households in each village. A simple random technique was use to select the required number of households for the individual interview. Only the household heads with at least ten years of permanent residence were considered.

3.4.2.3. Structural characterization of most useful forest plant species

A systematic sampling procedure was first applied by overlaying a grid of points spaced from each other of 1 km on Lama forest (Figure 3.5) and Penessoulou forest (Figure 3.6) maps, and 2 km on Sota forest map (Figure 3.7) using ArGIS together with data from the most recent National Forest Inventory (NFI) carried out in 2007. The intersections of the lines of the grid were considered as the centre of the plots. Different grid pace considered is related to the largest of the study area. The coordinate of the centre was recorded with the GPS Garmin GPSMAP 64s and located on the field. Square plot of 50 m x 50 m was designed, using an optical clinometer, in each forest and all individuals of the retained species, with DBH ≥ 5cm, were inventoried within each plot.

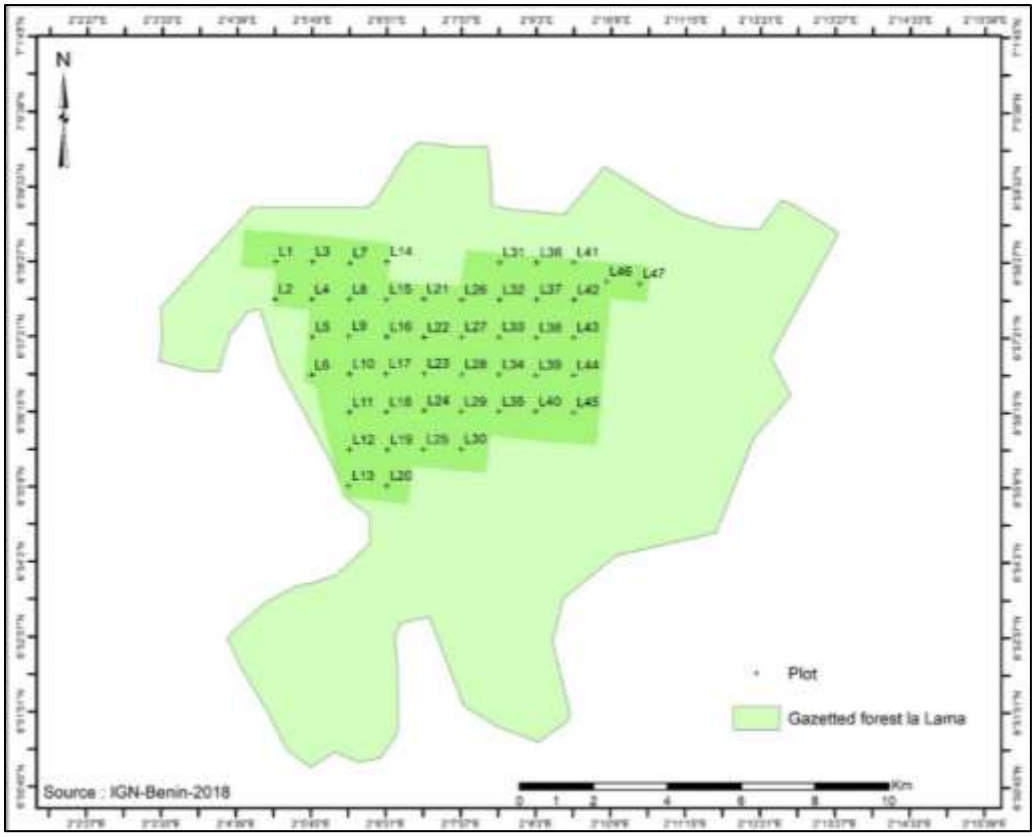


Figure 3.5: Map of plots distribution within "Noyau central" in the gazetted forest of Lama

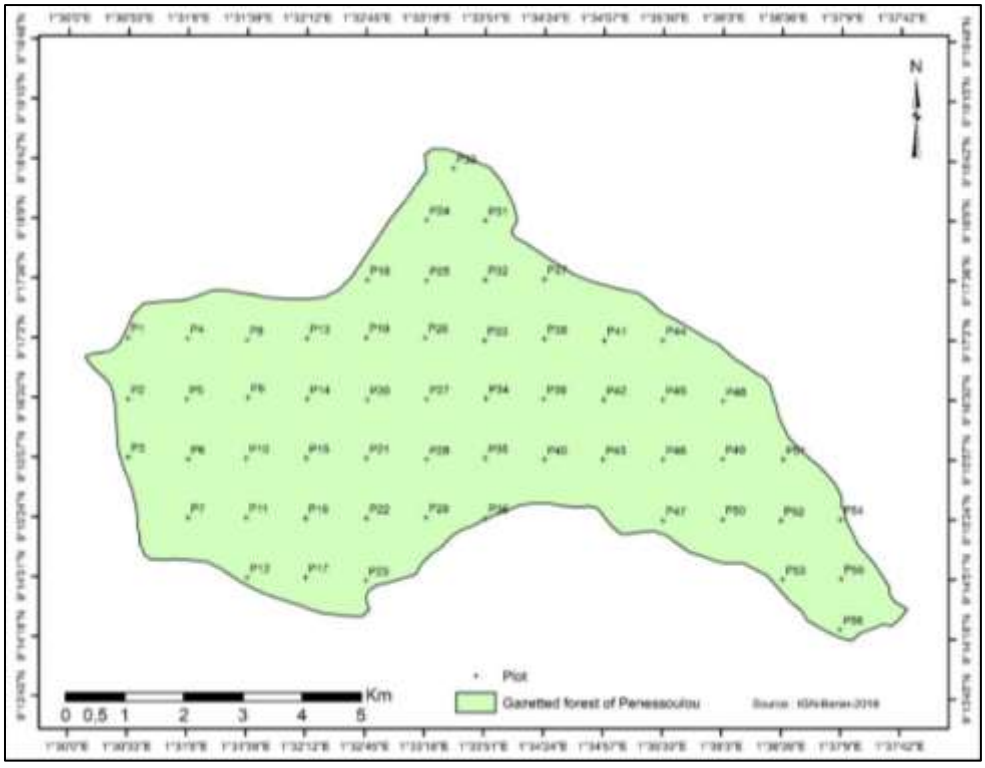


Figure 3.6: Map of plots distribution within the gazetted forest of Penessoulou

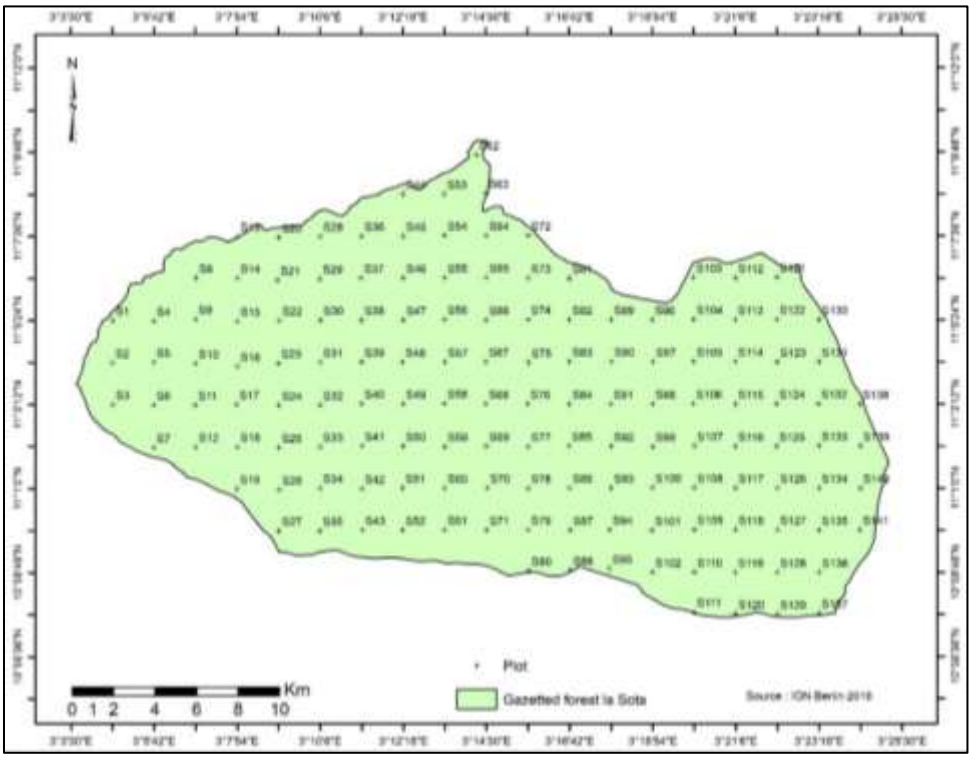


Figure 3.7: Map of plots distribution within the gazetted forest of Sota

3.4.2.4. Forest governance assessment

Information on the structure and the size of the local committee and village association managing the forest were collected from the forest officers. Thus, the sample size in each forest was determined using the Singh & Masuku (2014) sample estimation methods.

$$n = \frac{N}{1 + N(e^2)}$$

With n: sample size of the study

N: the total number of registered members in community forest association

e: the level of statistically significant set (0.05)

To determine the number of interviewees in each village, the sample size was redistributed proportionally to the number of households in each village. A simple random technique was use to select the required number of households for the individual interview. Lama forest is co-managed by 13 forest management committees of 13 members each and 2 forest management units of 5 members each with the National Wood Company (**SONAB**: Société Nationale du Bois). The sampling size was therefore distributed proportionally to the size of the committees and the units. The sample was then divided by the number of village forest management committees as the size of the committee member is the same Penessoulou and Sota forest. There are 4 village forest committees of 13 members each co-managing Penessoulou gazetted forest with the SONAB while 6 village forest committees of 7 members per committee co-managing Sota forest with the help of the Directorate General of Water, Forests, and Hunting (**DGEFC**: Direction Générale des Eaux Forêt et Chasse).

3.4.3. Selection of respondents

3.4.3.1. Perception and Knowledge: Perceived ecosystem services

A total of 436 household heads were surveyed to assess the perception of local communities on forest ecosystem services around the three forest reserves. the sample size around each forest was redistributed proportionally to the number of households in each village based on the national census of 2013 (INSAE, 2016) to determine the number of interviewees in each village. The distribution of the sample size per village and forest is summarised on the table 3.1. A simple random technique was use to select the required number of households for the individual interview. Only the household heads with at least ten years of permanent residence were considered.

Table 3.1. Sample size distribution at community level

Forests	Villages	Number of respondents
Lama forest (Total: 188)	Adjaho	15
	Agadjaligbo	10
	Agbaga	7
	Akiza	10
	Akpè	15
	Coussi/Za	8
	Don-Agonli	10
	Don-Zoukoutoudja	26
	Kui	10
	Koto-Aïvèdji	10
	Lonmè	15
	Massi	21
	Tovlamè	10
	Zalimè	11
	Zakpo	10

Penessoulou forest (Total: 115)	Nioro	16
	Pénélan	28
	Pénéssoulou	45
	Nagayilé	26
Sota forest (Total: 133)	Koutakroukou	15
	Gogbèdè	18
	Bensékou	32
	Zonzi	10
	Lougou	19
	Sinwan	16
	Gbéssaka	23

3.4.3.2. Forest dependence: Traditional knowledge of useful forest plant species

A total of 458 household heads were surveyed to assess the perception of local communities on forest ecosystem services around the three forest reserves. the sample size around each forest was redistributed proportionally to the number of households in each village based on the national census of 2013 (INSAE, 2016) to determine the number of interviewees in each village. The distribution of the sample size per village and forest is summarised on the table 3.2. A simple random technique was use to select the required number of households for the individual interview. Only the household heads with at least ten years of permanent residence were considered.

Table 3.2. Sample size distribution at community level

Forests	Villages	Number of respondents
Lama forest (Total: 190)	Adjaho	15
	Agadjaligbo	10
	Agbaga	7
	Akiza	10

	Akpè	16
	Coussi/Za	8
	Don-Agonli	10
	Don-Zoukoutoudja	26
	Kui	10
	Koto-Aïvèdji	10
	Lonmè	15
	Massi	21
	Tovlamè	10
	Zalimè	12
	Zakpo	10
Penessoulou forest (Total: 115)	Nioro	16
	Pénélan	28
	Pénéssoulou	45
	Nagayilé	26
Sota forest (Total: 153)	Koutakroukou	16
	Gogbèdè	18
	Bensékou	35
	Zonzi	12
	Lougou	25
	Sinwan	24
	Gbéssaka	23

3.4.3.3. Biophysical systems: Structural characterization of most useful forest plant species

After removing the croplands, plantations and plots outside the forest boundary, a total of 42 plots, 47 plots and, 86 plots were effectively inventoried respectively from Lama, Penesoulou and, Sota forest reserves. At this step, the 10 most cited plant species around each forest reserve were retained

(Table 3.3). Afterwards, all individuals per retained plant species with DBH equal or more than 5 cm were systematically considered for the field inventory.

Table 3.3. Retained most cited plant species

	Lama forest		Penessoulou forest		Sota forest	
	Species	RFC	Species	RFC	Species	RFC
1	*Cassia siamea*	25.30	*Olax subscorpioidea*	0.43	*Pterocarpus erinaceus*	0.19
2	*Dialium guineense*	22.83	*Clausena anisate*	0.27	*Afzelia africana*	0.14
3	*Dichapetalum guineense*	14.46	*Uvaria chamae*	0.24	*Ceiba pentandra*	0.11
4	*Anogeissus leiocarpus*	13.25	*Pericopis laxiflora*	0.19	*Combretum glutinosum*	0.1
5	*Milicia excelsa*	8.43	*Milletia thonningii*	0.14	*Cordyla pinnata*	0.1
6	*Momordica charantia*	7.23	*Securidaca longepedunculata*	0.14	*Daniellia oliveri*	0.1
7	*Prosopis africana*	7.23	*Zanthoxylum zanthoxyloides*	0.14	*Isoberlinia doka*	0.1
8	*Sarcocephalus latifolius*	6.02	*Cassia sieberiana*	0.11	*Securidaca longepedunculata*	0.1
9	*Pterocarpus erinaceus*	4.82	*Bequaertiodendron oblanceola*	0.11	*Burkea africana*	0.08
10	*Diospyros mespiliformis*	3.61	*Pentadesma butyracea*	0.08	*Hymenocardia acida*	0.05
11	*Piliostigma thonningii*	3.61	*Piliostigma thonningii*	0.08	*Voacanga africana*	0.05
12			*Pterocarpus erinaceus*	0.08		
13			*Xeroderris stulhmannii*	0.08		

3.4.3.4. Forest institutions: Forest governance assessment

A total of 211 household heads were surveyed to assess the perception of local communities on forest ecosystem services around the three forest reserves. the sample size around each forest was redistributed proportionally to the number of households in each village based on the national census of 2013 (INSAE, 2016) to determine the number of interviewees in each village. The

distribution of the sample size per village and forest is summarised on the table 3.4. A snowball technique was use to select the required number of households for the individual interview. Only the household heads with at least ten years of permanent residence were considered.

Table 3.4. Sample size distribution at community level

Forests	Villages	Number of respondents
Lama forest (Total: 129)	Adjaho	9
	Agadjaligbo	8
	Agbaga	11
	Akiza	9
	Akpè	11
	Coussi/Za	8
	Don-Agonli	5
	Don-Zoukoutoudja	10
	Kui	11
	Koto-Aïvèdji	10
	Lonmè	11
	Massi	7
	Tovlamè	5
	Zalimè	6
	Zakpo	8
Penessoulou forest (Total: 44)	Nioro	11
	Pénélan	12
	Pénéssoulou	10
	Nagayilé	11
Sota forest (Total: 38)	Koutakroukou	5
	Gogbèdè	7
	Bensékou	6
	Zonzi	6
	Lougou	5

Sinwan	5
Gbéssaka	4

3.5. Types and Sources of Data Collection

A mixed method was used to collect data during for this work. These methods vary from an objective to another. Objective 1, 2 and 4 employed mainly qualitative data collection method while objective 3 emphasised on quantitative data collection method. Qualitative data were collected using three main techniques which consist of a mixture of questionnaires targeting household heads living in village surrounding the retained forest reserves, Focus Group Discussions (FDG) and Key Informant Interviews (KII). Quantitative data were collected through a forest inventory carried out in each forest. The different steps of the data collection process were presented in the following sections. Quantitative data were collected through a forest inventory carried on useful forest plants species.

3.5.1. Exploratory Survey

An exploratory survey was conducted in May 2022 for the purpose of facilitating entry into the study communities, establishing contact with key stakeholders, and pre-testing the survey instrument for clarity, consistency, and validity. Key stakeholders included the Forest Officers in charge of the management, the SONAB officers, the VPMO Coordination Committee Chairman. The DGEFC was initially contacted for Sota forest while the SONAB was contacted for Lama and Penessoulou forest for introducing the aim of the research. These institutions referred the team to the local management administrations located near or inside the forest reserves. After some interactions, the Heads of the Participative Supervision Work (**CTEP**: Chef Travaux Encadrement

Participatif) handled the team around Lama and Penessoulou forest reserves while the coordinator Technical Forestry Management Unit (**CTAF**: Cellule Technique d'Aménagement Forestier) handled the team around Sota forest. They help the team to meet the VPMO committee members as well as the committee of the VPMO coordination members to who they handed over. The committee members handled the team and introduced them to each village people. Thirty (30) questionnaires equally distributed in the different villages surrounding each forest (2 per village around Lama forest, 8 per village around Penessoulou forest and 5 per village around Sota forest) were administrated for the exploratory survey. Kobotoolbox application was used to deploy the survey for more efficient and accurate counting and for real-time data validation. This exercise contributed to the computation of the sample size of the respondents of the first and second objective and facilitate fine-turning some questions for clarity and consistency for the completion of the final data collection.

3.5.2. Training of the Research Assistants

Four data collections assistants were engaged for the survey per region due to language barrier for the exercise to facilitate timely data collection. Data collection assistants, who had at least an undergraduate degree in forestry, were trained for two days to ensure clarity and common interpretation of all survey questions. After, introduction the rational of the research to the data collections assistants the first day, they survey questions were discussed in group and administrated each to the other under my supervision in French. Afterwards group discussion is set to try to get the possible translation in local language. The following day, the data collection assistants familiarized themselves with the Kobo collect application by interviewing each other and sending me the filled form after setting it on their smart phones.

The forest inventory was carried out with two data collection assistants in each forest after the survey step. The assistants were retained from those who participated to the survey and were trained on process of data collection in one day.

3.5.3. Data collection in the Study Area

The field data collection took place from March 2023 to August 2023 and from October 2023 to November 2023 and consisted on questionnaire administration, Focus Group Discussions (FGDs), Key Informant Interviews (KIIs) and Forest Inventories (FIs).

4.1.1.1. Questionnaire administration

A total of 458 respondents were interviewed using the questionnaire deployed on Kobotoolbox application unequally distributed within the three research objectives (436 for objective 1, 458 for objective 2 and 211 for objective 4). This difference is linked to the sample size required and the willingness of the respondent to undergo all the questionnaires. 3 to 5 minutes were used to get the respondent consent orally and get his agreement or not to be recorded or be taken in photo according to the consent form (Appendices 1.2 and 1.3). An average of 25 minutes, 15 minutes and 25 minutes were used to administer the questionnaire respectively for the objectives 1, 2 and 4. Questionnaires were administrated individually with respect to the respondent requirements (Figure 3.8, Appendix 6). Moreover, only the VPMO committee members were targeted for the questionnaire of the objective 4 as the pre-survey revealed that the non-members were fully ignorant about the questions. Questions were asked in French or local language and responses were reported in French. All filled and submitted forms of the questionnaires on the Kobotoolbox

application were deployed to me at the end of each day due to light and internet challenge. The filled forms were accepted or rejected and then refilled with the same respondent.

Figure 3.8: Administering semi-structured questionnaire to respondents at Akpè in Lama Forest (Left) and Gogbèdè in Sota Forest (right)

2.5.3.1. Focus Group Discussions and Key informant Interviews

FGDs were planned to be hold in each village but due to time constrains, local communities' availability, management problems in some villages (particularly around Lama and Penessoulou forest reserves) and terrorism problem around Sota forest, FDGs were organised per sector around Lama forest (Lama forest management is divided in three sectors: Akpè, Koto and Massi) and per close villages around Penessoulou forest (2 FGDs constituted of people of two villages per FGD). FGDs were hold only in the safest villages surrounding Sota forest (Gogbèdè, Koutakroukou and Bensékou) where the forestry station is still opened and working. FGDs were hold with 8 to 15 persons selected based on their interest to the survey and the responses provided and lasted for one (1) hour with open ended question (Figure 3.9, Appendix 6). FGDs helped to harmonise the responses on activities allowed to lead in the forest, the extent of forest accessibility and the names

of the plants collected in the forests. Unfortunately, men and women were mixed during the FGDs due to the low representation of women in the sample.

KIIs were hold with stakeholders other than local communities around each forest. Consequently, 2 SONAB officers were interviewed acting as Head of participative supervision works (**CTEP**: Chef Travaux Encadrement Participatif) in each of Lama and Penessoulou forest reserves. Moreover, the Head of participative Management Unit (**CUEP**: Chef Unité Encadrement Participatif) of SONAB were interviewed. The key informants around Sota forest were represented by the two (2) Head of the Forestry Station (**CPF**: Chef Post Forestier) in direct contact with the local community and the coordinator of the Technical Forestry Management Unit (**CTAF**: Cellule Technique d'Aménagement Forestier). KIIs lasted around one hour and consisted on open ended questions and were hold after the survey and the forest inventory works.

Figure 3.9: Focus group discussion at Agadjaligbo in Lama forest

2.5.3.2. Forest inventory

A list of useful forest plant species is done after the FGDs around each forest and one or two guides who master the plants were provided for identification in the forest. This process helped to identify and get the scientific name of the useful plant species either directly in the forests or based on a voucher collected for identification at the national Herbarium at the University of Abomey-Calavi (UAC) (Appendix 6). The forest inventory was carried out in each forest after determining the ten (10) most useful forest plant species around each forest. Only the ligneous plant species were retained to ease the measurements. At this stage, the centre of each plot was uploaded in a GPS Garmin and identified in each forest. All centre felling in a farmland or house is discarded. The four corners of each plot of 50m x 50m were installed using a tape, a clinometer SUNTO and the side delimited using a rope for a consideration of all the targeted plant species inside the plot. All individuals (with DBH equal or more than 5cm) of retained useful forest plant species were marked to avoid accounting many time the same individual. Their DBH was measured using a Pi tape and their bole height and total height were measured using the clinometer SUNTO (Figure 3.10). All the data were recorded using Kobktoolbox application (Appendix 6).

Figure 3.10: Taking Diameter at Breast Height (DBH) measure in Penessoulou forest (left) and taking height measure in Sota forest (right)

3.6. Definition and Measurement of Variables

3.6.1. Perceived forest ecosystem services

Initially, forest ecosystem services was identified based on the existing literature and divided into four categories of the Millennium Ecosystem Assessment (MEA, 2005): regulating services, supporting services, provisioning services, and cultural services. Adjustment was done, after having a discussion with experts in the area and the chairman of each village forest management committee. Afterwards, using a semi-structured questionnaire, demographic and socio-economic

characteristics of interviewees, including sex, age, education, family size, annual income, land size, membership status, livestock ownership, location to forest site etc were collected. Then, how local population perceive the value of the forest was assessed through the free listing of ecosystem services following the Millennium Ecosystem Assessment (MEA, 2005). Afterwards, respondents were asked to identify ESs within the list of ESs presented. Finally, respondents were asked questions dealing with their perceptions on the impact of PFM on the ecosystem services over the implementation period. The perceptions were measured using four nominal scales, i.e., '*declining*', '*improving*', '*no change*', and '*no idea*' (Tessema & Nayak, 2022). Additionally, respondents were provided open-ended questions to narrate their experience and views about the practice, importance, and management of PFM in their surroundings, impacting forest ecosystem services to harmonize the regulations around each forest and the perception on the impact of PFM on the forest ESs. Focus group discussions (FGD) were hold with 10 volunteer respondents around each forest. Three FGD were held around Lama and Sota forests and two FGD around Penessoulou forest.

3.6.2. Traditional knowledge of useful forest plants species

The free-listing technique was used to solicit the botanical knowledge of the informants. For instance, they were asked to list all plants from the forests they had ever used, part used, uses and period of harvesting. Collected information will help to provide an important database on traditional knowledge of useful forest plants in Benin. Semi-structured questionnaires were administrated to active users of forest products (hunters, women, young people, herbalists, snail sellers, sculptors, etc). Three focus group discussions (FGD) were held with 10 volunteer respondents around Lama and Sota forests and two FGD around Penessoulou forest to harmonize the names of the cited plants. Necessary information was collected with help of key informants

(forest officers and National Wood Society technician). Voucher specimens of unidentified species were collected and brought to the national herbarium of Benin at the University of Abomey-Calavi (UAC) for identification.

3.6.3. Structural characterisation of the most useful forest plant species

All useful plant species from the retained list with a diameter at height breast (DBH) ≥ 5cm was systematically considered within each square plot. Measurement of DBH, stem height and total height were performed on each individual plant species respectively with a tape and an optical Suunto clinometer.

3.6.4. Forest governance

Prior to household survey, pre-survey in the study area was conducted to gain an idea of good governance issues to inform the contents of the questionnaires. Questionnaires, key informant interviews, focus group discussion and document analysis was employed to collect data. Documents that have implication for forest governance and PFM were identified and reviewed to explore the de jure framework of decentralization. The different criteria and indicators for governance assessment (Table 3.5) was adapted from Baral (2014). A questionnaire was administrated to participants to generate the responses on good governance issue relating to the participation, transparency, and efficiency of PFM in the selected forests. The indicators were in the form of multiple-choice questions about the different aspects of forest governance (PROFOR & FAO, 2011). The questions were constructed using scoring of qualitative data on point scale (1 = very poor, 2 = poor, 3 = moderate, 4 = good and 5 = very good).

Table 3.5. Criteria and indicators for assessing good governance in the study area

Criteria	Indicators
Participation	(i) Women participation in AGM (Annual General Meeting) (ii) Participation of indigenous communities (iii) Mediation of different interest groups (iv) Women representation in the executive committee (v) Consultation of various interest group in OP (operational plan) preparation (vi) Participation in revenue collection
Transparency	(i) Information availability to members (ii) Decision of benefit sharing (iii) Annual reporting (iv) Auditing and reporting (v) Robustness of reports (vi) Extent of information accessibility
Effectiveness	(i) Structure of constitution (ii) Accomplishment of management objectives (iii) Implementation of meeting decisions (iv) Dispute resolution process
Efficiency	(i) Financial benefit of forest management (ii) Access to forest products (iii) Application of silvicultural systems (iv) Adequacy of silvicultural systems (v) Time management (vi) Surplus forest products pricing and sale (vii) Revenue collection system

Source: Adapted from Baral (2014)

3.7. Validity and Reliability of Research Instruments

Questionnaires and inventory forms were drafted, reviewed and amended by my advisor and supervisor for pre-testing. After the test some adjustments were done before approval for data collection.

3.8. Method of Data Analysis

3.8.1. Perceived forest ecosystem services

Collected data were entered into Microsoft Excel 2016 for cleaning. Microsoft Excel 2016 and R software version 4.1.2. were used to perform the statistical analysis. Frequency analysis and descriptive statistics were performed to describe the socio-demographic characteristics of household heads and characterize the importance and trends perceived in the last 10 years around each forest. Moreover, multiple linear regressions were used to determine the factors influencing the perception of the forest ecosystem services. Three indices of ecosystem services identification were used as dependent variable and computed as follow (Gouwakinnou et al., 2019): (i) the number of provisioning services identified out of the total number of provisioning services (N = 12); (ii) the number of regulating and supporting services identified out of the total number of regulating and supporting services (N = 12); and (iii) the number of cultural services out of the total number of cultural services (N = 4). The different explanatory variables are listed in the table 3.6.

Table 3.6. Summary of the explanatory variables used for the linear regression

Code	Independent variables name
sex	Sex
age_class	Age class

education_rate	Education rate
ethnic_group	Ethnic group
household_size	Household size
Seniority	Stay length
Native	Born on the place
main_activity	Main activity
Total_annual_income	Total annual income
VPMO_committee	Committee member
Forest_security	Level of forest security
Legal_land_holding	Holding land with administrative documents
Private_plantation_size	Size of the plantation owned
Dist to forest	Distance from home to forest

Moreover, data of the different type of ecosystem services were subjected to one-way analysis of variances (ANOVA) and the Tukey HSD test was used to compare the perceived forest ESs among the forests.

3.8.2. Traditional knowledge of forest plant species

Data were entered in Microsoft excel 2016 software for cleaning. Microsoft Excel and R software version 4.1.2 were used for the data analysis. Socio-demographic characteristics of the respondents were analysed through the computation of percentages. The ethnobotanical indexes Use Value (UV), Relative Frequency of Citation (RFC) and Informant Consensus Factor (ICF) were computed for each species in each forest.

The UV was computed according to the formula adapted from Phillips & Gentry (1993):

$$UV_s = \frac{\sum_{i=1}^{N} UR_S}{N} \qquad (1)$$

Where UR_s is the total number of use-reports for species s and N is the total number of informants. A use-report is defined as a use of a species in a sub-category mentioned by an informant i (Tardío & Pardo-De-Santayana, 2008). The UV is high when a plant has many use-reports, indicating that the plant is important for the community.

Relative frequency of citation (RFC) is a quantitative index that provides the local importance of the investigated species, which was calculated using the following the formula described by Tardiõ et al. (2008):

$$RFC = \frac{FC}{N} \qquad (2)$$

Where; FC is the frequency of citation and N is the total number of respondents who participated in interviews. The RFC value ranges from 0 (where none of the informants mentions the plant as being useful) to 1 (where each informant reports the plant as being useful).

Informant consensus factor (ICF) is used to assess the homogeneity of local knowledge which was calculated using the formula of Cornara et al. (2014). Prior to the analysis, the cited uses were categorised into cultural, food, medicinal, timber services and wood energy.

$$ICF = \frac{[N_{ur} - N_s]}{[N_r - 1]} \qquad (3)$$

Where; Nur is the number of reports of usefulness for each category. and Ns is the number of species used by all informants for certain categories. ICF values range from 0 to 1. A high ICF value (close to 1) indicates that relatively few plant species are used by a large proportion of the informants while a low value indicates the disagreement of the informants on the use of plant species in the different categories.

Moreover, a logistic regression was performed to show the relationship between knowledge of forest plants collected and socio-environmental factors. The dependent variable for this analyse

was the knowledge of useful forest plant species and the explanatory or independent variables used are listed in the table 3.7.

Table 3.7. Summary of suggested explanatory variables and expected hypothesis

Description of variables (Codes)	Definition	Expected signs
Forest (forest)	Lama = 1; Penessoulou = 2; Sota = 3	
Sex (sex)	Male = 1; Female = 0	-
Ethnic group (ethnic_group)	Aizo = 1; Anii = 2; Boo = 3; Fon = 4; Holly = 5; Kotokoli = 6; Mokolé = 7; Other = 8	
Age class (age_class)	Youth = 1; Adults = 2; Old = 3	+
Education rate (education)	None = 1; Primary = 2; Secondary = 3; Higher = 4	-
Household size (household_size)	Small = 1; Medium = 2; Large = 3	+
Stay length (seniority)	Short = 1; Medium = 2; Long =3	+
Main activity (main_activity)	Agriculture = 1; Commerce = 2; Forest activity = 3; Others = 4	
Member of the VPMO Committee (member_VPMO)	Yes =1; No = 0	+

3.8.3. Structural characterization of the most useful forest plant species

The tree density was computed per forest for each species. To establish the structure of stem diameter for each species stand, all individuals of the species were grouped into DBH classes of 5 cm. The density of the different classes was computed and adjusted to the 3-parameters (a, b, c) of Weibull Theoretical Distribution.

Data were entered in Microsoft excel 2016 software for cleaning and later analysed using both Microsoft Excel and R software version 4.1.2.

3.8.4. Governance assessment

Data were entered in Microsoft excel 2016 software for cleaning and later analysed using both Microsoft Excel and R software version 4.1.2. Descriptive statistics using percentages were computed to analyse the socio-demographic characteristics of the respondents. The independence test was carried out to test the similarity of the sample between the different forest management committee. Afterwards, the status of governance for each indicator was calculated by simple mathematical procedure. Average mean of participation, transparency and efficiency was computed using the collected scores and the number of respondents. Charts were used to present the governance status in each forest. Data of the scores of different criteria of governance were subjected to one-way analysis of variances (ANOVA) and comparison among means of each criterion and the global score was determined according to the Fisher's Least Significant Difference (LSD) test.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSIONS

4.1. Socio-demographic Characteristics of Respondents

4.1.1. Perceived forest ecosystem services

Table 4.1 presents the socio-demographic characteristics of the respondents of the study on forest ecosystem services. Out of the 436 respondents, 84.21% were male, and 15.79% were female. The average age was 41 years, with the youngest respondent being 18 and the oldest 75 years. Most of the respondents (67.11%) were adults. The grouping followed the age categorization adapted from Assogbadjo et al.(2008). Large household sizes (11-38 persons) were less frequent around Lama Forest compared to other forests, while medium household sizes (7-10) were less frequent in Penessoulou and Sota forest compared to Lama forest. Most of respondents living around Lama forest were Fon ethnic group (72.34%) whereas respondents surrounding Penessoulou forest were majorly Anii ethnic group (69.57%) and those surrounding Sota forest were mostly Boo ethnic group (59.40%). Sota forest respondents were mostly illiterates (48.12%), whereas Lama forest (39.89%) and Penessoulou forest (46.09%) respondents were mostly schooled with secondary school level. Most of the respondents were farmer around each of the three forests. Moreover, 8 FGDs (3 for Lama forest, 2 for Penessoulou forest and 3 for Sota forest) were held, and 7 key informant interviews (2 for Lama forest, 2 for Penessoulou forest, 2 for Sota forest, 1 representative of SONAB and 1 representative of DGFEC of Kandi) to collect further information.

Table 4.1. Socio-demographic profile of the respondents

Characteristics		Forests			Total
		Lama (n=188)	Penessoulou (n=115)	Sota (n=133)	(n=436)
Sex	Female	14.36	17.39	18.80	16.51
	Male	85.64	82.61	81.20	83.49
Age classes	Youth (≤30 years old)	18.09	20.00	41.35	25.69
	Adults (30-60 years old)	76.06	71.30	54.14	68.12
	Old (>60 years old)	5.85	8.70	4.51	6.19
Household size	Small (1-6 persons)	41.71	46.96	51.13	45.98
	Medium (7-10 persons)	41.18	22.61	17.29	28.97
	Large (11-38 persons)	17.11	30.43	31.58	25.06
Ethnic groups	Aïzo	9.57	0.00	0.00	4.13
	Anii	0.00	69.57	0.00	18.35
	Boo	0.00	0.00	59.40	18.12
	Fon	72.34	0.00	0.00	31.19
	Holly	16.49	0.00	0.00	7.11
	Kotokoli	0.00	27.83	0.00	7.34
	Mokolé	0.00	0.00	32.33	9.86
	*Others	1.60	2.61	8.27	3.90
Stay length	Short (10-20 years)	11.70	24.35	36.09	22.48
	Medium (21-35 years)	35.11	33.91	27.07	32.34
	Long (36-75 years)	53.19	41.74	36.84	45.18
Education rate	None	23.94	20.87	48.12	30.50
	Primary	34.04	29.57	17.29	27.75
	Secondary	39.89	46.09	29.32	38.3
	Higher	2.13	3.48	5.26	3.44
Activity of subsistence	Agriculture	53.19	57.26	87.97	64.84
	Trade	23.94	17.09	3.76	15.98

	Forest Activities	14.36	9.40	0.75	8.90
	Others	8.51	16.24	7.52	10.27
Member of VPMO*	No	35.11	58.26	69.92	51.83
committee	Yes	64.89	41.74	30.08	48.17
Perception of ESs	No	4.79	22.11	6.77	10.16
	Yes	95.21	77.39	93.23	89.84
Total		41.23	25.22	33.55	100

* Ethnics groups each representing less than 2% of the sample (Adja, Bariba, Dendi, Haoussa, Kando, Nago, Peuhl, Yoruba and Zerman)
VPMO: Village Participatory Management Organisation

4.1.2. Traditional knowledge of useful forest plant species

A total of 458 household heads was surveyed for assessing traditional knowledge on useful forest plant species (Table 4.2). Out of them, 84.28% were men and 15.72% were women. The average age of the respondents was 41 years old, with the younger respondent being 18 years old and the oldest 75 years old. 67.11% of respondents were adults. The grouping followed the age categorization adapted from (Assogbadjo et al., 2008). Large household sizes (11-38 persons) were less frequent around Lama forest compared to other forests while medium household sizes (7-10) were less frequent in Penessoulou and Sota forest compare to Lama forest. Most of respondents living around Lama forest were the Fon ethnic group (72.63%) whereas respondents surrounding Penessoulou forest were majorly Anii ethnic group (69.57%) and those surrounding Sota forest were mostly Boo ethnic group (62.75%). A large size of Sota forest respondents were illiterates (49.67%) whereas Lama forest (40.00%) and Penessoulou forest (46.09%) respondents were mostly schooled with secondary school level. Most of the respondents were farmer around each of the three forests. Moreover, 8 FGDs (3 for Lama forest, 2 for Penessoulou forest and 3 for Sota forest) were held, and 7 key informant interviews (2 for Lama forest, 2 for Penessoulou forest, 2

for Sota forest, 1 representative of SONAB and 1 representative of DGFEC of Kandi) to collect further information.

Table 4.2: Socio-demographic profile of the respondents

Characteristics		Forest			
		Lama (n=190)	Penessoulou (n=115)	Sota (n=153)	Total (n=458)
Sex	Female	14.21	17.39	16.34	15.72
	Male	85.79	82.61	83.66	84.28
Age classes	Youth (≤30 years old)	17.89	20.00	43.14	26.86
	Adults (]30-60] years old)	76.32	71.30	52.94	67.25
	Old (>60 years old)	5.79	8.70	3.92	5.90
Household size	Small (1-6 persons)	41.58	46.96	56.21	47.82
	Medium (7-10 persons)	41.58	22.61	16.34	28.38
	Large (11-38 persons)	16.84	30.43	27.45	23.80
Ethnic groups	Aïzo	9.47	0.00	0.00	3.93
	Anii	0.00	69.57	0.00	17.47
	Boo	0.00	0.00	62.75	20.96
	Fon	72.63	0.00	0.00	30.13
	Holly	16.32	0.00	0.00	6.77
	Kotokoli	0.00	27.83	0.00	6.99
	Mokolé	0.00	0.00	30.07	10.04
	Others*	1.58	2.61	7.19	3.71
Stay length	Short (10-20 years)	12.11	24.35	35.95	23.14
	Medium (21-35 years)	34.21	33.91	28.10	32.10
	Long (36-75 years)	53.68	41.74	35.95	44.76
Education level	None	23.68	20.87	49.67	31.66
	Primary	34.21	29.57	15.03	26.64
	Secondary	40.00	46.09	28.76	37.77
	Higher	2.11	3.48	6.54	3.93
Main activity	Agriculture	30.11	43.53	38.71	35.66
	Livestock farming	18.43	17.65	19.06	18.44
	Use of forest resources	27.92	14.51	33.43	26.57

	Others	23.54	24.31	8.80	19.32
Member of VPMO*	No	37.89	61.74	75.82	56.55
committee	Yes	62.11	38.26	24.18	43.45
Knowledge of useful	No	56.08	67.83	47.37	56.14
forest plants	Yes	43.92	32.17	52.63	43.86
Total		41.48	25.11	33.41	100

* Ethnics groups each representing less than de 2 of the sample (Adja, Bariba, Dendi, Haoussa, Kando, Nago, Peuhl, Yoruba and Zerman)

VPMO: Village Participatory Management Organisation

4.1.3. Forest governance assessment

A total of 211 VPMO were surveyed for assessing the perception of local community on forest governance (Table 4.3). Out of them, 85.78% were male, and 14.22% were female. The average age were 43 years, with the youngest respondent being 20 and the oldest 72 years. 72.20% of respondents were adults. The grouping followed the age categorization adapted from (Assogbadjo et al., 2008). Large household sizes (11-38 persons) were less frequent around Lama forest compare to other forests while small (1-6) and medium household sizes (7-10) were less frequent in Penessoulou and Sota forest compared to Lama forest. Most of respondents living around Lama forest were the Fon ethnic group (69.77%), whereas respondents surrounding Penessoulou forest were majorly Anii ethnic group (75.00%) and those surrounding Sota forest were mostly Boo ethnic group (60.53%). Sota forest respondents were mostly illiterates (47.37%), whereas Lama forest (43.41%) and Penessoulou forest (54.55%) respondents were mostly schooled with secondary school level. Most of the respondents were farmer around each of the three forests. Moreover, 8 FGDs (3 for Lama forest, 2 for Penessoulou forest and 3 for Sota forest) were held, and 7 key informant interviews (2 for Lama forest, 2 for Penessoulou forest, 2 for Sota forest, 1 representative of SONAB and 1 representative of DGFEC of Kandi) to collect further information.

Table 4.3. Socio-demographic profile of the respondents

Characteristics		Forest			
		Lama (n=129)	Penessoulou (n=44)	Sota (n=38)	Total (n=211)
Sex	Female	14.73	15.91	10.53	14.22
	Male	85.27	84.09	89.47	85.78
Age classes	Youth (≤30 years old)	14.73	11.36	13.16	13.74
	Adults (]30-60] years old)	78.29	79.55	76.32	78.20
	Old (>60 years old)	6.98	9.09	10.53	8.06
Household size	Small (1-6 persons)	40.31	29.55	26.32	35.55
	Medium (7-10 persons)	44.96	22.73	23.68	36.49
	Large (11-38 persons)	14.73	47.73	50.00	27.96
Ethnic groups	Aïzo	12.40	0.00	0.00	7.58
	Anii	0.00	75.00	0.00	15.64
	Boo	0.00	0.00	60.53	10.90
	Fon	69.77	0.00	0.00	42.65
	Holly	16.28	0.00	0.00	9.95
	Kotokoli	0.00	25.00	0.00	5.21
	Mokolé	0.00	0.00	28.95	5.21
	Others*	1.55	0.00	10.53	2.84
Stay length	Short (10-20 years)	8.53	15.91	26.32	13.27
	Medium (21-35 years)	37.21	38.64	18.42	34.12
	Long (36-75 years)	54.26	45.45	55.26	52.61
Education level	None	20.93	15.91	47.37	24.64
	Primary	32.56	22.73	21.05	28.44
	Secondary	43.41	54.55	28.95	43.13
	Higher	3.10	6.82	2.63	3.79
Main activity	Agriculture	53.49	68.18	89.47	63.03
	Commerce	20.93	20.45	2.63	17.54
	Forest related activities	17.05	2.72	0.00	10.90

Others	8.53	9.09	7.89	8.53
Total	61.14	20.85	18.01	100

* Ethnics groups each representing less than de 2% of the sample (Adja, Bariba, Dendi, Haoussa, Kando, Nago, Peuhl, Yoruba and Zerman)

4.2. Data Presentation on Research Issues

4.2.1. Perceived forest ecosystem services

4.2.1.1. Prioritization of ecosystem services

The combined data from interviews from communities adjacent to the considered forests indicated that the different ecosystems services (ESs) were unevenly perceived around the forests. Provisioning services were the most perceived ESs perceived followed by regulating and supporting services and provisioning services in all the forest reserves (Figure 4.1).

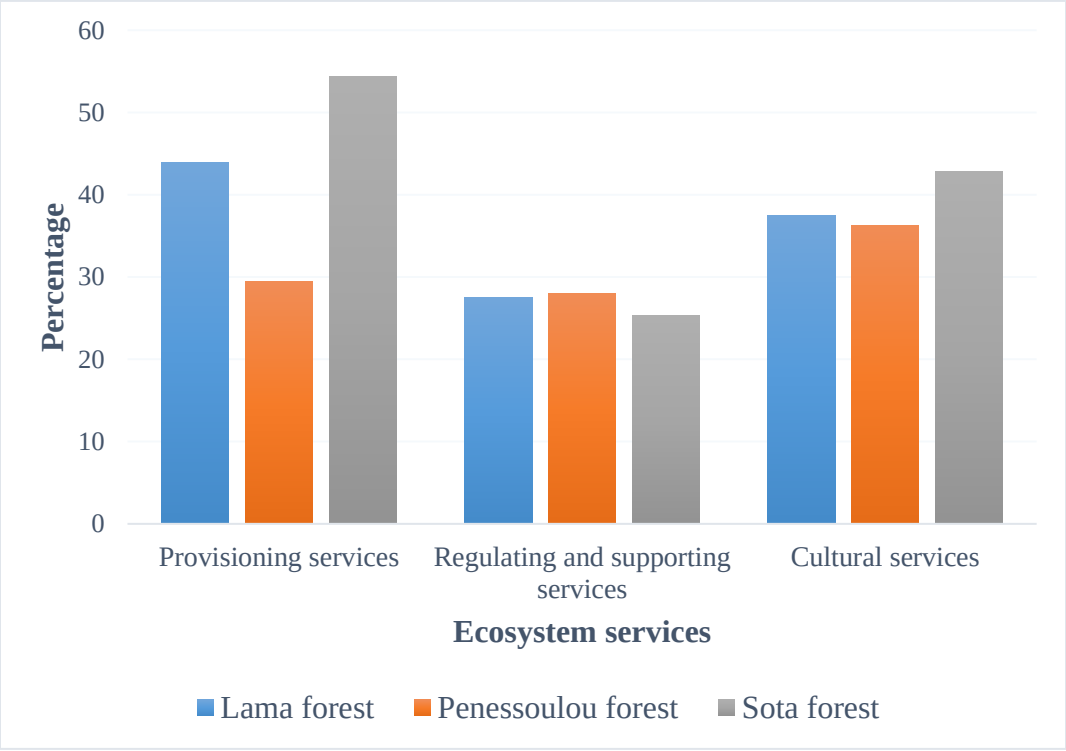


Figure 4.1: Perceived ecosystem services per forest type

Moreover, no significant difference was observed within the community perception on regulating and supporting services and cultural services while provisioning services were perceived with significant difference between three forest reserves (Table 4.4.).

Table 4.4. Comparison of the mean effects by forest ecosystem services

	Ecosystem services		
Forest	Provisioning	Regulating and supporting	Cultural
Lama	**43.88±6.22 b**	27.57±4.56 a	37.50±7.51 a
Penessoulou	**29.42±3.38 c**	28.04±5.94 a	36.30±4.82 a
Sota	**54.39±4.83 a**	25.31±4.87 a	42.86±7.49 a
Sum Sq	91.349	1.91	2.471
Df	2	2	2
F value	6.722	0.081	0.268
Pr(>F)	0.004 **	0.922	0.771

Signif. codes : 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Mean with different letters are significantly different based on Tukey' HSD post hoc test

Besides, the collection of firewood and timber were the most cited provisioning services by the people living close to Lama forest, while forest fruits, firewood and leaves were the most identified provisioning services around Sota forest reserves and the community surrounding Penessoulou forest perceived more the gathering of firewood and leaves as their main provisioning services (Figure 4.2).

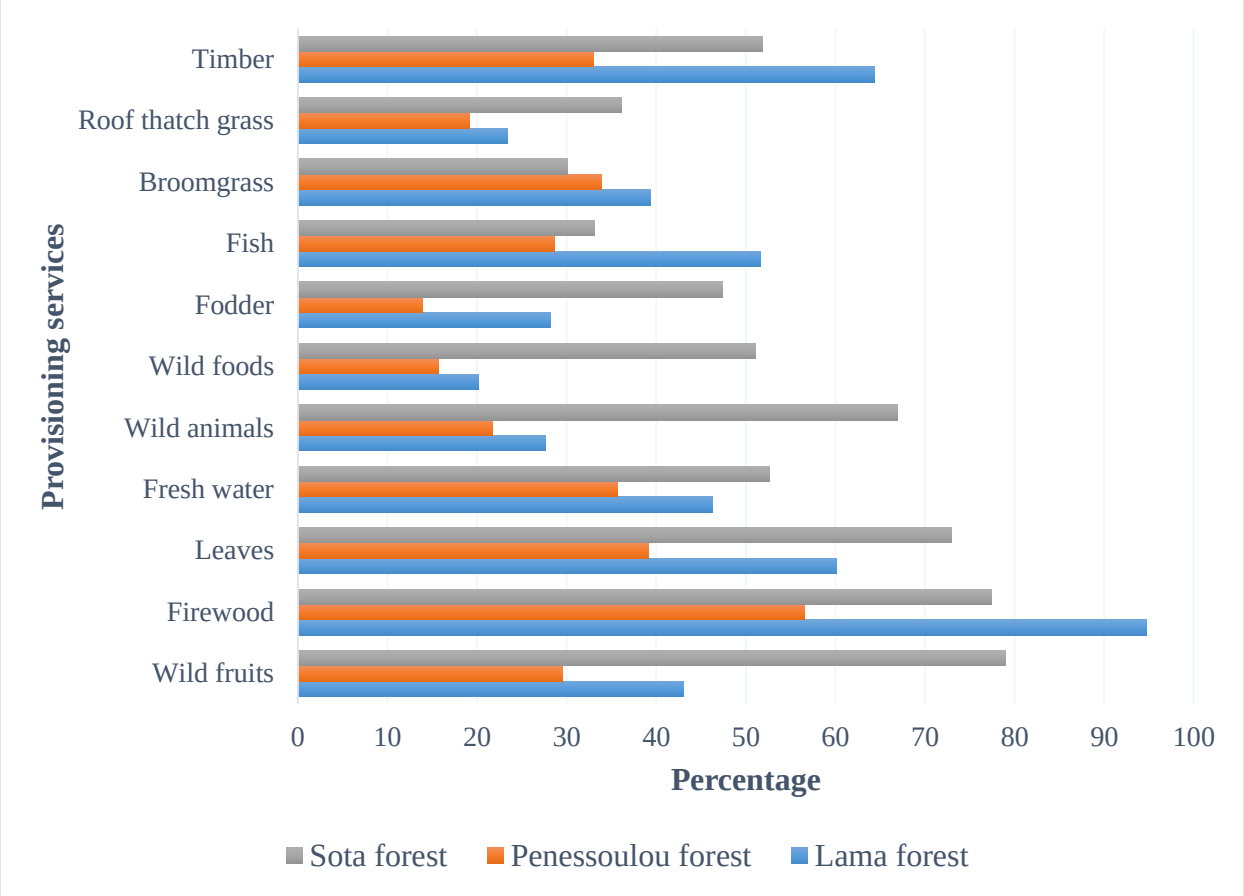


Figure 4.2: Identification rate of the different provisioning services

However, services like wild animals, wild fruits, wild food and fodder were more perceived around Sota forest than the two other forests. Regulating and support services were dominated by fresh air provision, carbon sequestration, and biodiversity conservation around Lama and Penessoulou forest while fresh air, carbon sequestration and soil protection were the most identified regulatory and supporting ESs around Sota forest (Figure 4.3).

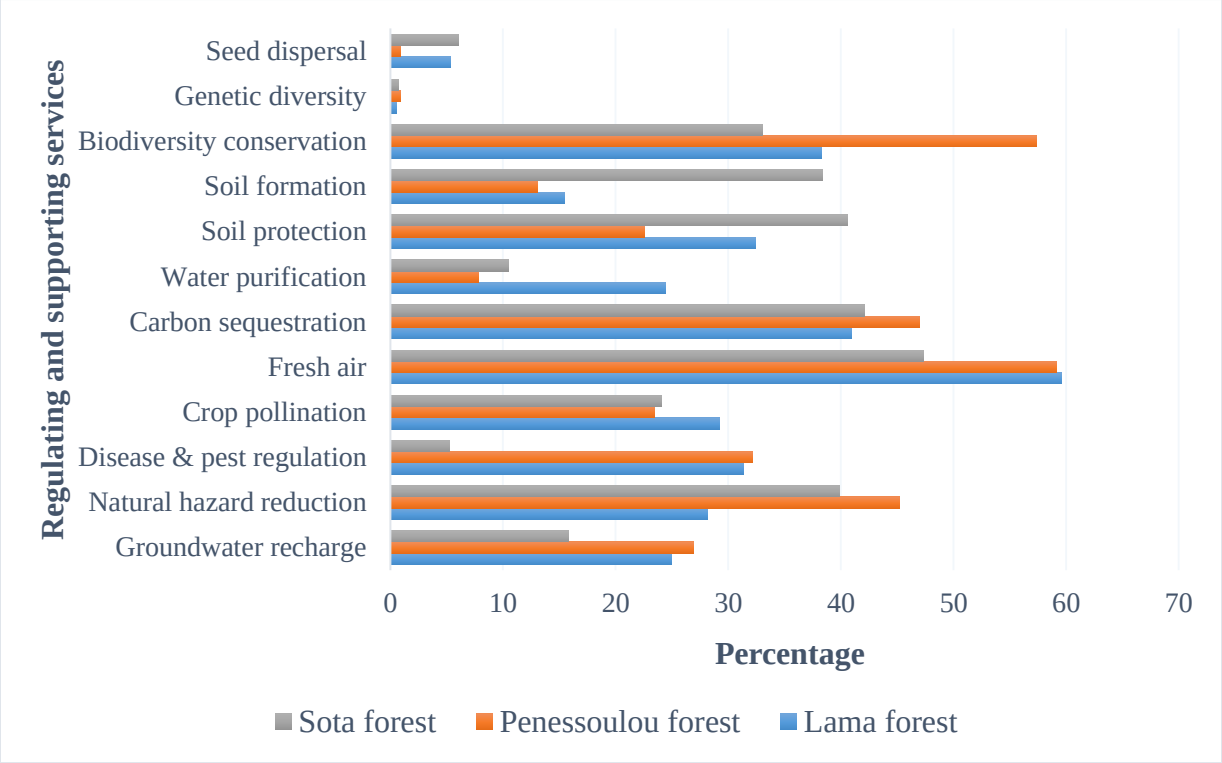


Figure 4.3: Identification rate of the different regulating and support services

Finally, ecotourism and aesthetic services were the most perceived cultural services around Lama and Penessoulou forest reserves while the community living around Sota forest perceived the most aesthetic and spiritual services as cultural services (Figure 4.4).

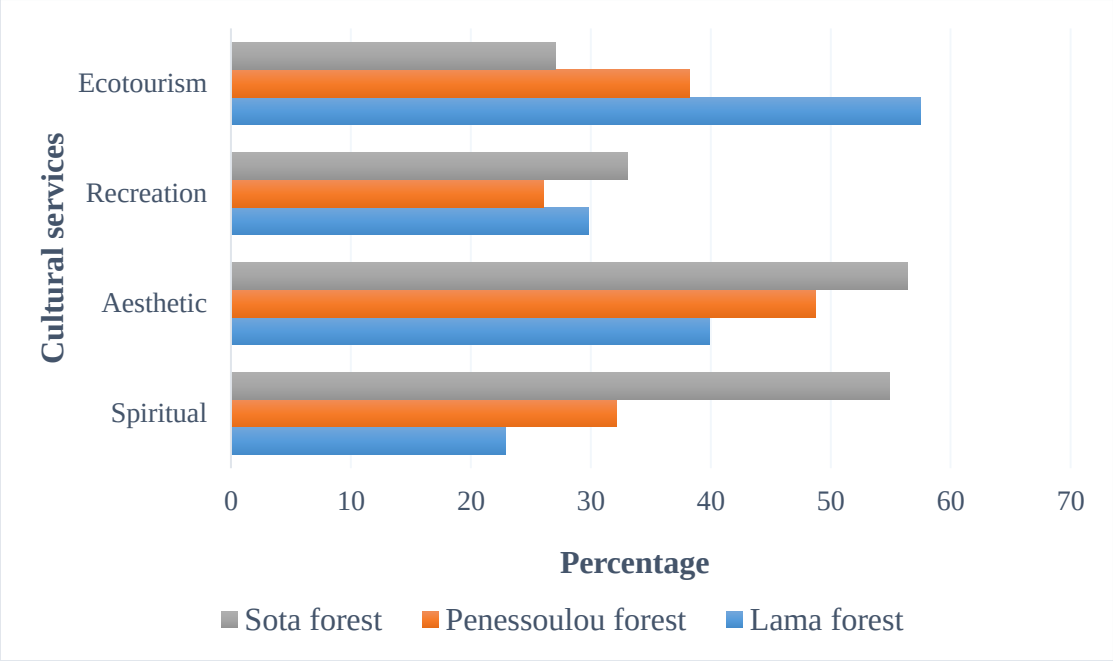


Figure 4.4: Identification rate of the different cultural services

4.2.1.2. Factors influencing the perception of ecosystem services

The results of the linear regression showed that the perception of ecosystem services was influenced by several socio-environmental factors in the different forests. In Lama forest, the perception of provisioning services was positively corelated with the length of stay of the respondents (0.144) in the area and the membership to the local management committee (0.217) while the perception of the regulating and supporting services was negatively corelated with the household size of the respondent and the perception of the cultural services was positively correlated with the membership to the local management committee and the legal land ownership (Table 4.5).

Table 4.5. Factors influencing the perception of Ecosystem Services in Lama forest

	Provisioning services				Regulating & Supporting services				Cultural services			
Factors	B	Std. Error	t	Sig.	B	Std. Error	t	Sig.	B	Std. Error	t	Sig.
Intercept	0.114	0.257	0.445	0.657	0.483	0.407	1.188	0.236	-0.066	0.378	-0.174	0.862
Sex	0.009	0.079	0.109	0.913	0.171	0.124	1.376	0.171	0.192	0.116	1.659	0.099
Age_class	-0.023	0.068	-0.341	0.734	-0.045	0.107	-0.423	0.673	0.076	0.100	0.761	0.448
Education_rate	-0.009	0.036	-0.245	0.807	-0.074	0.058	-1.284	0.201	0.004	0.054	0.068	0.946
Ethnic_group	0.000	0.045	-0.010	0.992	0.021	0.071	0.294	0.769	0.021	0.066	0.314	0.754
Household_size	-0.056	0.038	-1.474	0.142	-0.120	0.060	-1.987	**0.049**	-0.092	0.056	-1.631	0.105
Seniority	0.144	0.043	3.338	**0.001**	0.040	0.068	0.583	0.561	0.030	0.063	0.467	0.641
Native	-0.023	0.083	-0.280	0.780	0.152	0.131	1.167	0.245	0.187	0.121	1.541	0.125
Main activity	-0.004	0.025	-0.159	0.874	-0.014	0.040	-0.338	0.736	-0.049	0.037	-1.313	0.191
Total_annual_income	3.558E-8	0.000	1.097	0.274	-1.161E-8	0.000	-0.227	0.821	-2.206E-8	0.000	-0.463	0.644
VPMO_Committee_Yes	0.217	0.056	3.851	**0.000**	0.175	0.089	1.962	0.051	0.265	0.083	3.198	**0.002**
Forest_security_Yes	0.123	0.073	1.695	0.092	-0.031	0.115	-0.271	0.786	0.018	0.107	0.172	0.864
Legal_land_holding_Yes	0.041	0.053	0.773	0.441	0.142	0.083	1.708	0.089	0.217	0.077	2.813	**0.005**
Private_plantation_size	-0.002	0.004	-0.509	0.611	0.000	0.006	0.071	0.944	-0.003	0.005	-0.511	0.610
Dist to forest	-0.009	0.009	-1.014	0.312	-0.026	0.015	-1.793	0.075	-0.021	0.014	-1.509	0.133

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

VPMO: Village Participatory Management Organisation

In Penessoulou forest, the results revealed that the perception of provisioning services was positively corelated with the education level. Similarly, the perception of regulating and supporting services was positively correlated with the age class and the membership to the local management committee but negatively correlated with the total annual income (Table 4.6). Moreover, the perception of the regulating and supporting services decreased from the Anii ethnic group to Kotokoli ethnic group and the other ethnic group (Appendix 1). Finally, the education rate and the membership to the local management committee positively influenced the perception of cultural services while the total annual income negatively impacted the perception of these services (Table 4.6).

Table 4.6. Factors influencing the perception of Ecosystem Services in Penessoulou forest

Factors	Provisioning services				Regulating & Supporting services				Cultural services			
	B	Std. Error	t	Sig.	B	Std. Error	t	Sig.	B	Std. Error	t	Sig.
Intercept	1.1576	0.9965	1.1617	0.2485	1.025	0.727	1.410	0.162	0.958	0.861	1.113	0.269
Sex	-0.206	0.283	-0.728	0.468	-0.393	0.214	-1.836	0.069	-0.333	0.254	-1.314	0.192
Age_class	-0.137	0.198	-0.691	0.491	0.312	0.150	2.076	**0.040**	0.123	0.178	0.691	0.491
Education_rate	0.251	0.123	2.035	**0.044**	0.119	0.094	1.270	0.207	0.225	0.111	2.032	**0.045**
Ethnic_group	-0.015	0.198	-0.078	0.938	-0.436	0.150	-2.899	**0.005**	-0.321	0.178	-1.802	0.074
Household_size	0.133	0.117	1.144	0.255	-0.026	0.088	-0.289	0.773	-0.086	0.105	-0.827	0.410
Seniority	0.265	0.149	1.779	0.078	0.027	0.113	0.239	0.811	0.114	0.133	0.851	0.397
Native	0.396	0.316	1.253	0.213	-0.141	0.240	-0.587	0.559	0.030	0.284	0.106	0.916
Main activity	0.065	0.092	0.708	0.481	0.017	0.070	0.239	0.811	0.057	0.083	0.681	0.497
Total_annual_income	-2.243E-7	0.000	-0.455	0.650	-1.037E-6	0.000	-2.774	**0.007**	-1.027E-6	0.000	-2.322	**0.022**
VPMO_Committee_Yes	0.036	0.219	0.163	0.871	0.506	0.166	3.049	**0.003**	0.528	0.197	2.685	**0.008**
Forest_security_Yes	0.152	0.292	0.522	0.603	0.372	0.221	1.681	0.096	-0.199	0.262	-0.761	0.449
Legal_land_holding_Yes	-0.188	0.250	-0.751	0.454	-0.005	0.190	-0.027	0.979	-0.121	0.224	-0.538	0.592
Private_plantation_size	-0.047	0.035	-1.318	0.191	0.025	0.027	0.930	0.354	0.007	0.032	0.233	0.816
Dist to forest	-0.084	0.076	-1.108	0.270	-0.075	0.058	-1.310	0.193	0.056	0.068	0.820	0.414

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.00$

VPMO: Village Participatory Management Organisation

In Sota forest, the perception of provisioning services was positively corelated with the age class and the membership to the local committee but negatively correlated with the length of the stay in the area and the ownership of legal land (Table 4.7). Moreover, women perceived more provisioning services than men (Appendix 1). Besides, the perception of the regulating and supporting services increased with the education rate and the length of the stay in the area while the perception of supporting services was positively corelated with the stay length and decreased with the age class and the distance from the house to the forest (Table 4.7). Moreover, the perception of regulating and supporting services decreased from the respondents practicing forest-based activity as main activity to those practicing other activity and commerce, while the respondents practicing agriculture were the least perceiving regulating and supporting services (Appendix 1). The perception of cultural services increased with the length of the stay in the area but decreased with age and the distance from the respondent house to the forest (Table 4.7). Furthermore, the services are more perceived by the respondent having commerce as main activity followed by those practicing forest related activity, other activity and finally agriculture (Appendix 1).

Table 4.7. Factors influencing the perception of Ecosystem Services in Sota forest

Factors	Provisioning services				Regulating & Supporting services				Cultural services			
	B	Std. Error	t	Sig.	B	Std. Error	t	Sig.	B	Std. Error	t	Sig.
Intercept	0.395	0.321	1.229	0.221	-1.201	0.588	-2.041	0.043	0.578	0.468	1.235	0.219
Sex	0.248	0.098	2.538	**0.012**	0.194	0.179	1.085	0.280	0.038	0.142	0.269	0.789
Age_class	0.179	0.087	2.064	**0.041**	0.032	0.159	0.201	0.841	-0.251	0.126	-1.992	**0.049**
Education_rate	-0.011	0.041	-0.277	0.782	0.260	0.075	3.456	**0.001**	-0.067	0.060	-1.124	0.263
Ethnic_group	0.021	0.063	0.339	0.735	0.216	0.116	1.866	0.064	0.019	0.092	0.202	0.840
Household_size	-0.030	0.047	-0.646	0.520	-0.051	0.086	-0.586	0.559	0.047	0.069	0.689	0.492
Seniority	-0.142	0.057	-2.486	**0.014**	0.289	0.105	2.756	**0.007**	0.174	0.083	2.081	**0.040**
Native	0.164	0.096	1.720	0.088	0.115	0.175	0.658	0.512	0.124	0.139	0.889	0.376
Main activity	-0.020	0.050	-0.389	0.698	0.184	0.092	1.997	**0.048**	0.180	0.073	2.460	**0.015**
Total_annual_income	2.606E-8	0.000	1.173	0.243	-2.610E-8	0.000	-0.641	0.523	-3.143E-8	0.000	-0.971	0.333
VPMO_Committee_Yes	0.254	0.068	3.758	**0.000**	0.229	0.124	1.847	0.067	0.106	0.098	1.074	0.285
Forest_security_Yes	-0.044	0.075	-0.588	0.557	-0.133	0.138	-0.964	0.337	-0.006	0.109	-0.058	0.954
Legal_land_holding_Yes	-0.261	0.068	-3.826	**0.000**	0.161	0.125	1.286	0.201	0.043	0.099	0.430	0.668
Private_plantation_size	-0.008	0.008	-1.053	0.294	-0.004	0.014	-0.281	0.779	-0.019	0.011	-1.727	0.087
Dist to forest	-0.012	0.014	-0.850	0.397	-0.010	0.026	-0.393	0.695	-0.063	0.021	-3.031	**0.003**

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

VPMO: Village Participatory Management Organisation

4.2.1.3. Perceived changes of forest ecosystem services (ESs)

The study assesses how local communities perceived the impact of PFM implementation on FESs in the different riparian villages from 2013 to 2022. From the results, the implementation of PFM impacted differently the availability of the ESs in the different forest. While there is a global opinion that PFM has a no impact (no change) on provisioning ESs (except firewood and timber collection) for the respondents surrounding Lama forest, the respondents living around Penessoulou observed a decline of some provisioning ESs (wild fruits, firewood, leaves, wild animal, fodder, fish, and grazing) while the rest were unchanged and those living close to Sota forest observed a decline of all of the ESs they are aware of. Besides, the implementation has improved lightly fresh air provision and carbon sequestration in for respondents living near to Penessoulou forest while the respondents surrounding Lama forest did not perceive any change in the regulating and supporting services this last decade and Sota forest community observed the decline of most of these ESs. Finally, PFM have few impacts on cultural ESs. For instance, respondents observed from 2013 to 2022 an improvement of eco-toursim in Lama forest, an improvement of aesthetic service in Penessoulou and a decline of aesthetic service in Sota forest (Table 4.8).

Table 4.8. The perceived status of forest ecosystem services under the PFM

Status / Ess	Lama forest				Penessoulou forest				Sota forest			
	Declining (%)	Improving (%)	No change (%)	No idea (%)	Declining (%)	Improving (%)	No change (%)	No idea (%)	Declining (%)	Improving (%)	No change (%)	No idea (%)
Provisioning												
Wild fruits	7.98	10.11	58.51	23.40	70.43	0.87	9.57	19.13	42.11	21.80	10.53	25.56
Firewood	15.96	35.64	35.11	13.30	43.48	6.96	13.91	35.65	45.86	24.81	6.02	23.31
Leaves	15.96	22.87	32.45	28.72	56.52	5.22	16.52	21.74	39.10	21.80	14.29	24.81
Fresh water	7.98	21.81	53.19	17.02	20.00	13.04	64.35	2.61	18.05	18.05	14.29	49.62
Wild animal	2.66	13.83	69.68	13.83	78.26	3.48	6.09	12.17	36.09	18.80	10.53	34.59
Wild food	2.66	8.51	77.66	11.17	14.78	0.87	78.26	6.09	51.88	13.53	21.80	12.78
Fodder	4.79	3.72	72.87	18.62	86.09	1.74	5.22	6.96	55.64	14.29	3.76	26.32
Fish	11.70	10.64	47.87	29.79	71.30	4.35	20.87	3.48	9.02	17.29	9.77	63.91
Broom grass	3.72	10.11	58.51	27.66	28.70	5.22	59.13	6.96	33.83	14.29	3.76	48.12
Thatch grass	1.60	7.45	73.40	17.55	16.52	2.61	69.57	11.30	19.55	12.03	9.77	58.65
Timber	30.85	28.72	28.19	12.23	30.43	2.61	56.52	10.43	54.14	9.77	30.08	6.02
Grazing	3.72	6.38	70.21	19.68	73.04	0.87	7.83	18.26	38.35	15.04	41.35	5.26
Regulating & Supporting												
Ground water recharge	1.06	13.83	12.23	72.87	10.43	13.04	5.22	71.30	12.03	10.53	6.02	71.43
Natural hazard reduction	2.13	28.72	6.91	62.23	8.70	21.74	16.52	53.04	16.54	8.27	4.51	70.68

Disease and pest regulation	3.19	32.45	9.04	55.32	20.00	19.13	36.52	24.35	15.79	6.02	3.76	74.44
Crop pollination	0.00	29.79	8.51	61.70	0.00	0.00	23.48	76.52	18.05	12.03	6.77	63.16
Fresh air	4.26	15.96	39.89	39.89	7.83	43.48	39.13	9.57	45.86	12.03	35.34	6.77
Carbon sequestration	6.91	22.87	37.77	32.45	9.57	50.43	34.78	5.22	51.13	12.78	33.83	2.26
Water purification	1.06	18.62	12.77	67.55	0.00	7.83	8.70	83.48	10.53	7.52	4.51	77.44
Soil protection	3.72	26.60	17.02	52.66	6.96	4.35	21.74	66.96	46.62	13.53	33.08	6.77
Soil formation	1.06	13.83	9.04	76.06	3.48	4.35	15.65	76.52	49.62	11.28	32.33	6.77
Biodiversity conservation	5.32	32.45	53.72	8.51	0.00	32.17	22.61	45.22	57.89	12.03	28.57	1.50
Genetic diversity	0.53	3.19	5.85	90.43	4.35	22.61	12.17	60.87	9.02	1.50	9.02	80.45
Seed dispersal	1.06	3.19	7.98	87.77	2.61	14.78	16.52	66.09	10.53	1.50	3.76	84.21
Cultural services												
Spiritual	2.66	25.53	5.85	65.96	11.30	13.91	66.96	7.83	37.59	9.77	16.54	36.09
Aesthetic	4.26	38.30	52.13	5.32	0.00	52.17	44.35	3.48	36.09	13.53	25.56	24.81
Recreation	0.53	35.64	6.38	57.45	11.30	15.65	69.57	3.48	24.06	13.53	26.32	36.09
Ecotourism	1.60	59.04	11.17	28.19	8.70	26.96	58.26	6.09	18.05	3.76	27.07	51.13

4.2.2. Traditional knowledge of useful forest plant species

4.2.2.1. Diversity and richness of forest useful plant species and management context in each forest reserve

A total of 74 forest plant species belonging to 36 families and 67 genera were identified as useful plant species around the three selected forest reserve. The most represented families were Leguminosae (17 genera and 21 species), Combretaceae (4 genera and 6 species), and Anarcadiaceae (3 genera and 4 species) (Table 4.9). About 70.27% of plant families were less represented (1 species) and 37.14% of them had only one genus. Of the 74 reported plant species, 36 forest plants species belonging to 24 families were identified as useful by the community surrounding Lama forest, 29 species belonging to 18 families were identified by the community bordering Penessoulou forest and, 31 species from 15 families were identified by the community living around and inside la Sota forest. Only *Afzelia Africana*, *Nauclea latifolia* and *Pterocarpus* were common to the three forest reserves. Lama and Penessoulou forest reserves shared 9 common species while Lama and Sota forest reserves shared 9 common plant species, and Penessoulou and Sota forest shared 7 common plant species (Table 4.9).

In the present study, RFC ranges from 1.21% to 25.30% in Lama forest, 2.70% to 43.24% in Penessoulou forest and 1.25% to 18.75% in Sota forest with 61%, 45% and 29% of species cited only once respectively around Lama, Penessoulou and Sota forest reserves. Based on the RFC, most valuable and cited plant species by the riparian people were *Cassia siamea* (25.3%), *Dialium guineense* (22.89%), *Dichapetalum guineense* (14.46%) and *Anogeisus leocarpus* (13.25%) in Lama forest, *Olax subscorpioidea* (43.24%), *Clausena anisate* (27.03%), *Uvaria chamae* (24.32%) and *Pericopsis laxiflora* (18.92%) in Penessoulou forest, *Pterocarpus erinaceus* (18.75%), *Afzelia Africana* (13.75%) and, *Ceiba pentandra* (11.25%) in Sota forest (Table 4.9).

The use value (UV) is a measure of the types of uses attributed to a particular plant species (Mehwish et al., 2019). In this work, the most used plant species were *Cassia siamea* (0.253), *Milicia excels* (0.205), *Dialium guineense* (0.133) and, *Dichapetalum guineense* (0.108) in Lama forest, *Olax subscorpioidea* (0.460), *Uvaria chamae* (0.270) and, *Clausena anisate* (0.240) in Penessoulou forest, *Pterocarpus erinaceus* (0.440), *Afzelia africana* (0.400), *Ceiba pentandra* (0.300) and, *Cordyla pinnata* (0.30) in Sota forest (Table 4.9).

Table 4.9. Relative frequency of citation (RFC) and Use value of each species (UV) per forest

	RFC (%)				UV			
Species	**Lama**	**Penessoulou**	**Sota**	**Overall**	**Lama**	**Penessoulou**	**Sota**	**Overall**
Abrus precatorius	2.41	0.00	0.00	1.00	0.036	0.000	0.000	0.020
Acacia nilotica	0.00	2.70	0.00	0.50	0.000	0.080	0.000	0.020
Adansonia digitata	0.00	2.70	3.75	2.00	0.000	0.050	0.050	0.030
Afzelia africana	6.02	2.70	**13.75**	8.50	0.084	0.000	**0.400**	0.200
Albizia zygia	0.00	2.70	0.00	0.50	0.000	0.030	0.000	0.010
Annona senegalensis	0.00	0.00	3.75	1.50	0.000	0.000	**0.160**	0.070
Anogeisus leocarpus	**13.25**	2.70	0.00	6.00	0.084	0.050	0.000	0.050
Anthocleista vogelii	1.21	0.00	0.00	0.50	0.012	0.000	0.000	0.010
Bequaertiodendron oblanceola	0.00	10.81	0.00	2.00	0.000	**0.110**	0.000	0.020
Burkea africana	0.00	0.00	2.50	1.00	0.000	0.000	0.040	0.020
Carissa spinarum	1.21	0.00	0.00	0.50	0.012	0.000	0.000	0.010
Cassia siamea	**25.30**	0.00	3.75	12.00	**0.253**	0.000	**0.110**	0.150
Cassia sieberiana	0.00	5.41	2.50	2.00	0.000	**0.110**	0.000	0.020
Ceiba pentandra	1.21	0.00	**11.25**	5.00	0.012	0.000	**0.300**	0.130
Clausena anisata	0.00	**27.03**	0.00	5.00	0.000	**0.240**	0.000	0.050
Cleome gynandra	1.21	0.00	0.00	0.50	0.000	0.000	0.000	0.000
Cola gigantea	0.00	2.70	0.00	0.50	0.000	0.030	0.000	0.010
Combretum glutinosum	0.00	0.00	**10.00**	4.00	0.000	0.000	**0.290**	0.120

Combretum molle	1.21	0.00	0.00	0.50	0.012	0.000	0.000	0.010
Cordyla pinnata	0.00	0.00	**10.00**	4.00	0.000	0.000	**0.300**	0.120
Cymbopogon citratus	1.21	0.00	0.00	0.50	0.024	0.000	0.000	0.010
Cyrtosperma senegalense	0.00	5.41	0.00	1.00	0.000	0.050	0.000	0.010
Daniellia oliveri	2.41	0.00	**10.00**	5.00	0.000	0.000	**0.240**	0.100
Detarium microcarpum	0.00	0.00	2.50	1.00	0.000	0.000	**0.100**	0.040
Dialium guineense	**22.89**	0.00	0.00	9.50	**0.133**	0.000	0.000	0.060
Dichapetalum guineense	**14.46**	0.00	0.00	6.00	**0.108**	0.000	0.000	0.050
Diospyros mespiliformis	3.61	0.00	3.75	3.00	0.024	0.000	**0.150**	0.070
Flueggea virosa	0.00	0.00	1.25	0.50	0.000	0.000	0.060	0.030
Gardenia erubescens	0.00	0.00	1.25	0.50	0.000	0.000	0.040	0.020
Gymnosporia senegalensis	0.00	2.70	0.00	0.50	0.000	0.030	0.000	0.010
Harrisonia abyssiniea	1.21	0.00	0.00	0.50	0.012	0.000	0.000	0.010
Hymenocardia acida	0.00	0.00	5.00	2.00	0.000	0.000	0.050	0.020
Isoberlinia doka	1.21	0.00	**10.00**	4.50	0.000	0.000	**0.190**	0.080
Khaya senegalensis	1.21	0.00	0.00	0.50	0.012	0.000	0.000	0.010
Kigelia africana	1.21	0.00	0.00	0.50	0.000	0.000	0.000	0.000
Lagenaria siceraria	1.21	0.00	0.00	0.50	0.012	0.000	0.000	0.010
Lannea acida	0.00	0.00	2.50	1.00	0.000	0.000	0.030	0.010
Lannea barteri	0.00	5.41	0.00	1.00	0.000	0.050	0.000	0.010
Launaea taraxacifolia	1.21	0.00	0.00	0.50	0.012	0.000	0.000	0.010
Lophira lanceolata	0.00	2.70	3.75	2.00	0.000	0.000	**0.150**	0.060
Milicia excelsa	8.43	2.70	0.00	4.00	**0.205**	0.050	0.000	0.100
Milletia thonningii	0.00	5.41	0.00	1.00	0.000	0.050	0.000	0.010
Momordica charantia	7.23	0.00	0.00	3.00	0.072	0.000	0.000	0.030
Nauclea latifolia	0.00	5.41	0.00	1.00	0.000	**0.110**	0.000	0.040
Ocimum americanum	1.21	0.00	0.00	0.50	0.012	0.000	0.000	0.010
Olax subscorpioidea	1.21	**43.24**	0.00	8.50	0.012	**0.460**	0.000	0.090
Opilia celtidifolia	0.00	0.00	1.25	0.50	0.000	0.000	0.000	0.000
Paullinia pinnata	1.21	0.00	0.00	0.50	0.012	0.000	0.000	0.010
Pavetta crassipes	0.00	0.00	1.25	0.50	0.000	0.000	0.050	0.020

Pentadesma butyracea	0.00	8.11	0.00	1.50	0.000	**0.110**	0.000	0.020
Pericopsis laxiflora	0.00	**18.92**	2.50	4.50	0.000	**0.190**	0.000	0.040
Piliostigma thonningii	3.61	8.11	0.00	3.00	0.036	0.080	0.000	0.030
Prosopis africana	7.23	2.70	0.00	3.50	0.060	0.000	0.000	0.030
Protea madiensis	0.00	0.00	1.25	0.50	0.000	0.000	0.000	0.000
Pseudocedrela kotschyi	0.00	0.00	1.25	0.50	0.000	0.000	0.000	0.000
Pseudospondias microcarpa	0.00	2.70	0.00	0.50	0.000	0.030	0.000	0.010
Pterocarpus erinaceus	4.82	8.11	**18.75**	11.00	0.000	0.080	**0.440**	0.190
Pterocarpus santalinoides	1.21	0.00	0.00	0.50	0.024	0.000	0.000	0.010
Rauvolfia vomitoria	1.20	0.00	0.00	0.50	0.000	0.000	0.000	0.000
Ritcheia capparoides	1.20	0.00	0.00	0.50	0.024	0.000	0.000	0.010
Rourea coccinea	1.20	0.00	0.00	0.50	0.012	0.000	0.000	0.010
Sarcocephalus latifolius	6.02	0.00	1.25	3.00	0.048	0.000	0.000	0.020
Securidaca longepedunculata	0.00	**13.51**	**10.00**	6.50	0.000	**0.140**	0.060	0.050
Senna alata	1.20	0.00	0.00	0.50	0.012	0.000	0.000	0.010
Senna singueana	0.00	0.00	1.25	0.50	0.000	0.000	0.000	0.000
Spondias mombin	1.20	0.00	0.00	0.50	0.000	0.000	0.000	0.000
Swartzia madagascariensis	0.00	2.70	0.00	0.50	0.000	0.000	0.000	0.000
Tamarindus indica	0.00	0.00	3.75	1.50	0.000	0.000	0.060	0.030
Teleopsis suberosa	0.00	0.00	1.25	0.50	0.000	0.000	0.000	0.010
Terminalia avicennioides	0.00	0.00	2.50	1.00	0.000	0.000	0.030	0.010
Terminalia glaucescens	2.41	0.00	0.00	1.00	0.012	0.000	0.000	0.010
Trichilia emetica	0.00	2.70	0.00	0.50	0.000	0.030	0.000	0.050
Uvaria chamae	0.00	**24.32**	0.00	4.50	0.000	0.270	0.000	0.040
Voacanga africana	0.00	0.00	5.00	2.00	0.000	0.000	**0.100**	0.020
Xeroderris stulhmannii	0.00	8.11	0.00	1.50	0.000	0.080	0.000	0.030
Zanthoxylum zanthoxyloides	1.20	**13.51**	0.00	3.00	0.000	**0.140**	0.000	0.000

The Informant Consensus Factor (ICF) is used to gauge how well the community agrees on the use of diverse plant species. Overall, the ICF range from 0.500 to 0.857. Wood energy use had the

highest IFC value with 29 use report for 5 plant species. However, the lowest value (0.000) was noted for food in Lama and Penessoulou forest reserve. Cultural uses were neither mentioned in Lama forest and not in Sota forest, while timber service and wood energy uses were not mentioned in Penessoulou forest reserve (Table 4.10).

Table 4.10. Informant consensus factors (ICF) values for 5 uses categories of species collected in three forests

	Overall		
Uses categories	**Number of Species (Ns)**	**Number of use reports (Nur)**	**ICF**
Cultural	2	3	0.50
Food	16	50	0.69
Medicine	74	376	0.80
Timber service	10	49	0.81
Wood energy	5	29	0.86
	Lama forest		
Cultural	NA	NA	NA
Food	1	2	0.00
Medicine	38	107	0.65
Timber service	2	7	0.83
Wood energy	2	14	0.92
	Penessoulou forest		
Cultural	2	3	0.50
Food	2	2	0.00
Medicine	30	99	0.70
Timber service	NA	NA	NA
Wood energy	NA	NA	NA
	Sota forest		

Cultural	NA	NA	NA
Food	13	47	0.74
Medicine	31	170	0.82
Timber service	9	42	0.8
Wood energy	4	15	0.79

4.2.2.2. Factors influencing the knowledge of forest plant species among the forest reserves

The logistic regression showed that several socio-environmental and socio-economic factors influenced the knowledge of uses of forest plant species in each forest (Table 4.11). The knowledge increases with the education rate and decreases with age, the household size, the length of stay and the membership to the management committee around Lama forest. Around Penessoulou forest, men and Kotokoli ethnic groups cited more forest plant species respectively than women and Anii ethnic groups while youths and, respondents with medium (21-35years) and long (36-75years) stay period cited less forest plant species respectively than aged people and respondents of small stay period (10-20 years). Moreover, small-size (1-6) household heads were more knowledgeable than medium-size (7-10) household heads and less knowledgeable than large-size (11-38) household heads around Penessoulou forest. Finally, youth and olds, illiterates and primary school level cited less forest plant species respectively than adults and high school level respondents while respondents with long (36-75) period of stay and member of the management committee cited more forest plant species respectively than respondents with short (10-20) period of stay and those non-part of the management committee around Sota forest. Furthermore, short-size household heads were less knowledgeable than medium-size household heads and more knowledgeable than large-size household heads around Sota forest.

Table 4.11. Socio-economic factors influencing knowledge of the useful plant species in each forest

	Knowledge of plant reported			
Factors	Lama	Penessoulou	Sota	All forests
(Intercept)	0.765	-11.212	9.534	-0.754*
sexMale	0.198	**1.458*** **	0.102	0.443***
ethnic_groupsAïzo	-	NA	NA	-
ethnic_groupsAnii	NA	-	NA	-0.872***
ethnic_groupsBoo	NA	NA	-	0.509*
ethnic_groupsFon	-0.000	NA	NA	-0.123
ethnic_groupsHolly	-0.000	NA	NA	-0.035
ethnic_groupsKotokoli	NA	**0.908*** **	NA	0.136
ethnic_groupsMokolé	NA	NA	-0.148	0.521*
ethnic_groupsOthers	0.693	0.340	0.035	0.379
age_classOld	**-0.620***	0.246	**-0.910 ***	-0.237
age_classYouth	-0.239	**-0.651***	**-0.487***	**-0.316****
educationNone	**-2.211*** **	10.761	**-0.753***	-0.188
educationPrimary	**-1.306***	10.075	**-1.284*** **	-0.148
educationSecondary	-0.859	10.273	-0.237	0.310
household_sizeMedium	**0.501****	**-0.718***	**0.539***	**0.359*** **
household_sizeLarge	**0.499***	**0.589***	**-0.400***	**0.426*** **
seniorityMedium	**-0.475***	**-1.402*** **	0.320	**-0.359****
seniorityLong	-0.236	**-0.817****	**1.120*** **	0.085
main_activityAgriculture	0.113	-0.181	-9.185	0.008
main_activityCommerce	-0.172	0.132	-10.738	-0.297
main_activityOthers	-0.243	-0.304	-10.284	-0.108
member_VPMO_Yes	0.298*	-0.261	**0.929*** **	**0.275****

The logistic regression showed that there is a difference in forest plant uses between the communities surrounding the three forest reserves. (Table 4.12). Respondents living near Lama forest cited more forest plant species than those surrounding Penessoulou forest and less than the respondent around Sota forest. The trend was similar with the sex, the household size, the period of stay, the main activity and membership to the management committee except the age where the olds living close to Penessoulou forest cited more forest plant species than their counterparts surrounding Lama forest. Moreover, only the Anii ethnic groups surrounding Penessoulou forest were less knowledgeable than the Adja ethnic groups living close to Lama forest (Table 4.12).

Table 4.12. Socio-ecological factors affecting the knowledge of useful plant species of the considered forest reserves

	Knowledge of useful plant				Knowledge of useful plant		
Factors	Coef	SE	z value	Factors	Coef	SE	z value
Intercept	**-0.245*** **	0.060	-4.088				
forestPene	**-0.501*** **	0.101	-4.957	forestSota:household_sizeSmall	0.210	0.130	1.615
forestSota	**0.350*** **	0.089	3.918	forestSota:household_sizeLarge	**0.611** **	0.194	3.143
sexMale	**0.717*** **	0.184	3.901	forestSota:household_sizeMedium	**0.939*** **	0.205	4.571
forestPene:sexFemale	**-0.870** **	0.308	-2.822	seniorityMedium	-0.293	0.200	-1.465
forestPene:sexMale	**-0.436*** **	0.109	-4.019	seniorityLong	-0.110	0.189	-0.581
forestSota:sexFemale	**0.624** **	0.238	2.621	forestPene:seniorityShort	-0.201	0.231	-0.869
forestSota:sexMale	**0.322*** **	0.097	3.317	forestPene:seniorityMedium	-1.140	0.200	-5.715
age_classesOld	**-0.814** **	0.285	-2.858	forestPene:seniorityLong	**-0.314***	0.146	-2.147
age_classesYouth	-0.190	0.158	-1.202	forestSota:seniorityShort	-0.243	0.204	-1.194
forestPene:age_classAdult	**-0.544*** **	0.118	-4.624	forestSota:seniorityMedium	0.188	0.164	1.151
forestPene:age_classOld	**0.981** **	0.378	2.593	forestSota:seniorityLong	**1.001*** **	0.144	6.943
forestPene:age_classYouth	**-0.924*** **	0.251	-3.687	main_activityAgriculture	0.122	0.178	0.685
forestSota:age_classAdult	**0.679*** **	0.116	5.823	main_activityCommerce	-0.254	0.200	-1.269
forestSota:age_classOld	**1.674*** **	0.449	3.730	main_activityOthers	-0.288	0.264	-1.092
forestSota:age_classYouth	-0.074	0.176	-0.422	forestPene:main_activityForest_Acti	-0.182	0.307	-0.593
ethnic_groupAnii	**-1.033*** **	0.219	-4.725	forestPene:main_activityAgriculture	**-0.753*** **	0.137	-5.519
ethnic_groupBoo	0.148	0.210	0.703	forestPene:main_activityCommerce	**-0.622***	0.244	-2.550

ethnic_groupFon	-0.322	0.205	-1.569	forestPene:main_actyOthers	0.288	0.286	1.005
ethnic_groupHolly	-0.134	0.244	-0.548	forestSota:main_activityForestActi	14.789	254.826	0.058
ethnic_groupKotokoli	-0.125	0.241	-0.520	forestSota:main_activityAgriculture	**0.281****	0.109	2.588
ethnic_groupMokole	0.000	0.227	0.000	forestSota:main_activityCommerce	-0.909**.**	0.473	-1.924
ethnic_groupOthers	0.118	0.276	0.426	forestSota:main_actyOthers	-0.049	0.332	-0.147
household_sizeLarge	**0.365***	0.173	2.115	member_VPMOcom.Yes	**0.425*****	0.125	3.407
household_sizeMedium	**0.439*****	0.132	3.320	forestPene:member_VPMOcom.No	-0.161	0.143	-1.130
forestPene:household_sizeSmall	**-0.559*****	0.158	-3.535	forestPene:member_VPMOcom.Yes	**-0.784*****	0.15461	-5.068
forestPene:household_sizeLarge	0.068	0.200	0.340	forestSota:member_VPMOcom.No	**0.373****	0.125	2.979
forestPene:household_sizeMedium	**-1.154*****	0.211	-5.454	forestSota:member_VPMOcom.Yes	**1.041*****	0.170	6.136

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘**.**’ 0.1 ‘ ’ 1

4.2.3. Structural characterization of useful forest plant species

4.2.3.1. Tree species composition

After removing the croplands, plantations and plots outside the forest boundary, a total of 42 plots, 47 plots and, 86 plots were effectively inventoried respectively from Lama, Penesoulou and, Sota forest reserves.

The inventory data summarized in table 4.13. showed that the largest DBH was found in Lama forest with *Afzelia africana* (122.5 cm), while the highest tree was found in Penessoulou forest with *Pentadesma butyracea* (56.10 cm). Moreover, 73%, 54% and 90% of the most useful plant species retained were found respectively in Lama forest, Penessoulou forest and Sota forest during the field inventory.

Table 4.13. Species vegetative parameters in the different forests

Forest	Species	Total Count	DBH		Total height	
			Minimum	Maximum	Minimum	Maximum
Lama	*Afzelia africana*	108	5.2	122.5	1	26.8
Lama	*Anogeissus leiocarpa*	68	7.30	67.30	2.30	30.00
Lama	*Dialium guineense*	824	5.00	51.20	1.50	25.00
Lama	*Diospyros mespiliformis*	444	5.00	66.70	1.40	27.00
Lama	*Milicia excelsa*	3	11.80	59.00	7.10	12.00
Lama	*Pterocarpus erinaceus*	14	8.80	49.50	4.00	25.00
Lama	*Terminalia glaucescens*	5	13.60	20.70	4.00	15.00
Penessoulou	*Olax subscorpioidea*	7	5.09	10.18	3.66	6.75
Penessoulou	*Pentadesma butyracea*	7	9.23	51.09	4.70	56.10
Penessoulou	*Pericopsis laxiflora*	255	5.00	55.36	1.20	17.00
Penessoulou	*Piliostigma thonningii*	45	5.09	37.23	1.20	9.90
Penessoulou	*Pterocarpus erinaceus*	108	5.09	47.09	1.60	16.35

Penessoulou	*Uvaria chamae*	6	5.41	15.27	2.80	4.00
Penessoulou	*Xeroderris stulhmannii*	92	5.09	43.91	2.30	15.40
Sota	*Afzelia africana*	66	6.36	39.93	2.20	11.52
Sota	*Ceiba pentandra*	4	6.68	21.64	4.00	8.60
Sota	*Combretum glutinosum*	788	5.00	37.86	2.20	11.70
Sota	*Cordyla pinnata*	36	6.05	23.86	2.16	11.40
Sota	*Daniellia oliveri*	18	5.09	26.09	4.60	10.70
Sota	*Hymenocardia acida*	104	5.00	15.80	2.40	6.60
Sota	*Isoberlinia doka*	360	5.00	51.07	2.16	19.05
Sota	*Pterocarpus erinaceus*	95	5.89	38.82	2.16	11.80
Sota	*Securidaca longepedunculata*	50	5.00	26.09	3.00	12.60
Sota	*Voacanga africana*	11	6.05	33.41	3.92	10.35

Tables 4.14 shows that Lama forest was dominated by *Dialium guineense* (78.47 trees/ha), followed by *Diosperos mespiliformis* (42.29 trees/ha), while *Periscopsis laxiflora* (21.70 trees/ha) has the highest tree density followed by *Pterocarpus erinaceus* (9.19 trees/ha) in Penessoulou forest. The highest tree densities were found in *Combretum glutinosom* (36.65 trees/ha), followed by *Isoberlinia doka* (16.74 trees/ha) in Sota forest.

Table 4.14. Tree density of the most useful plant species

Forest	**Species**	Total plot number	Mean (trees/ha)
Lama	*Afzelia Africana*	42	10.29
Lama	*Anogeissus leiocarpa*	42	6.48
Lama	*Dialium guineense*	42	78.48
Lama	*Diospyros mespiliformis*	42	42.29
Lama	*Milicia excelsa*	42	0.29

Lama	*Pterocarpus erinaceus*	42	1.33
Lama	*Terminalia glaucescens*	42	0.48
Penessoulou	*Olax subscorpioidea*	47	0.60
Penessoulou	*Pentadesma butyracea*	47	0.60
Penessoulou	*Pericopsis laxiflora*	47	21.70
Penessoulou	*Piliostigma thonningii*	47	3.83
Penessoulou	*Pterocarpus erinaceus*	47	9.19
Penessoulou	*Uvaria chamae*	47	0.51
Penessoulou	*Xeroderris stulhmannii*	47	7.83
Sota	*Afzelia africana*	86	3.07
Sota	*Ceiba pentandra*	86	0.19
Sota	*Combretum glutinosum*	86	36.65
Sota	*Cordyla pinnata*	86	1.67
Sota	*Daniellia oliveri*	86	0.84
Sota	*Hymenocardia acida*	86	4.84
Sota	*Isoberlinia doka*	86	16.74
Sota	*Pterocarpus erinaceus*	86	4.42
Sota	*Securidaca longepedunculata*	86	2.33
Sota	*Voacanga africana*	86	0.51

Moreover, the highest values of tree density were found in Lama forest for all diameter class except for trees with DBH comprised between 10 cm and 15 cm mainly found in Sota forest. Penessoulou forest possessed the lowest number of trees with DBH between 10 cm to 35 cm while the lowest number of big trees were noted in Sota (Table 4.15).

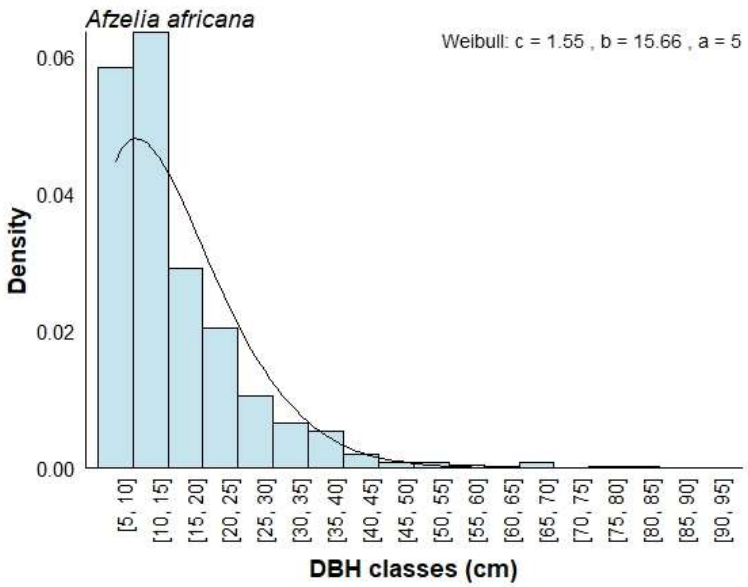
Table 4.15. Tree density (trees/ha) of the most useful plant species per diameter class

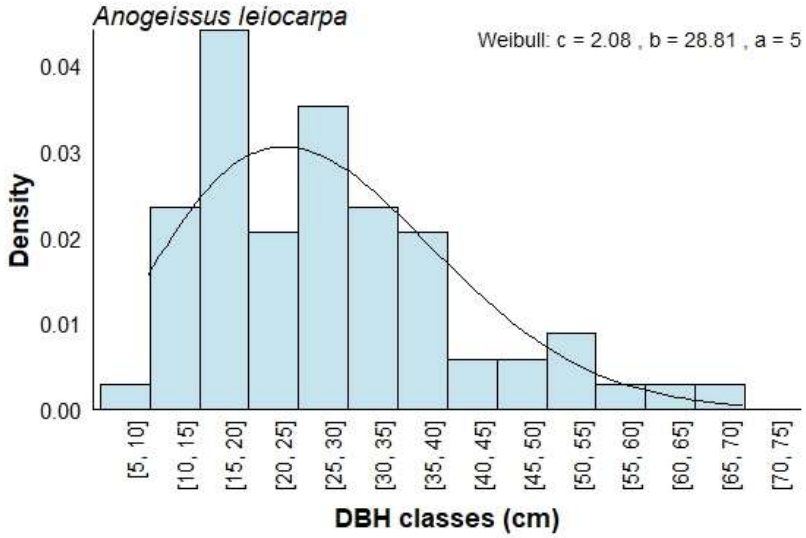
Diameter classes	Lama	Penessoulou	Sota
[5, 10[	73.71	24.09	23.35
[10, 15[	19.62	8.34	24.37
[15, 20[	12.95	3.83	9.26
[20, 25[	8.19	2.72	7.53
[25, 30[	6.00	2.13	3.07
[30, 35[	3.52	1.19	2.37
[35, 40[	2.29	1.28	1.21
[40, 45[	0.95	0.17	0.00
[45, 50[	0.67	0.34	0.00
≥ 50	1.43	0.17	0.09
Total	129.33	44.26	71.26

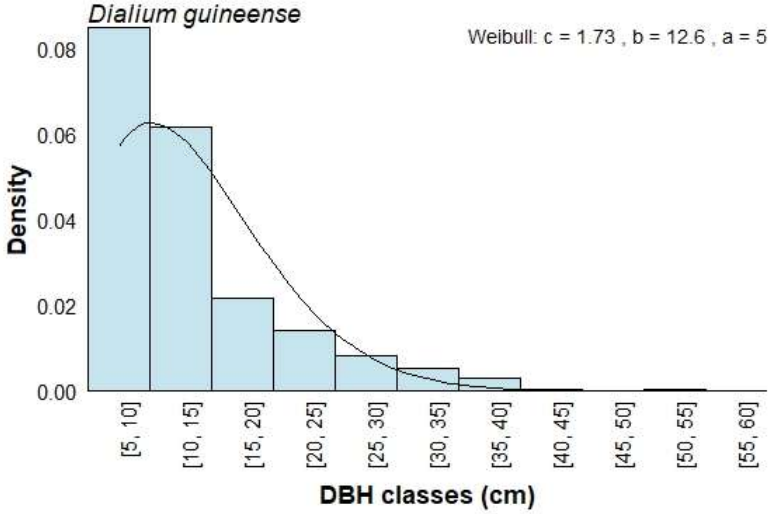
4.2.3.2. Population structure of forest useful plant species

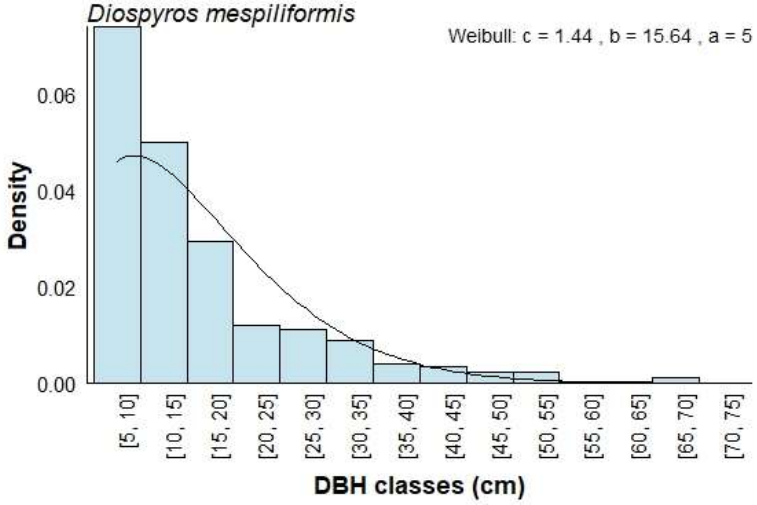
The size class distribution (SCDs) for the trees showed a non-normal and positively asymmetric distribution ($1 < c < 3.6$) except for *Terminalia glaucescens* (6.51) in Lama forest (Figure 4.5), *Olax subscorpioidea* (5.58) in Penessoulou forest (Figure 4.6) and *Daniellia oliveri* (5.8) in Sota forest (Figure 4.7). The asymmetry is strong for most of the species of Lama and Penessoulou forest reserves. These values of shape parameter of Weibull distribution characterized a monospecific stand with relatively more young individuals (Glèlè Kakaï et al., 2016). The stem diameter distribution of the aforementioned plant species was non-normal and negatively asymmetric ($c > 3.6$). These values of shape parameter of Weibul distribution characterized a monospecific stand with relatively low young individual (Glèlè Kakaï et al., 2016) (Figures 4.5, 4.6 and 4.7).

Lama forest


Afzelia africana
Weibull: c = 1.55 , b = 15.66 , a = 5
Density
0.06
0.04
0.02
0.00
[5, 10]
[10, 15]
[15, 20]
[20, 25]
[25, 30]
[30, 35]
[35, 40]
[40, 45]
[45, 50]
[50, 55]
[55, 60]
[60, 65]
[65, 70]
[70, 75]
[75, 80]
[80, 85]
[85, 90]
[90, 95]
DBH classes (cm)


Anogeissus leiocarpa
Weibull: c = 2.08 , b = 28.81 , a = 5
Density
0.04
0.03
0.02
0.01
0.00
[5, 10]
[10, 15]
[15, 20]
[20, 25]
[25, 30]
[30, 35]
[35, 40]
[40, 45]
[45, 50]
[50, 55]
[55, 60]
[60, 65]
[65, 70]
[70, 75]
DBH classes (cm)


Dialium guineense
Weibull: c = 1.73 , b = 12.6 , a = 5
Density
0.08
0.06
0.04
0.02
0.00
[5, 10]
[10, 15]
[15, 20]
[20, 25]
[25, 30]
[30, 35]
[35, 40]
[40, 45]
[45, 50]
[50, 55]
[55, 60]
DBH classes (cm)


Diospyros mespiliformis
Weibull: c = 1.44 , b = 15.64 , a = 5
Density
0.06
0.04
0.02
0.00
[5, 10]
[10, 15]
[15, 20]
[20, 25]
[25, 30]
[30, 35]
[35, 40]
[40, 45]
[45, 50]
[50, 55]
[55, 60]
[60, 65]
[65, 70]
[70, 75]
DBH classes (cm)

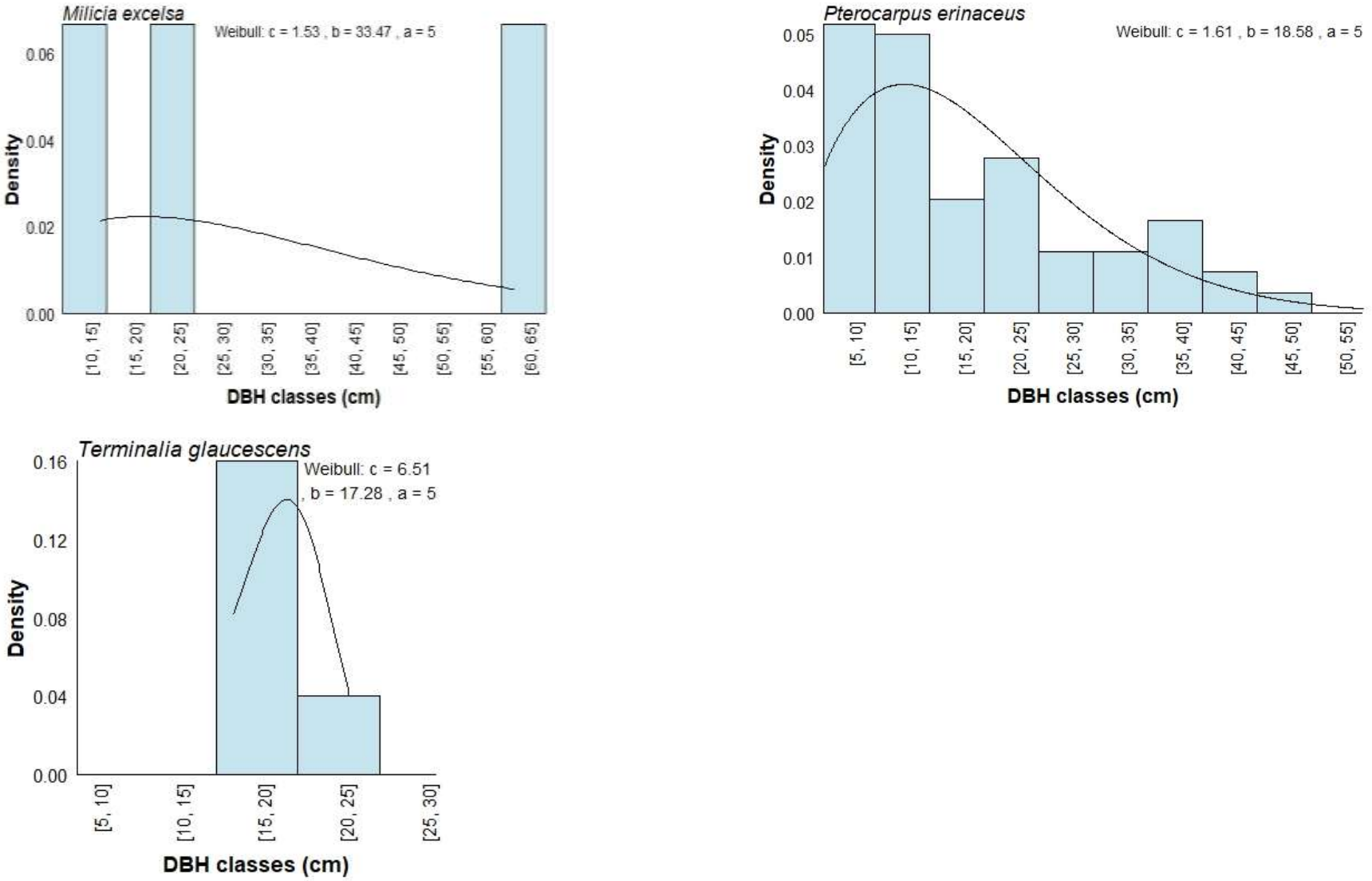
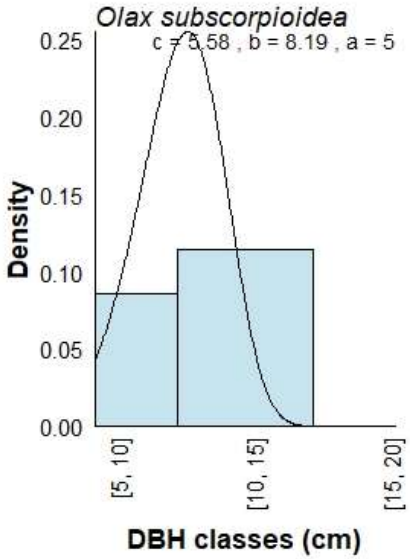
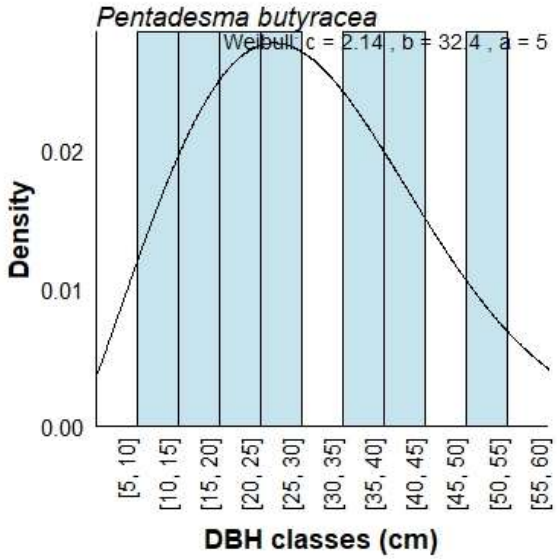
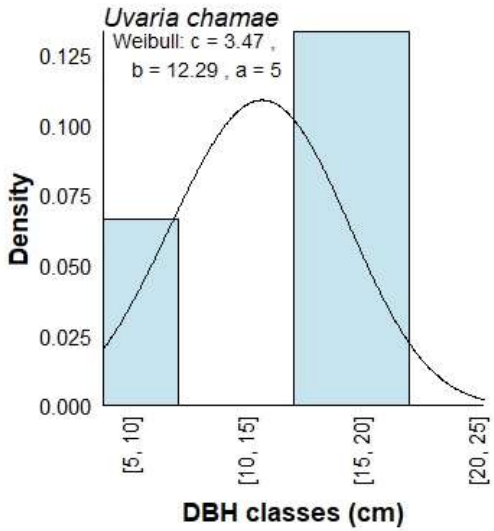


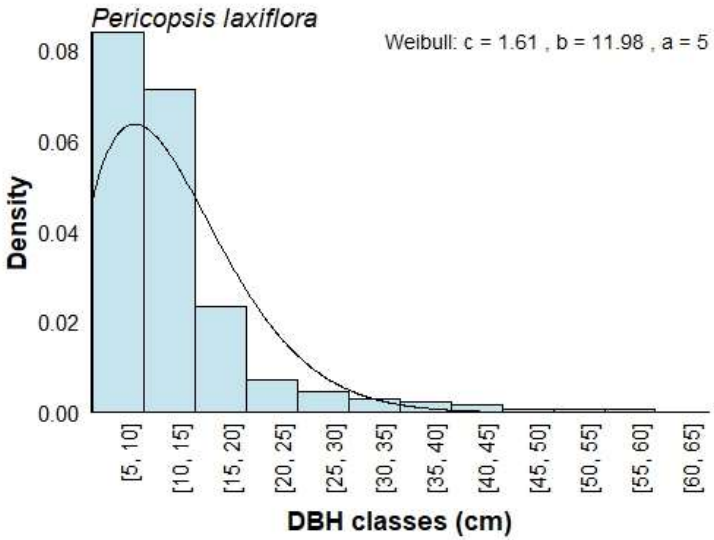
Figure 4.5: Class diameter distribution of forest useful plant species of Lama forest

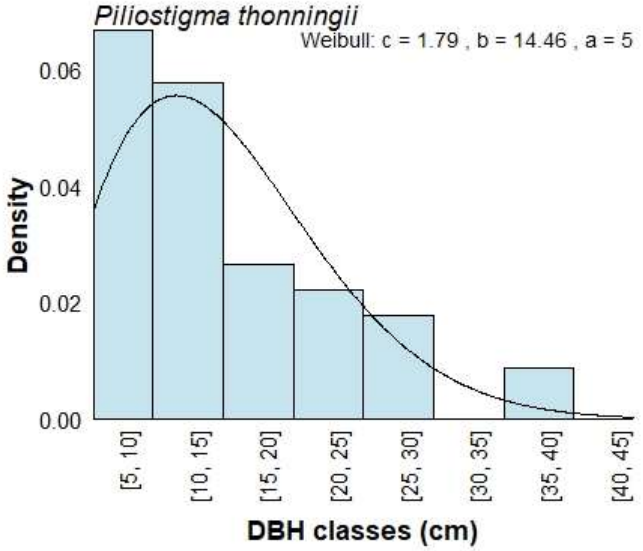
Penessoulou forest











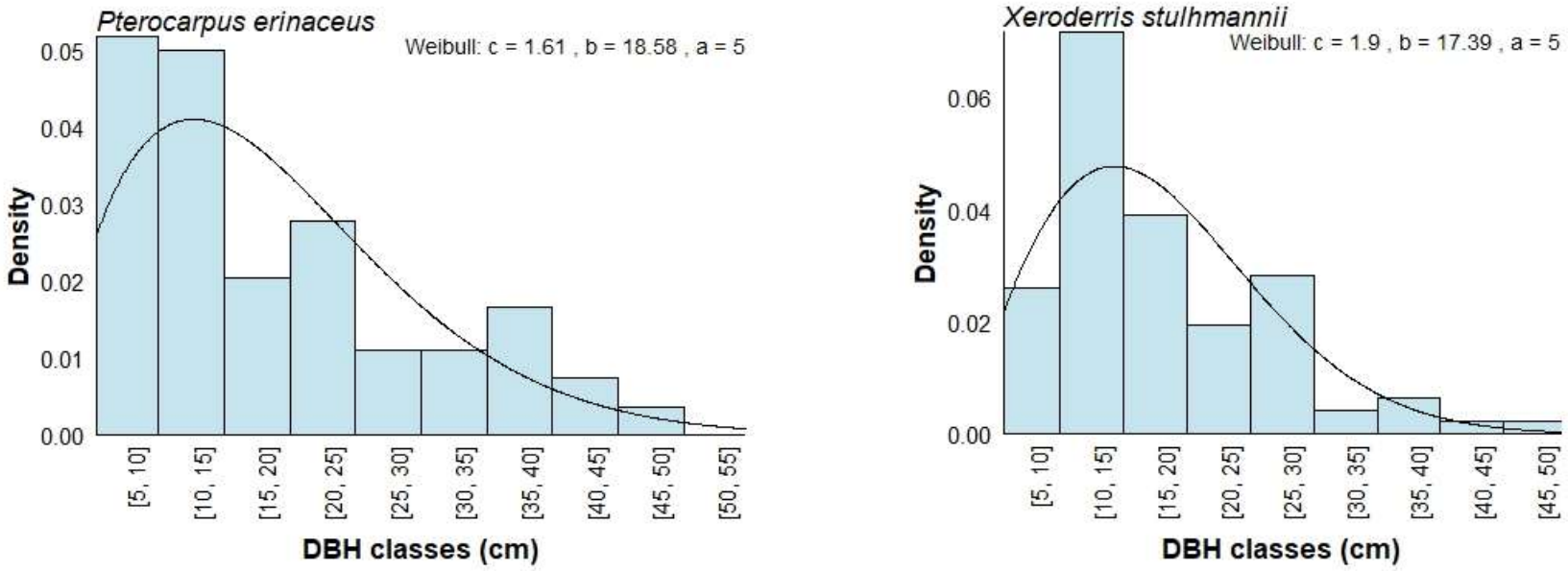
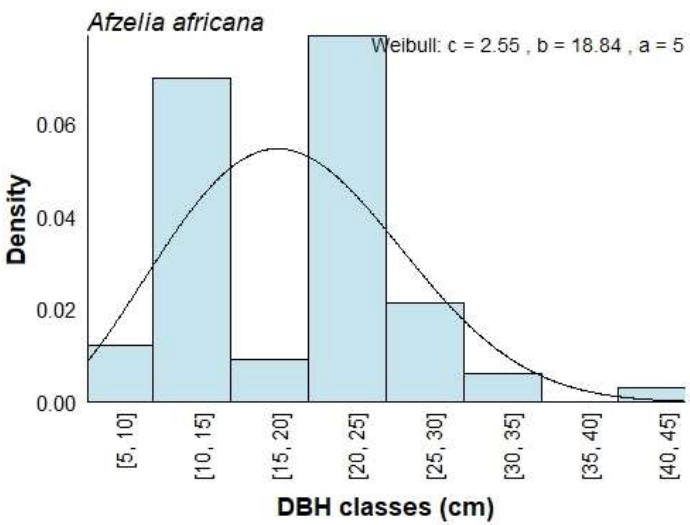
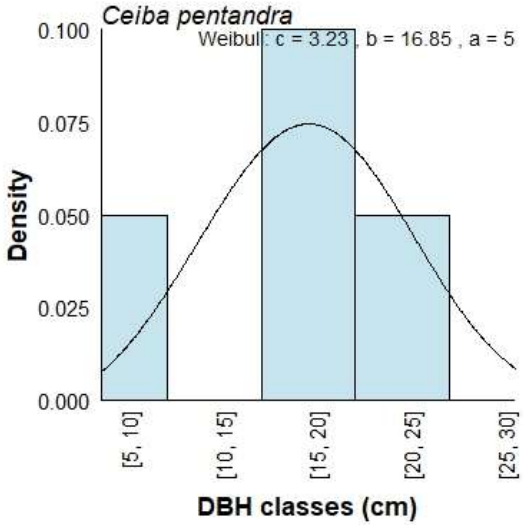
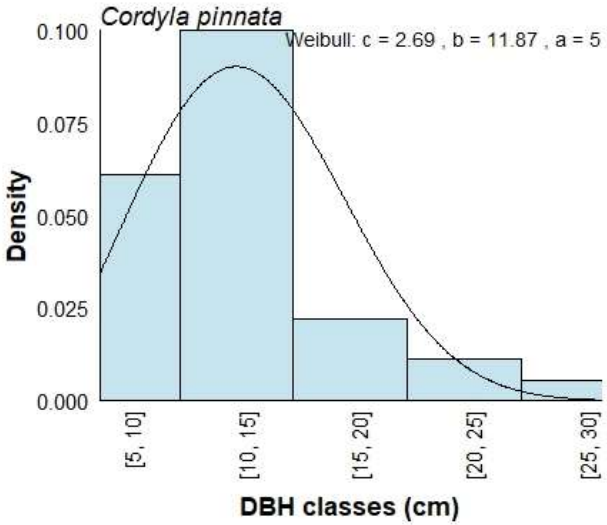


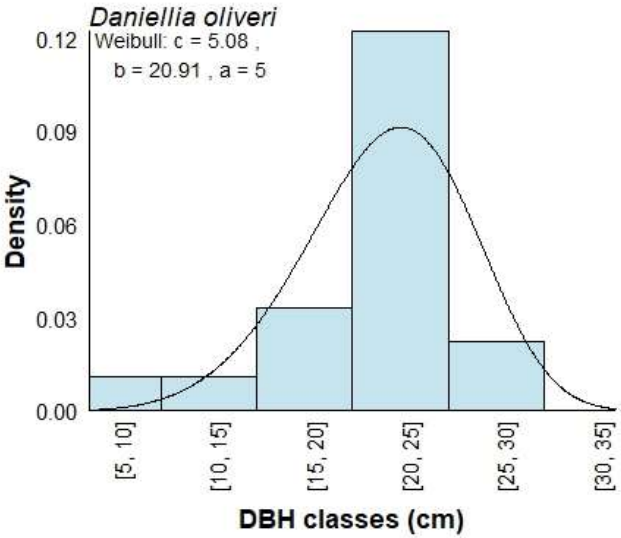
Figure 4.6: Class diameter distribution of forest useful plant species of Penessoulou forest

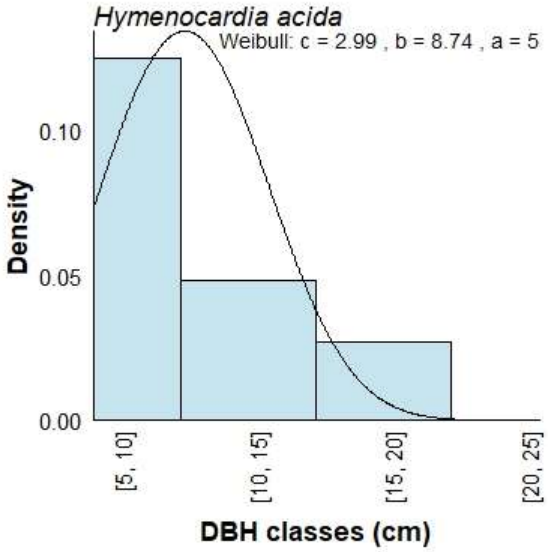
Sota forest

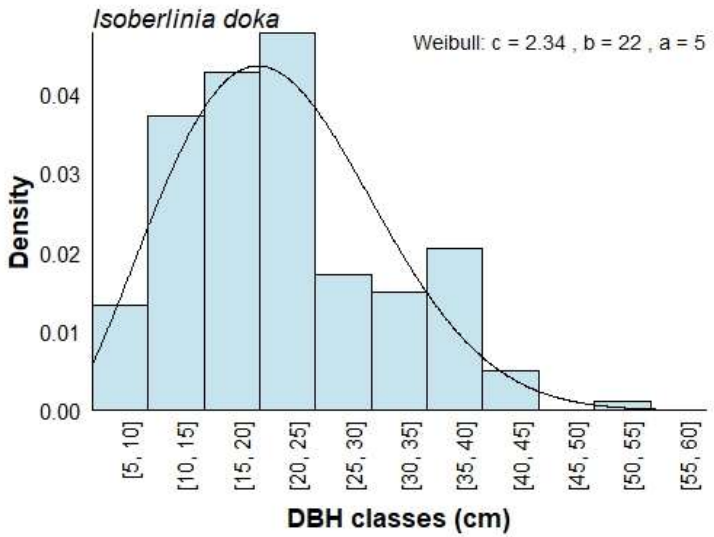

Afzelia africana
Weibull: c = 2.55 , b = 18.84 , a = 5
Density
0.06
0.04
0.02
0.00
[5, 10]
[10, 15]
[15, 20]
[20, 25]
[25, 30]
[30, 35]
[35, 40]
[40, 45]
DBH classes (cm)

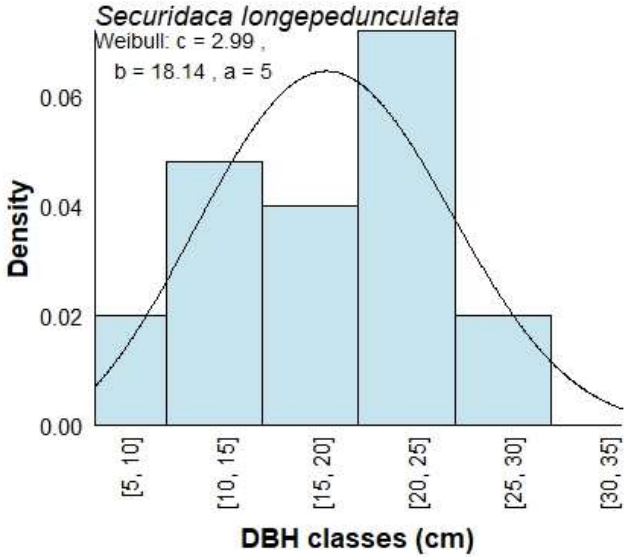

Ceiba pentandra
Weibull: c = 3.23 , b = 16.85 , a = 5
Density
0.100
0.075
0.050
0.025
0.000
[5, 10]
[10, 15]
[15, 20]
[20, 25]
[25, 30]
DBH classes (cm)

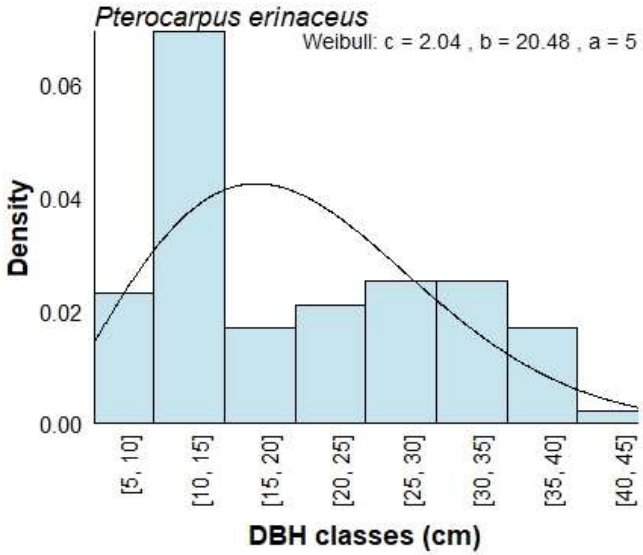

Cordyla pinnata
Weibull: c = 2.69 , b = 11.87 , a = 5
Density
0.100
0.075
0.050
0.025
0.000
[5, 10]
[10, 15]
[15, 20]
[20, 25]
[25, 30]
DBH classes (cm)


Daniellia oliveri
Weibull: c = 5.08 ,
b = 20.91 , a = 5
Density
0.12
0.09
0.06
0.03
0.00
[5, 10]
[10, 15]
[15, 20]
[20, 25]
[25, 30]
[30, 35]
DBH classes (cm)


Hymenocardia acida
Weibull: c = 2.99 , b = 8.74 , a = 5
Density
0.10
0.05
0.00
[5, 10]
[10, 15]
[15, 20]
[20, 25]
DBH classes (cm)


Isoberlinia doka
Weibull: c = 2.34 , b = 22 , a = 5
Density
0.04
0.03
0.02
0.01
0.00
[5, 10]
[10, 15]
[15, 20]
[20, 25]
[25, 30]
[30, 35]
[35, 40]
[40, 45]
[45, 50]
[50, 55]
[55, 60]
DBH classes (cm)


Securidaca longepedunculata
Weibull: c = 2.99 ,
b = 18.14 , a = 5
Density
0.06
0.04
0.02
0.00
[5, 10]
[10, 15]
[15, 20]
[20, 25]
[25, 30]
[30, 35]
DBH classes (cm)


Pterocarpus erinaceus
Weibull: c = 2.04 , b = 20.48 , a = 5
Density
0.06
0.04
0.02
0.00
[5, 10]
[10, 15]
[15, 20]
[20, 25]
[25, 30]
[30, 35]
[35, 40]
[40, 45]
DBH classes (cm)

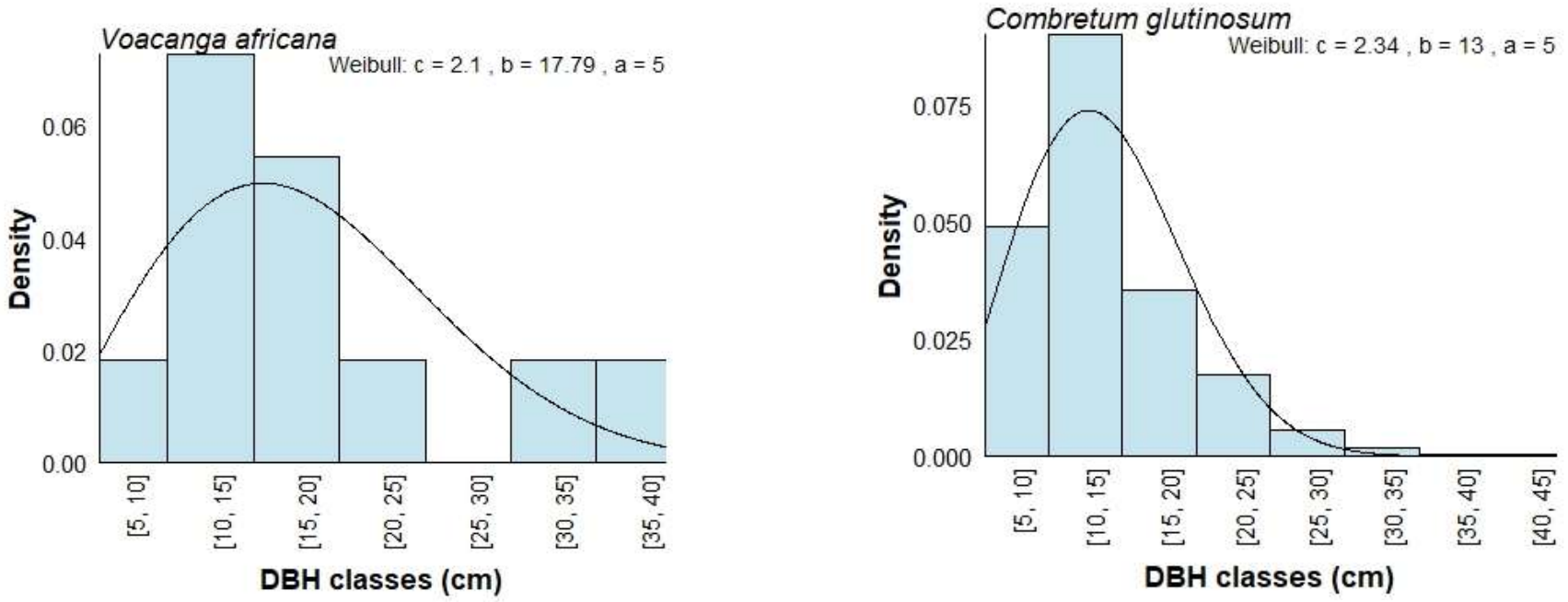


Figure 4.7: Class diameter distribution of forest useful plant species of Sota forest

4.2.4. Forest governance assessment

4.2.4.1. Organisation of the forest management structures

Lama and Penessoulou forest reserves were managed by the National Wood Company (**SONAB**: Société Nationale du Bois) with three offices in Lama forest covering and managing one sector each (sector of Akpè, sector of Massi and sector of Koto) and one office in Penessoulou forest. The offices are managed by forest officers which local representations are the committee of the Village Participatory Management Organisation (**VPMO**) locally called "**COGEPAF**: Comité de Gestion Participative des Forêts" and "contact committee". Each village surrounding the forest has a committee of 11 members COGEPAF for the old VPMO that fulfilled all the requirements and a committee of 5 members (contact committee) for VPMO newly created. The VPMO committees were organised in a coordination committee in each forest which is in touch with the forest officers for the share of useful information. Moreover, each office is endowed with a Head of Participative Management Works (**CTEP**: Chef Travaux Encadrement Participatif) who is also an agent of SONAB and is the direct contact between the VPMO committees and the SONAB offices. Sota forest is managed by the Directorate General of Water, Forests, and Hunting (**DGEFC**: Direction Générale des Eaux Forêt et Chasse) through the forestry cantonment of Kandi. The later coordinates the work of the two forestry stations in the forest (Poste Forestier (**PF**) de Pénéssoulou and PF de Lougou) through the Technical Forestry Management Unit (**CTAF**: Cellule Technique d'Aménagement Forestier). The forest is divided in six (6) management units (**UA**: Unité d'Aménagement) with 2 UA (UA of Bensékou and Koutakroukou) managed by the PF of Bensékou and 4 UA (UA of Zonzi, Lougou, Sinwan and Gbéssaka) managed by the PF of Lougou. Local representations of the DGEFC are the Village Forest Management Councils (**CVGF:** Conseil Villageois de Gestion de la Forêt) at village level, Managing Council of Planning Units (**CGUA**:

Conseils de Gestion des Unités d'Aménagement) at UA level and the Coordinating Council of Management Units (**CCUA:** Conseil de Coordination des Unités d'Aménagement) at forest level who are the direct interlocutor to the forestry administration. Each CVGF, CGUA and the CCUA has an executive committee is constituted of 5 members (Figure 4.8). OVGF is the representation of VPMO in Sota forest management approach.

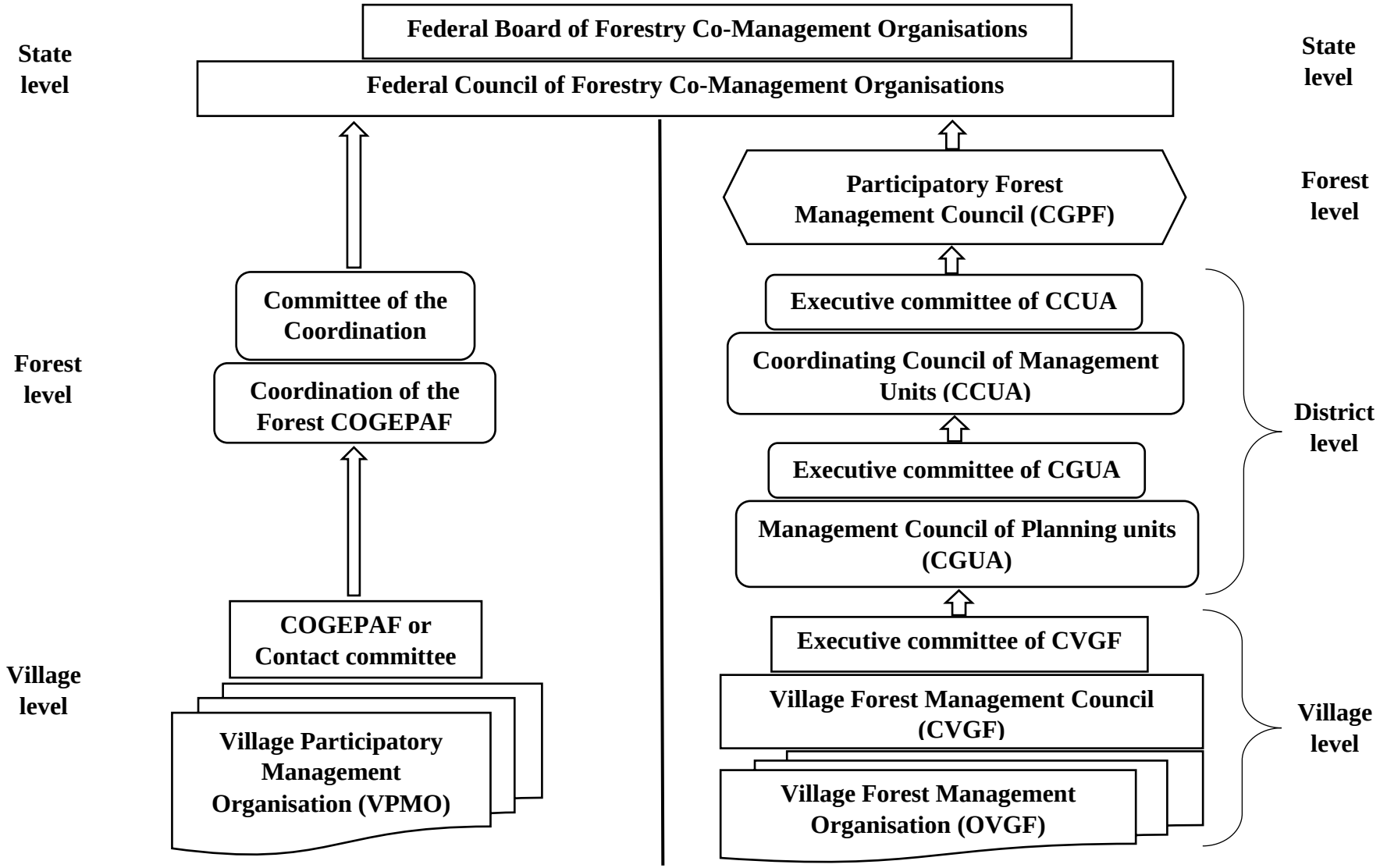
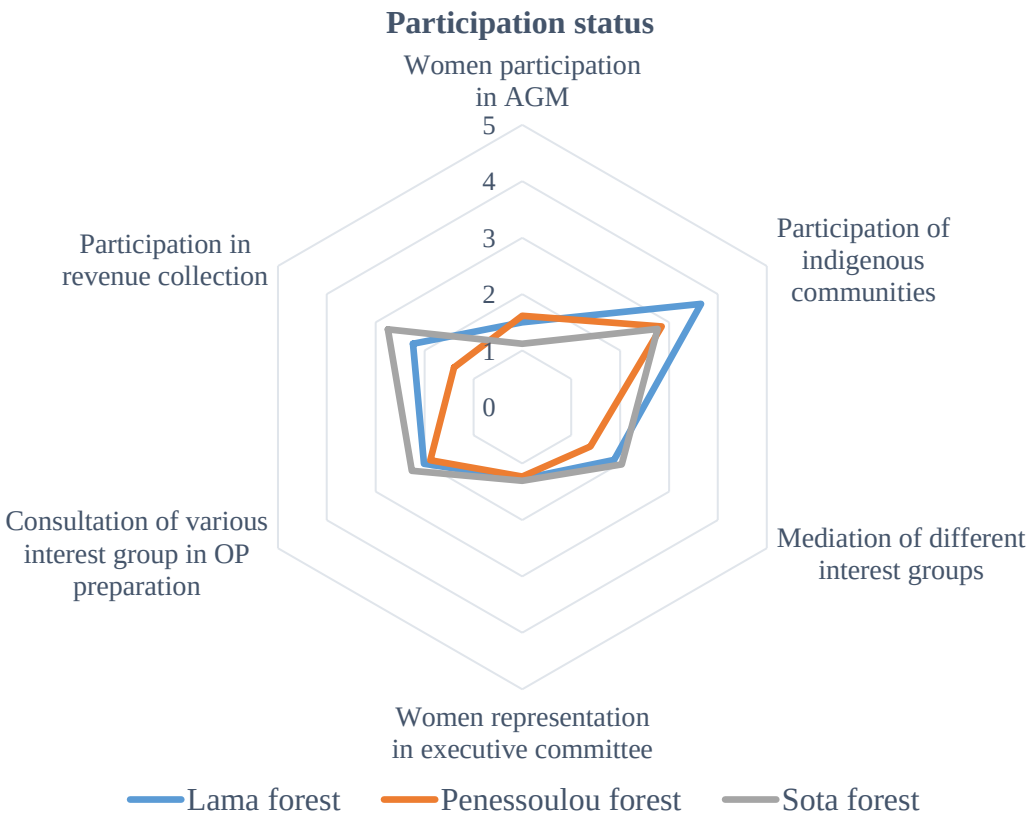


Figure 4.8: Organisation of co-management structures in Lama and Penessoulou forest reserves (left side) and Sota forest (right side)

Source: (Field work, 2022)

4.2.4.2. Participation status

The participation of local people is one of the key elements for improving good forest governance, promoting sustainable use and management while securing forest benefits and opportunities for this people (Baral, 2014; Mollick et al., 2018). In this study, a set of five indicators were examined to assess the perception of the forest user groups on the participation criterion of the governance. This study found a low participation of local communities in the management of all the considered forest reserves with a very low involvement of women in the management of all the considered forest reserves (Figure 4.9). Overall, there is a significant difference only between the participation levels of management of Lama and Penessoulou forest reserves (Table 4.16). However, slight variations were observed in the level of participation of the communities within the forests with the highest participation of indigenous groups around Lama forest and the highest participation of user groups in revenue collection around Sota forest (Figures 4.9).



AGM: annual general meeting OP: operational plan

Figure 4.9: Participation status in study forest user groups

Source: (Field work, 2022)

Table 4.16. Comparison of mean effect by participation status

	Lama	Penessoulou	Sota	SumSq	Df	F value	Pr(>F)
Participation	**2.093a**	**1.729a**	**2.041a**	0.464	2	0.448	**0.647ns**

Signif. codes : 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Mean with different letters are significantly different based on Fisher LSD post hoc test

Participation scores are very low for all the indicators around Lama forest except for the participation of indigenous communities to forest activities. Moreover, the user groups except in

those of Koto-Aïvedji expressed a low participation of the members of their community to the forest activities. (Figure 4.10).

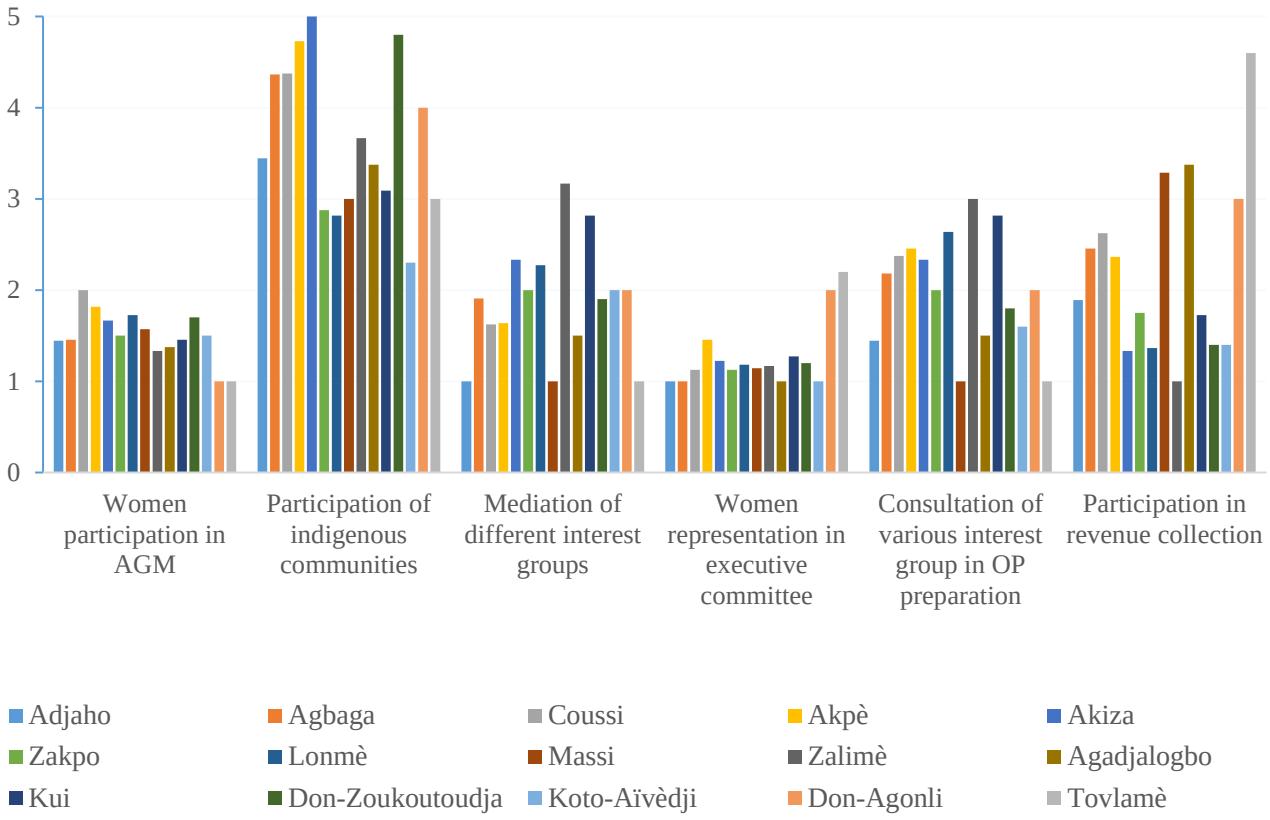


Figure 4.10: Participation status in study forest user groups of Lama forest reserve

Source: (Field work, 2022)

All of the participation indicators were lowly rated around Penessoulou. Nevertheless, the user groups of Nagayilé and Pénélan perceived a good participation of their indigenous community to the forest activities around Penessoulou forest (Figure 4.11).

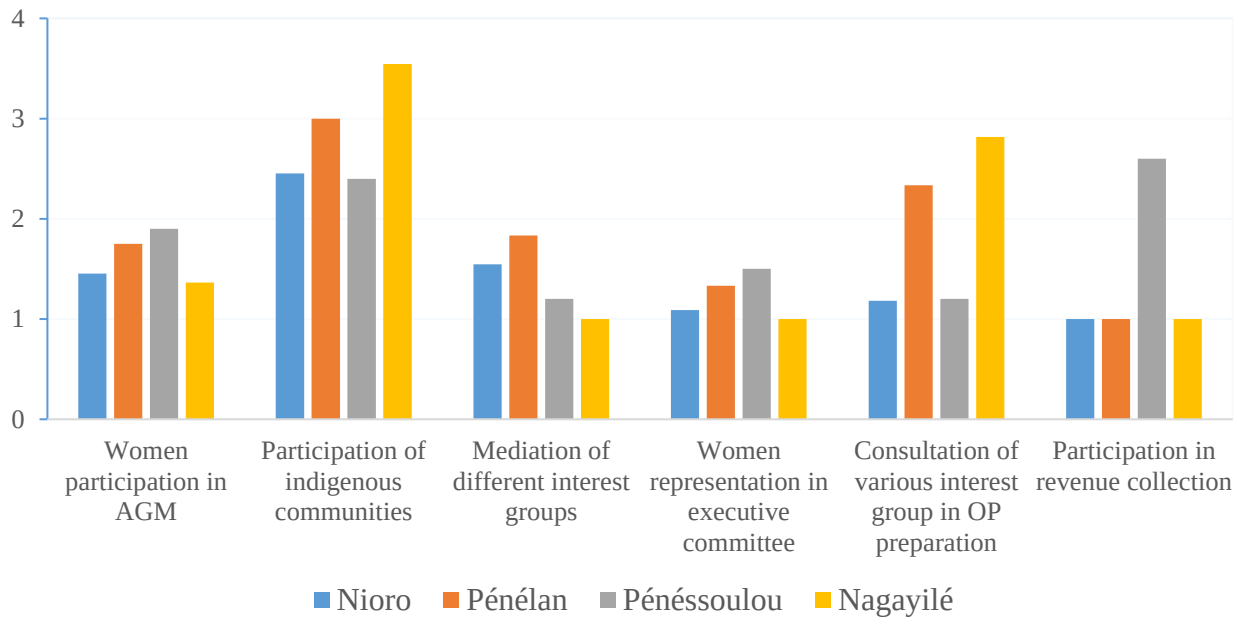


Figure 4.11: Participation status in study forest user groups of Penessoulou forest reserve

Source: (Field work, 2022)

The user groups surrounding Sota forest performed well only for participation of indigenous communities and participation in revenue collection except those of Zonzi and Lougou for Participation of indigenous communities and those of Lougou and Sinwan for participation in revenue collection (Figure 4.12).

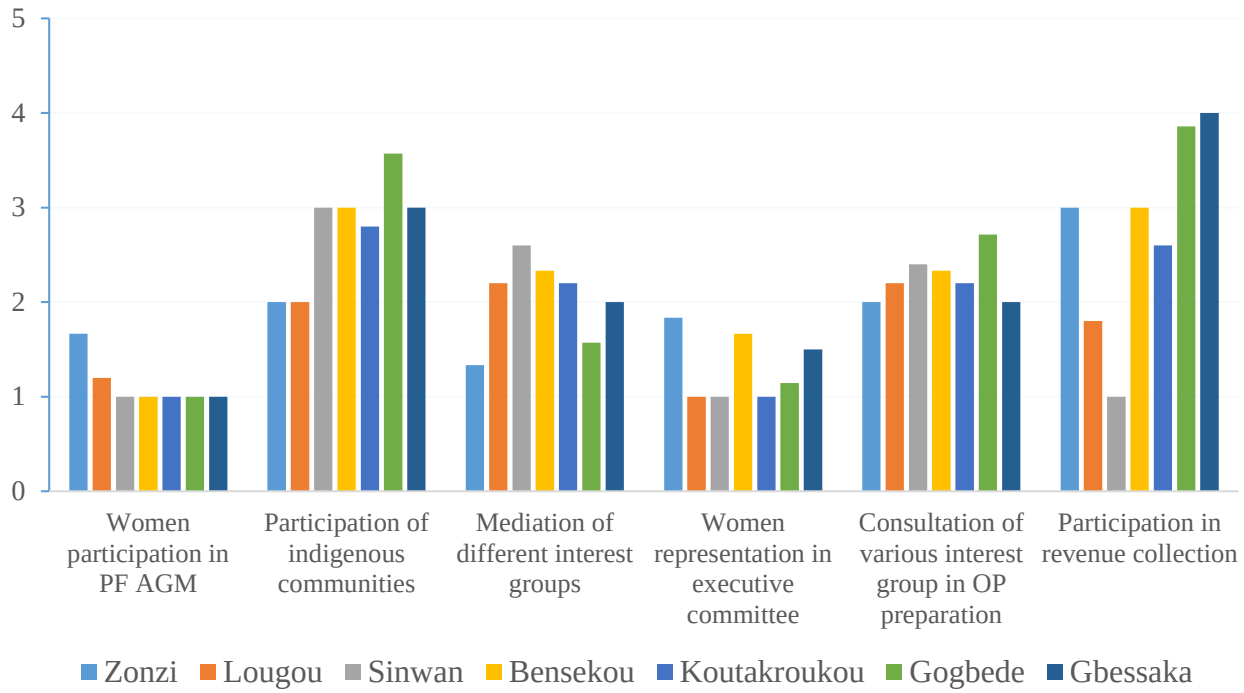


Figure 4.12: Participation status in study forest user groups of Sota forest reserve

Source: (Field work, 2022)

4.2.4.3. Transparency status

Transparency represents one other key pillar of the good forest governance after participation. It is a prerequisite for the participatory strategy (Stojanovska et al., 2014). Transparency was assessed using a set of seven indicators in this study. Overall, there is no significant difference between the transparency level of management of the considered forest reserves (Table 4.17). Forest user groups perceived the management of Lama and Sota forest reserves more transparent than the one of Penessoulou forest which looks opaque for all of the indicators except the accessibility of the information (Figure 4.13).

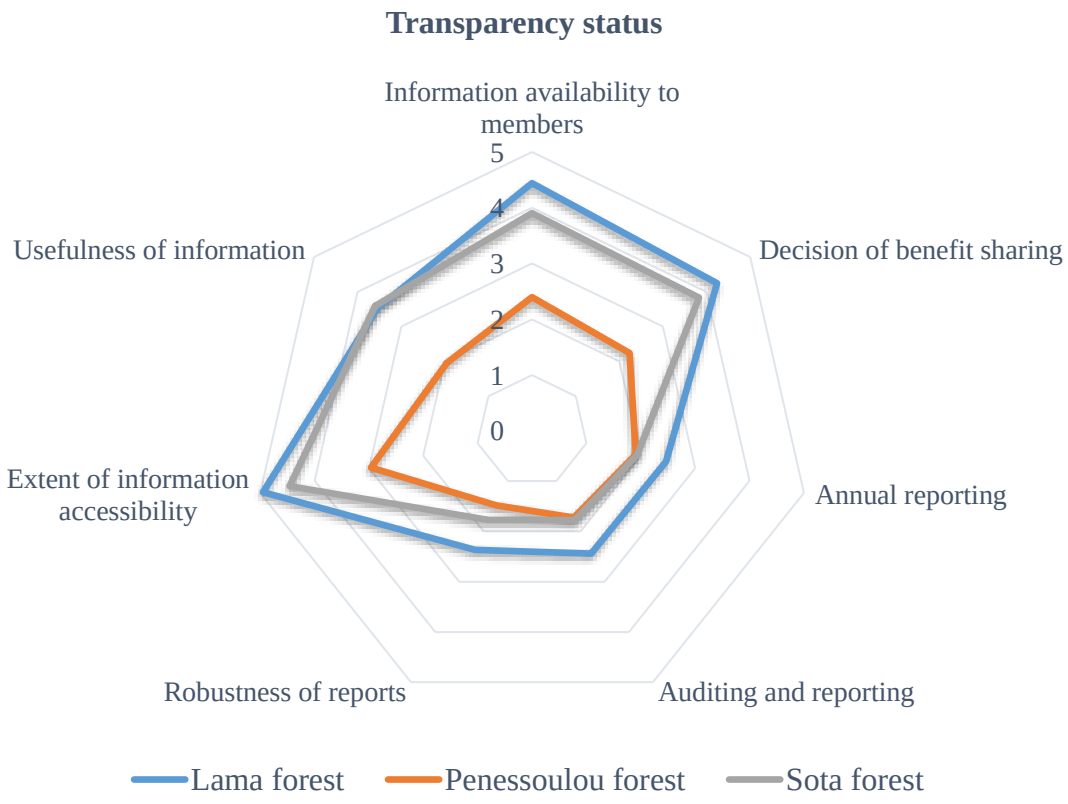


Figure 4.13: Transparency status in study forest user groups

Source: (Field work, 2022)

Table 4.17. Comparison of mean effect by transparency status

	Lama	Penessoulou	Sota	SumSq	Df	F value	Pr(>F)
Transparency	**3.492 a**	**2.095 b**	**3.039 ab**	7.1093	2	3.863	**0.040***

Signif. codes : 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Mean with different letters are significantly different based on Fisher LSD post hoc test

However, annual reporting system, auditing and reporting system and robustness of reports were underrated by user groups around all the forest reserves. Moreover, the transparency level showed a similarity in all the forest user groups of Lama forest reserve with an excellent accessibility of group members to the information (Figure 4.14).

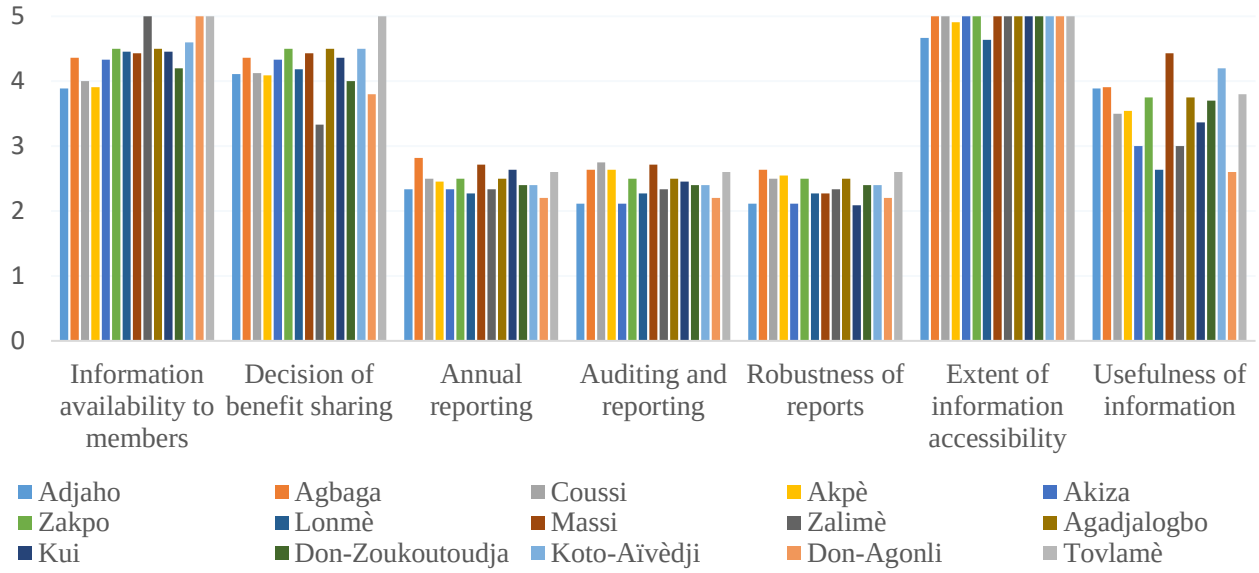


Figure 4.14: Transparency status in study forest user groups of Lama forest reserve

Source: (Field work, 2022)

Nioro and Pénélan forest user groups performed quite well in term of transparency while Pénéssoulou and Nagayilé forest user groups perceived an opacity in the management of the Penessoulou forest. Moreover, only the user group of Pénélan seemed satisfied in term of benefit sharing decisions (Figure 4.15).

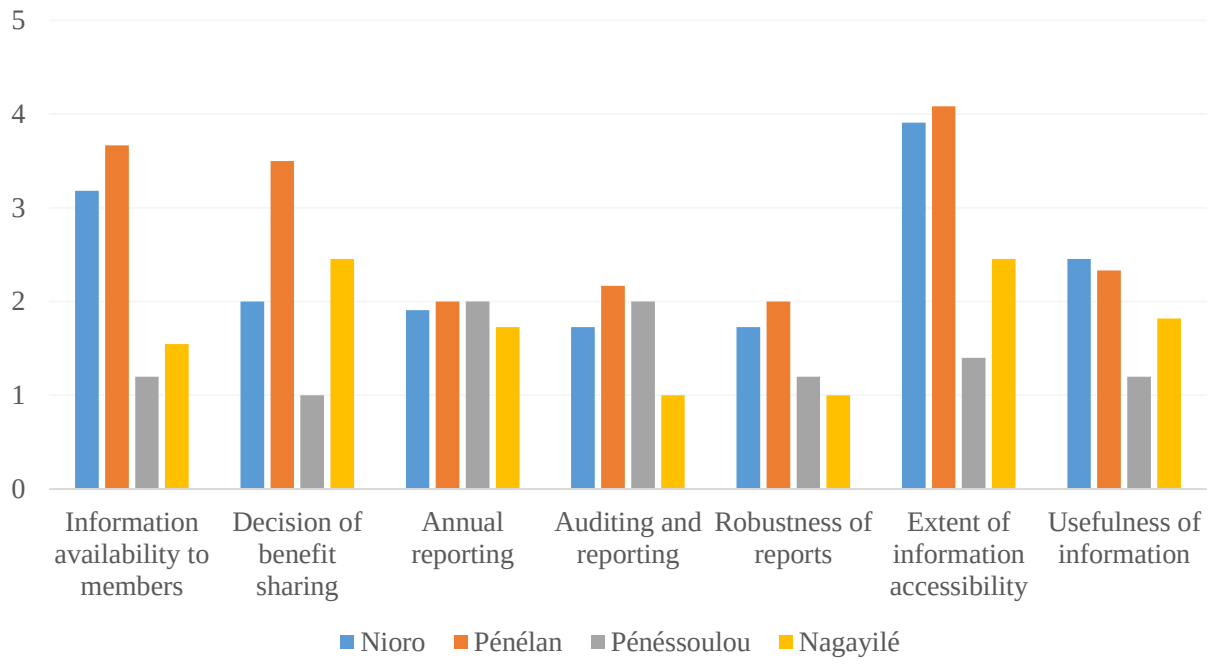


Figure 4.15: Transparency status in study forest user groups of Penessoulou forest reserve

Source: (Field work, 2022)

In Sota forest reserve, the user groups of Zonzi, Lougou, Gogbèdè and Gbéssaka performed quite better than the remaining forest user groups (Figure 4.16).

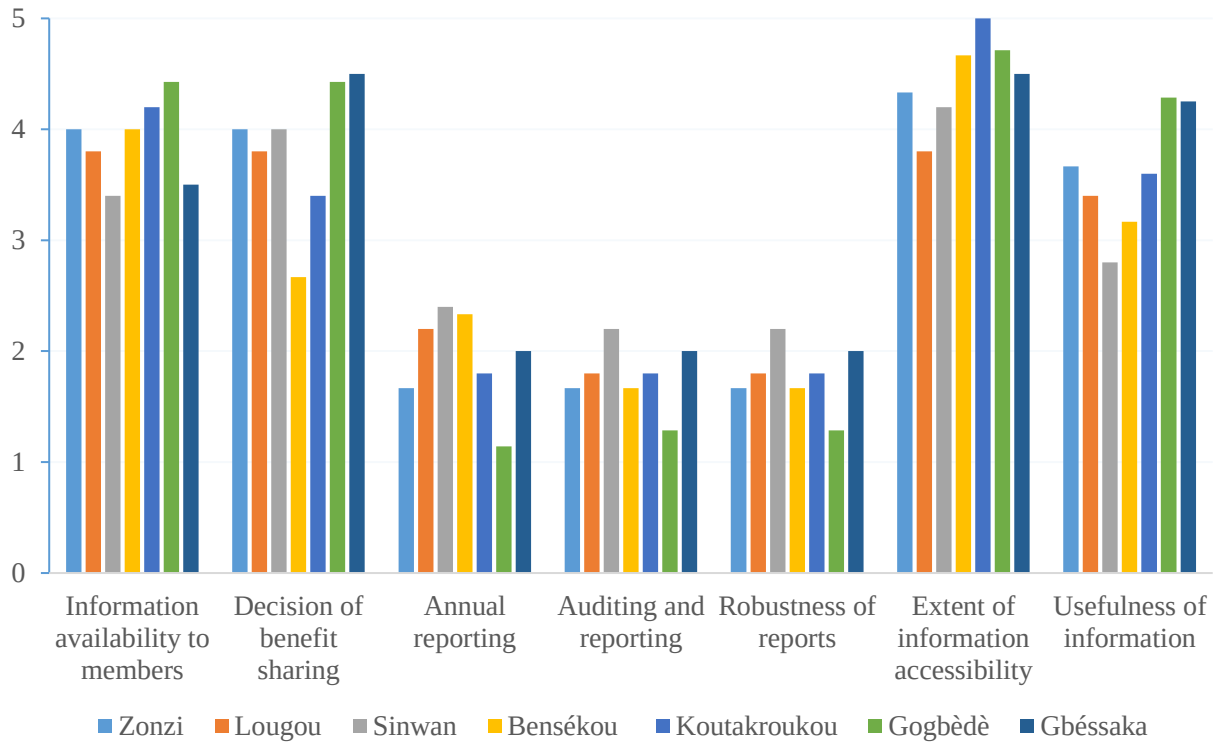


Figure 4.16: Transparency status in study forest user groups of Sota forest reserve

Source: (Field work, 2022)

4.2.4.4. Effectiveness status

Another important key point of governance is effectiveness. It represents the capacity to execute the planned activities to achieve the targeted goals. In this study, the effectiveness of governance arrangement is assessed through a set of four indicators. Overall, there is no significant difference between the effectiveness level of management of the considered forest reserves (Table 4.18). Lama forest management performed well on this criterion followed by Sota forest and Penessoulou forest was the last. However, the constitution of the Village Participatory Management Organisation (VPMO) is poorly understood by the communities. Moreover, management objectives were not accomplished in Sota forest, while neither management objectives nor meeting decision were implemented (Figure 4.17).

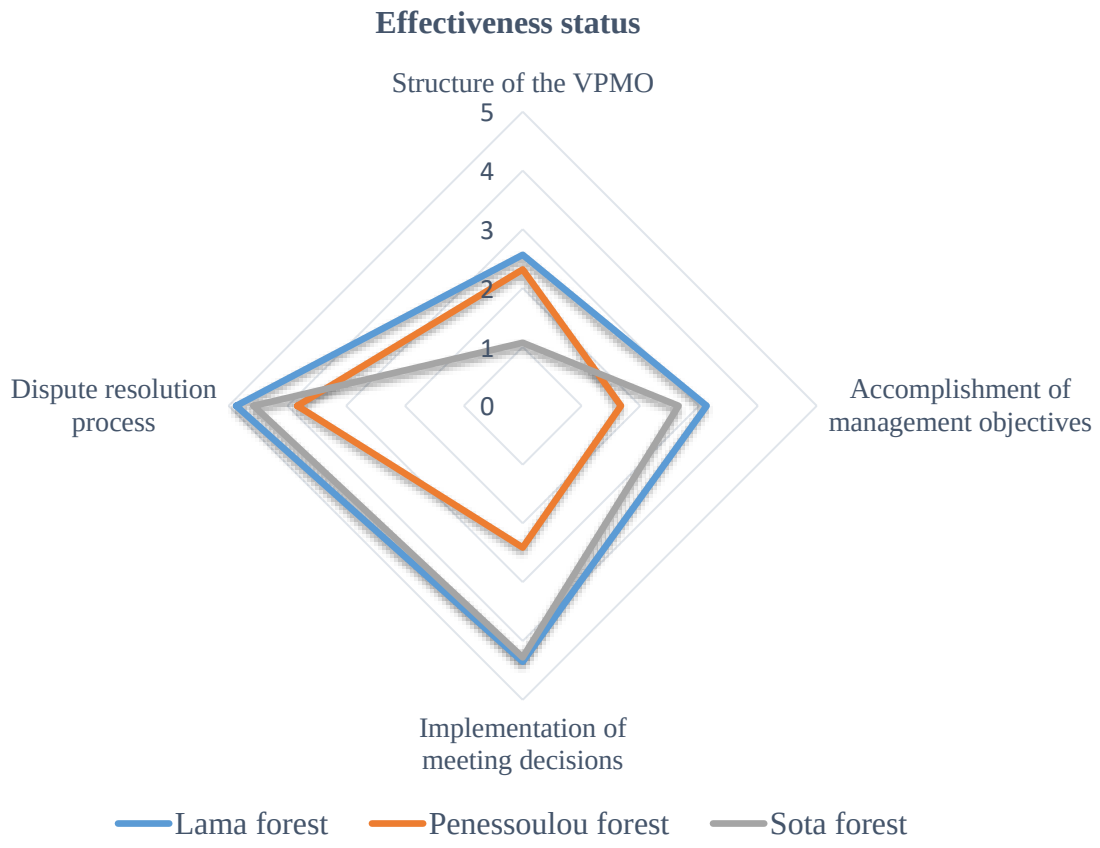


Figure 4.17: Effectiveness status of study forest user groups

Source: (Field work, 2022)

Table 4.18. Comparison of mean effect by effectiveness status

	Lama	Penessoulou	Sota	SumSq	Df	F value	Pr(>F)
Effectiveness	**3.729a**	**2.557a**	**3.144a**	2.747	2	0.898	**0.441**

Signif. codes : 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Mean with different letters are significantly different based on Fisher LSD post hoc test

In Lama forest, except the ignorance of the constitution of the VPMO, most forest user groups perceived a good management of the forest in term of effectiveness except the forest user groups of Massi for whom the forest management failed to achieve the targeted objectives (Figure 4.18).

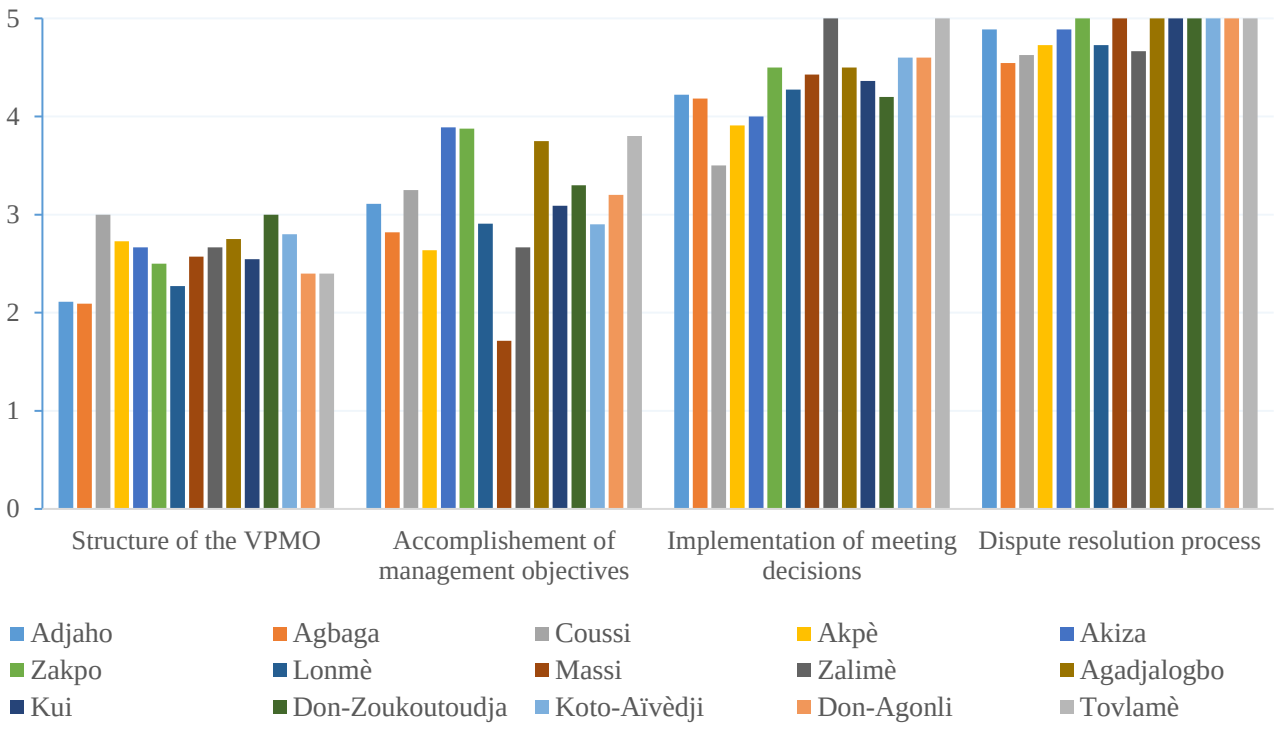


Figure 4.18. Effectiveness status in study forest user groups of Lama forest reserve

Source: (Field work, 2022)

All forest user groups surrounding Penessoulou forest performed well in term of effectiveness only in term of dispute resolution. Furthermore, forest user group from Pénéssoulou were the least implementing the meeting decisions and achieving the management objectives (Figure 4.19).

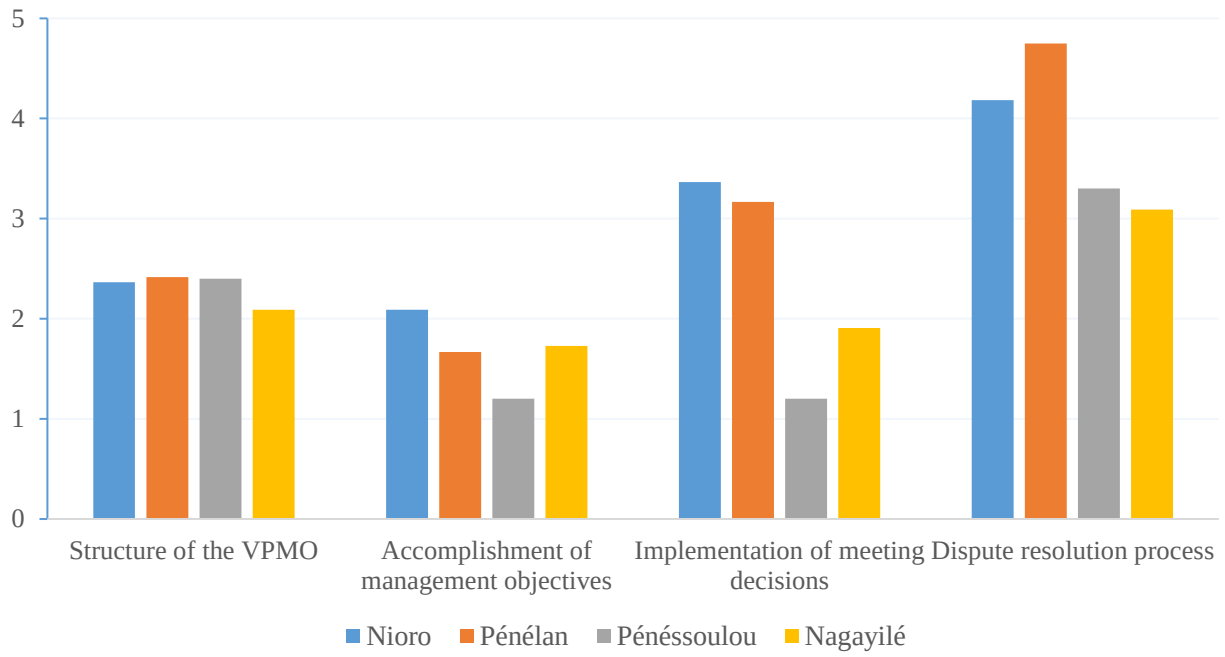


Figure 4.19: Effectiveness status in study forest user groups of Penessoulou forest reserve

Source: (Field work, 2022)

Finally, Sota forest user groups performed quite well for the effectiveness of the forest management except for the accomplishment of the management objectives with user groups from Lougou and Sinwan the least satisfied (Figure 4.20).

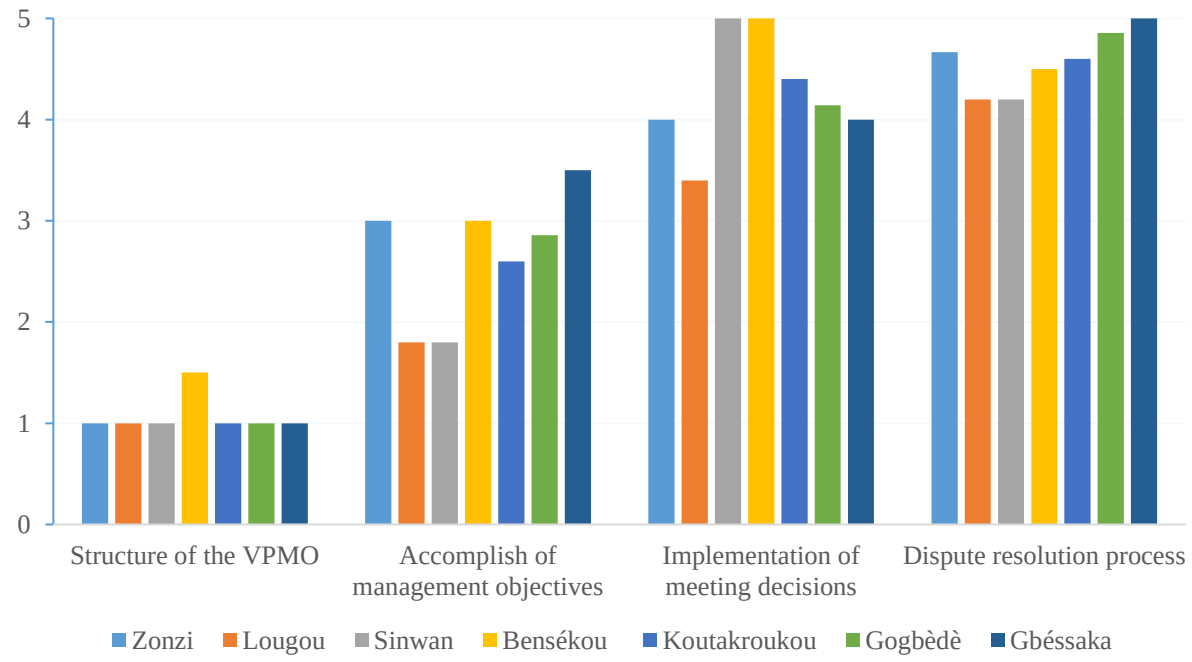


Figure 4.20: Effectiveness status in study forest user groups of Sota forest reserve

Source: (Field work, 2022)

4.2.4.5. Efficiency status

Efficiency refers to the best use of human, financial and other resources, without unnecessary delay or waste (PROFOR & FAO, 2011). The assessment of this criterion was performed using a set of seven indicators. Overall, there is a significant difference only between the efficiency level of management of Lama and Penessoulou forest reserves (Table 4.19). Lama forest user groups perceived their forest quite efficiently managed, while the user groups of Penessoulou forest found the management not efficient for them. Sota forets user groups appreciated the efficiency of most of the management strategies except the sale of surplus forest products they are not practicing. None of the forest user group applied the silvicultural system described in the management plan (Figure 4.21).

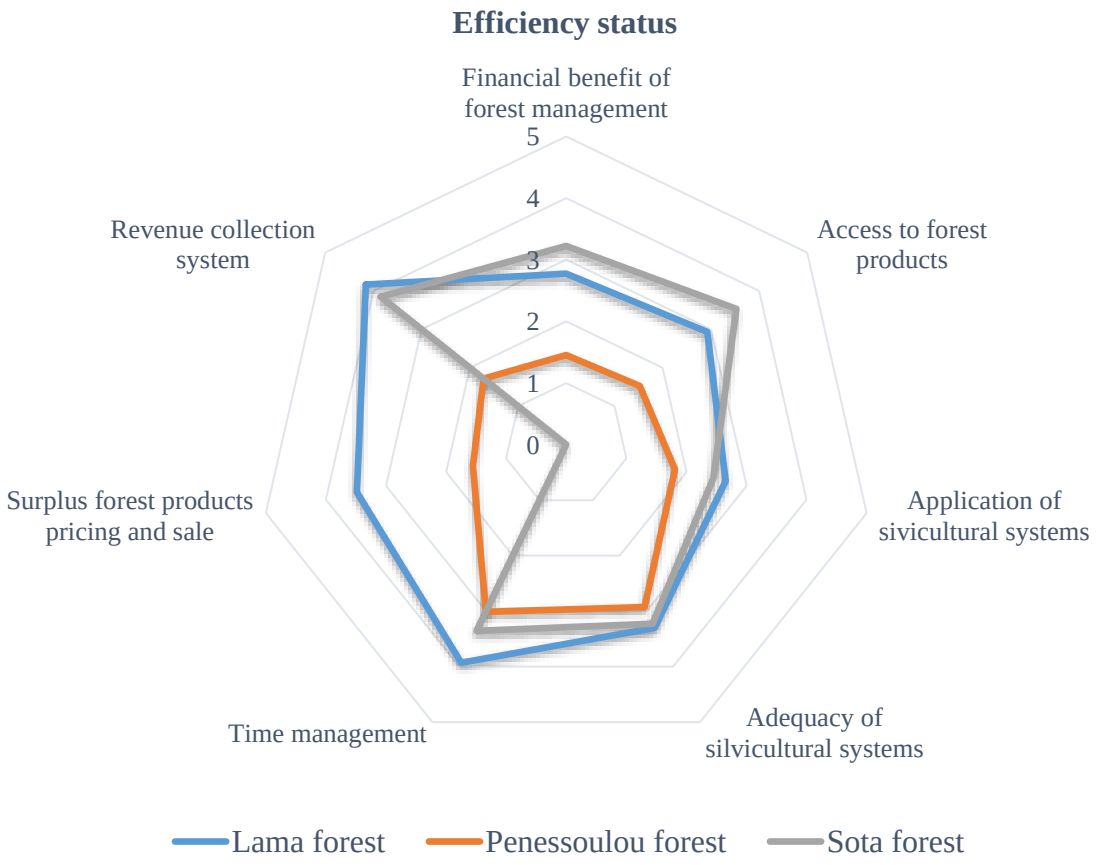


Figure 4.21: Efficiency status in study forest user groups

Source: (Field work, 2022)

Table 4.19. Comparison of mean effect by efficiency status

	Lama	Penessoulou	Sota	SumSq	Df	F value	Pr(>F)
Efficiency	**3.319 a**	**1.999 b**	**2.805 ab**	6.186	2	3.718	**0.045***

Signif. codes : 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Mean with different letters are significantly different based on Fisher LSD post hoc test

The management is quite efficient for all the forest user groups except for the indicators financial benefit of forest management, access to forest products and application of silvicultural system in Lama forest (Figure 4.22).

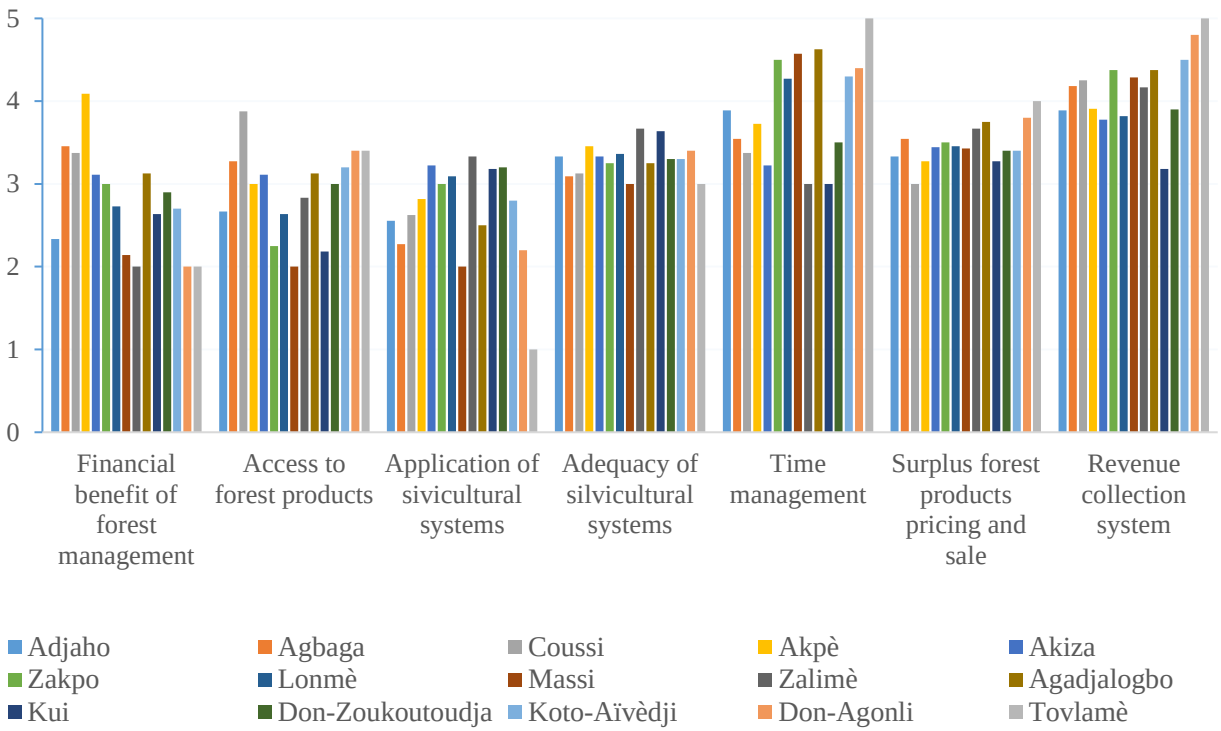


Figure 4.22: Efficiency status in study forest user groups of Lama forest

Source: (Field work, 2022)

Only user group of Pénélan partially agreed on the efficiency of the Penessoulou forest management on the indicators adequacy of silvicultural systems and time management. The remaining forest user groups found the management of the forest inefficient (Figure 4.24).

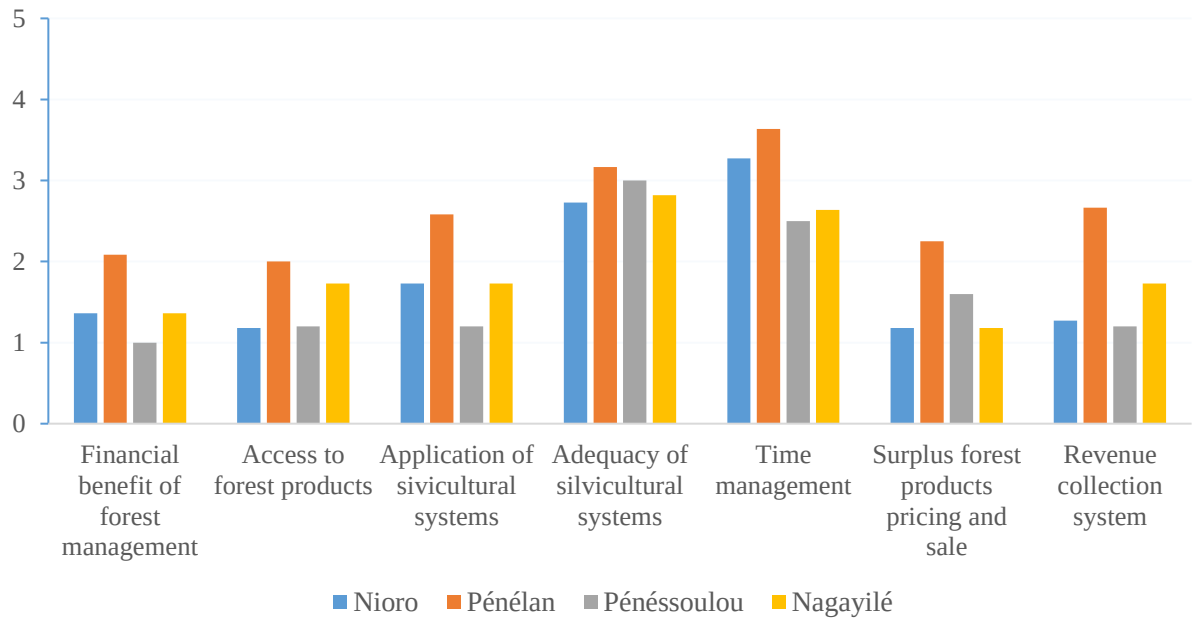


Figure 4.23: Efficiency status in study forest user groups of Penessoulou forest

Source: (Field work, 2022)

Most of the user groups of Sota forest perceived the management efficient except on application of silvicultural systems and surplus forest products pricing and sale that is inexistent in the management (Figure 4.25).

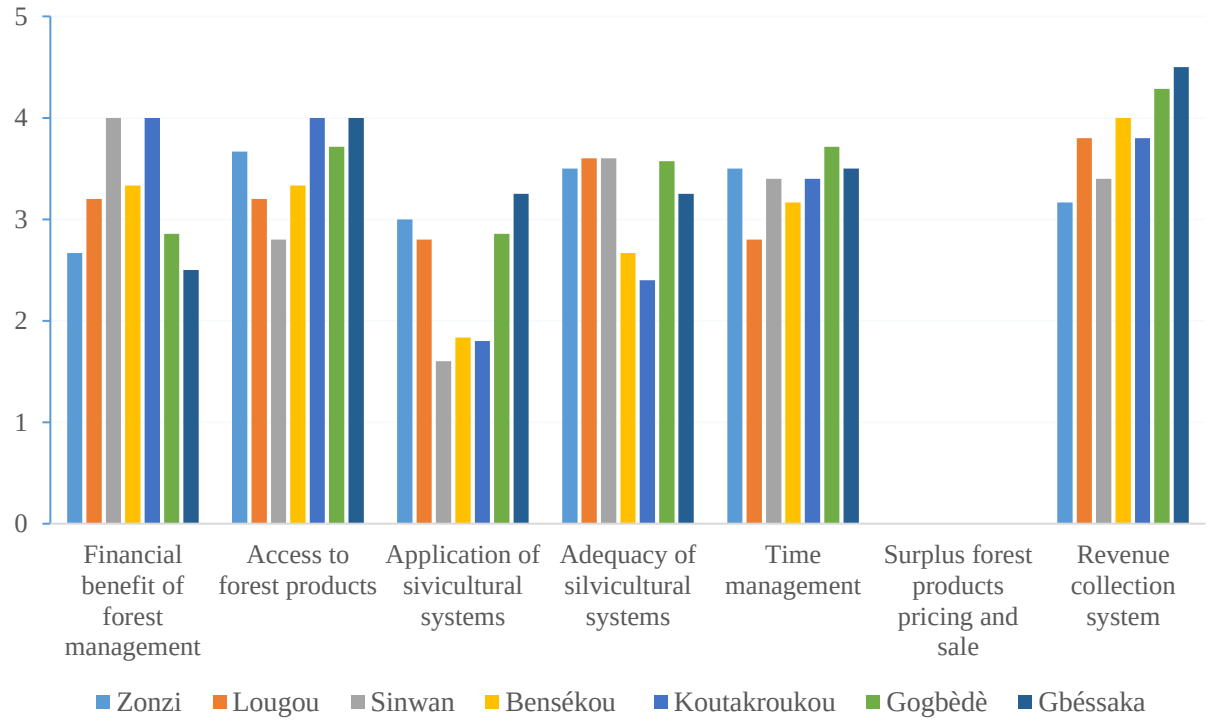


Figure 4.24: Efficiency status in study forest user groups of Sota forest

Source: (Field work, 2022)

4.2.4.6. Forest governance status

The forests presented in general a bad level of governance in Penessoulou (2.10) and Sota (2.76) forest reserves and an acceptable level of governance in Lama (3.16) forest. However, there is no significant difference between the governance level of the different forests (Table 4.20). In general, the governance tendency is similar in all the forests starting with a very low participation status and ending with a good effectiveness status. Moreover, Lama forest was the well governed forest while Penessoulou forest appeared as the with the low level of governance in each of the criteria (Figure 4.26).

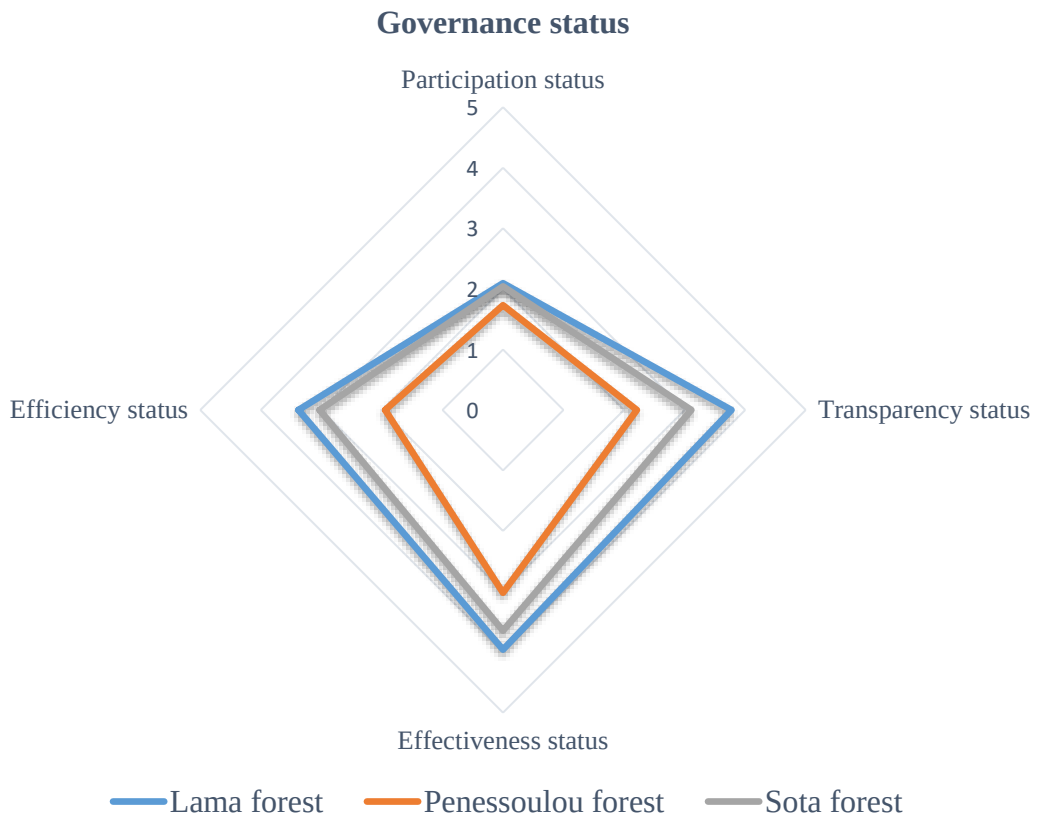


Figure 4.25: Governance status of Lama, Penessoulou and Sota forest reserves

Source: (Field work, 2022)

Table 4.20. Comparison of mean effect by governance status

	Lama	Penessoulou	Sota	SumSq	Df	F value	Pr(>F)
Efficiency	**3.158**	**2.095**	**2.757**	2.3041	2	3.842	**0.062**
Signif. codes :	0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

Mean with different letters are significantly different based on Fisher LSD post hoc test

4.3. Discussion of Findings

4.3.1. Perceived forest ecosystem services

4.3.1.1. Prioritization and mapping of ecosystem services

The perception of ecosystem services (ESs) varies within local community from a forest to another and from a service to another. In the current study, the local communities reported first provisioning services followed by cultural services and finally regulating and supporting services. These results are in line with previous studies which found that rural people perceived and value more provisioning services than indirect and non-use values of forest ESs (Ahononga et al., 2020; Djagoun et al., 2022; He et al., 2018; Tessema & Nayak, 2022). The high rate of provisioning services dominated by firewood and leaves collection in Lama and Penessoulou forest reserves and wild fruits, firewood and leaves collection in Sota forest is an indicator of the dependence of the local communities on these services for their livelihoods (Gouwakinnou et al., 2019) shaped by the diversity of natural conditions and the past and current conservation policies in the area (He et al., 2018). For instance, the type of vegetation managed which is plantation in Lama forest but natural forest in Penessoulou forest combined with similar administrative regulation in Lama and Penessoulou forest limited local perception to mainly leaves and wood related services compare to Sota forest respondents. The National Wood Society which is in charge of the management of Lama and Penessoulou forest reserves allowed local communities to collect dead woods and non-timber forest products (NTFP) and sometimes poles and, has therefore shaped their perception of provisioning services to the collection of firewood and leaves for consumption and medicinal purposes. Conversely, local community was allowed to practice more activities (grazing, farming, beekeeping, collection of NFTP) in Sota forest managed by the forestry cantonment of Kandi and have a different priority of provision services. Furthermore, the low rate of citation around

Penessoulou forest could be explained by the presence of wild animals like buffaloes mentioned by many respondents to be afraid of.

Cultural services were rated as the second most perceived forest ESs. These services were dominated by ecotourism and aesthetic services in Lama and Penessoulou forest reserves demonstrated the level of protection of the vegetation of these forest. Indeed, Lama forest has been subject of many works because its rich diversity of the natural vegetation and the success of the plantations resulting from the good management in term of resources conservation. Moreover, The natural vegetation of Lama forest named "noyau central" is well protected and contained a various type of plant and animal species attracting tourists (Worou & Sinsin, 2003). Respondent related the identification of aesthetic and ecotourism service in Penessoulou to the regrowth of the vegetation and the reappearance of big wild animals like buffaloes. This result contrasts with previous studies that reported a degradation of the forest and absence of *P. kotschyi* on the savannah (Dossa et al., 2021; Moussilimi et al., 2022). The study on land-use change (Dossa et al., 2021) covering the period 1995-2015 is not relevant to appreciate either the respondents perception of changes (2013-2022) or the impact of the participatory forest management implemented by the National Wood Society which started in 2012 in the forest. Moreover, the observation on *P. kotschyi* could also be explained by a progressive reconstitution of the population of this species after a long anthropogenic action period. An update land-use land-cover study appear then important to really access the dynamic of the vegetation of the forest. In contrast, ecotourism is the least perceived service in Sota forest. This could be explained by the forest degradation linked to anthropogenic activities (Aboudou et al., 2016) and the disappearance of big animals as testified by many respondents.

The most identified regulating services were fresh air, carbon sequestration and biodiversity conservation. This corroborates with previous studies that found air quality regulation and climate as the most identified regulating in different ecological zones in Benin (Ahononga et al., 2020; Gouwakinnou et al., 2019). The authors related this perception to the impact of environmental project through the various initiatives of sensitization and training in beekeeping in the areas. Indeed, the implementation of participatory forest management or Co-management in the considered forests has enable the collaboration between local community and extension services and other NGOs either directly or through the executive committees of the Village Participatory Management Organisations (VPMO). Moreover, climate change with global warming is a current concern for human livelihoods that is addressed during the sensitization sessions on forest management. Besides, the perception of soil formation and soil protection services in Sota forest could be explained by the fact that people allowed to farm in some part of the forest noticed the difference between forest soil and the soil of farmland outside the forest.

4.1.1.2. Factors influencing the perception of ecosystem services

The relationships established between local people and forests depends on their interests and benefits they derive from the forests. Studies on forest users' perception on forest ESs has gained attention this decade to sustainably plan forest management. Several socio-environmental (sex, age, education rate, household size) and socio-economic factors (annual income, poverty index…) have been reported influencing the perception of forest ESs around the world (Ahononga et al., 2020; Janeczko et al., 2023; Tessema & Nayak, 2022). This work further showed that sex, age class, education rate, ethnic group, household size, stay length, main activity, total annual income, membership to the local management committee, holding the paper of the land owned and distance

from house to forest are significant predictors of people's attitude towards forest ESs. However, the influence of these predictors depends on the type of ESs as well as the forest.

From the study, having a long stay around the forest and being part of the local forest management committee increased the perception of the provisioning services around Lama forest as people living around the forest were using the forest for their daily livelihoods mainly farming before being stopped and relocated inside the forest at the beginning of the participatory forest management to avoid the forest degradation (Mehou-Loko et al., 2013). Moreover, the members of the local forest management committees are allowed to access to the forest every time they need for ensuring the forest security (fighting wildfire and illegal logging). This could be a factor enhancing their knowledge of provisioning services of the forest. Besides, only education rate influenced the perception of the provisioning services around Penessoulou forest. This contrasts with most findings showing that provisioning services are most perceived by the poor people (Ahononga et al., 2020; Gouwakinnou et al., 2019; Ouko et al., 2018) who are generally illiterate in rural area. The result can be explained by the fact that the representatives of the population for the forest management are mostly educated people and are the most allowed to enter the forest for ensuring the security of the forest. More socio-environmental influenced the perception of provisioning services around Sota forest. For instance, women perceived more provisioning services respectively than men owing to their high involvement in firewood and other non-trees forest products collection for the achieving their responsibility as housemakers (Ahononga et al., 2020; Mensah et al., 2017; Moutouama et al., 2019). Moreover, old people and people with long stay perceived also more provisioning services than young people and people with short stay. Such observation showed that local community are allowed to freely enter the forest and old people with their long period of forest resource usage link to their stay master it better than young people.

Finally, the increase of perception of provisioning services with the membership to the local management committee could be explained by the fact that belonging to the local management committee is associated with the master of the forest.

Concerning regulating and supporting services, only household size influenced the perception of the services in Lama forest showing the high similarity of the perception on these ESs. In Penessoulou forest, the high perception of regulating and supporting services by old people may be related to the type of ESs which is related to the climate regulation and is easily perceived by old than young people. Similar findings were reported by previous studies which explained that young people do not have a reference base for perceiving the contribution of ecosystems to maintaining the global balance owing to their low experience (Ahononga et al., 2020; Mensah et al., 2017; Moutouama et al., 2019). Surprisingly, the length of the stay in the area did not influence these services meaning that other factors are involved in the positive correlation between age and the perception of the regulating and supporting services in this forest. Moreover, the members of the local management committee perceived more regulating and supporting services than the other. This awareness could be gained through multiple sensitization sessions and meeting attended by the local committee board to enhance their skill in forest management (Ahononga et al., 2020; Gouwakinnou et al., 2019). Furthermore, the Anii ethnic group perceived more regulating and supporting services than the others. This difference could be explained by the main ethnic group of the area and forest activities mainly targeted them and the subcontractor managing leading some forest activities is from this ethnic group. It comes from such result that sensitization sessions should target more the other ethnic groups of the area. In other side, the total annual income negatively influenced the perception of the regulating and supporting services showing that wealth people of the area do not care about the indirect services provided by the forest and this is a threat

as they may be part of the local decision-makers of the management of the forest (Chomba et al., 2015; Meshack et al., 2006). The perception of regulating and supporting services increased with the education rate in Sota forest. Similar findings were reported by previous studies where authors demonstrated that formal education enhance the perception of ESs (Ahononga et al., 2020; Gouwakinnou et al., 2019; Mensah et al., 2017; Moutouama et al., 2019). Moreover, the perception of regulating and supporting services increased with the length of the stay showing that those living close to the forest for long are more careful about the forest as they have high experience on the changes of the forest. Surprisingly, farmers were the least perceiving the regulating and supporting services around Sota forest while forest-based activity and commerce dwellers were perceiving more these services. Such results could be linked to the low educated rate of the farmer of the area who do not know the relation between the forest and the farming. Furthermore, these findings raise a problem of medium and long run forest degradation local people are allowed to farm inside some part of the forest with low knowledge on the indirect ESs provided by the forest.

In term of cultural services, only the membership to the local forest management committee and holding a legal land contributed to the perception of the services in Lama forest while the perception of these services in Penessoulou forest is influenced by the education rate, the total annual income and the membership to the local management committee. Surprisingly, neither the age class influenced the perception of the services as mentioned in previous studies (Ahononga et al., 2020; Djomo et al., 2022) but may be explained by the fact that the part of the forest allowed to enter is the plantation in Lama forest and do not contain some particular trees considered for traditional rituals. The positive impact of the education rate on the perception of the cultural services in Penessoulou forest may be explained by the ecotourism and aesthetic services prioritized by the respondents that are related to modern life and consequently formal education.

Age class, stay length, main activity and distance to forest were the significant predictors of the cultural services in Sota forest. The study found that age class is negatively correlated with cultural services. This contrasts with the previous studies which found that old people perceived more cultural services than youth (Ahononga et al., 2020; Riechers et al., 2018). The authors concluded that elderly people are cultural conservationist while youth are more attached to modern things. Our findings could be explained by the low number of old people interviewed (4.51%) limiting the level of knowledge of some cultural services around the Sota forest particularly the spiritual services. Moreover, the results showed that the length of the stay around the Sota forest increased the perception of the cultural services portraying a transmission of cultural services from the elders to the youths. Similar findings were reported in Cameroon where the learning of the local knowledge of an area increases with the time spent in the area (Djomo et al., 2022). In contrast, the perception of the services decreased with the distance from the house to the forest decreased revealing that people far from the forest were not able to frequently visit the forest in order to perceive or participate to such services.

4.1.1.3. Perceived changes of forest ecosystem services (FESs)

The results showed that no major change was noted on the availability of ESs around Lama forest while compare to the two other forest reserves. This could be explained by the adaptation of local community to the management regulation as the approach is implemented since more than two decades (Mehou-Loko et al., 2013). However, the perceived decrease of timber was explained by the lack of pole related to the advanced age of the plantation and represented one threat to local community engagement in forest management (Agbodossindji et al., 2023). In Penessoulou and Sota forest reserves, the perceived decrease of some provisioning services indicates that those

services were very important for the local community livelihoods as they are mostly farmers and lived in rural area. Moreover, the coincidence of the retained period of change (2013-2022) and the beginning of the new management approach added to the access to a limited provisioning services (firewood and NTFP) mentioned by respondents in Penessoulou forest can lead to the conclusion that the new regulations have negatively impacted important forest provisioning services in the area. However, knowing the negative impact that can result from overgrazing, uncontrolled fodder and wild animals catching, the development of alternative strategies to diversify local community revenue will be important for motivating community participation to the forest management. Conversely, the decrease of the provisioning services noted in the Sota forest can be related to the authorisation granted to local community to farm and graze in some part of the Sota forest and collect firewood that have worsen the degraded feature of the forest noted in previous studies (Aboudou et al., 2016; Bah Bani Orou & Sanibi, 2019). Few regulating and supporting services (fresh air provision, carbon sequestration and biodiversity conservation) were mentioned in Lama and Penessoulou forest reserves to have been impacted by the implementation of PFM. The results corroborates with the study of Ismaili et al., (2023) in Morocco and demonstrated the insufficient knowledge of the respondents of these forests to appreciate the importance of this type of services on their livelihoods. In contrast, respondents surrounding Sota forest identified more impacted regulating and supporting services including crop pollination, soil protection and soil formation that are crucial for the farming system. The granted access to the forest has then improved the skills of this community on the regulating and supporting services. However, forest activities such as grazing and farming should be avoided and replaced by beekeeping that is not harmful to the forest resources. PFM has contributed to improve of eco-tourism and aesthetic respectively in Lama and Sota forest while it has led to the decline of aesthetic service in Sota forest. This conclusion corroborates with the findings of previous study showing the development of tourism in the core

of Lama forest (Worou & Sinsin, 2003) and a decrease of forest cover in Sota forest (Aboudou et al., 2016).

4.3.2. Traditional knowledge of useful forest plant species

The ethnobotanical study is used to collect information of traditional knowledge local population on plant species. It helps to understand the relation between the local population and the plant species of their environment. According to the socio-demographic information, most of the respondents were male (86%). This is related to the fact that the interviewees were household heads and women can stand for household head only when his husband travels or passes away. The low number of women could have affected the number of plant species cited as women have in-depth knowledge of traditional herbal medicine and have a great responsibility as mothers and homemakers (Benlamdini et al., 2014; Borokini et al., 2013; Chohra & Ferchichi, 2019; Gnahore et al., 2023).

4.3.2.1. Diversity and richness of forest useful plant species and management context in each forest reserve

This study revealed that 74 forest plant species were collected from the forests by the surrounding communities for their livelihoods. This number is lower than the 97 utilitarian plant species identified around the forest areas under National Wood Service management (Déguénon et al., 2022) and lower than the 123 woody species found by Ahoyo et al., (2021) at the national scale to treat the diseases that included not only forest plant species but also non-forest plant species. The difference could be explained by the large number of forests (6) spread in the Guineo-

Congolese and the Sudano-Guinean zones that have a good rainfall pattern on the one side and the identified plants included plants collected outside forests on the other side while we focus here on plants collected exclusively on forest. Moreover, the number of plant species recorded in Lama forest (36) is lower than the 97 plant species identified in the Bahazoun forest (Adomou et al., 2017), 74 plant species (Lougbegnon et al., 2011) in the South Benin. The difference in the number could be explained by the fact that the local community surrounding Lama forest is granted access to only the plantations which have low species diversity compare to the forests. The core of Lama forest which is constituted of natural vegetation, is well protected and its access is prohibited to local community (Boedecker et al., 2014). However, the number is similar close to the 31 utilitarian plant species identified around the same forest by (Déguénon et al., 2022) as well as the 36 plant species identified in Banco National Park (Gnahore et al., 2023) and the 28 plant species identified in the swampy forest of Agonvè and related territories (Dossou et al., 2012). Besides, the number of plant species recorded in Penessoulou (29) is close to the 24 plant species identified around the same forest area by Déguénon et al., (2022) but lower than the 73 medicinal trees species recorded by Yaoitcha et al., (2015) and the 79 useful tree species recorded by Ahoyo et al., (2018) in Wari-Maro forest reserve. The difference can be explained by the size of the forest 5575.50 ha which represents around the 1/20 of the area of Wari-Maro forest which is 111,095.38 ha (PAMF, 2007) and consequently may have lower specie richness than the later. The number of plant species reported in Sota forest reserves (31) was less than the number identified (118) identified by Vodouhê et al., (2009) in Pendjari biosphere reserve. The difference in the number can be explained by the level of degradation of Sota forest highly due to anthropogenic activities (Aboudou et al., 2016) compare to the Pendjari biosphere reserve which is a well-protected park with big wild animals. Furthermore, the number of plant species reported is almost equal around Lama forest (36) Penessoulou (29) and Sota (31). Similar results were found in Guineo-Congolean (80),

Sudano-guinean (80) and Sudanian (84) zones with medicinal plant species (Ahoyo et al., 2021). Penessoulou and Sota forest belong to zones with low population density and where non protected vegetation are available and can provide local communities with some forest plant species. Conversely, the population density is high in the Guineo-Congolean zone where Lama forest is located and protected forests remain the place of conservation forest plant species mostly the tree species.

The Relative frequency of citation (RFC) shows the importance of each species according to who cited uses of these plant species to the local people (Vitalini et al., 2013). It is used to determine the commonly occurring plants used by the local population. Use value (UV) is the measure of use types that are related to a particular plant species. A high UV indicates that the species is used for many purposes. Most of the plant species were cited at least twice around Sota forest (71%) while the majority of the recorded species were cited only once around Lama (39%) and Penessoulou forests (55%), showing that the community living close to Sota forest are more used to forest plant species than those surrounding the two remain forests. This may be the result of the management plan implemented which forbids the access of local community to natural part of Lama forest and regulates resources collection in Penessoulou forest. The most important plant species were *C. Siamea, Dialium guineense, Dichapetalum guineense, A. leocarpus* and *M. excelsa* around Lama forest, *O. subscorpioidea, C. anasita, U. chamae* and *P. laxiflora* around Penessoulou forest, *P. erinaceus, A. africana* and *C. pentandra* around Sota forest. Therefore, the management of these plant species required serious attention for reaching the dual goal of satisfying local community needs and ensuring the conservation of the resources. further investigations need to be done on these species to determine their specific uses made by the local communities, characterize their population stands and analyse their mode of multiplication.

The IFC values showed that there is high agreement on the medicinal use of plant species around all the forests. This reflected the high importance of plant species to face health problems in the areas as their activity could not provide them enough income to afford modern medicine (Ahoyo et al., 2018). The IFC values showed that Sota forest community relies on their forest for food more than Lama and Penessoulou forest despite the high degree of conservation noted in Lama and the effort of conservation in progress in Penessoulou forest which should normally result in more forest food plant species. These findings can be explained by the fact that community aroud Lama forest are allow to access only to plantations mainly of *Tectona grandis*, *Acacia auriculiformis* and *Gmelina arborea* while the natural forest used for tourism purposes is forbidden to access to avoid human pressure (Boedecker et al., 2014) on this particular natural resources. In Penessoulou forest, respondents of Nioro and Penelan declared avoid entering the forest because of the presence of wild animals like buffaloes that represent a threat and frequently destroy the cultures of the farms close to the forest. The high ICF values for wood energy and timbers in Lama forest confirm the fact that the plantations are the most accessible part of the forest by the community. Conversely, medicine is the use category with the highest ICF value around Penessoulou forest revealing that the community of this forest rely more on the forest plant for treating diseases than other uses. Wood energy and timber uses were not mentioned in this forest. This could be attributed to the respect of the rules established by the National Wood Society that forbids the cutting of wood in the forest. Moreover, most of the respondents confirmed holding a plantation for the provision of wood and timber. Finally, Sota forest resources were used for all categories except cultural uses. This highlights the high importance of the forest resources for the riparian community and the free access to the forest granted to them.

4.3.2.2. Factors influencing the knowledge of forest plant species among the forest reserves

Studies on traditional knowledge demonstrated that sociodemographic characteristics govern indigenous ecological knowledge (Ahoyo et al., 2023; Das et al., 2022). They determine the usefulness of species and contribute to the tailoring of vegetation patches (Ahoyo et al., 2023). In the present study, the knowledge of useful forest plant species was influenced by the sex, ethnicity, age, household size, period of stay and membership to the management committee. Similar findings were reported by previous studies on ethnomedicinal knowledge in Benin (Ahoyo et al., 2018, 2023; Dassou et al., 2015; Kouchade et al., 2017). The logistic regression showed that the knowledge of plant utilities increases with the education rate in Lama and Sota forest reserves. These findings contrasted with the results of previous works on wild plant knowledge in Benin (Ahoyo et al., 2018, 2023; Dassou et al., 2015; Kouchade et al., 2017) which showed that people with higher level of education seek office jobs and give up traditional knowledge (Ahoyo et al., 2023). In the area of the present study, the implementation of PFM has increased the engagement of educated people in forest management as intermediary between forest officers or NGOs workers and local people without formal education. They are mostly members of the local management committee or helpers of the forest officers and have an easy access to the forest resources. The age was positively correlated with the ethnobotanical knowledge in Penessoulou forest. This result is consistent with the findings of previous studies (Ahoyo et al., 2023; Chohra & Ferchichi, 2019; Gnahore et al., 2023). This can be explained by the mistrust of young people who did not believe much in the traditional medicine while old people are more familiar with traditional medicine than the other age groups (Jaadan et al., 2020). In contrast, adults are more knowledgeable on useful plant species than old people around Lama and Sota forest reserves. These results can be related to the very small number of old people inquired around these forests (5.79% for Lama forest and

3.92% for Sota forest) coupled with the high involvement of adults in forest activities that are energy demanding especially around Lama forest. Household size is positively correlated with useful forest plant knowledge in Lama and Penessoulou forest reserves where PFM rules seem better applied. Studies in some African countries revealed that participation to PFM increases with households' size as large households hold available free labour for off-farm works (Bakala et al., 2021; Danano, 2020; Zewdu & Beyene, 2018). Consequently, this could lead to the high knowledge of plant species by this category of households surrounding forest under effective PFM. Conversely in Sota forest the disinterest of large households to plant knowledge can be explained by the depletion of the resources that may require more effort to satisfy the needs of these households. Furthermore, some young literate respondents were involved in popularizing of drugs and tablets and getting profit from the sensitization of local communities on the advantages of those medicines in the area.

The period of stay is negatively correlated with the ethnobotanical knowledge in Lama and Penessoulou forest reserves while they are positively correlated in Sota forest. Previous study found that vertical transmission (transmission from the grandparents to their grandchildren remains the main diffusion method for ethnomedecine knowledge (Ahoyo et al., 2023; Upadhyay et al., 2011; Yoro, 2012). Thus, the more kids stay with their parents the more gain plants knowledge from the parents as it seems the case in Sota forest where the access to the forest resources is allowed. In contrast in Lama and Penessoulou forest reserves, people with long stay who were generally illiterate, fearing to infringe PFM rules, comply with the recommendation given by the management committee members who are educated and have less stayed in the area. Consequently, the people who have stayed in the area since long ago were less knowledgeable on the forest than the youths.

The results showed that the community surrounding Penessoulou forest were the least knowledgeable on forest plant species followed by those close to Lama forest and the riparian to Sota forest. This result highlights the impact of the type of management on the relation between the local communities and forest resources and indirectly the impact the management on the traditional knowledge around each forest. In fact, the management forbids access to the core vegetation in Lama forest and regulates access to the vegetation in Penessoulou forest while the community living close to Sota forest are allowed to enter the forest. Furthermore, the presence of wild animal in Penessoulou forest is a fear impeding the entrance of the community.

4.3.3. Structural characterisation of useful forest plant species

4.3.3.1. Tree species composition

The results showed that 90% of the most cited plant species were found in Sota forest, 73% were found in Lama forest and only 54% were found in Penessoulou forest. Overall, the absence of some species in all the forests could result from a confusion of the respondents who would have mixed exclusive forest plant species with other plant species that are scarcely met in the area. The view of a large number of plant species among the cited plant species in lama forest demonstrated that the ban of access to the natural forest of Lama forest did not impact as much the knowledge of forest plant species. This can be explained by the fact that some areas of the natural forest like fallow and disturbed forest may be accessible to some people from the surrounding villages. The low percentage of plant species encountered in Penessoulou forest reflected the fear of the population not only for the rules but also for the big wild animals as they are not allowed to enter the forest with any weapons.

The results showed that the scarce useful plant species (less than 5 tree/ha) were *P. erinaceus, T. glaucescens* and *M. excelsa* in Lama forest, *O. subscorpioidea, P. butyracea U. chamae* and *P. thonningii* in Penessoulou forest, and *A. africana, C. pentandra, C. pinnata, Daniellia oliveri, H. acida, P. ericenaceus, S. longepedunculata* and *V. africana* in Sota forest. Previous studies on useful plant species reported the scarcity of *A. africana, P. erinaceus M. excelsa* (Akpona et al., 2017; Déguénon et al., 2022; Yaoitcha et al., 2015), *D. oliveri, S. longepedunculata* (Yaoitcha et al., 2015) owing to their overexploitation related to the usefulness of these species to the local communities coupled with galloping human population (Fonton & Sagbo, 2004; Neuenschwander et al., 2010). The presence of few plant species with very low tree density in Lama and Penessoulou forest reserves compared to Sota forest can be related to the management rules including effective sensitization of local communities on the importance of forest resouces. Cakpo et al., (2017) demonstrated that Lama forest communities were more aware of the negative impact of debarking than their counterpart of Lokoli forest and this awareness could result from the forest administration intervention through committee inspection.

4.3.3.2. Population structure of forest useful plant species

The results revealed that the size class distribution showed a non-normal and positive asymmetric distribution characteristic of dominance of young individuals for almost all of the useful plant species of the different forests. The predominance of this category of individuals suggested that the species are not overexploited by riparian populations and are more preserved in these different protected forests (Assongba et al., 2013). However, the presence of few number of saplings in smallest diameter class of some species (*A. leiocarpa* and *M. excelsa* in Lama forest, *P. butyracea, U. chamae* and *X. stulhmannii* in Penessoulou forest and all of the species of Sota forest) reflected

the disturbances on these species (Sapkota et al., 2019). Furthermore, the stem diameter of *T. glaucescens* in Lama forest, *O. subscorpioidea* in Penessoulou forest and *D. oliveri* in Sota forest were non-normal and negatively asymmetric characteristic of dominance of old individuals. In contrast to the previous plant species, the later suggested that the species were overexploited by riparian populations. The low number or absence of some small-size individuals indicating the lack of individuals to sustain future replacement will negatively affect poor households who live near forest areas and have subsistence-base livelihoods, possibly leading to greater societal issues (Sapkota et al., 2019). Attention needs to be paid to all these plant species and either an assisted regeneration or plantations need to be installed in order to avoid their extinction in the different forest reserves.

4.3.4. Forest governance assessment

The participatory approach to forest governance is considered as a means of minimising the cost of forest conservation, by sharing the responsibilities of forest management with local people, enhancing indigenous people's tenure security and empowering them in the decision-making process (Mohammed et al., 2017). The quality of governance often determines whether forest resources are used efficiently, sustainably and equitably, and whether countries achieve forest-related development goals (Bennett & Satterfield, 2018). Good governance is therefore the key of the success of the participatory forest management approach. In this study, we assessed the good governance status of Lama, Penessoulou and Sota forest reserve using four criteria namely participation, transparency, effectiveness and efficiency.

4.3.4.1. Participation status

The present study revealed a global low participation in all forests highlighting the low involvement of local community in the management of all the considered forest reserves. It is noticed that women are not interested in participating in forest activities. Few women were interested in forest activities around the different forest reserves. A maximum of two (2) women were noted per management committee. The low number of women in the annual general meeting (AGM) and the management committee according to the majority of the respondents is related to the fact that women are busy for home activities and not available for forest activities which are time consuming. Most of the interview acknowledged that the majority of men impede their spouses to involve in forest activities and take care of the children. This concurs with findings in Kenya and Ethiopia explaining that women's productive and reproductive tasks mostly constrain them from participating in PFM activities that are highly time demanding (Engida & Mengistu, 2013; Mbeche et al., 2021). Besides, the tradition does not allow women to have full access rights to land by the tradition and indirectly to natural resources hinder women participation to forest management activities as they may not able to make decision on the resources uses. Similar findings were reported in Burkina Faso (Westholm & Kokko, 2011), Cameroon (Gautier & van Santen, 2014) and DRC (Samndong & Kjosavik, 2017). Women were involved in collecting NFTP such as medicinal plants and *Tectona grandis* leaves around Lama forest, medicinal plants around Penessoulou forest and firewood, medicinal and wild fruits around Sota forest. Thus, it is important to create women association that will contribute to the sustainable forest management through the management of NTFP used by women around each forest. Respondents went further saying that the women in the committee are designated to comply to the recommendation to meet the recommendation of the management rules and did not frequently attend the meetings or participate

to forest activities. On the other side the low participation of women to the AGM was explained by the fact women were not interested in forest activities as they are hard and fit much with men than women. Forestry activities generally consisted in safeguarding the plantations from wildfire and illegal logging on one side and removing branches and stems from plots locally called "plot unloading" after logging in Lama and Penessoulou forest reserves while it consisted in tree planting in Sota forest. Furthermore, the fear of women to talk in front of men. This corroborate with the findings of Khatun et al., (2015) who reported that in Tanzania, women are consulted if only they are elderly or have specific knowledge on specific issues. This points out the importance of developing the skill of the women on specific domain to help them involve in decision-making process whatever their age. On the other hand, most of the women even those of the committee were illiterate and therefore unable to freely express themselves in men meeting. Previous studies found a strong link between school education and the level of self-confidence of women participation to public forums on forest management in DRC (Stiem & Krause, 2016). It urges then to encourage the schooling of girls and women in rural areas to facilitate their free expression in public and their participation in decision-making process for getting their rights.

Respondents perceived that interest groups (women, poor and marginalised people) were not consulted during the preparation of the operational plan and their interests were not negotiated. They declared that they have no voice to defend the community interest because all the meetings with forest authorities focused on how to successfully lead the activities in the plantations. According to the respondents surrounding Lama and Penessoulou forest reserves, the AGM are organised to review the financial situation of the funds collected by the COGEPAF and explain its distribution to the forest communities. Many respondents stated in Lama and Penessoulou forest

reserves that the COGEPAF members applied the instructions coming from the coordination committee. The respondent AKI3 from the COGEPAF Akiza in Lama forest stretched:

"*The COGEPAF does not gain much money to think about the marginalized persons. Our focus is to organise people who are strong enough and can work in the plantations when the coordinating team informs us*".

Some respondents from COGEPAF Pénéssoulou stated:

*"We are afraid of the responsibility of managing the forest who lives in the village of Pénélan and represent the National Wood Company (**SONAB**: Société Nationale du Bois) authority here"*.

According to the SONAB authorities the overall communities' interests were taken into account during the elaboration of the participatory management plan that was implemented. They said to have tried these last four years the public contract system for the silvicultural activities forest security within the plantations and local communities were used as sub-contractors in both Lama and Penessoulou forest reserves. The Head of the Participatory Control Unit (CTEP: Chef Travaux Encadrement Participatif) stated:

"*The forest riparian communities are well involved in the process of elaboration of the participatory management part through the general assemblies during which their perception, opinions and vision towards plantations were noted. Our experience with the subcontracting system these last four years showed that local communities were exploited and more reluctant to participate in forest activities*".

On the side of the Sota forest, most of the respondents declared that the forest officers do not listen to them, and they are just there to apply what is decided by the forest officers.

The general perception of the non-involvement of the community in the elaboration of the management plan can be related to the long period of implementation of a management plan (20 years) after its validation triggering to a lapse of memory of the old people and an ignorance of the young people. Therefore, a periodic sensitization on the management plan will be helpful to keep local community conscious of their contribution in such document. Furthermore, giving more responsibility to local communities by using them directly instead of using subcontracting system will increase their involvement and their interest in the management of the forest. All of the representatives of the SONAB interviewed concurred with such conclusion and talked about a new system coming to be implemented from 2024 in which local community will be organised in groups and directly employed for different silvicultural activities.

The respondents were more involved in the management of Sota and Lama forest reserves than those of Penessoulou forest because financial activities are led in these forests in contrary to Penessoulou forest. Indeed, committee members in Sota forest contributed to the distribution of the tickets to community members who practice activities (farming, pasture and beekeeping) inside the forest in conformity with the management plan and helped the accountant of the coordination committee to collect le founds. This was testified by the respondent BEN10 from Bensékou in Sota forest who said:

"I collect the money from those hiring plots in the allowed areas of the forest for farming and those allowed to practice pasture or beekeeping in the forest with the help of the members of the committee of each village".

In Lama forest, the members of the COGEPAF contribute to the collect of the vouchers and present them to the accountant of the coordination. The respondent ZAL6 from the COGEPAF Zalimè in Lama forest stated:

"Customers come on the forest with the voucher collected from the teller after making deposit on the coordination bank account and the COGEPAF members on duty will collect the voucher, serve him and give him back an invoice that will allow him to take his goods out of the forest. The collected vouchers are then returned to the coordination committee for the rest of the process".

The respondents of Penessoulou forest declared in majority to ignore much about the financial aspect because they were not involved in the sale of the timbers, they harvested last year since no one is interested on them there.

With regards to participation of indigenous communities, only dominant ethnic groups are considered in the villages. For instance, Adja and Aïzo ethnic groups were excluded from most Village Participatory Management Organisation (VPMO) in Lama forest while Nago, Kabiè and Peulh ethnic groups were excluded from most VPMO in Penessoulou forest and, Dendi, Bariba and Zerma ethnic groups were excluded from most VPMO in Sota forest.

It results from the participation status that local forest department hold the majority of planning and decision-making, while implementation activities were to some extent to local forest participants. These findings corroborate with those found in Bengladesh where forest participants were not fully invested the responsibility of decision-making (Dhali et al., 2012; Mollick et al., 2018). Mollick et al., (2018) concluded that the management activities need to be improved to sustain the benefit of participatory forestry governance. Consequently, local communities need to be more involved in silvicultural activities in Lama and Penessoulou forest in order to increase their interest to the forest management. Besides, the management of Sota forest needs to be more structured with common and forest-friendly activities like plantation, assisted regeneration, beekeeping, mushroom growing and snail raising for increasing local people valuation of forest resources and their interest to the forest management. Previous studies showed that the involvement

of local forest participants in the management committee meeting as well in the decision-making process is crucial to enhance the capability of management committee who take the decisions (Mollick et al., 2018). Therefore, local communities need to be frequently sensitized on the management plan given to them as recommended by the article 80 of the forestry law (Bénin, 1996) in order to remind them their responsibility on the management in progress. Moreover, listening and discussing their opinion at the beginning and the end of each general meeting assembly will be helpful to integrate their view in the management and increase their engagement as it is allowed to involve local communities in the decision-making committee according to national forestry law (Direction Générale des Forêts et des Ressources Naturelles & DGFRN, 2012).

4.3.4.2. Transparency status

Transparency refers to the visibility of decision-making processes; the clarity with which the reasoning behind a decision is communicated and the ready availability of relevant information about a governance authority's performance (Lockwood, 2010). Respondents from all village Participatory Management Organisations (VPMO) declare that their committee were not tasked to submit any annual report or did not have any audit, but it is the duty of the coordination committee and the head of participative supervision works in Lama and Penessoulou forest reserves and the post chiefs in Sota forest. Therefore, they cannot check the robustness of the information. The lack of annual report from the VPMO committee could be related to the low level of education of the members who do not have skill in report writing. Similar results were noted in Bangladesh (Baral, 2014). Such situation calls for a training of VPMO committee members which writing skills in report making in order to provide archives of their management. Besides, the very low transparency

level of the indicators in Penessoulou forest was justified by the non-activity period since the installation of the COGEPAF as argued by the respondent NIO5 from the VPMO of Nioro:

"We did not have any meeting for two years I became the chairman of this COGEPAF. When we made the cuts, the price set by the SONAB for the poles was not on line with the realities of the area, reason why the poles had not been sold over a year. Moreover, we did not have the funds to motivate the members because we had not been paid for the unloading we performed on our own expenses".

The limited activities assigned to the Village Forest Management Council (**CVGF**: Conseil Villageois de Gestion de la Forêt) committee in Sota forest justified the lack of reports and audits. These activities are in charge of the government representatives as argued by the coordinator of the Technical Forestry Management Unit (**CTAF**: Cellule Technique d'Aménagement Forestier) of the Sota-Goungoun-Goroubi forest complex:

"The management units do not make any reports. It is the head posts that are in contact with them and make the reports they send us. The head posts do the permanent monitoring. We go out spontaneously to check on them too".

Respondents in Lama and Penessoulou forest declared sharing information on time through WhatsApp pages created for all the COGEPAF and including the head of participative supervision work. Furthermore, either meetings were organised with population or a public bawler was used to inform the population according to the urgency of the information around all the forest reserves. The high transparency in information availability and accessibility and, in decision of benefit sharing is a good path for the motivation of the population towards the forest management.

4.3.4.3. Effectiveness status

The results revealed that the performance of the forests in term of effectiveness is quite good. The lack of power to make decision on forest management was pointed as the main reason around all the forests, constraining them to wait for the state institution planning before planning themselves. Rules and regulations were established for the guidance of the associations around each forest either by the National Wood Service for the user groups under its control or by the forest administration for the user groups of Sota forest. However, few members were aware of the existence of such documents and most of them declared to refer to the recommendations of the literate members of the groups and the administration agents because of the low education rate around the forests. Moreover, only one respondent was aware of such document around Sota forest despite the presence of people highly educated in the user group committees. This highlights the level of the user groups of this forest in knowing their right and duties toward the forest. Besides, the lack of activities was raised in Penessoulou forest as the main factor impeding the organisation of meetings from which objectives will be planned and decisions be taken. Most respondents in Lama and Penessoulou forest user groups declared that forestry activities have been entrusted to a service provider who manages its workers on a subcontracting basis. The Head of Participatory Management Unit (**CUEP**: Chef Unité Encadrement Participatif) of the National Wood Company (**SONAB**: Société Nationale du Bois) stated:

"The mission of the COGEPAFs is to help us raise their awareness of the management model that we use, to help us bring about a change in behaviour towards the plantations, and to inform us about the drivers of plantation degradation. Overall, the COGEPAF offices are doing a satisfactory job. However, some have financial difficulties due to the National Wood Society's work

schedule, which limits their effectiveness. In this case, the umbrella organisation (the Federation) helps them by funding their activities."

And the National Wood Service authorities attached to Penessoulou forest stretched:

"The COGEPAF offices lack working capital, which prevents members from being motivated to take part in the activities carried out. This is due to the fact that they are not yet deriving any direct benefit from the activities carried out. Indeed, forestry activities were allocated through the public procurement system and were won by people with no knowledge of the field, which prevented us from respecting our timetable. Following this failure, the government accepted our request to move to a dispensation whereby local people organised into groups would be the ones to take charge of forestry activities."

The management of forest encounters currently difficulties like delay of sylvicultural activities as well as the loss of motivation of VMPO committee. Such situation will lead to the degradation of the forest if it continues. It is then expected that the involvement of local communities in the whole forestry activities by the SONAB will motivate forest users by increasing their profit and at the same time enhance the forestry activities they are allowed to perform as found in previous studies on participatory forest management in Lama forest (Mehou-Loko et al., 2013).

The main objective of the forest management stated by forest users surrounding Sota forest was to protect the forest but most respondents complained to not have power to stop some bad activities happening inside like logging which is mostly covered by powerful persons. This contrasts with the obligation of the forest office mentioned in the rules and regulations document of the VPMO stating that forest office must assist surrounding communities to expel illegal loggers (DGFRN, 2014). This calls for a frequent presence of forest officers on the local communities' sides to help

them more effective in stopping illegal activities occurring in the forest. However, the occurrence of terrorism in the area has been mentioned as factor impeding the assistance of forest officers as they were told to be the main target of the terrorists. Then, the VPMO committee members were only able to monitor the activities of the population working in the forest and collect the authorisation fees that are put in the forest association account.

4.3.4.4. Efficiency status

Efficient management of forest resources is the key of the success of participatory forestry programme. It ensures the sustainability of participatory forest management activities (Mollick et al., 2018). Forests represent an important asset for the livelihoods of local people in rural areas of developing countries. Thus, an efficient management of the forest results in providing resources for facing daily needs for them. This study showed that the management strategies that allow local people surrounding Sota forest to access and utilize forest resources satisfied local community demands. However, the activities are more individuals and forest degrading and the communities lack social financial activities that can benefit to the community especially marginalized people. The few plantations installed close to some villages under the forest administration control were poorly managed with uncontrolled logging by local people (Akouehou et al., 2017). However, according to the Coordinator of the Technical Forestry Management Unit (CTAF) of the Sota-Gougoun-Goroubi forest complex, all the local community benefit from the forest. He justified by the statement:

"Forest users pay an amount between 2500 to 5000 FCFA/ha/year to access and use forest resources for farming and 100 FCFA per animal per entrance in the forest for pasture. The

collected funds are put in the forest association account and shared at the end of each year within five (05) structures (Figure 4.27).

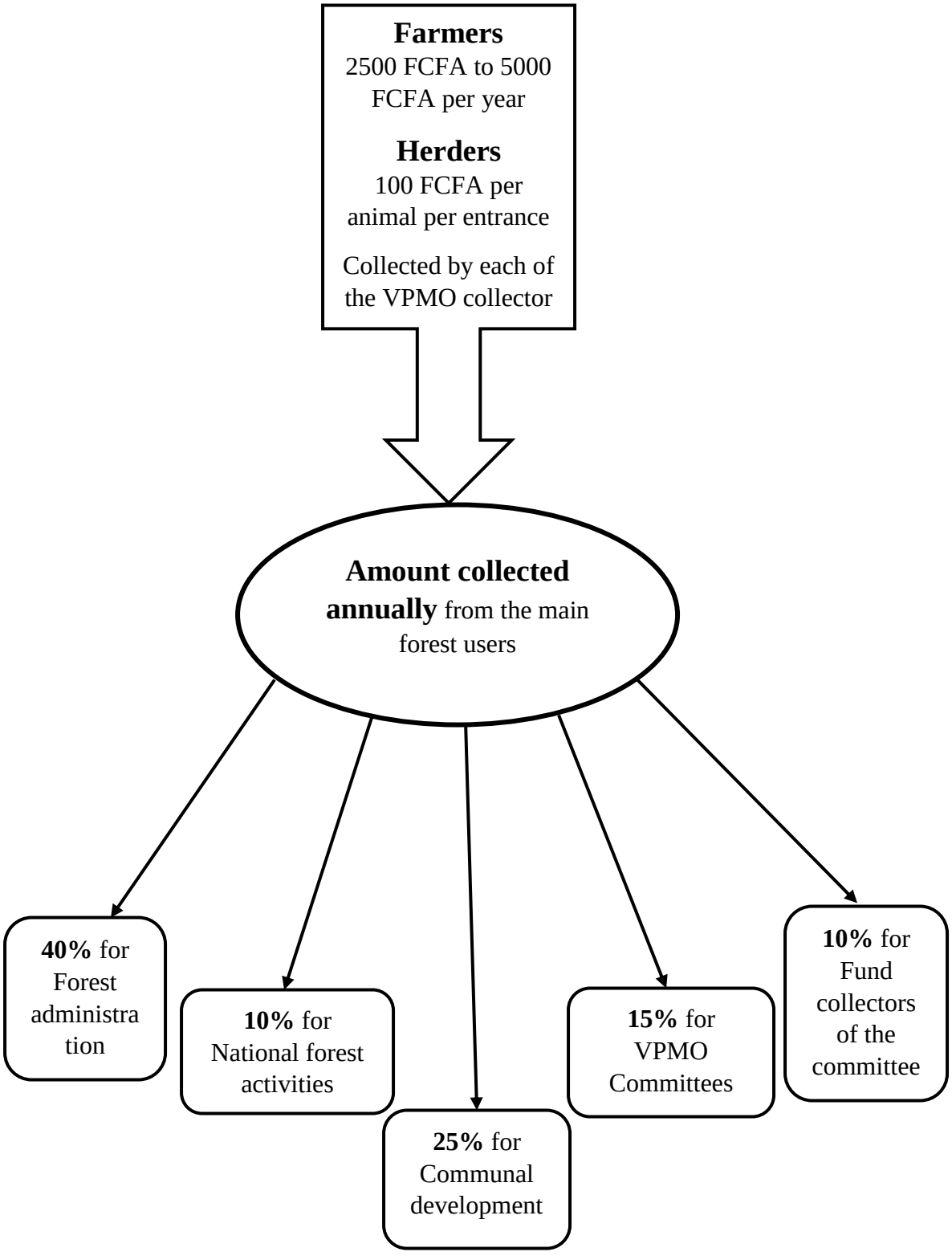


Figure 4.26: Distribution of the fund from the management of Sota forest

The community surrounding Lama forest expressed being the most satisfied despite their incapability to access to the natural forest resources. This means that the involvement of the local community in the management of the plantations covers the majority of their needs. However, the user groups explained to be involved only in unloading and cleaning activities while the rest of silvicultural activities are executed in subcontract work and reduced their profits. The same problem was raised in Penessoulou forest to explain the lack of funds in the COGEPAF account to lead the activities. The SONAB officers explained who the funds were managed within them and the local management organisations:

"The forest user groups of the closest village to plot where the activities are going to happen are invited and workers are paid after selling the products they gathered. Then, the rest of the funds is shared as planned by the management plan between the Village Participatory Management Organisation, the SONAB, the forest administration and the communal administration. However, no retention is made by SONAB and national forest administration on the sale of products like the thin branches. Moreover, surrounding villages are granted 10 million CFA per year by the SONAB for communal development managed by the mayor and his team."

Further details given by the forest user groups showing that the collected money from the sale of forest products after unloading was shared by COGEPAF administration, the village, the coordination administration, forestry activities and the federation (Figure 4.28). Similar results were found in a recent study on the disinterest to the participatory forest management in Lama forest (Agbodossindji et al., 2023). The authors found that the local community surrounding Lama forest have observed a decreased of their benefits these last years because of the lack of pole resulting from the old age of the plantation. New strategies need to be developed to increase the benefits of the local community and ensure the sustainability of the approach.

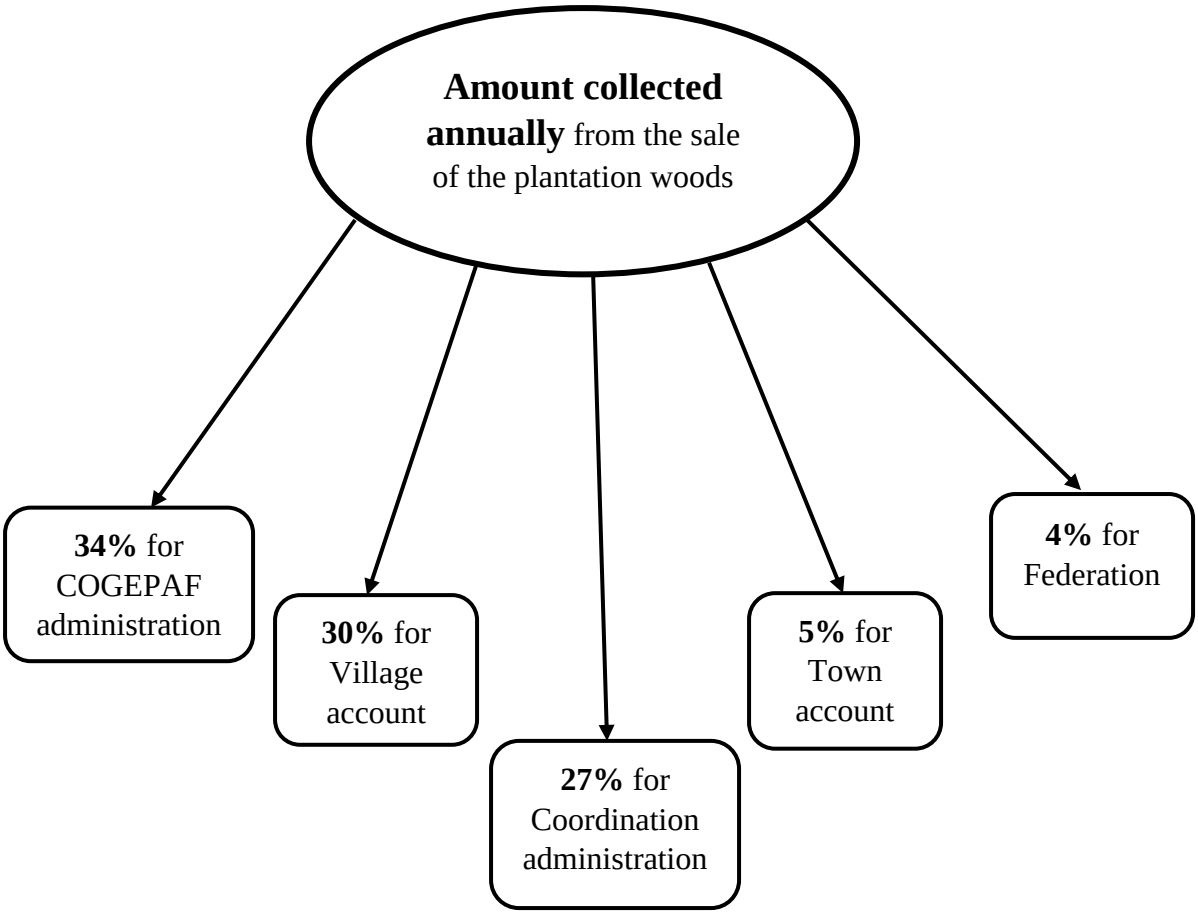


Figure 4.27: Distribution of the funds from the management of Lama and Penessoulou forest reserves

4.3.4.5. Governance status

This work showed that there is no significant difference between the governance status of the different forests. The moderate level of governance expressed demonstrated that the communities were partially satisfied of the participatory approach implemented in the considered forest reserves. However, the communities surrounding Lama and Sota forest expressed more satisfaction than their counterparts living around Penessoulou forest owing to the benefits they get from their forest. Only the participation level was very low in all the forests showing that the approach is still not yet well implemented as participatory forest management seeks to promote participation by local

people in forest management by transferring rights and responsibility over the resources, while these reforms appear to be dominated by state forest officials (Lund, 2015; Ribot et al., 2010). Previous studies on participatory forestry in Kenya (Mutune & Lund, 2016), Tanzania (e.g. case of JFM), Uganda and Cameroon (Magessa et al., 2020) and, Bangladesh (Mollick et al., 2018) corroborate with the findings of this study and reported that the current forest governance approaches have failed to support participation in practice.

4.4. Problem encountered in the field

The elaboration of the present work has faced many challenges

- The lack of co-supervisor despite the multiple requests to help my supervisor to assist me has seriously affected the progression of the work;
- Unavailability of the research budget on time after request has forced to undertake the work based on loan and has delayed the activities;
- The slowness of the administrative process for delivering the authorisation to access to the different forest reserves;
- The high reluctance of some local people owing to the misunderstanding between them and local representatives or government representatives has limited the sampling work in some areas;
- The fear of local communities to the interviewers because of their past experience from the governmental surveys has limited the sampling work in some areas;
- The fear of the local communities to the current government limited the willingness of some to freely express themselves;

- The lack of network in some remote areas has hampered the ease connexion with local communities for planning;
- The lack of energy to recharge the electronic stuffs used for the work in some areas has slowed the data collection and delayed the fieldwork.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

Climate change with its side effect notably erratic rainfall, high temperatures and extreme weather events constitute a threat for life on the earth. This work seeks to examine the contribution of participatory forest management (PFM) approach implemented in Benin to ensuring the sustainable management of forests which represent a key component in adapting and mitigating climate change. Three forest reserves (Lama, Penessoulou and Sota forest reserves) distributed in the three climatic zones of the Republic of Benin were selected based on specific criteria (being a gazetted natural forest stand, being implementing effective participatory forest management approach, and having efficient local committee and forest association). Firstly, quantitative and qualitative data were collected from respondents randomly selected among the community surrounding each forest to assess their perception on forest ESs, their indigenous knowledge on forest plants and their perception on the forest governance through questionnaires, focus group discussions (FGDs) and key informant interviews. Secondly, forest inventory was conducted in each forest to characterize the population stand of the most cited forest plant species around each forest.

A total of 436 respondents (188 for Lama forest, 115 for Penessoulou forest and 133 for Sota forest) were questioned, 8 FGDs (3 for Lama forest, 2 for Penessoulou forest and 3 for Sota forest) were held, and 8 key informant interviews (2 for Lama forest, 2 for Penessoulou forest, 2 for Sota forest, 1 representative of SONAB and 1 representative of DGFEC of Kandi) were led for assessing the perception of local community on forest ecosystem services (ESs). The results revealed that:

- Several socio-environmental characteristics influenced the forest ESs. However, most of people surrounding Lama forest showed almost a similar view on the services, the perception of the community living around Penessoulou and Sota forest reserves is influenced by many factors.
- The community around Sota forest that had large access to their forest resources perceived significantly more provisioning services than those around Lama forest having access to plantation resources who also perceived significantly more this ESs than the community surrounding Penessoulou forest who have limited access to their forest resources. No significant difference was perceived in the remain ESs within the forest communities.
- The management of the forest negatively impacted the provisioning ESs provided to the communities surrounding Penessoulou and Sota forest reserves. Forest management were perceived to have improved regulating and supporting ESs around Lama and Penessoulou forest reserves while these ESs were perceived to have declined around Sota forest. The management approach has contributed to improving cultural ESs in Lama and Penessoulou forest reserves whereas it has led to a decrease of these services in Sota forest.

A total of 458 respondents (190 for Lama forest, 115 for Penessoulou forest and 153 for Sota forest) were questioned, 8 FGDs (3 for Lama forest, 2 for Penessoulou forest and 3 for Sota forest) were held, and 8 key informant interviews (2 for Lama forest, 2 for Penessoulou forest, 2 for Sota forest, 1 representative of the National Wood Company (**SONAB**: Société Nationale du Bois) and 1 representative of the General Direction of Forest Water and Wildlife (DGFEC) of Kandi were led for evaluating the knowledge of local community on useful forest plant species. The results showed that:

- 74 useful forest plant species were reported around the three forest reserves with 36, 29 and 31 plant species respectively around Lama, Penessoulou and Sota forest reserves.
- There is a decreasing trend on the knowledge of forest plant species from the community surrounding Sota forest to those around Lama forest and the community living close to Penessoulou forest which may be related to the management rules.
- Community with full authorisation have a large range of plant species uses while those under high forest access restriction have a small range of plant species uses. Forest plants were mainly used for wood energy, timber and medicinal purposes around Lama forest while they were used for cultural and medicinal purposes around Penessoulou forest and for food, medicine, timber services and wood energy purposes around Sota forest.

42, 47 and 86 plots were effectively inventoried out of 47, 56 and 124 plots obtained from the systematic sampling respectively of Lama, Penessoulou and Sota forest reserves. The results of the inventory revealed that:

- Most of the plant species had a tree density less than 5 trees/ha in the different forest reserves.
- The restriction to forest access contributed to the conservation of the useful plant species. Useful plant species conservation trend decreased from Lama forest to penessoulou forest and finally Sota forest.

A total of 211 respondents (129 for Lama forest, 44 for Penessoulou forest and 38 for Sota forest) were questioned, 8 FGDs (3 for Lama forest, 2 for Penessoulou forest and 3 for Sota forest) were held, and 7 key informant interviews (2 for Lama forest, 1 for Penessoulou forest, 2 for Sota forest, 1 representative of the National Wood Company (**SONAB**: Société Nationale du Bois) and 1 representative of the Directorate General of Water, Forests, and Hunting (**DGEFC**: Direction

Générale des Eaux Forêt et Chasse) of Kandi were conducted for assessing the perception of the local community towards the forest governance using for criteria: participation, transparency, effectiveness and efficiency. The results are presented in the table 5.1.

Table 5.1. Summary of the governance criteria status and overall governance status per forest

Criteria / Forest	Participation status	Transparency status	Effectiveness status	Efficiency status	Governance Status
Lama forest	Low	Medium	Medium	Medium	Medium
Penessoulou forest	Low	Low	Medium	Low	Low
Sota forest	Low	Medium	Medium	Medium	Medium

5.2. Conclusion

Sustainable forest management is crucial for dealing with climate change and improve rural community livelihoods in developing countries. Participatory forest management (PFM) is designed to reach this goal by involving local community in the management of forest resources. The study revealed that the considered forests are under delegation management and deconcentration management with low participation of local community in decision-making process. Such conditions failed to make local community aware of their responsibilities on the advantages of the sustainable management of forest resources through the long-term conservation of plant species they used and the valuation of indirect ecosystem services provided by the forests. Efforts need therefore to be deployed to increase local community involvement in the decision-making process of the management of the forests which could enhance their willingness to the targeted sustainable management. This study demonstrated the possibility to sustainably manage forest resources and meet local people demands by installing plantation to satisfy local community

needs in firewood and timber while minimizing the impact of local community on native plant species through the collection of non-trees forest products.

5.3. Recommendations

Based on the above findings, this study draws some policy implications for planners and policy makers regarding better management of forest. The study recommends:

- Forest administrations to develop alternative revenue activities (non-related to trees) for improving the local community financial status such as beekeeping, mushroom growing, rabbit breeding and snail raising for improving the local community financial status and simultaneously reducing local community dependence on forest resources and increase local people valuation of forest resources and their awareness on indirect ecosystem services.
- DGEFC to establish plantations around each forest in order to satisfy local community needs of firewood and timber.
- Forest administrations develop environmental education in the local languages through media to raise awareness on the risk of extinction of some species.
- Forest administration to give training to local communities on soil management and impact of pesticides on farming process.
- Forest administration and educated VPMO committee member to strengthen the management skill of local communities to help them to understand and take good decision of forest management.
- Forest administration to involve more local community in decision-making process to enhance their interest to the PFM approach.

5.4. Contribution to knowledge

The current study fills a number of gaps in the literature of participatory forest management. The research shared light on the changes created by the implementation of the new approach of forest management (participatory forest management or forest co-management) on the valuation of forest ecosystem services and forest plant species by the community surrounding forest under such approach. The research

- Provides evidence of the understand the ESs perceived by the community surrounding the forests.
- Provides evidence of the understand the useful plant species to the local community surrounding the forests.
- Developed a set of 23 governance indicators grouped in 4 criteria to assess good governance in participatory forest management in Benin.
- Provides evidence of the strengths and the weaknesses of PFM implemented in Benin.
- Provides information for the government, donors and other organisations supporting PFM programme.

5.5. Suggestions for further Studies

The current study has help to identify the perception of ecosystem services, the ethnobotanical knowledge and needs of local community involved in forest management. Further studies are recommended on the remaining forests under participatory management systems to collect useful information for improving the approach implemented. Women and old people who are the most vulnerable groups of the rural areas were less represented in this study. Further studies tackling the

need and knowledge of these category of people is recommended to increase the efficiency of PFM. The study has developed a set of indicators to assess forest governance in Benin. More research efforts are required to improve these indicators in the context of PFM in Benin and West-Africa. Further studies are required to get the view of the members of the federation committee and other indirect actors involved in the implementation of PFM.

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APPENDICES

APPENDIX 1

Household Questionnaire (Main Survey) residing for at least ten years in the area

Household characteristics

1. Name of investigator: _____

2. Date of interview: _____ Department: _____

Municipality: _____ Village: _____

Place of residence: _____

_____

Start time: _____ End time: _____

3. Name and first name of the respondent: _____

_____

_____

4. Gender of respondent: a. Man b. Woman

5. Religion:

a. Christian b. Muslim c. Others _____

6. What ethnicity do you belong to? _____

7. Age of respondent: _____

8. Civil status of the respondent: a. Married b. Single c. Divorced

d. Other _____

9. Respondent's education level:

a. Illiterate b. Only read and write c. Primary course (to be specified)

d. Secondary course (to be specified) _____

e. University (to be specified) _____

10. Position occupied in the household (Husband, wife, son, daughter…) _____

11. Sex of the head of household: a. Man b. Woman

12. What is the total number of members in your household:

a. Man _____ b. Woman _____ c. Under 18 years of age _____

13. Role of the respondent in the local community (religious leader, member of an association, student…) _____

_____

_____

14. How long have you been staying in the area? _____

i. Were you born here? Yes No

ii. If **No**, please specify your place of origin and the reason for this location as your choice of destination_____

_____

_____

15. What are the main sources of household income? _____

_____

_____

16. Wealth level: a. Rich b. Average c. Poor

17. House type: a. Chalet b. Buildings c. Other

1. FOREST ECOSYSTEM SERVICES

Section I: Biophysical characteristics of the area

1. Your accommodation is located:

a. In the forest b. Adjacent to the forest c. Out of the forest

2. How far is it from home to the market (in hours of walking)? _____

_____

_____

3. How far is it from your home to the location of the forest (in hours of walking)? _____

_____

_____

4. Distance from your home to your main place of work in hours of walking: _____

_____

_____

Section II: Household economic status

1. What are your main livelihood activities?

a. Agriculture b. Livestock breeding c. Use of the forest

d. Others _____

_____

2. What is your annual household agricultural income (in CFA)? _____

3. What annual income did you earn only from forest resources last year (in CFA)? _____ and other sources last year (in CFA)? _____

4. How much do you estimate your total annual expenses to be (in CFA)? _____

5. Is there a Village Participatory Management Organization (VPMO) which manages the forest?

Yes No

- If **Yes**, what is its name? _____

  _____

  _____

- If **No**, how is the forest managed? _____

  _____

  _____

6. Are you a member of the VPMO?

a. Yes b. No

- If **Yes**, how long have you joined as a member of the VPMO? _____ years
- If **Yes**, what made you want to become a member of the VPMO?

  a. Proximity to the forest site b. Awareness created by forest officers

  c. Impressed by the benefits enjoyed by members

  d. Others _____

  _____

- If **Yes**, what types of incentives do you receive as a member that are not given to non-users?

  a. Training & awareness. b. Access to low-cost seedlings

c. Others _____

_____

_____

- If **No**, what are your reasons for not joining the VPMO?

  a. My house is far from the forest b. I was informed late

  c. Others _____

  _____

  _____

- If **No**, what economic benefits do you lose because you were not a member of the cooperative?

  a. Lack of access to employment in the forest b. Lack of access to grass/fodder

  c. Others _____

  _____

  _____

7. List the different products authorized to be extracted from the forest area:

a. Firewood b. Grass/fodder c. PFNL

d. Other _____

_____

_____

8. For what purpose do you collect the products listed above?

a. Only my own consumption b. To sell

c. Others _____

_____

_____

9. Are you satisfied with the sharing of forest benefits in the VPMO?

a. Yes b. No

10. What do you think about the level of forest protection?

a. Secure b. Not secure

c. Other_____

_____

_____

11. What are the positive and negative impacts of the project for community members who are not members of the VPMO?

a. Aesthetic effect b. Protection of land against erosion

c. Shortage of fodder and pasture

d. Other _____

_____

_____

12. What alternative energy-saving technologies do you use to reduce your dependence on the forest?

a. Fuel-efficient improved stoves b. Biogas

c. Other _____

_____

_____

13. What are the alternative livelihood practices developed in your own home and on your land in addition to agricultural production?

a. Beekeeping b. Production of NTFPs c. Nurseries

d. Manufacturing of fuel-efficient improved stoves e. Vegetable garden

f. Other _____

_____

_____

14. Are there any family members employed by the participatory forest management project?

a. Yes b. No

- If **Yes**, how many members of your family are employed? _____, and what is the monthly income from work? _____in CFA?

15. Do you own any livestock?

a. Yes b. No

- If **Yes**, please detail the types of livestock:

		Before the implementation of PFM		After the implementation of PFM		Total annual income
		Quantity	Unit price	Quantity	Unit price	
Livestock	Cow					
	Oxen					
	Goat/Sheep					
	Donkey					
	Horse					
	Chicken					
	Others					
Livestock products	Milk / litter					
	Butter / Kg					
	Meat / Kg					
	Egg / number					
	Honey /Kg					
	Other					

- If **No**, is it related to the implementation of the project?

  a. Yes b. No

  - If the non-owing of livestock is related to the implementation of the project, please specify the side effect please:

    a. No access to open pastures b. Increases the cost of fodder

    c. Others _____

    _____

    _____

16. Where do you source fodder for your livestock before implementing Participatory Forest Management (PFM)?

a. Open pasture b. Residues from agricultural production

c. Other _____

_____

_____

17. Where do you currently source your livestock feed?

a. Open pasture b. Residues from agricultural production

c. Project grazing

d. Other _____

_____

_____

Section III: Socio-political status of the household

1. Do you have legal land ownership of the land you farm?

a. Yes b. No

- If **No**, how did you acquire this land?

  a. By rental b. By borrowing c. By inheritance

  d. Other _____

  _____

  _____

- What is the total area of agricultural land in hectares (ha)?

a. From the rental _____ b. Of the loan _____

c. Other means _____

_____

_____

- If **YES**, what is the total area of legally owned agricultural land in hectares (ha)? _____

2. What is the area of land used for forest plantations (in hectares)? _____

3. Are you involved in social affairs in your village?

a. Yes b. No

4. Do you participate / have local power / in political affairs?

a. Yes b. No

5. If **Yes**, please specify _____

_____

_____

Section IV: Ecosystem services used and perceived by households

1. Are you aware of the ecosystem services provided by forest resources in your area?

   a. Yes b. No

2. Specify the ecosystem services that the forest can provide

Table 2: Considering the following ecosystem services (use and importance of forest and trees), mention ecosystem services that you can obtain from the forest.

Type ES		Yes/No	Type ES		Yes/No	Type ES		Yes/No
Code	**Provisioning**		**Code**	**Regulation and support**		**Code**	**Cultural**	
1	Wild fruits		**13**	Groundwater recharge		24	Spiritual function	
2	Firewood		**14**	Reduction of natural disasters		25	Aesthetic function	
3	Leaves		**15**	Regulation of diseases and pests		26	Leisure function	
4	Fresh water		**16**	Pollination of crops		27	Ecotourism	
5	Wild animals		**17**	Fresh air				
6	Wild foods other than fruits		**18**	Carbon sequestration				
7	Fodder		**19**	Water purification				
8	Fish		**20**	Soil protection				
9	Broom Grass		**20**	Soil formation				
10	Roof Thatch Grass		**21**	Maintaining biodiversity				
11	Timber		**22**	Genetic diversity				
12	Pasture		**23**	Seed dispersal				

3. From the following table, describe whether you use ES services for money or for subsistence since GFP is practiced in your area.

Table 3. List of forest provisioning ecosystem services. Check (√) your answer.

Type of service	Used for		Type of service	Used for		Type of service	Used for	
	Subsistence	**To have money**		**Subsistence**	**To have money**		**Subsistence**	**To have money**
Wild animals			Framework			Roof Thatch Grass		
Wild fruits			Feed			Lumber		
Wild Foods			Fish			Pasture		
Fresh water			Grass broom			Beekeeping		
PFNL			Broom Grass					

Table 3: Household perception of the importance and impact of participatory forest management on each ecosystem service over the past ten years

Type ES	**Trend/Impact**			**Type Es**	**Trend/Impact**		
Provisioning	**Decline**	**Improvement**	**No change**	**Regulation and support**	**Decline**	**Improvement**	**No change**
Wild fruits				Reduction of natural disasters			
Firewood				Regulation of diseases and pests			
Leaves				Pollination of crops			
Fresh water				Fresh air			
PFNL				Carbon sequestration			
Wild foods other than fruits				Water purification			
Feed				Soil protection			
Fish				Soil formation			
Broom Grass				Maintaining biodiversity			
Roof Thatch Grass				Genetic diversity			
Lumber				Seed dispersal			
Pasture							
Cultural							
Spiritual function							
Aesthetic function							
Recreational function							
Eco-tourism function							

Section V: Household willingness to pay for sustainable forest conservation management

Let's say the local government and NGOs are considering providing an improved forest management service in your environment, which is better than the current service/management. At the same time, all PFM projects planned to transfer full financial responsibility to the Communities. Let's say this service involves training and monitoring experts, providing seedlings and providing legal protection services, which have been provided so far by NGOs and the government. However, this program is not being continued. The new program will ensure the ecological, economic and social sustainability of your area. Therefore, households are required to pay for this service.

1. Would your household be willing to pay for an improved forest management service?
   a. Yes b. No.
   - ❖ If **Yes**, what is the maximum lump sum amount that your household is willing to pay per month without permanent influence (in CFA)? _____
   - ❖ What are the other forms of contribution in addition to fixed monthly payments?
     a. Work b. Guard c. Any other (specify): _____
   - ❖ If **No**, could you tell me the reason why your household does not want to pay anything for this improved forest management?
     a. We are poor and we cannot pay
     b. We live outside the project and do not share any benefits from the forest
     c. We are satisfied with the current situation (it does not need improvement)
     d. Good forest management is the responsibility of government and NGOs
     e. Other reasons (specify) _____

Section VI: Household willingness to pay for sustainable forest ecosystem services

Assuming that the local government and NGOs are considering providing an improved forest ecosystem service (ES) in your environment that is better than current services. Suppose that this service involves protecting and conserving biodiversity, improving carbon storage and protecting against natural hazards, reducing soil erosion, increasing NTFPs and increasing water quality and

quantity, and improving livelihoods. Both users and non-users are expected to benefit from the project directly or indirectly.

However, to provide and maintain these services, the program will require a huge budget and resources. Therefore, the beneficiary community should contribute in terms of labour and money to support the SE and benefit from it. The new program will ensure the ecological, economic and social sustainability of your area. Therefore, households are required to pay for this service.

4. Would your household be willing to pay for improved forest ecosystem services?

a. Yes b. No.

- If **Yes**, for which ecosystem service(s) are you willing to pay first?

  a. Supply services b. Regulatory services

  c. Support Service d. Cultural services

  Service details _____

- If **Yes**, what is the maximum lump sum amount your household is willing to pay per month without permanent influence (CFA)? _____
- If **Yes**, what will be the other forms of contributions in addition to the fixed monthly payments?

  a. Work b. Guard c. Other (specify): _____

- If **No**, could you tell me the reason why your household does not want to pay anything for this improved forest management?

a. We are poor and we cannot pay

b. We live outside the project and do not share any benefits from the forest

c. We are satisfied with the current situation (it does not need improvement)

d. It is the responsibility of the government and NGOs

e. Other reasons (specify) _____

2. Ethnobotanical study

Section I: Ethnobotanical information

1. Do you use plants in your daily activities?

   Yes No

i. If **Yes**, what are these activities? _____

_____

_____

ii. If **No**, why? _____

_____

_____

2. Were you aware of any forest plants used?

   Yes No

   a. If **Yes**, list them _____

   _____

   _____

   b. Specify the usefulness of each plant as well as the organs or parts used _____

   _____

   _____

   c. If **No**, please specify the reason. _____

   _____

   _____

3. Did you know of any useful plants in your area other than forest and cultivated plants?

   Yes No

   a. If **Yes**, list them _____

   _____

   _____

   b. Specify their uses and their place of collection _____

   _____

   _____

Section II: Information for prioritization

1. At what moment of year do you collect the listed forest plants? _____

   _____

   _____

   _____

   _____

2. How often are the listed forest plants collected? _____

   _____

   _____

   _____

   _____

3. How do you assess the availability of the forest plants mentioned? _____

   _____

   _____

   _____

   _____

4. Which forest plants are commercialized and which are not? _____

   _____

   _____

   _____

   _____

5. How are these plants marketed? _____

   _____

   _____

   _____

6. Are there totems on some of the forest plants mentioned?

   Yes No

   If **Yes**, please specify them _____

   _____

_____

_____

_____

7. Are there any conservation strategies for the forest plants mentioned?

   Yes No

   If yes, which ones? _____

   _____

   _____

   _____

3. Characterization of the population of priority useful plants

Dendrometry data collection sheet

PLOT INVENTORY SHEET						
Interviewer ID	Date	Site	Formation type	Plot code	Latitude	Longitude
No.	Species	DBH	Tree-operator distance	Down slope	Crown slope	Up slope
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						

4. Forest governance under co-management

Part A: General information on participatory management

1. What is the current mode of forest management?

   a. State management b. Community management c. Participative management

   d. Other: _____

2. Is there a Village Participatory Management Organization (VPMO) that manages the forest in this area? _____

   - If **Yes**, what is it name? _____

     _____

   - If **Yes**, when was it created? _____
   - If **Yes**, how is it organized (What are the different positions occupied)? _____

     _____

   - If **Yes,** does it hold regular general meetings? Yes No
     - If **it does,** when are they held? _____
     - If **it does not,** how are the meetings held? _____
   - If **No**, how does the village participate in forest management? _____

     _____

Part B: Participation in forest management

Do all interested VPMO members have the opportunity to influence decision-making? (6 indicators, maximum score 30, minimum score 6)

3. What is your estimate of the percentage of women who participate in the VPMO general assembly?

   - 80-100% ☐
   - 60 -80% ☐
   - 40-60% ☐
   - 20-40% ☐
   - 0-20% ☐

4. How many ethnic groups participate in the VPMO general assembly compared to the total number of ethnic groups present in the village (to be specified)? _____

- All ethnic groups of FUG ☐
- 60-80% of FUG ethnic groups ☐
- 40-60% of ethnic groups in FUG ☐
- 20-40% ethnic groups in FUG ☐
- 0-20% ethnic groups in FUG ☐

What motivates or prevents the participation of all ethnic groups in the community? _____

_____

5. Give your point of view on the following statement "the interests of marginalized people (the poor, women, the disabled, ...) are well defended at the general assembly of the Organization".

- I totally agree ☐
- I moderately agree ☐
- I agree ☐
- I moderately disagree ☐
- I don't agree at all ☐

6. How many women are there in the VPMO executive committee compared to the total number of committee members (please specify)? _____

- 80-100% ☐
- 60 -80% ☐
- 40-60% ☐
- 20-40% ☐
- 0-20% ☐

If they represent less than 50% of the committee members, explain the reasons for their low representativeness? _____

_____

7. "Interest groups (poor, women, disabled) are consulted in the development of the VPMO management plan." Indicate the extent to which you agree with the statement.
    - I totally agree ☐
    - I moderately agree ☐
    - I agree ☐
    - I moderately disagree ☐
    - I don't agree at all ☐

8. Do VPMO members participate in revenue collection? _____
    - I totally agree ☐
    - I moderately agree ☐
    - I agree ☐
    - I moderately disagree ☐
    - I don't agree at all ☐

❖ If **Yes**, which ones? _____
_____
_____

❖ If **No,** which institution is responsible for collecting revenues generated by the forest? ____
_____

Part C: Transparency

Is information about the forest and how it is managed reasonably accessible to all FUG members? (7 indicators, maximum score 35, minimum score 7)

9. "All VPMO information is freely accessible to members of the organization upon request." Indicate the extent to which you agree with the statement.
    - I totally agree ☐
    - I moderately agree ☐
    - I agree ☐

- I moderately disagree ☐
- I don't agree at all ☐

10. "The VPMO decision-making process regarding benefit sharing (use of forest products) is clear and transparent to all members." Please indicate the extent to which you agree with the statement.
    - I totally agree ☐
    - I moderately agree ☐
    - I agree ☐
    - I moderately disagree ☐
    - I don't agree at all ☐

11. Are the VPMO annual reports submitted to the relevant agencies?
    - Submission of annual reports to the General Assembly and the forest office ☐
    - Submission of annual reports to the General Assembly only ☐
    - Submission of annual reports to the Executive Committee only ☐
    - Annual report known only to key officials ☐
    - No annual report ☐

❖ If annual reports are not submitted to the relevant agencies, why do you think this is the case? _____
_____

12. Are required audits and reports other than the VPMO annual reports submitted to the relevant agencies?
    - Submission of audit reports to the General Assembly and the Forest office ☐
    - Submission of audit reports to the General Assembly ☐
    - Submission of audit reports to the Executive Committee ☐
    - Audit report known to the key manager ☐
    - No audit report ☐

❖ If audits and reports (other than the annual report) are not submitted to the relevant agencies, why do you think this is the case? _____

_____

13. "The information contained in the annual report and other reports is complete." Indicate the extent to which you agree with the statement.
    - I totally agree ☐
    - I moderately agree ☐
    - I agree ☐
    - I moderately disagree ☐
    - I don't agree at all ☐

14. How widely accessible is VPMO information to all its members?
    - Publicly available ☐
    - Available for elite groups ☐
    - Available to committee members ☐
    - Available for key officials ☐
    - Available only president and secretary ☐

❖ If you think that information is not easily accessible to VPMO members, can you give an example? _____

_____

15. To what extent do you agree or disagree that the information available is in a format useful to VPMO members?
    - I totally agree ☐
    - I moderately agree ☐
    - I agree ☐
    - I moderately disagree ☐
    - I don't agree at all ☐

❖ If you think the information available to VPMO members is in useful formats, can you give an example? _____

_____

Part D: Effectiveness

Do the governance arrangements enable the objectives expressed by the members of the VPMO to be achieved? (4 indicators, maximum score 20, minimum score 4)

16. Do you think the constitution is structured appropriately to achieve the expressed objectives of the VPMO? _____

- I totally agree ☐
- I moderately agree ☐
- I agree ☐
- I moderately disagree ☐
- I don't agree at all ☐

❖ If **Yes**, detail the structure (the different positions of the VPMO): _____

_____

❖ If **No**, please explain why and give an example. _____

_____

17. Do you think that last year's VPMO objectives regarding forest management have been achieved? _____

- I totally agree ☐
- I moderately agree ☐
- I agree ☐
- I moderately disagree ☐
- I don't agree at all ☐

❖ If **Yes**, specify the objectives achieved.

❖ If **No,** please explain why and give an example.

18. Do you think that the decisions of the meetings are implemented and applied? _____

- I totally agree ☐
- I moderately agree ☐
- I agree ☐
- I moderately disagree ☐
- I don't agree at all ☐

❖ If **No,** please explain why and give an example. _____

_____

19. Please rate your perception of the VPMO dispute resolution process on a scale from highly participatory/consultative/win-win to coercive?

- Highly participatory/consultative/win-win ☐
- Participatory and consultative ☐
- Moderately participatory and consultative ☐
- Less participatory and less consultative ☐
- Coercive ☐

Part F: Efficiency

Does the Forest User Group (FUG) governance structure minimise waste of resources? (6 indicators, maximum score 30, minimum score 6)

20. Do the financial benefits of forest management outweigh the costs? Financial benefits of forest management versus the financial costs involved? _____

- The benefits far outweigh the costs involved ☐
- The benefits outweigh the cost ☐
- Benefits and costs are equal / more or less the same ☐
- Costs outweigh benefits ☐
- The costs far outweigh the benefits ☐

❖ If **No,** please explain why you think this happens and give an example. _____

_____

21. Does the right to harvest/collect forest products compensate FUG members for their in-kind contributions?

- Very high level of right to harvest/collect forest products ☐
- High level of right to harvest/gather the forest ☐
- Moderate ☐
- Low level of rights to harvest/collect forest products ☐
- No right to harvest/gather forest products ☐

22. Does the VPMO apply the forestry system according to the approved management plan?

- I totally agree ☐
- I moderately agree ☐
- I agree ☐
- I moderately disagree ☐
- I don't agree at all ☐

❖ If **Yes**, can you give at least one example of a forestry system applied by the VPMO?

Assisted regeneration, Coppice system, Selection system, Thinning, Pruning, Cleaning,

Other : _____

_____

23. To what extent are forestry systems adequate to achieve FUG objectives?

- More than enough ☐
- Adequate ☐
- Moderately adequate ☐
- Less than adequate ☐
- Not adequate ☐

❖ If you think it is insufficient, can you explain why? And what do you think will be sufficient? _____

_____

_____

24. Describe your views on time management in meetings (including the general meeting)

- On time and very efficient ☐
- Good time management ☐
- Moderate time management ☐
- Rough time management ☐
- Poor time management ☐

❖ If meetings are poorly managed in terms of time, explain why you think this is happening. _____

_____

_____

25. Are your VPMO's forest products sold at market price or at a discount?

- Product sold more expensive than the market price ☐
- Price equal to market price ☐
- 25% below market price ☐
- 50% below market price ☐
- > 50% below market price or offered for free ☐

❖ If forest products are sold at a discount to the market price, why does this happen? Can you give an example? _____

_____

_____

26. "My VPMO has an effective system for collecting revenue (from the sale of forest products, fines for transgressions, etc.). Please indicate the extent to which you agree with the statement.

- I totally agree ☐
- ☐
- ☐
- ☐

- I moderately agree
- I agree
- I moderately disagree
- I don't agree at all

❖ If you consider your VPMO's revenue collection system to be inefficient, what could you do to improve it? _____

_____

_____

Thank you for your time and help.

ANNEX 1-1 INFORMATION SHEET FOR AN INDIVIDUAL HOUSEHOLD

Project: Decentralized governance of forests in Benin

Information Sheet Interviews VPMO Members and Non-Members

1. Invitation to participate You are cordially invited to participate in the research project entitled "Participatory management of Benin's forests".

The researcher, **Hamzath AS KORA**, is a PhD student at the Faculty of Agricultural Sciences, University of The Gambia, The Gambia. This research project is being conducted to fulfil one of the requirements of the Doctor of Philosophy in Natural Resource Governance. The researcher is conducting his research under the supervision of Prof. Dr. Ir. Achille E. ASSOGBADJO and Dr. Juliano S. HOUNDONOUGBO, Faculty of Agricultural Sciences, University of Abomey-Calavi, Benin.

This research is open to participants who are not:

Pregnant; Under 18; Involved in illegal activities; or Cognitive impairment;

2. What is the purpose of the research?

This research analyses the impact of governance on the conservation of biodiversity of useful plants in forests under participatory management in the south, centre and north of Benin. The research aims to study the relationship between forest governance, resource management and community outcomes in Beninese forest user groups under co-management.

3. Why was I invited to participate in this study?

You were selected for this study because you live in one of the co-managed forest user group regions under investigation or have other expertise in forest governance. The VPMO members and non-members selected in this research represent a diversity of household types based on forest user group membership/non-membership and socio-economic characteristics (male/female, rich/poor, ethnicity, etc.).

4. What does the study consist of?

The study involves voluntarily participating in an interview of approximately one (1) hour. The interview will use a semi-structured questionnaire on items such as existing rules and regulations for forest management applied by your community forest user group, your participation in decision-making and management, and access and benefits received. The interviewer will take notes during the interview and a transcript will be prepared. You will have the opportunity to edit, remove or add to any of the comments you made.

You are not obliged to accept this invitation. If you decide to participate, you have the right to:

• refuse to answer any particular question; • withdraw from the study at any time; • ask questions about the study at any time during your participation; • provide information on the understanding that your name will not be used; • have access to a summary of the results of the project when it is completed

The information you provide will be used for analysis and interpretation purposes. A summary of the results, written in French, will be sent to your forest user group three months after the interviews are completed. It is important that you understand that your participation in this study is voluntary. While I sincerely hope that you will participate, I respect your right to refuse. There will be no consequences for you if you decide not to participate. If you decide to discontinue your participation at any time, you may do so without providing any explanation.

Participants are informed that although the data may have uses unrelated to the research project, they will not be released for such uses. If you wish to withdraw from the project, all data recorded up to the date of withdrawal will be destroyed.

5. Benefits of the study

This is an academic study and no immediate benefits from participation are anticipated. The study will inform the theory and practice of participatory forest management in general in Benin, particularly with regard to the relationship between community forestry governance, forest management and community benefits. These findings could inform community forestry policy in the medium to long term.

6. Photographs

As part of the process of documenting the structure and operation of the VPMO, the researcher will take photographs which may include images of individuals. Individuals in these photographs may be identified to illustrate aspects of the VPMO's operations. If you wish, you may exclude your image from inclusion in the photographs when you sign the consent form for the project.

7. Are there any possible risks to participating in the study?

There are no specific risks anticipated with participation in this study. However, if you find that you are in distress, I will arrange for you to see a counselor at no cost to you. Interview transcripts and published results may be cited in published reports and articles. While every effort will be made to maintain anonymity, there is a slight risk that you may be identified by the character of your responses. Interview transcripts will be kept confidential to the researchers. A copy of the transcribed interview will be forwarded to you for review and correction. Once the transcript is corrected and finalized, the data will be securely stored in the university's electronic doctoral data storage system.

Additionally, you may be identified from photographs taken of the VPMOs designed to illustrate their structure and operation. As noted above, you will be able to exclude your image from use in the images by checking the "No" box when signing the project consent form.

8. What if I have questions about this research?

If you have any questions regarding this research, please contact me (Hamzath AS KORA) at the following addresses:

Researcher: Hamzath AS KORA

In Benin: University of Abomey-Calavi (UAC)

Laboratory of Applied Ecology (LEA)

Such. +229 97174997 Email. hamzath.kora@gmail.com

In Gambia: University of the Gambia (UTG),

E-mail.hkora-wascal@utg.edu.gm

Thank you for your participation and support.

APPENDIX 1-2 TELEPHONE SHEET

Project title: Decentralized community forest governance in Benin

Telephone contact sheet

The following approach will be used to recruit people for interviews and focus groups

Good morning

My name is Hamzath AS KORA and I am contacting you because you are a member of the [insert name of community forest user group].

I am undertaking this research as part of my doctoral studies at the University of The Gambia, The Gambia. My study focuses on how community forest user groups in Benin are governed and how governance arrangements influence the benefits received by different social groups.

You have been randomly selected from a list of members of the [insert name of community forest user group] to be invited to participate in a [focus group or interview].

It would be very beneficial to my study if you were available to participate in a [focus group or interview]. If so, I will provide you with further information about the study and the [focus group or interview].

If the participant is willing to consider being interviewed/participating in the focus group, the researcher will then provide details about the study from the information sheet and, if the participant is willing to participate, arrange an appointment.

ANNEX 1-3 PARTICIPANT CONSENT FORM

Project title: Decentralized governance of community forests in Benin

Consent Form

Participant must read and sign

1. I agree to participate in the research study mentioned above.

2. I have read and understood the information sheet for this study.

3. I confirm that I am not Pregnant; Under 18 years of age; Involved in illegal activities; or Cognitively impaired;

4. The nature and possible effects of the study have been explained to me.

5. I understand that the study involves the following modalities: interviews of approximately one hour on the theme of the role of my organization in community forestry/decentralization and good forest governance.

6. I agree to be photographed during the interview/focus group.

Yes No

7. I understand that I may be asked to participate in a follow-up interview.

8. I understand that the following risks are involved: small risks of being misquoted and identified as the source of the comment. These risks will be mitigated by (a) circulating a draft interview/focus group manuscript for editing/elaboration; and (b) referencing your comments by sector, not by individual, and anonymizing interviewees using a letter/number system.

9. I understand that all research data will be stored securely in the University's secure storage system for five years from publication of the study results and then destroyed.

10. All questions I asked were answered to my satisfaction.

11. I understand that the researcher(s) will maintain confidentiality and that any information I provide to the researcher(s) will only be used for the purposes of the research.

12. I understand that the results of the study will be published so that I cannot be identified as a participant.

13. I understand that my participation is voluntary and that I may withdraw at any time without any effect.

14. I understand that once I have had the opportunity to correct the record, the information I have provided cannot be withdrawn, but that changes, clarifications and additional information may be provided.

Name of participant: _____

Signature of participant: _____

Date: _____

Interviewer's Statement

I have explained the project and the implications of his/her participation to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

If the investigator did not have the opportunity to speak to participants prior to their participation, the following items should be checked.

The participant was provided with the information sheet where my contact details were provided so that participants had the opportunity to contact me before consenting to participate in this project.

Name of Interviewer: _____

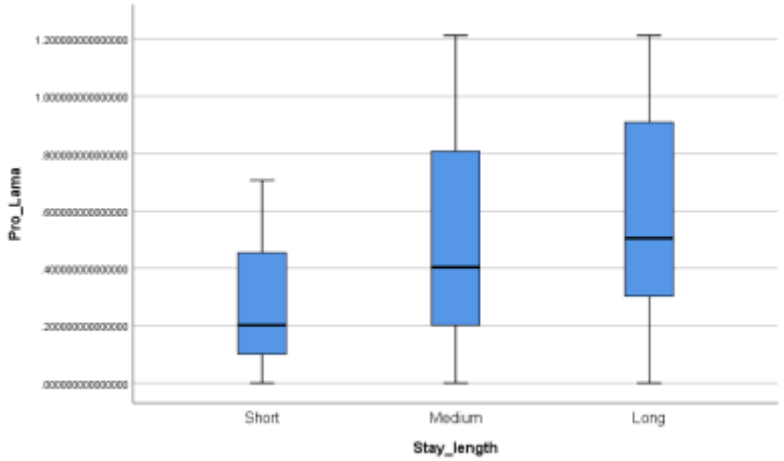
Signature of Interviewer: _____

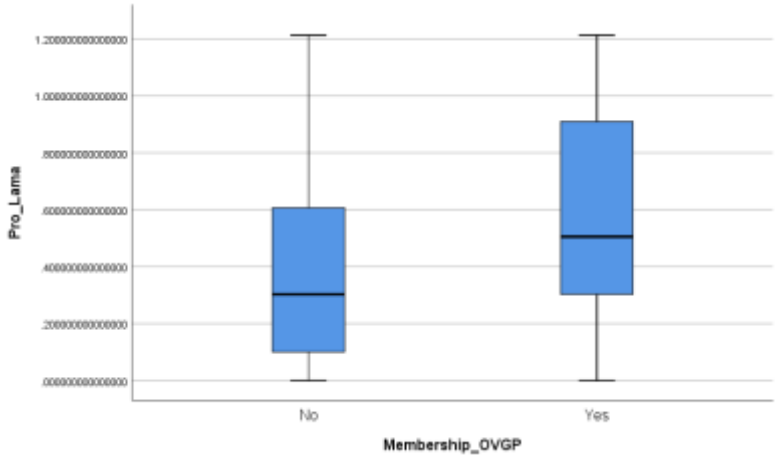
Date: _____

Appendix 2: Identification rate of categorical forest ecosystem services according to socio-environmental factors around the three forest reserves

Lama forest

Provisioning services

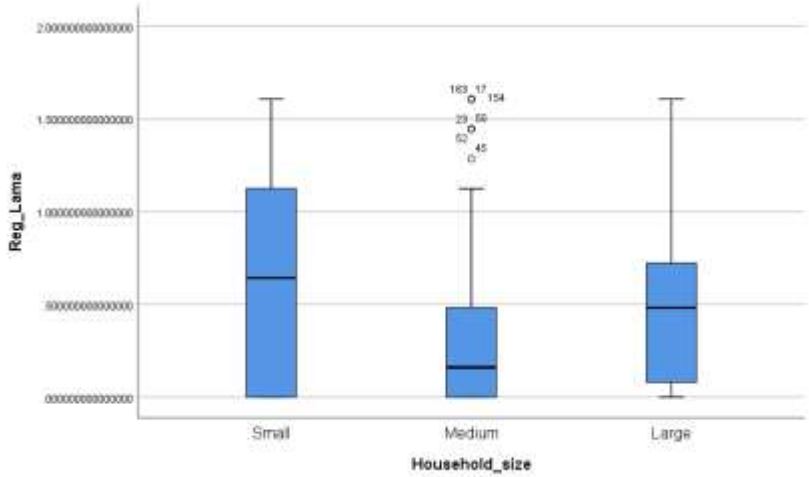




Descriptives

			Mean	Std. Error
Pro_Lama	Stay_length	Short	0.281071585419412	0.047926561837897
		Medium	0.511266511266511	0.044399662835523
		Long	0.603030303030303	0.036191335267457
	Membership_VPMO	No	0.368839914294460	0.037490767620510
		Yes	0.620135784070210	0.032483234277978

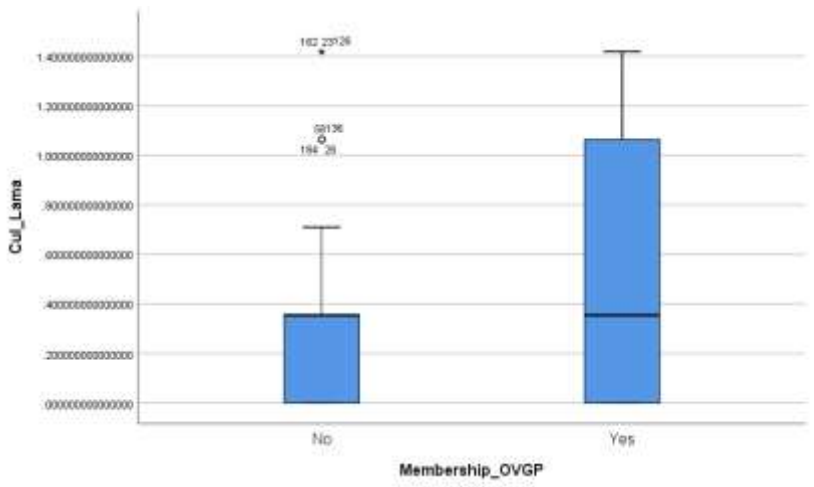
Regulating and supporting services

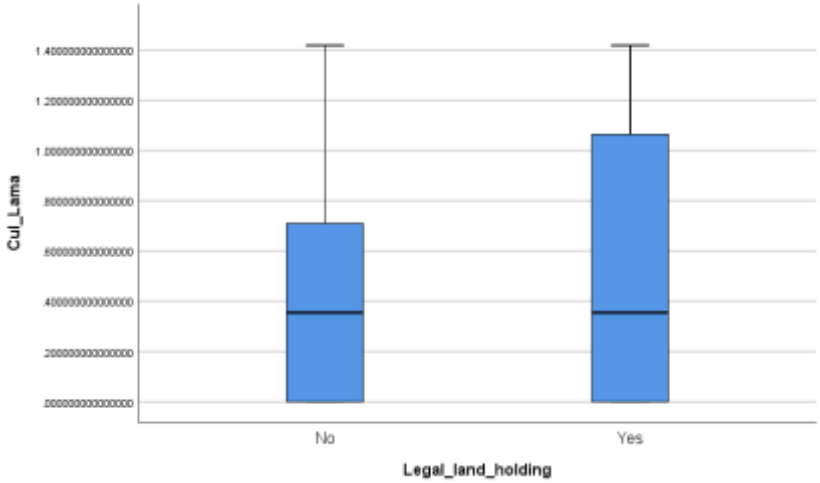


Descriptives

	Household_size	Statistic	Std. Error
Reg_Lama	Small	0.669542919939762	0.064599613398809
	Medium	0.382093790453919	0.054968039004348
	Large	0.552652733118971	0.082603947003130

Cultural services



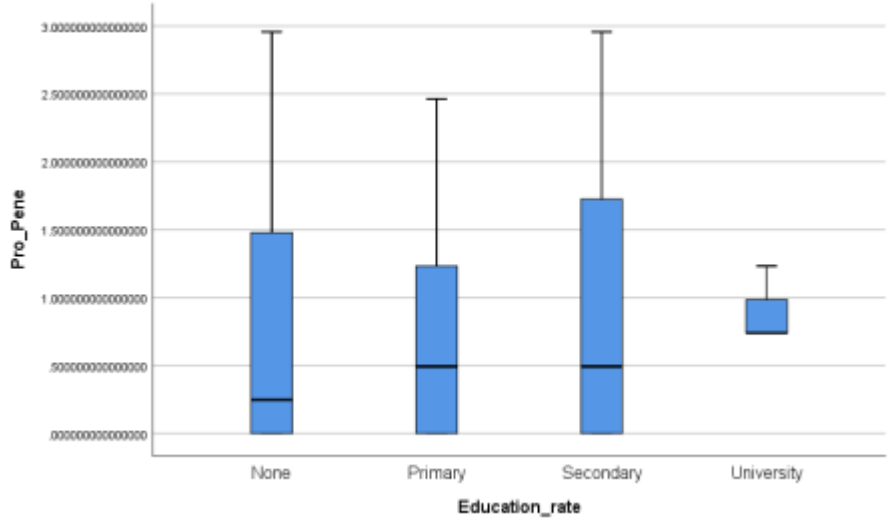


Descriptives

			Mean	Std. Error
Cul_Lama	Membership_VPMO	No	0.338491295938104	0.045575764543266
		Yes	0.636553889082665	0.050372883587332
	Legal_land_holding	No	0.465618254702436	0.044744785935577
		Yes	0.636354804235889	0.065608527294733

Penessoulou forest

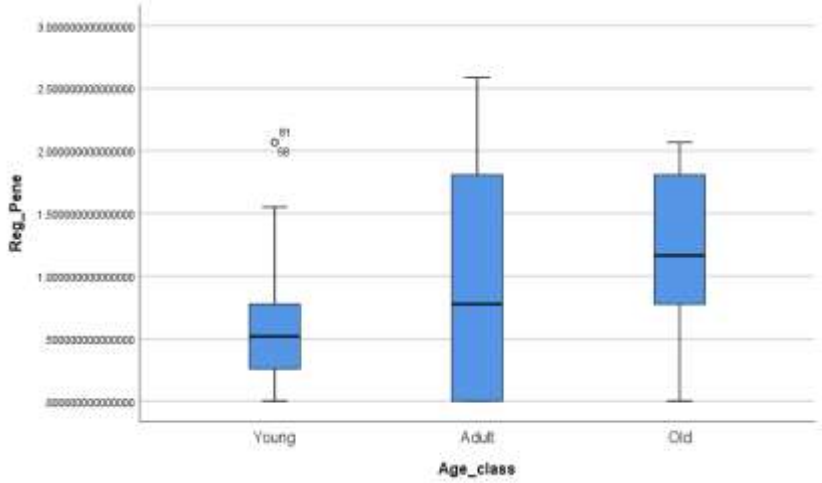
Provisioning services

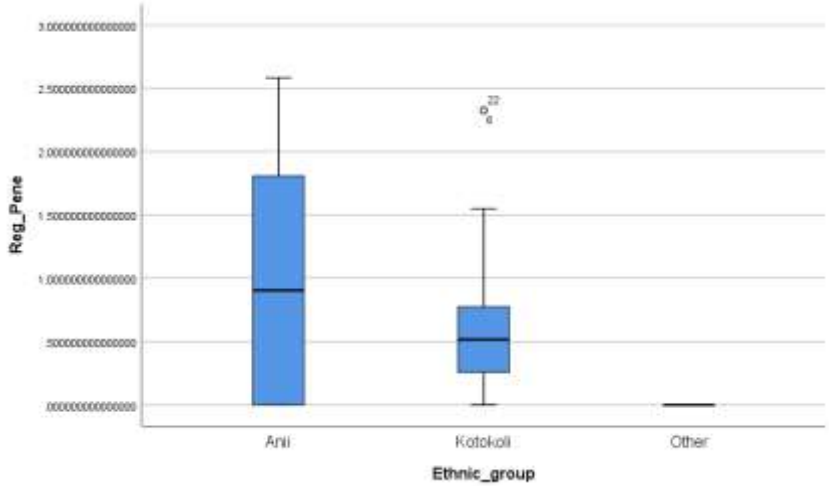


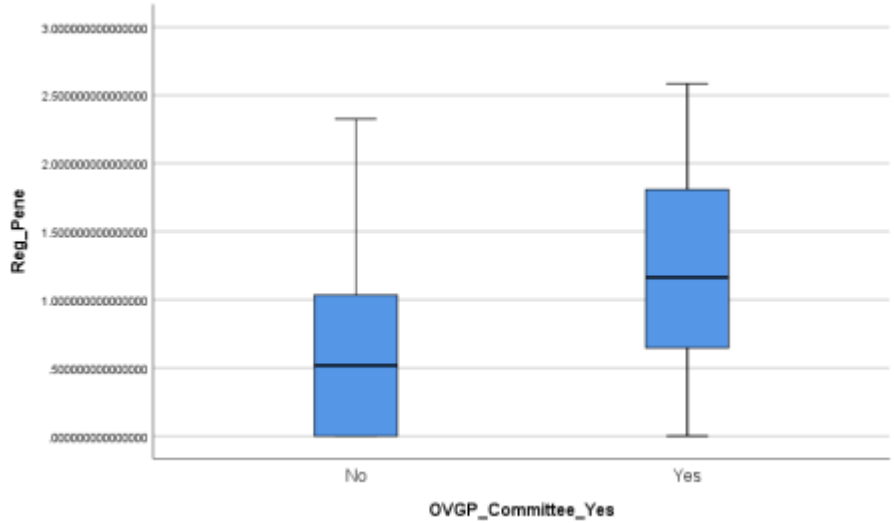
Descriptives

	Education_rate	Statistic	Std. Error
Pro_Pene	None	0.670969933752336	0.149160307389416
	Primary	0.687956514353661	0.149901160138634
	Secondary	1.078167115902965	0.151917850880981
	University	0.862068965517241	0.123152709359606

Regulating and supporting services



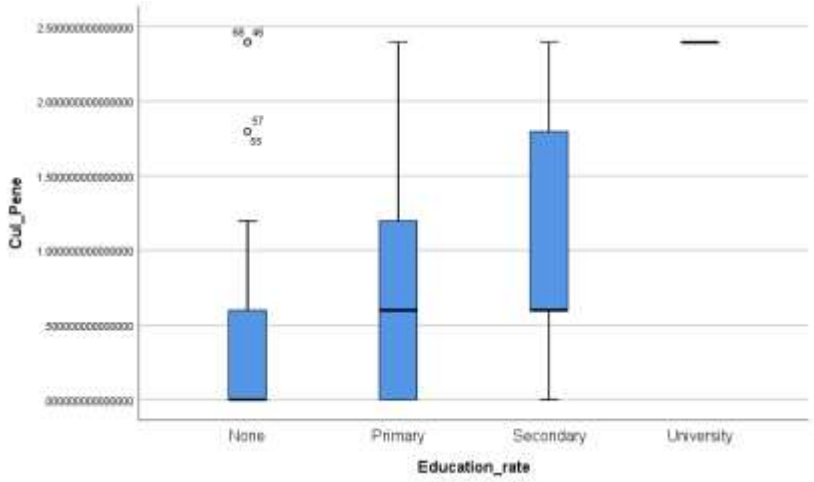


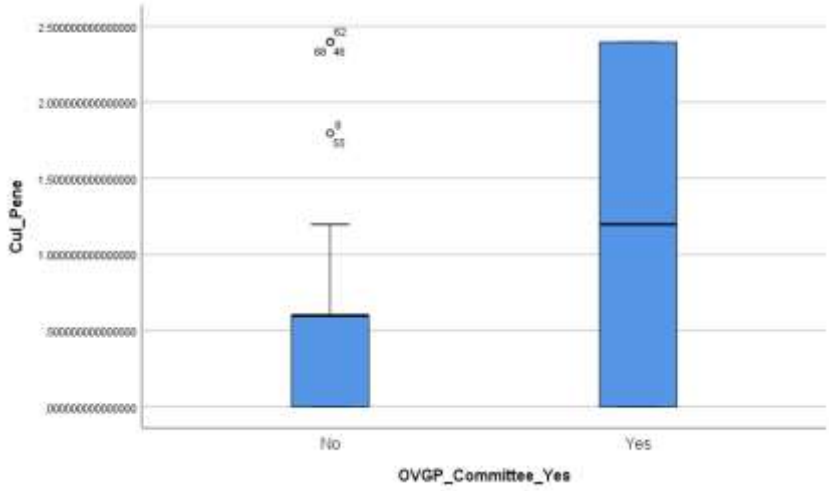


Descriptives

			Mean	Std. Error
Reg_Pene	Age_class	Young	0.617908100213459	0.125561999437064
		Adult	0.901241570555240	0.091919003511749
		Old	1.188630490956073	0.211683130533066
	Ethnic_group	Anii	0.988372093023256	0.093277195847797
		Kotokoli	0.654069767441860	0.104411615202929
		Other	0.000000000000000	0.000000000000000
	VPMO_Committee	No	0.651779860387983	0.084126873461935
		Yes	1.173557278208441	0.118682024062799

Cultural services



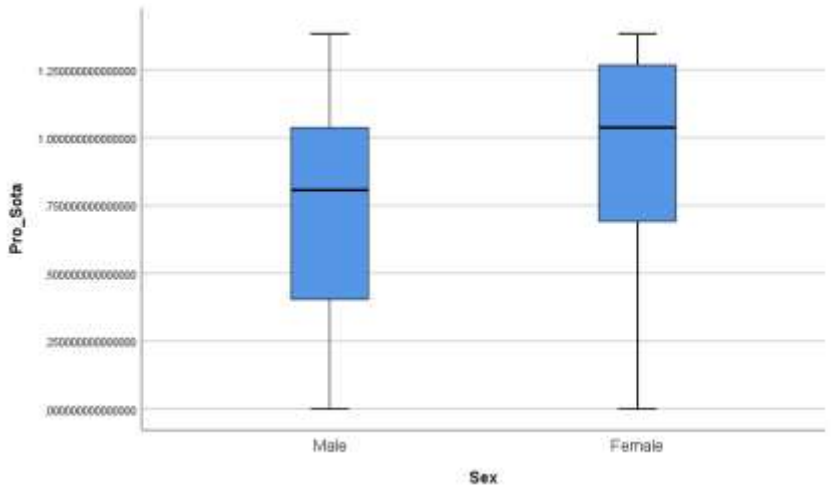


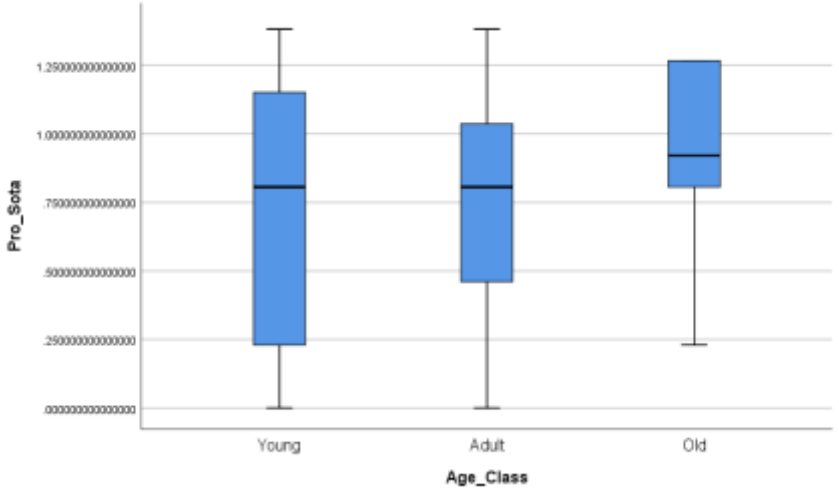
Descriptives

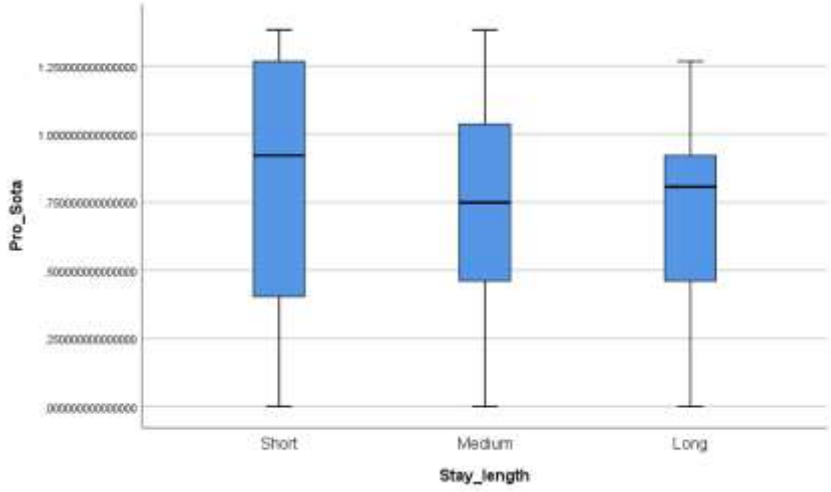
			Mean	Std. Error
Cul_Pene	Education_rate	None	0.578154036754078	0.150018124715512
		Primary	0.846582696675614	0.172049987568717
		Secondary	0.926448988814823	0.118060245377877
		University	2.395209580838323	0.000000000000000
	VPMO_Committee_Yes	No	0.625614442756278	0.085836910982801
		Yes	1.210079840319361	0.149689538952445

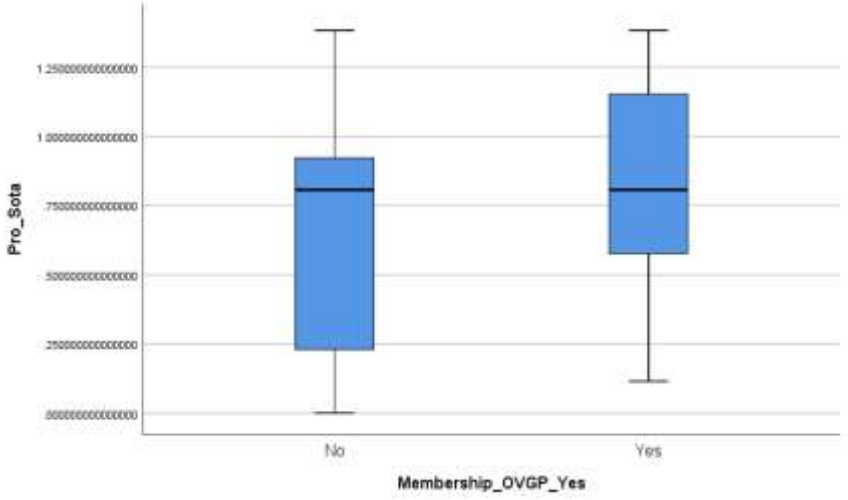
Sota forest

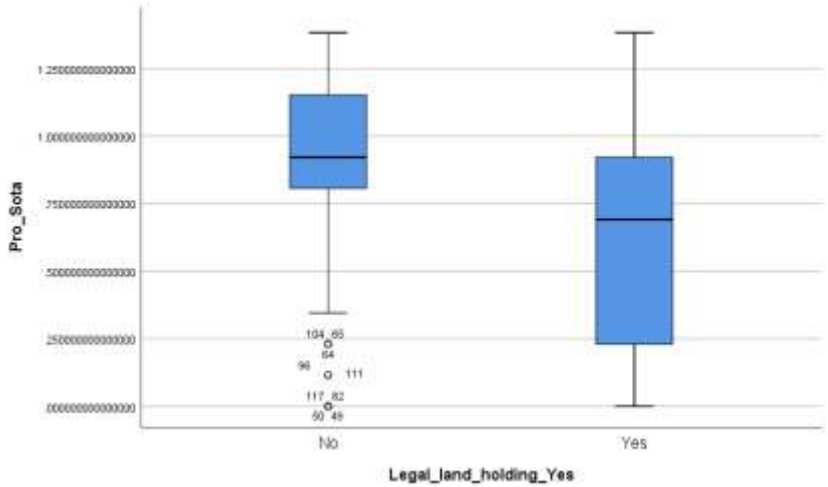
Provisioning services







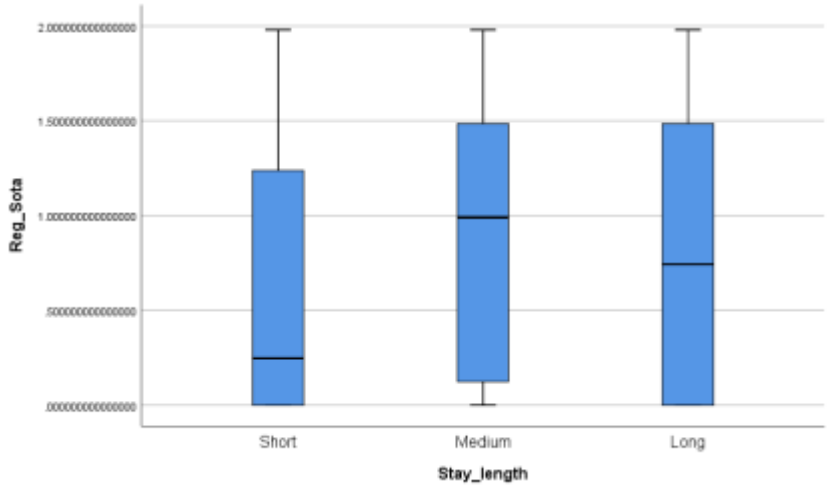


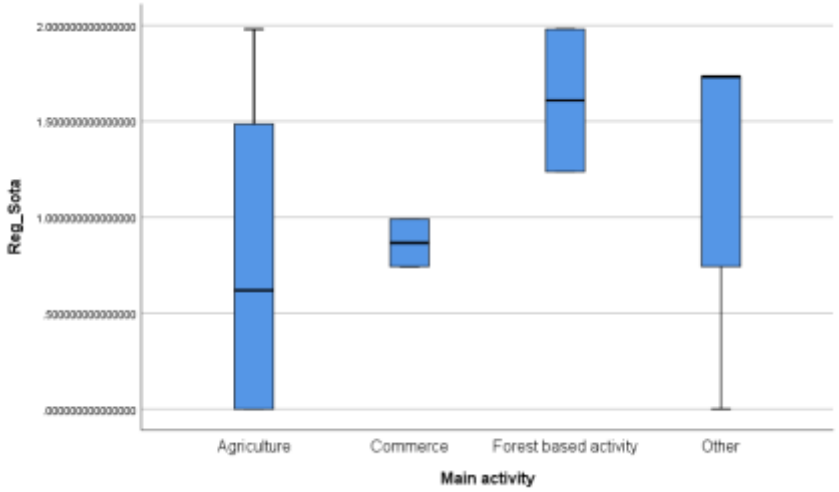


Descriptives

			Mean	Std. Error
Pro_Sota	Sex	Male	0.714712408260795	0.039194615656653
		Female	0.912442396313363	0.078679129396147
	Age_Class	Young	0.737327188940092	0.062539687189190
		Adult	0.750448028673834	0.043713910790402
		Old	0.902457757296467	0.155754990711776
	Stay_length	Short	0.844854070660522	0.066189893788341
		Medium	0.694444444444443	0.073078072585308
		Long	0.703000094046835	0.046093344470148
	Membership_VPMO_Yes	No	0.629800307219662	.058888956579205
		Yes	0.852218925572880	.039869737435550
	Legal_land_holding_Yes	No	0.862455197132616	0.044420933404810
		Yes	0.621364357482813	0.052930391233423

Regulating and supporting services

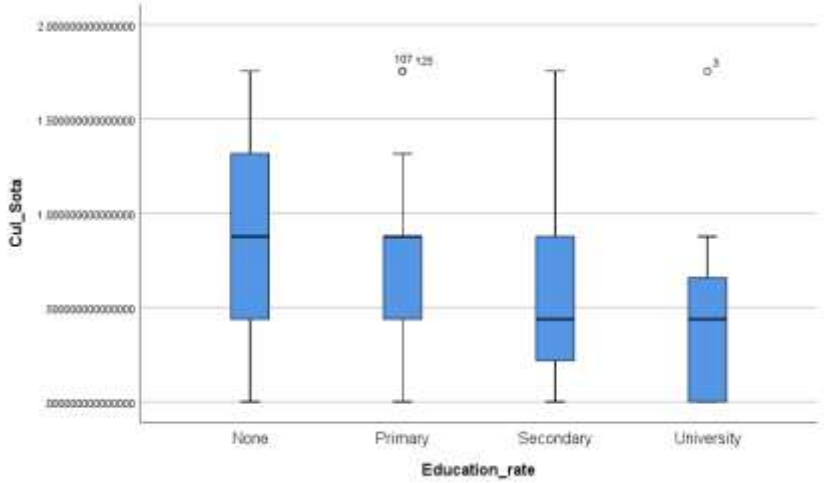


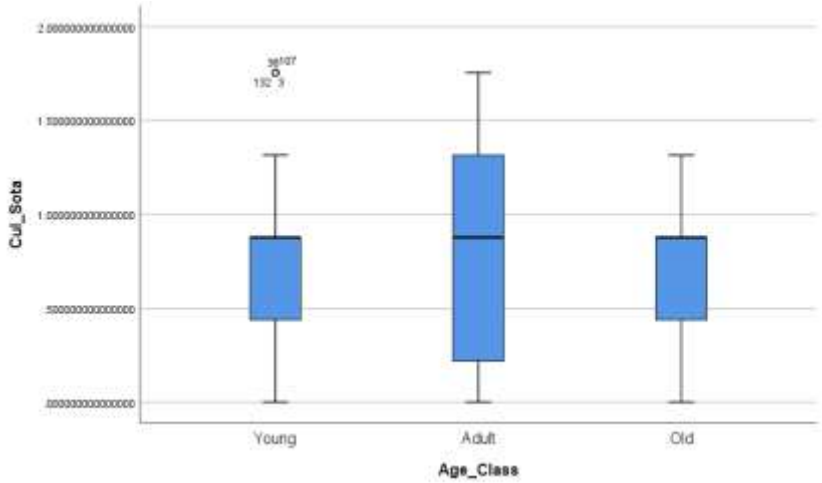


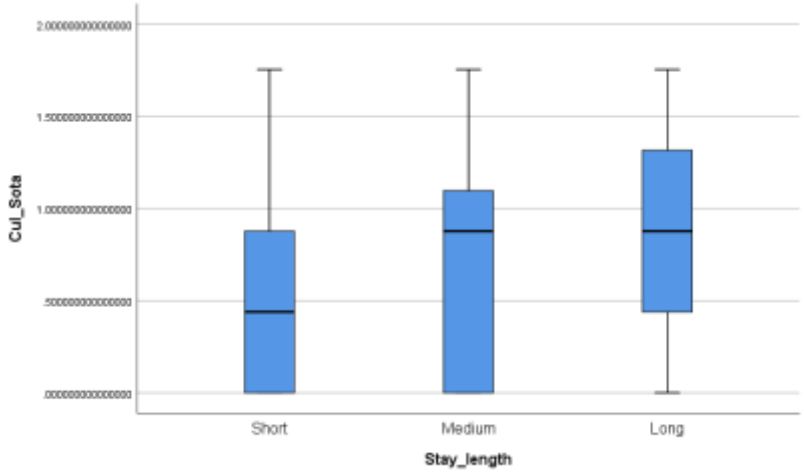
Descriptives

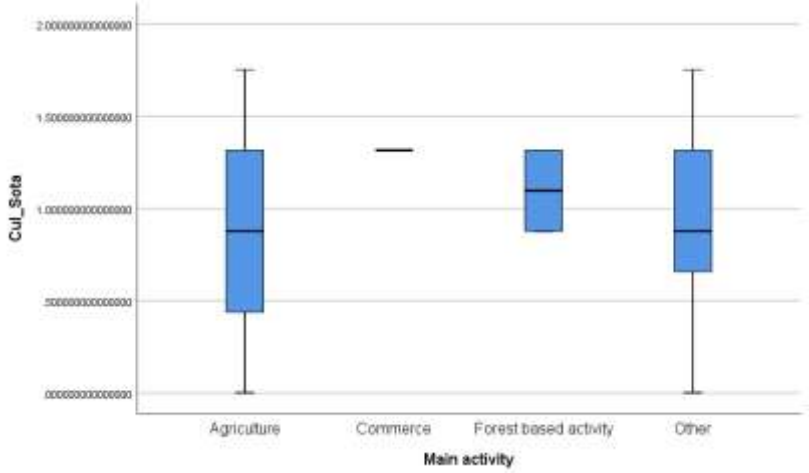
			Mean	Std. Error
Reg_Sota	Stay_length	Short	0.582714521452145	0.101718442335885
		Medium	0.914466446644666	0.110617093174281
		Long	0.798141038593656	0.105901471475230
	Main activity	Agriculture	0.710111994806039	0.063773062999114
		Commerce	0.866336633663366	0.123762376237624
		Forest based activity	1.608910891089109	0.371287128712871
		Other	1.202263083451202	0.312297060336911

Cultural services









Descriptives

			Mean	Std. Error
Cul_Sota	Education_rate	None	0.808662280701754	0.072587723241891
		Primary	0.781845919145690	0.099254248722694
		Secondary	0.686009896536212	0.090852020050429
		University	0.501253132832080	0.242668129461617
	Age_Class	Young	0.741626794258373	0.072764363521701
		Adult	0.761452241715399	0.069938804730191
		Old	0.730994152046783	0.184928518138502
	Stay_length	Short	0.648757309941520	0.077246709473553
		Medium	0.718810916179337	0.094348467288277
		Long	0.877192982456140	0.081894251991218
	Main activity	Agriculture	0.726200747771067	0.050736576385926
		Commerce	1.315789473684210	0.000000000000000
		Forest based activity	1.096491228070176	0.219298245614035
		Other	0.939849624060150	0.242668129461617

Appendix 3: Useful forest plant species local and scientific names

Appendix 3.1. Useful forest plant species identified around Lama forest

Scientific names	Plant names in Fon
Cassia siamea	Cassia
Dialium guineense	Assouinsouin
Dichapetalum guineense	Gbaglo
Anogeisus leocarpus	Hlinhon
Milicia excelsa	loko
Momordica charantia	Yinkinsi
Prosopis africana	Kakè
Afzelia africana	Abzelia
Sarcocephalus latifolius	Kodôo
Pterocarpus erinaceus	Kosso
Diospyros mespiliformis	Kenwi
Piliostigma thonningii	Clonman, Acloman
Abrus precatorius	Viviman
Daniellia oliveri	zouzou
Terminalia glaucescens	Alotoun
Anthocleista vogelii	Gotoun
Carissa spinarum	Ahanzo
Ceiba pentandra	Guédéhouzoun
Cleome gynandra	Akaya
Combretum molle	Djètin
Cymbopogon citratus	Tchaman
Harrisonia abyssiniea	Tohè
Isoberlinia doka	Kpakpa
Khaya senegalensis	Zounza, Zounhè
Kigelia africana	Gnanblipko
Lagenaria siceraria	Èka
Launaea taraxacifolia	Gnantoutou
Ocimum americanum	Késsoukéssou
Olax subscorpioidea	Mitii
Paullinia pinnata	Adakloma
Pterocarpus santalinoides	Gbègbèman
Rauvolfia vomitoria	Lèwé
Ricinus comminus	Gogozunkuin
Ritcheia capparoides	Alianhouansoué
Rourea coccinea	Vikploman

Senna alata	Amassou
Spondias mombin	Akounkon
Zanthoxylum zanthoxyloides	Hêtin

Appenedix 3.b. Useful forest plant species identified around Penessoulou forest

Scientific names	Name in Kotokoli	Name in Anii
Olax subscorpioidea	Féré	Goushibanta
Clausena anisata	Kakaoré	Gakirè
Uvaria chamae	Tchanmano	Gakolékolé
Pericopsis laxiflora	Sissina	Otalokpè/Gatoloukpè
Securidaca longepedunculata	Forzé	Gouminin
Zanthoxylum zanthoxyloides	Kelingnahou	Goukalowé
Bequaertiodendron oblanceola	Kéditia	Guigoungopi/Gagohoungopi
Pentadesma butyracea	Koolou	Guingourmin, M'Moramin (Anwornin)
Piliostigma thonningii	Bako	Gotchermè, Goutchérimè
Pterocarpus erinaceus		Goukpala
Xeroderris stulhmannii		Yobolofonon
Cassia sieberiana		Okamantchinin
Cyrtosperma senegalense	Kpaloo, kpalou	
Lannea barteri		Gobatayé
Milletia thonningii	Koudoulia	
Nauclea latifolia		Goranboh
Acacia nilotica	Filisikou (Isirirowa)	
Adansonia digitata	Kadara, Katara	Gotonbo, Gatongaboi
Afzelia africana	Kèemè	Guiyobolo
Albizia zygia		Okpakpalpè
Anogeisus leocarpus		Gokankla
Cola gigantea	Gorofodè	Goukoubô
Gymnosporia senegalensis	Tchapya, Nigalia	
Lophira lanceolata	Kprakpraka, bôbôtou-tôhôo	Goubolanlanh
Milicia excelsa		Iroko
Prosopis africana		Worokpè
Pseudospondias microcarpa	Kpaïkpaï	Goudjimpra
Swartzia madagascariensis		Otossoukpè
Trichilia emetica		Gokonalè

Appenedix 3.c. Useful forest plant species identified around Sota forest

Species	Plant names in Boo	Plant names in Mokole
Pterocarpus erinaceus	Kpinli	
Afzelia africana	Gbiili	Enkpa
Ceiba pentandra	Gbinli	Kpékpé
Combretum glutinosum	Gaakooli	Kowo
Cordyla pinnata	Gbanyé	
Daniellia oliveri	Gbinninli	
Isoberlinia doka	Gbalali	Sém
Securidaca longepedunculata	Guinzinan	Kpatafounfoun
Hymenocardia acida	Kpinninganan	
Voacanga africana	Gbèkanan	
Adansonia digitata	Fonli	Itché
Annona senegalensis	Monsoa	
Cassia siamea	Cassia	
Diospyros mespiliformis	Nin	
Lophira lanceolata	Kôôlè, kouè	Sém
Tamarindus indica	Sanma	
Burkea africana	Soh, Soo	
Cassia sieberiana	Sassilali	Wèguè
Detarium microcarpum	Boussounan	
Lannea acida	Baataanan	Tchémbé
Pericopsis laxiflora	Gbanyili, gbaaéli, souténanli	
Terminalia avicennioides	Bèlè	
Flueggea virosa	Gaaga	
Gardenia erubescens	Kanaan	

Opilia celtidifolia	Sawacoula	
Pavetta crassipes	Vouanzapili	
Protea madiensis	Zoukpaè	
Pseudocedrela kotschyi	Kounan	
Sarcocephalus latifolius	Défou	
Senna singueana	Guia	
Teleopsis suberosa	Tinmon	Émiatchon

Appendix 4. Comparison of ethnobotanical knowledge between the forests

Appendix 4.a. Comparison of the number of species cited among the forests

Characteristics		Number of species cited			
		Lama	**Penessoulou**	**Sota**	**Overall**
Gendre	Female	1.50±0.04b	**2.00±0.10**a	1.36±0.05c	1.50±0.03
	Male	1.59±0.02b	**2.50±0.05a**	1.62±0.02b	1.78±0.02
Age classes	Youth	1.71±0.05b	**1.80±0.09**a	1.29±0.02c	1.49±0.02c
	Adults	1.55±0.02c	**2.33±0.05**a	1.69±0.03b	1.75±0.02b
	Old	1.67±0.06c	**3.80±0.16**a	2.00±0.18b	**2.67±0.11**a
Household size	1-6 persons	1.57±0.03b	**2.43±0.08**a	1.54±0.03b	1.70±0.02b
	7-10 persons	1.45±0.02c	**2.17±0.09**a	1.67±0.05b	1.58±0.02c
	11-38 persons	1.93±0.06b	**2.59±0.07**a	1.60±0.04c	**1.98±0.03**a
Ethnic groups	Aïzo	1.44±0.03	NA	NA	1.44±0.03e
	Anii	NA	2.00±0.04	NA	2.00±0.04b
	Boo	NA	NA	1.69±0.03	1.69±0.03c
	Fon	1.66±0.02	NA	NA	1.66±0.02c
	Holly	1.36±0.03	NA	NA	1.36±0.03f
	Kotokoli	NA	3.13±0.09	NA	**3.13±0.09**a
	Mokolé	NA	NA	1.35±0.03	1.35±0.03f
	Others	1.50±0.07	2.00±0.00	1.50±0.09	1.56±0.07d
Seniority	1-20 years	1.27±0.03	2.67±0.09	1.43±0.04	1.72±0.04
	21-35 years	1.62±0.03	2.14±0.06	1.29±0.03	1.58±0.02
	36-75 years	1.63±0.03	2.44±0.07	1.81±0.03	1.84±0.02
Education level	None	1.45±0.03c	**2.60±0.11**a	1.72±0.03b	**1.82±0.03**a
	Primary	1.45±0.03b	**1.78±0.04**a	1.30±0.03c	1.48±0.02b
	Secondary	1.75±0.03b	**2.72±0.07**a	1.39±0.03c	**1.86±0.02**a
	Higher	1.00±0.00b	NA	**2.00±0.06**a	1.62±0.05b
Activity of subsistence	Agriculture	1.60±0.04	2.46±0.09	1.61±0.05	1.78±0.03b
	Livestock farming	1.80±0.06	2.43±0.15	1.82±0.07	**1.90±0.05**a
	Use of forest resources	1.63±0.04	2.75±0.14	1.63±0.05	1.75±0.03b
	Others	1.44±0.04	2.57±0.11	1.50±0.08	1.73±0.04b
Member of VPMO	No	1.70±0.04b	**2.29±0.06**a	1.58±0.03c	**1.78±0.02**a
	Yes	1.52±0.02c	**2.77±0.06**a	1.60±0.03b	1.71±0.02b
Overall		1.58±0.02b	**2.46±0.05**a	1.58±0.02b	1.75±0.01

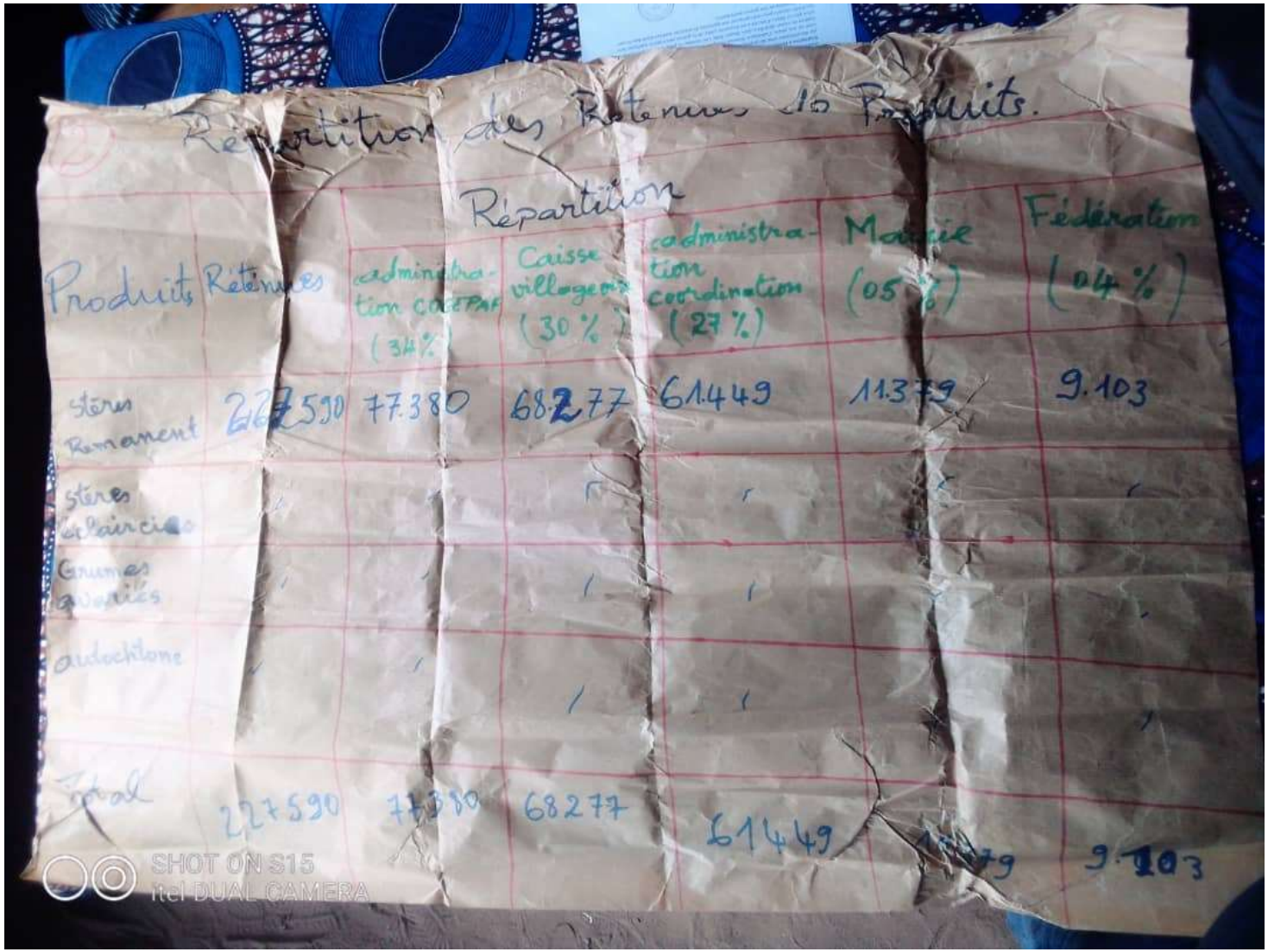
Appendix 4.b. Comparison of the number of parts of species used among the forests

Characteristics		**Number of parts of species used**			
		Lama	**Penessoulou**	**Sota**	**Overall**
Gendre	Female	1.17±0.08	1.00±0.00	**3.40±0.12**	**2.15±0.12**a
	Male	1.16±0.05	1.28±0.04	**2.02±0.07**	1.49±0.03b
Age classes	Youth	1.33±0.06	1.44±0.08	**2.55±0.14**	**1.94±0.08**a
	Adults	1.15±0.05	1.33±0.05	**2.11±0.08**	1.52±0.04b
	Old	0.60±0.11	0.95±0.07	1.62±0.31	1.06±0.09c
Household Size	1-6 persons	1.19±0.07	1.15±0.05	2.33±0.09	1.65±0.05
	7-10 persons	1.29±0.07	1.38±0.13	2.24±0.13	1.56±0.06
	11-38 persons	0.86±0.07	1.32±0.06	1.95±0.13	1.42±0.06
Ethnic groups	Aïzo	1.46±0.16	NA	NA	1.46±0.16d
	Anii	NA	1.19±0.07	NA	1.19±0.07f
	Boo	NA	NA	2.17±0.08	**2.17±0.08**a
	Fon	1.04±0.05	NA	NA	1.04±0.05g
	Holly	1.63±0.12	NA	NA	1.63±0.12c
	Kotokoli	NA	1.36±0.05	NA	1.36±0.05e
	Mokolé	NA	NA	2.04±0.12	**2.04±0.12**b
	Others	0.67±0.14	0.50±0.19	2.78±0.26	**2.00±0.22**b
Seniority	1-20 years	1.93±0.12	1.00±0.06	**2.33±0.12**	**1.72±0.07**a
	21-35 years	1.33±0.07	1.47±0.08	**2.82±0.16**	**1.77±0.07**a
	36-75 years	0.92±0.05	1.39±0.06	1.91±0.09	1.39±0.04b
Education Level	None	0.94±0.05c	1.35±0.05b	**1.99±0.09**a	**1.68±0.18**a
	Primary	1.10±0.06c	1.56±0.09b	**2.62±0.21**a	1.48±0.07b
	Secondary	1.19±0.06b	1.12±0.06b	**2.62±0.12**a	1.47±0.05b
	Higher	**2.67±0.38**a	NA	1.60±0.19b	**1.85±0.18**a
Activity of subsistence	Agriculture	1.17±0.09	1.26±0.08	2.22±0.14	1.54±0.07
	Livestock farming	0.98±0.08	1.35±0.09	2.25±0.18	1.53±0.09
	Use of forest resources	1.16±0.09	1.32±0.12	2.29±0.15	1.60±0.08
	Others	1.30±0.11	1.25±0.11	2.95±0.27	1.50±0.09
Member of VPMO	No	1.17±0.05c	1.15±0.05b	**2.01±0.08**a	1.54±0.04
	Yes	1.15±0.06c	1.44±0.07b	**2.55±0.11**a	1.57±0.05
Overall		1.16±0.04b	1.26±0.04b	**2.19±0.07**a	1.55±0.00

Appendix 4.c. Comparison of the number of parts of species used among the forests

Characteristics		Number of used parts cited by specie			
		Lama	**Penessoulou**	**Sota**	**Overall**
Gendre	Female	0.67±0.11c	1.00±0.00b	**2.73±0.12**a	1.67±0.11
	Male	0.89±0.03c	1.06±0.03b	**2.19±0.07**a	1.39±0.03
Age classes	Youth	1.17±0.06	1.22±0.07	2.36±0.11	1.77±0.07
	Adults	0.81±0.04	1.10±0.04	2.26±0.08	1.38±0.04
	Old	0.60±0.11	0.84±0.06	1.75±0.33	1.03±0.10
Household Size	1-6 persons	0.89±0.05c	1.12±0.05b	**2.35±0.09**a	**1.55±0.05**a
	7-10 persons	1.02±0.06b	1.15±0.11b	**2.22±0.11**a	1.38±0.06b
	11-38 persons	0.55±0.06c	0.98±0.04b	**2.15±0.13**a	1.29±0.06b
Ethnic groups	Aïzo	0.67±0.12	NA	NA	0.67±0.12
	Anii	NA	1.07±0.05	NA	1.07±0.05
	Boo	NA	NA	2.17±0.08	**2.17±0.08**
	Fon	0.76±0.03	NA	NA	0.76±0.03
	Holly	1.53±0.09	NA	NA	1.53±0.09
	Kotokoli	NA	1.06±0.03	NA	1.06±0.03
	Mokolé	NA	NA	2.40±0.14	**2.40±0.14**
	Others	1.00±0.00	0.50±0.19	2.56±0.16	**1.93±0.16**
Seniority	1-20 years	1.21±0.18b	0.91±0.05c	**2.48±0.11**a	1.62±0.07
	21-35 years	1.07±0.05c	1.20±0.09b	**2.50±0.12**a	1.52±0.06
	36-75 years	0.69±0.03c	1.11±0.04b	**2.06±0.10**a	1.29±0.04
Education Level	None	0.75±0.08c	1.00±0.00b	**1.99±0.09**a	**1.58±0.06**a
	Primary	0.79±0.07c	1.44±0.11b	**2.69±0.19**a	1.28±0.07b
	Secondary	0.97±0.04b	0.96±0.04b	**2.66±0.12**a	1.33±0.04b
	Higher	0.33±0.14b	NA	**2.30±0.25**a	**1.85±0.23**a
Activity of subsistence	Agriculture	0.90±0.07	1.05±0.06	2.28±0.14	1.41±0.07
	Livestock farming	0.79±0.07	1.18±0.10	2.32±0.17	1.44±0.09
	Use of forest resources	0.86±0.07	1.09±0.08	2.31±0.14	1.44±0.08
	Others	0.92±0.08	1.02±0.08	2.86±0.28	1.21±0.08
Member of VPMO	No	1.11±0.05b	0.98±0.04c	**2.12±0.08**a	1.53±0.04
	Yes	0.74±0.04c	1.17±0.05b	**2.54±0.11**a	1.29±0.05
Overall		0.87±0.03c	1.05±0.03b	**2.26±0.07**a	1.42±0.00

Appendix 5: Sharing of collected fund after the sale of the products in Lama forest plantation



Appendix 6: Some pictures of the field work

Appendix 6.1: Survey field work

a. Administrating the questionnaire to respondents

b. Focus Group Discussion

Appendix 6.2: Forest inventory field work

a. Tree numbering

b. Measuring the tree's DBH

c. Record of the tree measurements

d. Measuring the trees' heights

e. Plot installation

f. Rope delimiting the plot boundary

g. Burnt areas in Sota forest

h. Farmland inside Sota forest

i. Plants identification