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CONSERVATION BY LOCAL PEOPLE IN THE NIASSA NATIONAL RESERVE: MONEY OR IN-KIND PAYMENTS TO ADOPT CONSERVATION-FRIENDLY PRACTICES

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Abstract

The expansion of Protected Areas (PAs) has been considered as the main strategy to contain deforestation and forest degradation in Developing Countries (DCs), and protect most of the vulnerable and endangered species, including the large carnivores and herbivores of African Savannas. Mozambique is one of DC which has also embarked in this expansion of PAs, with a network of protected and conservation areas cover 45.68% of all-natural forest in the country. The Niassa Province cover most of the PAs in the country. In most of Mozambican PAs, there is also an unprecedented growth of human population, whose livelihoods depend on harvesting natural resources. Illegal and unregulated harvesting of natural resources imposes a great threat to biodiversity conservation in the country, which needs to be urgently addressed through policies aimed at changing people's behaviors to conserve biodiversity the country's PAs.

The Niassa National Reserve (NNR) is the largest PA in the country encompasses 5.3% of all-natural forest and 45% of the overall land under PA in the country. Using the NNR as a case study, we aim to explore policy ways to improve the conservation status of PAs in Mozambique and DCs in general, through identifying and analyzing the role of the drivers for local people engagement in activities that threat biodiversity conservation. We explore possible incentive measures that PAs residents may be willing to accept to collaborate with park authorities and other relevant stakeholders operating in the reserve. This main objective was addressed by surveying conservation experts spread through the country and local households in the NNR. As regards the expert survey, Cluster Analysis was applied to identify the different experts' views about to the main practices that threaten biodiversity conservation in the NNR, the underlining drivers for local people involvement with such practices, the main responsible for each practice and the effectiveness of the new proposed compensation measures. A cluster procedure was also used to identify the different

Livelihood and Farming Systems (LFS) prevailing in the reserve, based on data from the household survey. A Multinomial Logistic Model (MLM) was also estimated to understand the drivers of household choice of LFS.

Our results suggested that outsiders conduct most of the illegal activities that threat biodiversity conservation in the reserve (poaching, illegal logging and mining). At the same time, local people tend to engage in illegal activities that they need to carry out to cope with their daily needs. Most of the new in-kind incentives (e.g. provide animal protein, conservation related jobs opportunity and scholarships for the kids of PA residents), explored in the surveys, showed a greater acceptance from local people compared to those currently applied in the reserve. Moreover, livelihood systems were mainly driven by socio-economic factors, while FS were mostly driven by biophysical conditions. Finally, households who were employed and had diversified farming and off-farming activities, were better off, more resilient to climate change and crop raiding animals and held more conservation friendly attitudes.

Keywords: Conservation-threatening practices; illegal natural resource harvesting; Livelihood and farming system, socio-economic and biophysical drivers.

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Chapter 1

General introduction and conceptual approach

1.1. Introduction

In the last three decades, the expansion of Protected Areas in Developing Countries (DCs) has been growing fast, as the principal strategy for conservation and sustainable management of natural resources (Vedeld et al., 2012). However, in most PAs in DCs, there is also a parallel growth of human population, which is quite dependent on natural resource harvesting to cope with their daily needs (MacKenzie et al., 2017a). Thus, the future success of PAs will rely upon on how conservation managers and decision-makers delivering policy or management decisions that enhance the living standard of poor and marginalized people. Since their livelihoods depend on harvesting natural resources, while simultaneously reduce the impact of the anthropogenic activities on biodiversity. This requires designing conservation programs that are more attractive for PA residents, so that they can embrace conservation-friendly attitude and cooperating with conservation agents in tackling conservation problems. For conservation managers to set tangible and more realistic conservation objectives, they first need consistent guidelines for engagement of local people in nature conservation. In this regard, it is thus important to collect conservation expert knowledge and understand from the local people's point of view, what kind of incentives (money or in-kind) and related commitments will be more acceptable for PA residents which will be more likely lead to sign cooperation agreements with conservation agents.

Mozambique is a developing country with an extensive network of protected and conservation areas, that cover about 45.68 % of the Nation's forest land, Ministério da Terra, Ambiente e Desenvolvimento Rural (MITADER, 2018). The population in the country has been growing exponentially reaching out to 30 million in 2018, and it is expected to double by 2050 (Zinkina and Korotayev, 2014). Unfortunately, population growth is not an economic endowment for the country, since it is ranked in the bottom 10 poorest in the

world (United Nations, 2019). With most of rural and urban population depending on agriculture and forest to meet their daily needs (Zorrilla-Miras et al., 2018), and the with the projected growth population, the pressure on natural resources will likely rise in the near future (Mbanze et al., 2019; Wertz-Kanounnikoff et al., 2014), if the policies does not change to engage local people in conservation friendly attitude. The expansion of the PAs network is the country's main strategy to hinder deforestation and forest degradation (Ministry for Coordination of Environmental Affairs (MICOA, 2014)). However, there is still a lack of basic information that is needed to improve conservation policies. In order to help to fulfill the existing information gap, we used the Niassa National Reserve (NNR) as a case study to inform and propose new policies to improve conservation in Mozambique. We selected the NNR because it is the largest conservation area in Mozambique, accounting for 45% of the total extent of PAs in the country, and is also the third largest conservation area in Africa (Mbanze et al., 2019; Prin et al., 2014; Zafra-Calvo et al., 2018); in particular, it is one of only seven remaining PAs in the world that protect more than 1000 African lions each (*Panthera leo*)(Riggio et al., 2013); it also protects a substantial elephant (*Loxodonta Africana*) population. These two species are designated as vulnerable by the International Union for Conservation of Nature (IUCN). The number of local residents inside the NNR, who is natural resources dependent has been dramatically increasing in the last 10 years (NCP, 2017), which also contributes to exacerbate illegal harvesting activities.

This thesis aims at understanding what drives local people to engage or collaborate with illegal activities that threaten biodiversity conservation in the NNR and to explore possible incentive measures they are willing to accept to collaborate with park authorities and other relevant stakeholders to improve biodiversity conservation in the reserve. This overall objective was addressed through specific analyses and discussions that composes

the six chapters of this thesis. In this first introductory chapter, we provide the readers with a review of the relevant literature that is the backbone to understand what lays behind the research. We start by contextualizing the importance of consensual (vs contradictory) of views between PA residents and conservation experts as regards a range of different conservation-related topics, including the identification of the most conservation-threatening practices and the drivers for local people involvement in these (mostly illegal) practices. We then move forward by addressing the challenges for local people of living within a PA, the lack of incentives and the type of incentives that are needed to promote conservation-friendly behavior in the future, as well as the analytical framework and the research questions of the thesis are also discussed in this introductory chapter.

Since we had lack of basic and consistent information about e.g. major conservation threats, main actors related to each threat, policy options that should frame our dialogue with PA residents on the ground, we devoted the second and the third chapters of this thesis to discuss what we have found out, from conservation experts with deep knowledge about conservation policies under implementation in Mozambique. The experts were requested to provide their views as regards the role of local people in major threats to conservation, the drivers for PA residents' involvement in such threats, and appropriate policies to address these drivers. The information was useful to triangulate with the household's opinions which are discussed in the fourth and the fifth chapters of this thesis. The aim of the fourth chapter was to assess the available management options for local households in the NNR which have been described as different livelihood and farming systems; the factors that drive these agents' choice for livelihood and farming system, are also analyzed in the fourth chapter, as a ground on which policymakers can build appropriate measures to improve conservation in the reserve through behavior change. In the fifth chapter, we use a spatial-based approach

and the indirect questioning to local residents to understand how the perceived costs and benefits of living inside a PA can lead households to participate in illegal resource harvesting activities. In the last chapter, the general conclusions, including the management implication of our findings, are drawn.

1.2. General objectives and research questions of the thesis

This research aims to understand which current practices threatening biodiversity conservation in the NNR, the drivers of local people involvement in such practices and possible incentives and compensations that can be implemented to make local residents adopting of conservation-friendly behaviors by local residents. To comprehensively address this goal, the following specific objectives were set:

i) Understanding the role of local people in the major threats to conservation and the underlying drivers for their involvement in conservation-threatening practices;

ii) Identifying the available management options in the NNR for local households and, describing them as different Livelihood and Farming Systems (LFS); identifying the factors that drive the agents' choice among the available LFS options; use this knowledge about LFS drivers to discuss appropriate incentives for local people to cooperate in biodiversity conservation through their productive choices, and,

iii) Understanding how the perceived costs and benefits of living inside a PA can lead local people to participate in illegal resource harvesting, by using a spatially-based (village level perceptions) approach that uses non-sensitive and indirect ways of questioning local residents about participation in illegal activities.

Each objective was addressed through a set of research questions, as follows:

i.a) Is there a consensus or diverging views among conservation experts about the drivers of local people involvement in conservation-threatening practices and the different incentives needed to change local people´s behavior?

i.b) Are experts' views more related to the conservation research literature about a specific PA, for instance, the NNR or to overall narratives about conservation in DCs?

i.c) Can the different experts' views be explained by the expert's background and experience in conservation?

ii.a) Which land management options among the existing LFS options offer a higher potential for diversification and intensification strategies aimed at improving livelihoods and local food security?

ii.b) Which are the factors driving local agents to choose these LFS options?

ii.c) Are there any factors that contribute to agricultural intensification or land expansion in the NNR? What are the implications of agricultural intensification and expansion for local agents and biodiversity conservation?

iii.a) Are there significant spatial associations between village-level perceived costs and benefits of living in a PA, opinions regarding conservation policies and incentives in the NNR, and the likelihood of participating in illegal resource harvesting?

iii.b) Can local people's undervaluation of the impact of illegal harvesting on conservation (when compared to experts' views on the same subject) be used as an indirect indicator of their involvement in these illegal activities?

The three specific objectives and research questions related to each of them are addressed in the next four chapters of the thesis. The conceptual framework of the research workplan in Figure 1 gives a broader overview of the steps followed to fulfill the overall and specific objectives of the thesis.

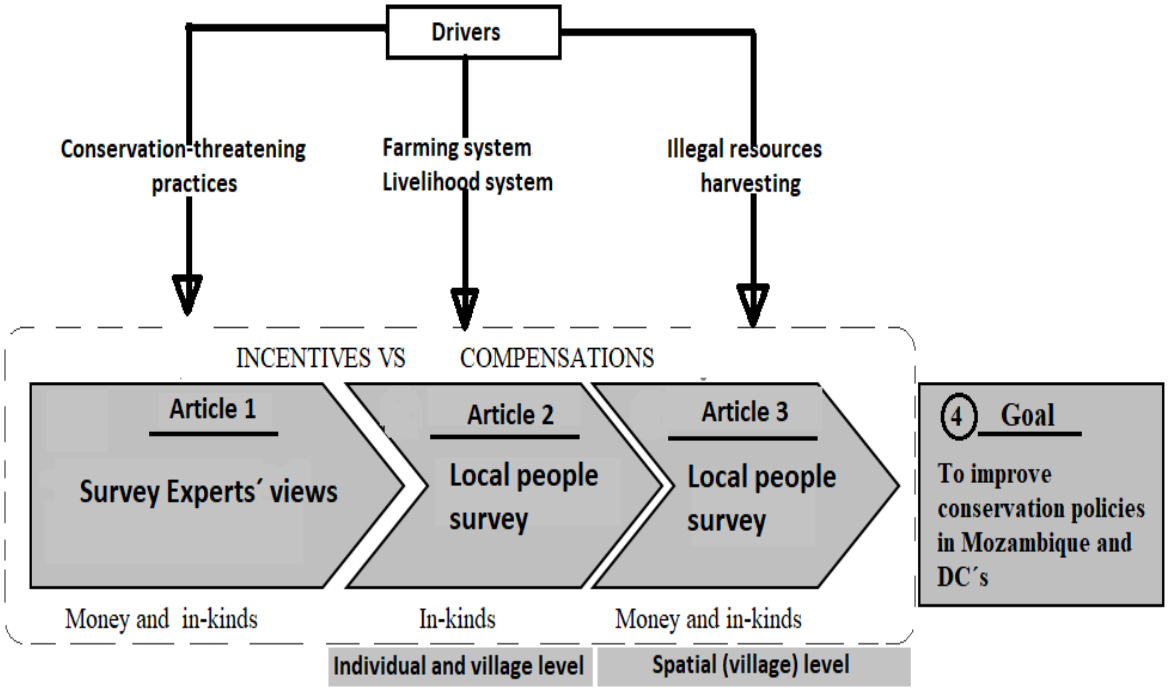

Figure 1.1. Research framework outlining the steps of the work: 1) Experts´ views on the reasons for local People engagement in conservation-threatening practices and the effectiveness of the current and new proposed compensation measures to improve pro-conservation behavior; 2) Analysis of LFS approach to improve pro-conservation behavior in the reserve; 3) The role of perceived costs and benefits of living inside a PAs and its implications for illegal Harvesting participation; 4) The goal of the research is to propose management options and policies to improve conservation in the reserve, by engaging local people in pro-conservation behavior

Step 1 – Conservation threatening practices: this task aims to understand the role of local people in major threats to conservation, the drivers for their involvement in

conservation-threatening practices and effectiveness of current and proposed new incentives to engage local people in conservation-friendly practices. This task was accomplished through surveying 55 experts engaged in conservation in Mozambique and covered by the second and third chapters of the thesis, which also generate two papers published in the Journal for Nature Conservation and Data in brief journal (*An expert-based approach to assess the potential for local people engagement in nature conservation: The case study of the Niassa National Reserve in Mozambique and Dataset from 55 experts engaged in nature conservation in Mozambique*). Results from these chapter were useful to draw the household survey that was used in the next steps.

Step 2 – Livelihood and Farming systems: The typologies of LFS at household level, and their representation at the village (spatial) level, were based on a survey of 339 households living in seven villages within NNR. Cluster analysis was used to identify the four livelihood types of gatherers, hunters, farmers and employees, based on the effort of harvesting different NTFPs in relation to farming; farming system types (specialized farming system of maize, rice and sorghum, and one mixed farming system) were identified based on agricultural inputs and outputs. A Multinomial Logistic Model (MLM), was also applied to understand the drivers of LFS choice. The methodology, results and discussion from this step, presented in chapter four; resulted in one paper intitled: *A Livelihood and Farming System approach for effective conservation policies in Protected Areas of Developing Countries: The case study of the Niassa National Reserve in Mozambique*. The paper was submitted to Land Use Policy Journal and a revised version is being developed to answer all the reviewers´ comments.

Step 3 – Illegal harvesting: This step was accomplished by asking local households about their perceived impact of several activities on biodiversity conservation (illegal

harvesting of natural resources). Other evidence was also used, such as the perceived costs and benefits of living within the PA, and their opinions about conservation measures under implementation in the reserve. The information from the previous three chapters were also useful to complement this step. The Chi-squared and Kruskal-Wallis tests were applied to investigate statistical differences across villages, for each major theme related to the costs and benefits of living within PA, including the likelihood of involvement in illegal harvesting. The results from this step are presented and discussed in chapter 5, which also generated one paper intitled: *"Participation in illegal harvesting of natural resources and the perceived costs and benefits of living within a protected area***",** which is under review in Ecological Economics Journal.

Step 4 – To improve conservation and policies in Mozambique and DCs: The results from the previous steps were used to generate broader conclusions and advice to conservation managers and decision-makers on how to improve conservation in PAs of developing countries. A general reflection about the present research and recommendations for future research are also discussed in this step, which is the last, conclusive chapter of the thesis.

1.3. Theoretical background and conceptual approach

The global consensus on the importance of biodiversity conservation and the need for sustainable management of natural resources has been built in numerous international and local agreements and strategies (e.g. 1990s Convention on Biological Diversity and 2003 World Summit on Sustainable Development-WSSD); (CBD, 2003; Dungumaro, 2013). Stopping species extinction and protecting a proportion of land area have been set as explicit targets (Vedeld et al., 2012). Yet, over-exploitation of environmental goods and services has increasingly threaten animal and plant species, due to increasing anthropogenic

pressures and multiscale environmental disturbance (Sapkota et al., 2018). The failure to protect habitats from degradation and conversion, or species from decline and extinction, has forced scientists and decision-makers to adopt an holistic approach, including the recognition and incorporation of local-people needs in management decision (Primmer et al., 2015). Community Based Natural Resource Management (CBNRM) and Payment for Ecosystem Services (PES) are increasingly recognized as effective incentive policies to improve community participation in sustainable natural- resources use and PA management programs. Although to some extent, there are reports of successful cases (Pokharel, 2012), there are also many stories of failure (Calfucura, 2018), as in many conservation areas in Mozambique (MICOA, 2014; Muarapaz, 2016). In this regard, it is thus important to understand what factors drive local people within PAs to engage in conservation-threatening behavior, their views about the policies under implementation and what costs and benefits they perceive as resulting from living inside a PA. This understanding is essential to assist decisions-makers to improve conservation outcomes by adopting policies that can be more easily accepted by local communities and that can enroll the participation of PA residents in the required conservation effort.

1.4. Conservation threatening practices and their drivers: the need to understand the views of key conservation actors to draw consistent conservation guidelines

Identifying conservation-related topics where there is consensus (or lack of it) among conservation experts and between them and local people in PAs of DCs is important, for several reasons: First, local people are the ones who face the daily challenges and restrictions that are imposed by conservation. Since the management of natural resources in most DCs is still implemented through a top-down command-and-control approach (Mapedza, 2007; Sapkota et al., 2018), natural-resource-dependent people are more often

voiceless about the possible incentives and commitments they may be willing to accept to insure sustainability in natural resource use. Meanwhile, in recent years, several authors have been advocated a CBNRM as a mean to empower local natural-resource-dependent people in the management decision (bottom-up approach) (Stringer et al., 2012). Second, local economic agents who live inside PAs, in both developed and developing countries, are human beings who need to fulfil their daily needs. The main difference is that people in DCs are more willing to engage in illegal practices to cope with their needs due to lack of alternative income sources and poor conservation payment schemes (Zafra-Calvo and Moreno-Peñaranda, 2018). Third, despite the fact that expert opinion is key to improve conservation decisions and to shape public opinion (Lute et al., 2018; Selge et al., 2011), most expert views are based on the general narrative about conservation in PAs of DCs, coming from international organizations and environmental NGO´s, often not compatible to the local context and required solutions for a specific PA and people living within. Fourth, conservation decisions are often more dependent on expert advice than on direct consultation to local people or scientific research (Lute et al., 2018; Moreto, 2019; Pasgaard et al., 2017). So, understanding the points of consensus (and lack of it) between local people and experts can serve as a starting point for both parts to grasp the need for deeper and cross-check research to provide the grounds for consistent policy proposals that will more likely be accepted and/or adopted by PA residents.

Local people in PAs of DCs are often directly or indirectly involved in practices that threaten conservation such as: poaching, hunting for bushmeat, illegal extraction of park resources, human and wildlife conflict (HWC) (Mackenzie and Ahabyona, 2012; Moreto, 2019) and shifting cultivation (Galvin et al., 2006). The reasons for such involvement include: i) retaliation from restrictions that are imposed by the PA authorities; ii) retaliatory

killing of crop and livestock raiding animals (Baral and Heinen, 2007); iii) lack of involvement in park management and, iv) lack of alternative and decent livelihoods (Shepherd and Magnus, 2004). To date, most of these drivers are poorly understood for many PA of DCs, in particular in Mozambique and within the NNR. However, its believed that these drivers act combined in a multifaceted and complex manner (Campbell-Smith et al., 2010; Campbell et al., 2000; Dickman, 2010; Moreto, 2019; Travers et al., 2019), with its own peculiarities, depending on space and time (Galvin et al., 2006). Thus, achieving long-lasting conflict resolution in the NNR will rely upon policy-makers and conservation experts to embrace in a much broader and holistic approach, which in turn requires more in-depth knowledge on the role of those drivers, to propose conservation policies that address them. In fact, each one of these drivers of conservation-threatening practices needs to be addressed through specific policies that promote the required behavior changes.

Most policies and incentives for changing local people behavior and actions towards a conservation-friendly direction have already been spotted in the scientific literature review and particular cases studies. They generally relate to (i) sharing the benefits of conservation with local people who bear most of the conservation costs (Adams and Hutton, 2007; Campbell et al., 2000; Galvin et al., 2006); (ii) providing local people with alternative sources of income, especially when their crops and livestock are systematically raided (Mackenzie, 2012; Moreto, 2019; Shepherd and Magnus, 2004); (iii) improving and assisting local people with mitigation measures to alleviate negative externalities of crop and livestock raiding (Travers et al., 2019) and (iv) promoting environmental education to raise awareness of local people regarding the importance of intangible benefits of conservation (Dickman, 2010; NCP, 2017).

1.5. Costs and benefits of living around or inside protected areas in developing countries

Social support is one of the key factors that determine the success of PAs. The balance between the costs and benefits that people perceive as related to the existence of established PA influence their support for conservation activities (Zorondo-Rodríguez et al., 2019). Thus, the benefits of nature conservation must be balanced with socioeconomic activities and opportunities developed in the same areas (Adams et al., 2010; Chen, 2019). In this regard, the selection of priority areas for nature conservation must strike the right balance between the costs and benefits of conserving biodiversity, protecting Ecosystem Services (ES), and allowing for human activities including natural resource use. PAs characterized by lower population densities, with low opportunity costs of conservation, have potential to decrease the overall use of natural resources and improve the cost efficiency of biodiversity conservation effort (Manhães et al., 2018).

Many ecosystem services in the NNR are mostly used as *open access (common pool) resources*. Open access resources are fast depleted, since one cannot prevent others from using the same resources (non-excludable), which could lead to overexploitation, leaving less and less to others (because the resources are rival). This is the typical case of most provisioning services (Fisher et al., 2009). However, conservation programs aim to promote sustainable use of ES, by: i) identifying alternatives that can generate long term and sustainable benefits for local communities (e.g. employment); and, ii) other environmental friendly uses, such as ecotourism or sustainable intensification of agriculture practices, which in turn may depend up on interaction and feedback among actors.

People living around and inside the PA can earn many direct and indirect benefits. These benefits may include: i) infrastructures, opportunity for business and employment,

benefit-sharing schemes, and sustainable extraction of park resources (MacKenzie et al., 2017a, 2017b); ii) revenues from tourism and recreation services (Heagney et al., 2019; Karanth and Nepal, 2012); iii) enjoyment of cultural ecosystem services (Martinez-Harms et al., 2018; Palomo et al., 2013); iv) direct use of provisioning services (water supply, fodder, and genetic resources); v) regulating services (water purification, carbon storage, and control of erosion) (Manhães et al., 2018; Palomo et al., 2013) and vi) supporting services (water balance, net primary productivity, and soil fertility); (Manhães et al., 2018). But, local PA residents can also accrue high burdens for park establishment, especially when conservation managers do not provide the desirable benefits nor even offset the costs from crop and livestock raiding (Vedeld et al., 2012). These conservation costs include: i) crop losses and livestock raiding (Fraser-Celin et al., 2018; Hill and Wallace, 2012; Mackenzie and Ahabyona, 2012; Rogan et al., 2018, 2017; Vedeld et al., 2012); ii) increased risk of injuries and casualties from wild animal attacks; iii) time and effort lost in crop guarding (Hill, 2000; Mackenzie and Ahabyona, 2012); and, iv) restrictions on resource extraction (Dickman, 2010).

In most PAs of DCs, local households are in general willing to support conservation measures if their daily livelihood needs are met (Karanth and Nepal, 2012). Understanding the dynamic nature of local people's perceptions about costs and benefits they accrue for living closer or inside PAs, provides a tool to adapt PAs management plans, prioritize conservation resources, and engage local communities in conservation goals (MacKenzie et al., 2017b).

1.6. The role of incentives in promoting conservation-friendly behavior in NNR: money or in-kind payments?

Conservation incentives are important to ensure the sustainable use of ecosystem services and offset the costs of park restrictions for those who are entirely dependent on the extraction of park resource to support their livelihood (Aheto et al., 2016; Amin, 2016; Bluwstein and Lund, 2016; Narloch et al., 2014; OECD, 2010). In DCs, the larger part of incentives that are given to local people is funded by international donors, tourism activities and some local non-governmental NGO´s (Amin, 2016). The benefits arising from conservation can be easily allocated individually or collectively (OECD, 2010), its disbursement depends on the periodical assessment of the PA performance, through performance-based indicators (NCP, 2017).

In the NNR, most of conservation funding, including that used to pay compensations to the local people, come from international donors and conservation revenues (Massuque, 2013; NCP, 2015), which are either allocated through private organizations (e.g. Wildlife Conservation Society (WCS), NCP and others), that operate directly in the reserve, in close collaboration with the governmental institutions (Ministry of Environment, Agriculture and Tourism). The funds are mostly used to run the reserve, including, payment of administrative costs; building and improving infrastructures, capacity-building, range patrol and improving the local communities' wellbeing. This dependency from international donors constraints conservation activities, as currently tourism activities do not generate enough funds, despite its enormous potential, including its vast extension (Booth, Vernon R.; Dunham, 2014). For instance, the NNR has double-fold extension of the Kruger National Park, which is considered the most profitable PA in Africa (Michel et al., 2006).

For sustainable conservation of NNR ecosystem services, it is first important to ensure the self-sufficiency of park activities through e.g. tourism services, which might cover in the future a significant share of the conservation costs. Since there are so many uncertainties about the future, such as the possibility of other emerging humanitarian priorities (e.g. refugees in Syria and Iraq and hunger in South Sudan, Somalia, Nigeria, Chad and Myanmar), as well as the unpredictable behavior of most large donors (E.g. American first in the US and the emerging of populist parties in Europe).

Non-monetary incentives can either be generated locally by the ecosystem itself (e.g. resource harvesting, landscape enjoyment and welfare increase), or by converting the received funds into in-kind incentives (e.g. providing scholarships, capacity-building in conservation agriculture or business management), that will be allocated to local people. Whether monetary or in-kind, incentives may be allocated collectively or individually. The right choice among these two options still generates a vibrant debate and depends on several factors including local culture, religion and education, social ties, motivation for conservation, trustiness among different conservation actors, corruption and the way that population is spatially-disposed inside or around a PA, among others. For example, Narloch et al. (2014) found that in Bolivian and Peruvian Andes conservation project the collective payments seem to provide stronger conservation incentives than individual payments.

According to the Mozambican legislation, conservation incentives are mostly allocated collectively once a year. They are mainly a share (usually 20%) of the revenue earned through taxes payed by the operators of hunting concession and other touristic activities (Wertz-Kanounnikoff et al., 2014). The governmental authorities are responsible for collecting the money for later distribution to local people (Massuque, 2013). However, this procedure still constrains conservation, as the majority of local beneficiaries would like

to directly receive the 20% from the concession operators, because conservation transaction costs and lack of transparency dilutes most of the money. The money is mainly used to support community development initiatives (SRN, 2008).

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Chapter 2

An expert-based approach to assess the potential for local people engagement in nature conservation: The case study of the Niassa National Reserve in Mozambique

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An expert-based approach to assess the potential for local people engagement in nature conservation: The case study of the Niassa National Reserve in Mozambique

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Abstract

Implementation of new conservation measures without consistent consultation with key stakeholders has resulted in multiple failures that have been replicated elsewhere. In this study, we propose and test an improved method to identify: (i) the role of conservation actors (including local people), in major threats to conservation in a particular Protected Area (PA); (ii) the underlying drivers for the involvement of local people in conservation-threatening practices; and, (iii) appropriate policies to address those drivers. The method was developed and tested in the context of the Niassa National Reserve (NNR), the third major PA for the conservation of Miombo woodlands, savannah keystones and umbrella species in Africa. Experts' answers were grouped according to opinions related to threats for conservation and current and proposed compensation schemes to improve conservation in the NNR.

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The results show a high degree of consensus among experts in relation to the current practices that threaten conservation in the reserve (poaching, illegal logging and mining). Local people were held responsible for activities that they carry out to meet their daily needs. While, outsiders carrying out illegal activities, were also responsible for practices that represent the top threats to conservation. The proposed new incentives, such as assisting local people with conservation agriculture, providing alternative sources of animal protein and providing scholarships for their children, may greatly improve the support of local people for biodiversity conservation in the reserve.

Keywords: *Conservation incentives, Protected areas, Conservation threats, Local people, Legal and illegal outsiders*

2.1. Introduction

Protected Areas (PAs) of Developing Countries (DCs) are the home of most of threatened species on earth (Macdonald et al., 2012; Wei et al., 2018). Yet, most of these PAs are performing poorly (Brister, 2016; Cooney et al., 2017) due to factors such as weak law enforcement (Sundström, 2016) and the increase of human population inside PAs, which contributes to farmland expansion (Snyman and Bricker, 2016), which in turn exacerbates human-wildlife conflict (HWC) (Fraser-Celin et al., 2018; MacKenzie et al., 2017). There is a growing literature that goes beyond traditional ecology-based conservation science and uncovers the complexity and diversity of local PA problems, which possibly require tailored solutions (Brister, 2016; Lute et al., 2018). This literature is mostly based on surveying local residents (Fraser-Celin et al., 2018; MacKenzie, 2018; Moreto, 2019). However, real-world conservation decisions often rely on expert advice to decision-makers, rather than surveying local residents (Lute et al., 2018; Pasgaard et al., 2017). When

conservation experts are asked to advise decision-makers, they tend to use general narratives about conservation in PAs of developing countries (DCs) (coming from international organisations and environmental NGOS), such as the general effects of poverty and lack of education on biodiversity loss, rather than relying on deeper knowledge (such as that provided by studies in the conservation research literature) about the particular PA at stake. Since expert views shape public opinion and conservation decisions (Lute et al., 2018; Selge et al., 2011), it is important to identify topics where there is consensus (vs divergence) of opinion among experts, because consensus can increase the probability that advice is used by the decision-makers; or whether expert recommendations are consistent with deeper knowledge about a particular PA.

In this study conservation experts were surveyed to hear their views on the following themes: (i) the role of local actors in the major threats to conservation in a particular PA; (ii) the underlying drivers for local people's involvement in conservation-threatening practices; and, (iii) appropriate policies to address these drivers. The methodology was applied to the Niassa National Reserve (NNR), the largest PA in Mozambique (Prin et al., 2014; Ribeiro et al., 2008). Some specific questions to be addressed with this research were:

- Is there consensus or diverging views among conservation experts for each of the abovementioned themes?
- Are these expert's views more related to the conservation research literature and the conditions in the particular PA or to general narratives about conservation in DCs?
- Can differences in views be explained by the expert's background and experience in conservation?

- Are each expert's views on problem identification coherent with his or her evaluations of current or proposed conservation policies?

2.1.1. Literature review

The selection of appropriate policies to effectively shift local people's behaviour towards conservation-friendly actions requires that researchers, government agents and others conservation-related actors first identify the main drivers for local people's involvement in practices that threaten biodiversity, since local residents living inside PAs represent a major threat to nature conservation in DCs (Travers et al., 2019). The drivers for local residents involvement with conservation threatening-practices can be classified into proximal and underlying (Moreto, 2019). Underlying drivers are multifaceted, systemic and difficult to solve (Moreto, 2019), and include demographic, economic, socio-political and institutional drivers (Geist and Lambin, 2002).

The most commonly accepted reasons why local people engage in conservation-threatening practises are: (1) Increasing pressure of human population inside and around PA, resulting from the immigration of people who seek arable lands (Campbell et al., 2000; Galvin et al., 2006), natural resources for use and employment in conservation and other related activities (Adams and Hutton, 2007; Baral and Heinen, 2007). This increases conflict between people and animals; (2) Increasing wildlife populations resulting in increased human wildlife conflict (HWC) and retaliation by local people (Baral and Heinen, 2007); (3) Lack of compensation for crop and livestock loses can increase food insecurity (Mackenzie and Ahabyona, 2012); (4) Unfair distribution of revenue sharing leads to the involvement of local people in conservation-threatening practices (Moreto, 2019; Zafra-Calvo et al., 2018); (5) Loss of trust between communities and conservation authorities as

a result of weak legislation and poor institutional arrangements, which do not protect the rights of indigenous people (Shepherd and Magnus, 2004), and the incapacity of PA authorities to effectively respond to crop and livestock raiding can lead to frustration from both parties (Moreto, 2019); (6) Inaction (or delay) of PA managers to set consistent buffer zones and corridors between animals and communities (Moreto, 2019); (7) Availability of markets to sell goods from illegal activities (Brashares et al., 2011; Doughty et al., 2015) can drive illegal wildlife use; (8) Clashes between conservation objectives and social and cultural factors such as ethnicity group, cultural beliefs and customary practices (traditions and religion) (Boer and Baquete, 1998; Chang et al., 2019); (9) Environmental factors such as the location of agricultural edges and the palatability of crops can also increase HWC (Dickman, 2010) and (10) International advocacy of protection of endangered species that emphasizes biodiversity conservation but neglects the rights of indigenous people (Gaillard et al., 2019; Galvin et al., 2006).

HWC is increasingly viewed through the lenses of social and political processes that involves local people's livelihoods and government processes (Gaillard et al., 2019). Yet, formulating effective strategies to reduce HWC is hampered by the complexity of human needs and behaviour. Wildlife conflict is still neglected as a small-scale hazard or disaster event, but results in a constant erosion of people's ability to cope with their daily needs and increases vulnerability for those who already stand at the margin of the society (Gaillard et al., 2019; Galvin et al., 2006).

To date, most of those drivers are poorly understood in the context of Mozambican PAs, and particularly in the NNR. Achieving long-lasting conflict resolution will rely upon decision makers adopting broader and more holistic approaches to conservation based on a

deeper knowledge of the existing drivers for local people involvement in conservation-threatening practices.

2.2. Methodology

2.2.1. Study area: the Niassa National Reserve

The NNR is located in the Mecula district, northern Mozambique, between coordinates: 12°38′48.67″S; 11°27′05.83″S and 36°25′21.16″E; 38°30′23.74″E. The reserve covers an area of 42,000 km^2 (Prin et al., 2014), of which over 34,000 km^2 are occupied concession blocks with additional block up for tender in 2019 (*Sociedade de Gestão da Reserva do Niassa* (SGRN, 2004)).

The NNR accounts for 5.3% of the national territory and 44.9% of all designated PAs in Mozambique (Prin et al., 2014). The reserve encompasses one of the few remaining intact miombo woodland savanna (Ribeiro et al., 2013; WWF, 2012), holding one of the seven remaining population of lions with more than 1000 individuals (NCP, 2015; Riggio et al., 2013). About 60,000 people live inside the reserve, a double-fold increase in just 10 years (NCP, 2015; SRN, 2008). People living in the reserve rely on shifting cultivation, hunting for bushmeat and fishing for their livelihoods. Poverty and food insecurity are a serious concerns inside NNR (NCP, 2016).

The NNR is managed by the Government of Mozambique, through the National Administration of Conservation Areas (ANAC) in partnership with the Wildlife Conservation Society (WCS). There are also some non-government projects, such as the Niassa Carnivore Project (NCP), as well as sport hunting concessions, and tourism concessions who assist with conservation management and social development. Exploitation of firewood, medicinal plants, fish and other non-forest wood products

(NFWP), such as honey gathering, are allowed in small quantities for domestic purposes (SRN, 2008). There is a compensation scheme currently in place, which consists of sharing with local residents 20% of the revenue of hunting fees paid by game concessionaires (Jorge et al., 2013; Massuque, 2013).

2.2.2. Survey data

An online self-administrated questionnaire was delivered to experts that are involved in design and implementation of conservation management in Mozambique. For more information regarding the criteria used to select experts, see Mbanze et al., (2019). Surveyed experts were working for different conservation organizations (NGOs, governmental bodies, universities and research institutions) at all levels. An overview of experts' institutional affiliation is presented in Mbanze et al. (2019). Potential respondents were identified based on governmental and private organizations reports, scientific papers, technical documents, and attendance in the national congresses of conservation and environment-related meetings.

The questionnaire was composed of four sections. In the first section, respondents were requested to select the main practices that threaten conservation in NNR, responsible for these practices and the reasons for local people's involvement in such practices. The second section was about the effectiveness and limitations of the current compensation measures implemented in NNR. In the third section, respondents were requested to select a new proposed measure that could be implemented to effectively engage local people in conservation to enhance the conservation state of the reserve. The last section was about the socio-economic profile of respondents. The survey included both compulsory and non-compulsory questions (see Mbanze et al., 2019).

The conservation problems and the new compensation measures were taken from the literature after an in-depth review, as well as brainstorming with a selected group of experts who have deep knowledge about conservation in NNR. The development of the questionnaire was informed by published and unpublished scientific material and official reports mostly from Mozambique. Other possibilities for helping local people to adopt conservation agriculture, providing local people with alternative sources of animal proteins, giving collective conservation performance-based payments and providing education for local people (e.g., scholarships) are under implementation in a pilot phase by the Niassa Carnivore Project/ Mariri (NCP)[2] in concession block L5 South in Mbamba Village and other villages since 2012.

The questionnaire was pretested with three conservation experts working in Mozambique. Before being officially released, the survey was modified based on the main recommendations from the experts in the pretesting round. The survey was conducted between June and September 2017. Response rate was 68.76% (N=57), with two non-valid responses dropped from the analysis. The questionnaire is available in Mbanze et al., (2019).

2.2.3. Data Analysis

Experts' answers were coded in different rating scales depending on the question. Respondents' ratings were first analysed through Principal Component Analysis (PCA) for dimension reduction. The PCs with eigenvalue >1 were retained to detect cluster structures. We used the Square Euclidian Distance as a measure of dissimilarity, and ran the Ward's method on the retained scores, in order to minimize the object function error (Legendre and

[2] http://www.niassalion.org

Legendre, 2003). A dendrogram was used to detect the suitable number of clusters. These clusters thus, represent classes of experts that assessed the questions differently in each theme (Q.1 to Q.4, see Table S3 in Mbanze et al., 2019). Cluster and overall median ratings were then computed for each alternative within the themes. A nonparametric Kruskal-Wallis (KW)[3] test was used to investigate whether median ratings statistically differ across clusters. Post-hoc pairwise comparisons with Bonferroni correction were used to test for statistical differences of medians between pairs of clusters.

For better visualisation of the relationship between the degree of threat and the actors responsible for each conservation problem, conservation problems were grouped in a hierarchical cluster analysis based on actor responsibility. Actors were classified as: Donors (Do); Reserve Administration (ReAd); Non-residents (NoRe); Local People (LoPe); Private Sector (PrSc); and, Traditional Authorities (TrAu). Clustering results and the degree of threat associated to each conservation problem were then attached to the heatmap of proportions of responsibility shared among different actors, to facilitate the visualization of the relationship between responsible actors and degree of threat in a dendrogram-heatmap.

Relationship between different views of respondents was tested through crosstabulation based on Fisher's Exact test and Asymptotic Person's Chi-Square. The same technique was applied between clusters of major themes and socio-economic profile of respondents to understand whether their socio-economic background can also explain the points of view of respondents (see more on Mbanze et al., 2019).

[3] The Kruskal-Wallis test of median is regarded as powerful in the sense that, differently from other median tests, this takes into consideration the direction and magnitudes of the observations (Ica and Um, 2013).

2.3. Results

2.3.1. Respondents profiles

Most of the surveyed experts were men with higher education (M.Sc. or Ph.D. degrees) in agriculture, environmental, biology, social sciences and others (see Table S2 in Mbanze et al. 2019). More than half have been working in conservation for more than three years, and the majority had visited the reserve at least once. The main objective of the trip to the reserve was either to work or to conduct research. Among those who have been in the reserve, the time that they spent (sum of all the time), ranged from less than a month to more than one year.

2.3.2. Conservation-threatening practices in the NNR and the responsibility of different actors

Table 1 presents results from experts' views on the degree of threat that each existing problem represents for conservation in the reserve. The overall and cluster medians (high =3 and very high = 4) and the non-significative (*P-value* ≥ 0.05), show that there is a high level of consensus among experts regarding most of higher level conservation threats in NNR: poaching; illegal logging; population growth; and, illegal gold and ruby mining. Slash-and-burn agriculture is also perceived overall as a major threat, although there is no consensus. Extraction of wood fuel, commercial farming and fishing were scored overall as moderate threats.

Table 2.1. Degree of threat to conservation associated with each problem in the NNR – overall and cluster medians (values in the brackets, represent the number of experts per clusters and its respective percentage).

		Cluster medians				
Nº	**Problems**	**N1 (24|44%)**	**N2 (19|34%)**	**N3 (12|22%)**	**Overall median**	**P-Value (α)**
1	Slash-and-burn agriculture	3^{ab}	3^{a}	2.5^{b}	3	0.018*
2	Commercial farming	2^{a}	2^{a}	1^{b}	2	0.001**
3	Sport hunting	1^{ab}	2^{a}	1^{b}	1	0.018*
4	Poaching	4	3	4	4	0.050
5	Bushmeat	1^{b}	3^{a}	1.5^{ab}	1	0.004**
6	Extraction of non-timber products	1^{b}	1^{a}	2^{a}	1	0.001**
7	Wood fuel	2	3	2	2	0.262
8	Illegal logging	3	2	3	3	0.195
9	Fishing	2^{b}	2^{b}	3^{a}	2	0.006**
10	Population growth	2.5	3	3	3	0.196
11	Human and wildlife conflicts	2^{c}	3^{b}	4^{a}	3	0.000***
12	Illegal gold and ruby mining	3	3	3	3	0.952
13	Projects and Infrastructures	1^{b}	2^{a}	1.5^{ab}	1	0.000***

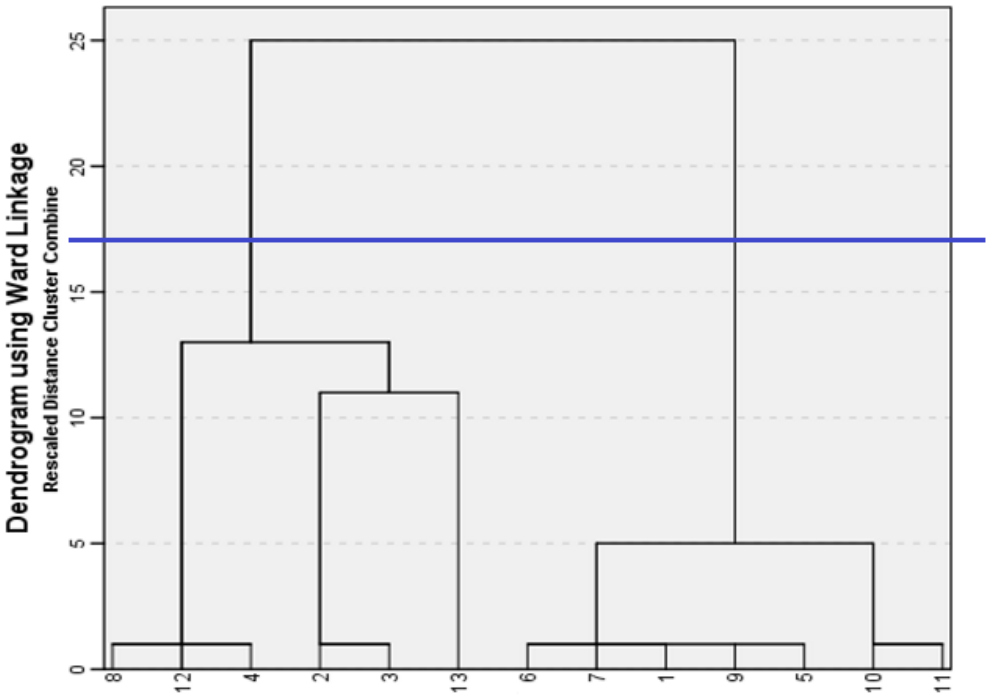
Note: Respondents rated the degree of threat associated to each problem in a 5-point scale from 1 (null) to 5 (very high). The P-value corresponds to the Kruskal-Walls (KW) test, with the following levels of significance: *= significant at 0.05, ** = significant at 0.01 and *** = significant at 0.001. Lowercase letters in the line represent post hoc statistical differences between clusters resulting from pairwise comparisons - values with the same letter are not statistically different.

All problems rated overall as minor threats (overall median =1) are non-consensual. For those non-consensual responses, one can see that experts in the first (N1) or second (N2) clusters (depending on theme) tend to perceive local people's activities as minor threats, while outsiders' legal practices are seen as significant threats. Conversely, experts in the last cluster (N3) seem to have an opposite view, although some threats have intermediate ratings between experts in the first and second clusters.

Experts' views on the actor seen as the most responsible for each conservation problem is presented in Figure 1, where the profile of perceived actor responsibility for each problem is presented in the heatmap attached to the dendrogram from the cluster analysis of the 13 conservation problems. In the two-cluster solution, all threats that experts associate with outsiders as the main responsible actor area grouped in the LHS cluster; they are carried out either illegally by non-residents (NoRe), or legally by the private sector (PrSc) or

government authorities (Go). On the other hand, all threats associated by experts to local people as main responsible actor are grouped in the RHS cluster.

The three-cluster solution is less robust than the two and four-cluster solutions. In the four-cluster solution, the first cluster represents the set of all illegal activities carried out by non-residents. All of these are seen by experts as top threats. The second cluster represents much fewer threatening problems associated with legal outsider activities. The third cluster only includes one problem, in which government authorities (Go) are considered as being mainly responsible. The fourth cluster groups all problems whose responsibility is mostly attributed to local people, although there are some problems whose responsibility is shared by local people and governmental authorities or reserve administration. Shifting cultivation, HWC and population growth are the only problems in this cluster that experts perceive as significant threats.



Actors	Illegal logging	Illegal gold and ruby mining	Poaching	Commercial farming	Sport hunting	Projects and infrastructures	Extraction of NTFPs	Wood fuel	Shifting cultivation	Fishing	Bushmeat	Population growth	Human-wildlife conflict
Donors	2	0	4	4	2	2	2	2	4	0	2	0	5
Traditional Authorities	2	0	0	2	0	0	5	0	4	2	9	5	5
Private Sector	9	4	4	38	45	4	2	5	2	5	2	4	2
Reserve Administration	7	9	5	9	27	11	7	4	7	7	5	15	20
Government authorities	16	18	13	16	13	82	2	7	7	13	7	31	15
Non-residents	51	55	55	5	7	0	5	4	11	7	5	16	5
Local People	13	15	20	25	5	2	76	78	65	65	69	29	47
Degree of threat	3	3	4	2	1	1	1	1	3	2	1	3	3

Figure 2. 1. Dendrogram with thirteen data points, which represent the different conservation problems. Attached to the dendrogram is the heatmap of actor's and their share of responsibility for each problem in percentage (from red to green represents the high to less gradient of responsibility shared by each actor), and degree of threat (from red to green represents very high to little degree of threat each problem represents for conservation.

2.3.3. Drivers of local people involvement in conservation-threatening practices

The views of experts on reasons for local people's involvement with practices that threaten conservation are represented in Table 2. It can be observed that the lack of involvement of local people in decision making is the only consensual reason. Despite being

less consensual, overall medians show that conservation-threatening behaviours are mainly driven by insufficient livelihoods, poor awareness of local people regarding the importance of conservation, outsider corruption, feeling of injustice about benefit sharing, opposition to the ongoing restrictions and lack of environmental education.

Table 2.2. Reasons for local people being involved in conservation-threatening practices in the NNR - overall and cluster medians. (values in brackets represent number of experts in each cluster and its respective percentage in the sample)

		Cluster medians						
Nº		**N1 (7|13%)**	**N2 (14|25%)**	**N3 (13|24%)**	**N4 (13|24%)**	**N5 (8|15%)**	**Overall median**	**P-Value**
1	Livelihood Insufficiency	1^{ab}	1^{b}	2^{a}	1^{ab}	2^{ab}	1	0.018*
2	Conservation does not bring any benefit	0^{ab}	-1^{b}	-1^{b}	-1^{ab}	1^{a}	-1	0.000***
3	People don't know the importance of conservation	-1^{acd}	-1^{d}	1^{abc}	2^{a}	2^{ab}	1	0.000***
4	The local people are corrupt	0^{b}	2^{ab}	1^{ab}	1^{ab}	2^{a}	1	0.044*
5	Feeling of injustice in benefits sharing	2^{a}	1^{bc}	1^{abc}	-1^{c}	1^{ab}	1	0.000***
6	Conservation only creates problems	-1^{ab}	-1^{b}	-1^{ab}	-1^{ab}	-1^{a}	-1	0.012*
7	Conservation only benefits foreigners	0^{ab}	-1^{b}	-2^{b}	-1^{b}	1^{a}	-1	0.000***
8	Local people are not involved in the decision making	1	1	1	1	2	1	0.405
9	Opposition to the restrictions	1^{abcd}	1^{ab}	1^{abc}	-1^{d}	1^{a}	1	0.010*
10	Low education	0^{c}	1^{abc}	2^{ab}	1^{abc}	2^{a}	1	0.001**
11	Lack of infrastructure	2^{ab}	-1^{c}	1^{abc}	-1^{c}	2^{a}	0	0.000***

Note: Each reason for local people being involved in conservation-threatening practices in the NNR was rated by respondents in a 5-point scale from strongly disagree (-2) to strongly agree (2). The P-value corresponds to the Kruskal-Walls (KW) test, with the following levels of significance: *= significant at 0.05, ** = significant at 0.01 and *** = significant at 0.001. Lowercase letters in the line represent post hoc statistical differences between clusters resulting from pairwise comparisons - values with the same letter are not statistically different.

Significant divergence among experts allowed us to group them into five clusters (see Table 2). The first cluster groups mostly undecided respondents. Experts in the second cluster seem to believe that conservation does provide benefits to local people, but they do not see those benefits because of current policies that hinder their engagement in conservation, lower education and corruption by illegal outsiders. On the other hand, experts in the fourth cluster believe that the single most important reason for local people involvement in conservation-threatening practices is ignorance.

The third cluster groups those experts who strongly disagree that conservation only benefiting foreigners is a reason for local people's involvement with conservation-threatening behaviours. Experts in the last cluster (N5) believe the rights of local people are being sacrificed in the name of conservation.

2.3.4. Effectiveness and limitations of ongoing compensation measures

The six compensation measures currently under application in the NNR were ranked by experts as regards their perceived importance. The results are presented in Table 3. It can be observed that providing jobs for local people was consensually seen as the most important compensation, followed by the allocation of hunting quotas, whose importance is not consensual, and the delivering of 20% of revenue for local people, which was consensual. Promotion and respect of culture and beliefs of local communities were ranked as the fourth most important compensation, whereas food allowances were perceived as the least important.

It can be observed that in general, experts agree with all eight limitations they have assessed, although there is only consensus about the limitation of the three most important

compensation measures: jobs are not allocated in a transparent way; hunting quotas allocated to local people and the sharing of 20% of PA revenues are both not enough.

Table 2.3. Compensation measures that are currently placed in the NNR and its limitation - overall and cluster medians (values in the brackets represents the number of experts per cluster and its respective percentage).

		Clusters medians				
Nº	**Current compensation measures**	**N1 (26|47%)**	**N2 (15|27%)**	**N3 (14|26%)**	**Overall median**	**P-value**
1	Jobs for the local people (e.g. Forest ranger position)	6	6	5	6	0.110
2	Hunting quotes allocated to communities	4^{b}	5^{a}	5^{a}	4	0.008**
3	20% of revenues of concessions delivered to local people	4	4	4	4	0.068
4	Food allowances for local people	1^{b}	1^{ab}	3^{a}	1	0.009**
5	50% of the revenue of the fines delivered to local people	3^{a}	2^{b}	3^{ab}	2	0.038*
6	Promotion and respect of culture and beliefs of local communities (e.g. sacred places)	3^{a}	3^{ab}	2^{b}	3	0.001***
Nº	Limitations of the current compensations					
1	Lack of transparency in the criteria of job allocation	1	1	1	1	0.584
2	The hunting quotas allocated are insufficient	1	1	1	1	0.988
3	The money allocated is insufficient	1	0	1	1	0.351
4	Lack of monitoring and accountability of revenues (20%)	2^{a}	1^{ab}	0^{b}	1	0.000***
5	In many cases, the detectors of the offenders aren't awarded	1^{a}	0^{b}	1^{a}	1	0.000***
6	Weak training and advice in how to use the compensation	2^{b}	1^{a}	0^{a}	1	0.000***
7	Poor monitoring and evaluation of the results from the projects implemented in NNR	1^{a}	0^{b}	1^{ab}	1	0.008**
8	The above compensations are not enough to motivate the community	1^{ab}	-1^{b}	1^{a}	1	0.022*

Note: Compensation measures that are currently placed in the reserve were ranked by respondents as most 6=important and 1= least important. While limitations were rated in a 5-point scale from -2 (strongly disagree) to 2 (strongly agree). The P-value corresponds to the Kruskal-Walls (KW) test, with the following levels of significance: *= significant at 0.05, ** = significant at 0.01 and *** = significant at 0.001. Lowercase letters in the line represent post hoc statistical differences between clusters resulting from pairwise comparisons; values with same letter are not statistically different.

Experts in the first cluster agree with all raised limitations, being the most important: lack of monitoring and accountability of the 20% of PA revenue shared with local people; and, the weak training and advice on how to use the compensations. Experts in the second cluster were undecided with some limitations, but they do not know whether the above-mentioned compensation was enough to engage local people with conservation friendly

actions. The last cluster was assigned as an intermediate between the first and the second, and the most notable difference is that experts in this cluster are undecided about the lack of monitoring and accountability in the revenue sharing.

2.3.5. New proposed compensation measures

Table 4 presents the results from experts' answers about the effectiveness of new compensation measures proposed to improve conservation in the NNR. The overall medians show that all proposed compensations have huge potential to positively improve the engagement of local people in conservation. Out of 11 new measures proposed, only three were consensual, which are, provide more jobs, promote education and improving services, that are expected to have a positive impact. Helping local people with practices aimed at enhancing the sustainable use of natural resources should also have a significant impact, although with no consensus among experts.

Experts in the first and last clusters give less relevance to the increment of revenues and the attribution of collective performance-based payments. While experts in the second and third clusters, believe that an increase in the revenue distributed to local people, can help to improve conservation in the reserve, but they disagree with sustainable agriculture and forest-use practices incentives. All proposed incentives would greatly improve terrestrial and aquatic biodiversity and human behaviour orientation towards conservation-friendly practices in the reserve (see Table 5).

Table 2.4. Compensation measures proposed to improve conservation in the NNR - overall and cluster medians (values in the brackets represents the number of experts per clusters and its respective percentage).

		Clusters medians					
Nº	**New compensations**	**N1 (14|25%)**	**N2 (19|35%)**	**N3 (11|20%)**	**N4 (11|20%)**	**Overall median**	**P-Value**
1	Create areas for cultivation of high-yield commercial crops	0^{c}	2^{ab}	2^{ab}	2^{a}	1	0.000***
2	Help local people to adopt conservation agriculture practices	1^{abc}	2^{a}	0^{c}	2^{ab}	1	0.012*
3	Provide local people with alternative sources of animal proteins	1^{b}	1^{ab}	2^{ab}	2^{a}	1	0.036*
4	Promoting certification of non-timber products	1^{a}	1^{ab}	-2^{c}	1^{abc}	1	0.014*
5	Help local people with practices to enhance the sustainable use of forest resources	1^{ab}	2^{a}	1^{b}	1^{ab}	2	0.016*
6	Involve local people in the management and decision-making	1^{ab}	2^{a}	-1^{b}	1^{b}	1	0.000***
7	Increase in the percentage of revenues charged to distribute to communities	0^{b}	1^{a}	2^{a}	-1^{b}	1	0.000***
8	Increased employment in conservation and recreation activities;	2	2	2	1	2	0.525
9	Attribution of collective conservation performance-based payments	0^{b}	1^{a}	1^{ab}	0^{b}	1	0.000***
10	Provide education for local people (e.g. scholarships)	1	2	2	1	1	0.797
11	Improve services delivery for local people	1	1	2	2	1	0.142

Note: The effectiveness of new proposed compensation measures to improve conservation in the reserve were ranked by respondents as 2 (very positive) and -2 (very negative). The P-value corresponds to the Kruskal-Walls (KW) test, with the following levels of significance: *= significant at 0.05, ** = significant at 0.01 and *** = significant at 0.001. Lower case letters in the line represent post-hoc statistical differences between clusters resulting from pairwise comparison; values with same letter are not statistically different.

In relation to biodiversity, consensus was observed for: increases of biodiversity in general; increase of large carnivores and herbivores; and, the increase of fish stocks. While for human-related behaviour, consensus among respondents was observed for reduction of local people engaged in illegal activities; reduction of unsustainable trophy hunting and hunting for bushmeat. The difference between clusters is that, for non-consensual items, experts in the first cluster tend to be more optimistic in relation to the level of improvements. On the other hand, experts in the last cluster are intermediate between the first and second. The last cluster contains the most pessimistic experts.

Table 2.5. Improvement of environmental assets and human behaviour toward conservation, after the implementation of new, measures. overall and cluster medians (values in the brackets represents number of experts per clusters and its respective percentage)

		Clusters medians				
Nº	**Level of improvement with new measures**	**N1 (23|41%)**	**N2 (19|35%)**	**N3 (13|24%)**	**Overall medians**	**P-Value**
1	Increases of the biodiversity in general	4	3	4	3	0.054
2	Increases of forest cover	4^{a}	2^{b}	3^{a}	3	0.000***
3	Increase of large carnivores and herbivores	3	2	2	2	0.315
4	Increment of fish stocks	3	2	2	2	0.365
5	Increase of large aquatic animals	3^{a}	1^{b}	2^{ab}	2	0.017*
6	Reduction of degraded area due to slash-and-burn agriculture	3^{a}	2^{b}	3^{b}	3	0.000***
7	Reduction of degraded area due to extraction of non-timber	3^{a}	2^{b}	2^{ab}	3	0.002**
	People behaviours and motivation for conservation					
1	Reduction of local people engaged in illegal activities	3	3	3	3	0.839
2	Reduction of unsustainable trophy hunting	2	3	1	2	0.587
3	Reduction of illegal bushmeat	3	3	2	3	0.232
4	Knowledge of local communities regarding the importance of conservation	4^{a}	4^{a}	2^{b}	3	0.000***
5	Motivation of local people in conservation	4^{a}	3^{a}	2^{b}	3	0.000***
6	Disclosure of offenders	3^{a}	3^{a}	1^{b}	3	0.000***
7	Mutual respect and trustiness amongst all actors	3^{b}	3^{a}	2^{a}	3	0.000***
8	Increase of local people employed in the reserve	3^{a}	2^{ab}	2^{b}	3	0.011*
9	Reduction of human and wildlife conflicts	3^{b}	2^{a}	2^{a}	2	0.000***
10	Reduction of frequency and forest fires intensity	3^{b}	2^{a}	2^{a}	3	0.000***

Note: the level of improvement with implementation of new compensation measures were ranked by experts as 0=0% to 4= [75 -100%] for biodiversity attributes and 0=Null to 4=Very high for human behaviour attributes. The P-value corresponds to the Kruskal-Walls (KW) test, with the following levels of significance: *= significant at 0.05, ** = significant at 0.01 and *** = significant at 0.001. Lower case letters in the line represent post-hoc statistical differences between clusters resulting from pairwise comparison; values with same letter are not statistically different.

2.3.6. Relationships between experts' views on different topics and their socio-demographic profile

Results from Pearson's and Fisher's exact Chi-Square test from crosstabulation between different clustered major themes are presented in Table 6. It can be observed that experts' views on the degree of threat associated with each conservation problem in the NNR (Q.1) are

significantly related with reasons for local people's involvement in conservation-threatening practices (Q.2); experts' assessment of compensations that are currently placed in the NNR (Q.3) and level of improvement of biodiversity and human-related behaviour, after the implementation of new measures.

Expert's assessments of compensation measures that are currently placed in the reserve (Q.3) show significant association to the reasons given for local people's involvement in practices that threaten conservation (Q.2), and the levels of improvements in biodiversity and human-related behaviour (Q.4.1), after the implementation of new measures.

Table 2.6. Results from crosstabulation between different views of professionals who were clustered based on answers to four major themes

	Q.1	**Q.2**	**Q.3**	**Q.4**	**Q.4.1**
Q.1	-----	0.034* (0.014*)	0.000*** (0.000***)	0.101ns (0.096^{ns})	0.000*** (0.000***)
Q.2	------	-------	0.034* (0.014*)	0.095^{ns} (0.117^{ns})	0.226^{ns} (0.155^{ns})
Q.3	------	-------	--------	0.101^{ns} (0.117^{ns})	0.000*** (0.000***)
Q.4	------	------	-------	------	0.832^{ns} (0.846^{ns})
Q.4.1	------	------	------	------	------

Nota: Numbers into the brackets are p-value from the Fisher's Exact Test while out of brackets are α from Person Chi-square test. ns = not significant, * = significant at 0.05, ** = significant at 0.01 and *** = significant at 0.001

Q.1. Degree of threat that each of the existing problems in the reserve represents for conservation based on the experts scores.
Q.2. Reasons for local people involvement with practices that threaten conservation.
Q.3. Compensation measures that are currently placed in the reserve and its limitations.
Q.4. Cluster of proposed measures to improve conservation in the NNR.
Q.4.1. Level of environmental and human-related behaviour improvements after the implementation of new measures.

A post hoc cellwise test between experts' answers regarding Q.1 and Q.2 (see Table S4 in Mbanze et al.,2019) shows significant relation (Z_{ij} = 0.0038, α=0.0033), between the main reasons for local people's involvement in practices threatening conservation. And results from post hoc tests in the cross-table between answers to theme Q.1 and Q.3 (see Table S5 in Mbanze et al.,2019)

were significant, with adjusted alpha (α=0.0056), meaning that experts views on most problems that threaten conservation, in which local people are involved, are related to the fact that the compensation measures in place in the reserve are not enough to engage local people in conservation activities.

The significance relation between theme Q.1 and Q.4.1 in the post hoc cellwise (see Table S6 in Mbanze et al., 2019) can be interpreted as, although the ongoing threats to conservation in the reserve, with implementation of new proposed measures, it is likely to reduce the degraded area in the reserve due to slash-and-burn agriculture and extraction of non-timber products. We also found a relationship between theme Q.2 and Q.3 ($\alpha = 0.0033$, $Z_{ij} = 0.0038$), that is represented in the Table S7 in Mbanze et al.,2019, meaning that local people have been engaged with practices threatening conservation because they are either corrupt or they don't have enough to support their livelihoods. While the significant relation between themes Q.3 and Q.4 (see Table S8 in Mbanze et al., 2019) is not worthwhile to be explained, as both measures are mutually exclusive.

Table 7 presents the results from Person's and Fisher's exact tests of crosstabulation between clusters of expert's opinions and their socio-demographic characteristics. The degree of education was associated with expert´s assessment of the level of improvement of different attributes after the implementation of new conservation measures.

Table 2.7. Crosstabulation between clusters of respondents and socio-demographic characteristics of respondents

	Q.1	Q.2	Q.3	Q.4	Q.4.1
Gender	0.375^{ns} (0.406^{ns})	0.654^{ns} (0.633^{ns})	0.375^{ns} (0.406^{ns})	0.160^{ns} (0.147^{ns})	0.770^{ns} (0.770^{ns})
Field	0.935^{ns} (0.943^{ns})	0.311^{ns} (0.142^{ns})	0.935^{ns} (0.943^{ns})	0.071^{ns} (0.070^{ns})	0.608^{ns} (0.534^{ns})
Education	0.244^{ns} (0.195^{ns})	0.190^{ns} (0.271^{ns})	0.244^{ns} (0.195^{ns})	0.250^{ns} (0.315^{ns})	0.004** (0.010**)
Nº of visit	0.430^{ns} (0.478^{ns})	0.976^{ns} (0.977^{ns})	0.430^{ns} (0.478^{ns})	0.771^{ns} (0.802^{ns})	0.397^{ns} (0.461^{ns})
Time Spend	0.110^{ns} (0.074^{ns})	(0.48^{ns}) (0.55^{ns})	0.110^{ns} (0.074^{ns})	0.623^{ns} (0.502^{ns})	0.055^{ns} (0.054^{ns})
Objective	0.659^{ns} (0.697^{ns})	0.586^{ns} (0.702^{ns})	0.659^{ns} (0.697^{ns})	0.515^{ns} (0.384^{ns})	0.542^{ns} (0.541^{ns})
Experience	(0.671^{ns}) (0.649^{ns})	0.998^{ns} (0.863^{ns})	0.671^{ns} (0.649^{ns})	0.530^{ns} (0.471^{ns})	0.658^{ns} (0.671^{ns})

Gender = Is the gender of the expert;
Field = Is the Major field (area of education) of the expert;
Education = Is the degree of education of the expert;
Nº of visit = Is the number of time that the expert has being visit the reserve;
Time Spend = Sum of the time that the expert spends in the reserve (sum of all trips);
Objective = Is the objective of the trip/visit to the reserve;
Experience = Is the years of experience in conservation.

The significant relation between professionals holding the upper secondary degree and experts in the cluster N2 (see Table S9 in Mbanze et al., 2019), suggests that the level of education affects the experts forecast on the effectiveness of new measures to improve conservation in the reserve, with higher educated people, providing a more pessimistic forecast.

2.4. Discussion

2.4.1. Conservation problems, their importance and drivers

According to the experts, the most important threats for biodiversity conservation in the NNR are poaching, logging, mining, population growth, slash-and-burn agriculture and HWC. These findings are in accordance with a plenty of existing studies in Mozambique (Giva, 2016; Wertz-Kanounnikoff et al., 2014) and in the NNR in particular (Massuque, 2013; Muarapaz, 2016). There is consensus among experts that poaching, logging, mining and population growth are the top threats to biodiversity in the Reserve. These findings are consistent with the dominant

conservation narrative in developing countries (Booth, Vernon R.; Dunham, 2014;UNEP et al., 2013), especially for non-fenced PAs (Gandiwa et al., 2013; Lindsey et al., 2017). In the case of NNR, the first three of those threats are illegal activities that are mostly carried out by outsiders (Jorge et al., 2013). Local people are increasingly led to cooperate with outsiders (Kideghesho, 2016) because, according to the experts, poverty, insufficient compensations and opposition to the ongoing restriction are seen as the main reasons for involvement by local people with conservation-threatening practices. Those findings are in accordance with current conservation narrative in the DCs (Brashares et al., 2011; MacKenzie, 2018).

HWC was reported as one of the top threats to conservation in the NNR. Moreto et al. (2019) and Dickman et al. (2015), found that HWC can induce poaching, because poaching is the only effective way to react to crop-raiding animals when there is a delay or no response from park authorities. Local people may prefer to call outsiders to poach the animals to reduce HWC, because they do not want to be engaged in the illegal activity themselves (Shepherd and Magnus, 2004). While experts seem to view HWC as a proximal driver of poaching in NNR, they also agree that current policy measures aimed at compensating local people for the costs of conservation, such as e.g. benefit sharing of the revenue from hunting concessions or the creation of conservation-based employment (wardens), are not sufficient to engage local people in conservation, because they are not perceived as offsetting losses from crop or livestock raiding in addition to all other costs of living inside the Reserve.

The results of the cluster analysis of conservation problems according to actor's responsibility (Figure 2) can help to tackle each problem focusing on the main group or organisation responsible. For example, government authorities were held responsible for project

and infrastructure development, likely because the permission for those projects must be approved by government (Leitão et al., 2015). Local people were held responsibility for a significant part of the problems, probably because they are entirely dependent on ecosystem services (ES) to cope with their daily needs. However, most of the problems attributed to the local people were not considered top threats to biodiversity conservation in the NNR. In addition, there is no clear consensus for those that are considered top threats. For instance, shifting cultivation is only considered as a proximate driver of forest degradation, because it only implies lowering of biomass density (Herold et al., 2011). Population growth is likely to be the underlying cause of most direct drivers of biodiversity loss in the reserve (Muarapaz, 2016; NCP, 2017; Tembo et al., 2015), since it implies increased demand for ES (Wei et al., 2018; Wertz-Kanounnikoff et al., 2014). For instance, from 2003 to 2018, the population living inside NNR increased from 25,000 to 60,000, representing more than a double-fold increase (NCP, 2017).

The presence of human settlements within African's PAs is positively correlated with hunting for bushmeat, poaching and HWC (Lindsey et al., 2017). Thus, when enforcement is weak there is a clear tendency to increase non-compliance with the existing rules (Bragagnolo et al., 2017; Zafra-Calvo et al., 2018). However, the challenge is more than simply providing enforcement, since there are also studies pointing out that increasing enforcement in PAs of developing countries does not necessarily deter poaching (Chang et al., 2019)

2.4.2. Compensation measures and their expected effectiveness

HWC was reported to occur with high frequency and to be an uncontested hindrance for conservation in the NNR. To give one example, in only two years (2017 and 2018), the NCP reported that their 34 community wildlife guardians, spread through 38 villages within the reserve, recorded 8581 HWC events in which 79% of the events were invasion of crop fields, mostly by baboons. These figures are still below those presented by other studies, see for instance Mackenzie (2018).

There was consensus among experts that most of the compensations delivered to local people in the NNR are not carried out in an appropriate way. For instance, the 20% of NNR revenue shared with local communities is not enough and is also undermined by poor allocation. The share of 20% of the PA revenue is in the Mozambican legislation to improve the livelihoods of the poor and marginalized rural people (Wertz-Kanounnikoff et al., 2014). However, it is also very controversial as a large portion of the incentive is diluted by transaction and other related costs, because the revenue must be delivered to the provincial authorities, for later allocation to the local people; second, the management committee who is responsible to allocate the funds, is not made accountable through audits; third, those committees are not clearly advised on how to allocate the money (Massuque, 2013); fourth, there are no clear audits to verify whether the hunting concessions are declaring all revenues, and finally, it is not clear if the authorities are delivering the agreed amount. Experience from Tanzania Community-Based Natural Resources Management (CBNRM) pointed at elite capture of conservation benefits aimed at the poor and marginalized majority (Zafra-Calvo et al., 2018).

Experts agree that all 11 new proposed measures would positively improve conservation in the NNR. Of these, only the following three: increasing employment; providing education; and, improving services for local people, were consensual. It is interesting to note that those three consensual compensation measures are not only part of mainstream general narratives about conservation in developing countries (Adams and Hutton, 2007; Wei et al., 2018), but also the ones most widely promised by politicians. For example, the Millennium Development Goals (MDGs) and now the Sustainable Developments Goals (SDGs) have prioritized the same measures for DCs (Kabeer, 2005; Sachs, 2012). The consensual nature of these proposals and their consistency with general sustainable development narrative will probably make its implementation easier, because, among other reasons, any expert who will be advising decision-makers would more likely identify or support measures in that package.

The majority of experts have agreed that the current compensations are not sufficient to engage local people in conservation (Table 3), which is why they pointed out, the new measures needed to effectively promote conservation-friendly behaviour. Increases 20% of revenue sharing, was less consensual among the new compensation, while the same measure was superior consensual among the current compensations under implementation. This apparent disparity is probable because the financial compensation (increase the 20% of revenue share), was presented together with other, mostly in-kind, compensation measures in the new proposed compensations. Providing rural residents with in-kind incentives was also found important in other related studies conducted in PAs of DCs similar to the NNR (Narloch et al., 2014; Travers et al., 2019; Vorlaufer et al., 2017), which is probably because in-kind incentives can help local people to overcome some obstacles, such as: illiteracy; and, lack of training and transparency in the allocation of financial incentives. Payment for ES and benefit sharing, either financial or in-kind, are both perceived as

important mechanisms to engage local people in sustainable use and conservation of natural resources (Irvine, K. et al., 2016; Narloch et al., 2014). Conversely, if local residents bear the costs of those activities, without receiving any benefit, they may be unsupportive (Kline, 2001; Lackey, 2006).

2.4.3. Consistency on experts' views across themes

Experts were consistent in their views (Table 6). For instance, an expert's view on what are the major threats to conservation is related to the (1) reasons for involvement by local people in conservation-threatening practices, (2) current compensation measures and their limitations, and (3) the improvement of environmental and behavioural change of the local people, that are expected after the implementation of new measures. This is an important finding, since experts have agreed on the relevance of delivering tangible benefits, while empowering the people in the decision-making process, which in turn, will increase the transparency of benefit sharing. Meanwhile, providing better education will reduce the level of threat for conservation as people will be more aware about the importance of conservation.

The socioeconomic background of respondents did not affect their views in relation to the major themes surveyed, except for the level of improvement in the ES after the implementation of new measures (Q.4.1.), with higher educated experts (mainly from the cluster 2), providing more pessimistic forecast. This is probably because, answering this question required future projections, thus the more educated experts are in a better position to accurately provide those projections. Indeed, even with new compensations in place, it is least likely that most of the provisioning services in the reserve will recover over 50%, since there are still other larger sources of uncertainties in the future, such as the effects of climate change and population growth on

biodiversity (Adams and Hutton, 2007; Wei et al., 2018), which will add further pressure on Land Use Change (LUC) and ES.

In general, experts' feedback leads us to consider two most possible scenarios: either they are truly aware about the drivers of conservation-threating behaviour and possible measures that can be implemented to improve local people behaviour, or they may have drawn their answers from a common rhetoric of "one size fits all" concept. That is: PAs in developing countries share common features and there is a general framework that can be implemented to solve the problem of local people's involvement in conservation-threatening practices. To give one example, there was common agreement that, if local people are provided tangible benefits, they will embrace conservation-friendly actions, because the root causes of the conservation-threatening behaviour is related to poverty. Travers et al, (2019) have already advised about the weakness of using that approach, instead of thinking more broadly and holistically, such as using a mix of polices that include education and empowerment of local people. However, as a preliminary approach, we believe that the experts provided us with important insights that can be useful to triangulate with in-deep field exploratory research with communities living inside the NNR and other relevant actors, which will be developed in the follow up of this and other researches elsewhere.

2.5. Conclusion

In this study, we improved a method to identify the role of local people in major threats to conservation and the underlying motives/drivers for their involvement in those practices. We also discussed policy options to address these drivers in the NNR. Our results show that there is a consensus among experts that most activities which constitute the top threats to conservation in the NNR are mainly carried out by outsiders. This is in accordance with previous studies. Direct

and indirect responsibilities of locals and outsiders in those activities were well identified in our clusters analysis of conservation problems in the NNR; these results can be used to design appropriate conservation policy to tackle the identified actors, behaviours and their drivers. The new compensations that have been included in our questionnaire, namely in-kind compensations, were clearly more effective than the existing ones.

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Chapter 3

Dataset from 55 experts engaged in nature conservation in Mozambique

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Dataset from 55 experts engaged in nature conservation in Mozambique

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Abstract

The data content of this article is related to the original article entitled *"An expert-based approach to assess the potential for local people engagement in nature conservation: The case study of the Niassa National Reserve in Mozambique"*(Mbanze et al., 2019), published in *Journal for Nature Conservation*. The dataset is from an online and self-administrated survey with 55 experts aware of conservation policies and incentives implemented at Niassa National Reserve (NNR), the largest protected area in the country and third-largest in Africa. The survey included four sections of both compulsory and non-compulsory questions, mostly in closed-ended Likert-scale. In the first section, experts were asked about the main practices that threaten conservation in the NNR, the actors who are directly and indirectly responsible for each practice, and the reasons for local people's involvement with those practices. The second section was about the

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effectiveness and limitations of the current compensation measures to engage local residents with conservation-friendly practices. In the third section, respondents were asked to select new measures to enhance the current conservation status and engage local people more effectively in conservation. The last section was about the socio-economic profile of respondents. The survey was conducted from June to September 2017. The paper includes the survey itself, raw data in an Excel spreadsheet, descriptive analysis, crosstabulation and Post Hoc cellwise tests (goodness of fit). Data are provided for public use and can serve as a benchmark for collaboration in order to conduct more comprehensive research, comparative analysis as well as panel data can be derived. This data can also have applications in other fields such as mathematics, statistics, and computation.

Keywords: Conservation experts, Developing countries, Perceived views and Niassa National Reserve

3.1. Specifications Table

Subject area	Environmental science
More specific subject area	Management, Monitoring, Policy, and Law
Type of data	*Excel files, table and online questionnaires*
How data was acquired	*Online* and self-administration survey
Data format	*Raw, filtered and analyzed*
Experimental factors	*Respondents were selected based on education, number of visits, time spent while visiting, the objective of the visit and years of experience in conservation*
Experimental features	*Online* and self-administration survey was conducted to 55 experts engaged in conservation in Mozambique, from June to September 2017
Data source location	*Mozambique countrywide (mainly in Maputo city, Lichinga city, Mecula, Marrupa and Mavago districts in the Niassa Province, closer to the Niassa National Reserve)*
Data accessibility	*Data are available with this article*
Related research article	Author's name: Aires Afonso Mbanze, Natasha Sofia Ribeiro, Carina Vieira da Silva and José Lima Santos Title: *"An expert-based approach to assess the potential for local people engagement in nature conservation: The case study of the Niassa National Reserve in Mozambique"* Journal: Journal for Nature Conservation DOI: https://doi.org/10.1016/j.jnc.2019.125759

3.2. Value of the data

- Data can be used for site comparison among different conservation areas;
- Data can serve as a benchmark for further collaborative research;
- The questionnaire can be replicable and improved in future studies;

- Data can be analyzed on different ways to come up with other possible scenarios to advise decision-makers and conservation experts on how to improve conservation of protected areas in developing countries;
- Data can also be used in other fields, including statistics and computer sciences.

3.3. Data

The dataset of this article is related to experts' views about conservation policies and incentives implemented at Niassa National Reserve (NNR). The questionnaire used to generate the dataset is presented in Appendix A. Raw Excel dataset is online available on mendely data (https://data.mendeley.com/datasets). The detailed information regarding the profile of respondents is presented in Table 1. Table 2 presents more detailed information about the socio-demographic information of respondents. Table 3 presents the different rating scales used for each major themes; Table 4 to 8 are the post-hoc cellwise comparisons between major themes with meaningful explanation; and Table 9 presents a post-hoc cellwise test between experts' level of education and the level of improvement of different attributes after implementation of new proposed measures.

Table 3.1. Organizations from which the surveyed respondents were selected.

Organization	**Number of respondents (%)**
Conservation NGOs	9 (16)
Private sector (concessionaries of Hunting Blocks)	4 (7)
Governmental institution	
National Ministry of Land, Environment and Development	5 (9)
Provincial and district environment and conservation related institution	19 (35)
Academic Institutions	
Universities and Technical Institutes	10 (18)
Research institutions	2 (4)
Others	6 (11)
Total	55 (100)

3.4. Experimental Design, Materials and Methods

Data were obtained from experts highly involved in the design and implementation of conservation measures in Mozambique. The criteria used to select the experts were the following: (1) have worked or still work in Mozambique in conservation-related activities, irrespective of being Mozambican citizens; (2) have substantial knowledge about policies and laws that govern protected areas in Mozambique; and (3) know the current management state of the NNR including threats, compensation schemes and the role of all actors involved in conservation. The socio-demographic profile of surveyed experts is presented in table 2. The questionnaire used to generate the dataset is presented in Appendix A. An online and self-administrated survey was presented to experts engaged in conservation in the NNR, in both Portuguese (Mozambican National Language) and English. The survey's main aim was to collect experts' perceptions and opinions on conservation-related issues, namely: (i) main practices threatening conservation in the NNR and those responsible for each practice; (ii) the reasons for local people's involvement with practices threatening conservation; (iii) effectiveness and limitations of current compensation measures to engage local people in conservation; and (iv) new measures that can be proposed to enhance conservation on the reserve. The survey also included a section on the socio-economic profile of respondents. The response rate was 68.76%, with two non-valid responses, that were dropped from the analysis.

Table 3. 2**.** Socio-demographic information of respondents

Nº	Variables	Frequency	Percentage (%)
1	**Gender**		
	Male	43	78.2
	Female	12	21.8
2	**Education**		
	Professional Education (basic or secondary)	15	27.3
	Upper Secondary School	6	10.9
	Higher Education	34	61.8
3	**Major Field**		
	Agriculture	32	58.2
	Biology	4	7.3
	Social Sciences	9	16.4
	Others	10	18.2
4	**How long have you stayed there?**		
	Any time	12	21.8
	less than a month	13	23.64
	1 - 4 Months	10	18.2
	5 - 8 months	2	3.6
	8 - 12 months	3	5.5
	>12	15	27.3
5	**The main objective of your trip**		
	Working	29	52.7
	Research	11	20
	Just passing through	1	1.8
	Tourism	4	7.3
	Visit	1	1.8
	Others	9	16.4
6	**Years of experience in conservation**		
	1 - 2	16	31.37
	3 - 5	19	37.25
	6 - 10	12	23.53
	> 10	4	7.84

The survey was coded in different rating scales depending on the question being analysed, according to the Excel spreadsheet and Table 3. Most of the questions were taken from the literature and brainstorming with a selected group of experts who have deep knowledge about conservation in NNR and other related conservation areas in the country. More detailed information about all the topics is available in Table 3 of Mbanze et al., (2019).

Table 3.3. Rating scale coded for the four major themes that experts were requested to answer

Nº	Major themes	Rating scale	Source
Q.1	Identify the degree of threat each of the existing problems in the NNR represents for conservation	0=very little, 1=little, 2=moderate, 3=high and 4=very high	(Booth, Vernon R.; Dunham, 2014; Jorge et al., 2013; Martins, 2015; MICOA, 2014; Muarapaz, 2016; NCP, 2016, 2015; Ribeiro et al., 2008)
Q.1.1	Among different actors, indicate the main responsible for each of these threats.	0 = No, 1 = Yes	
Q.2	Several reasons for local people to be involved with practices that threaten conservation	2=strongly agree, 1=agree, 0=undecided, -1=disagree and -2=strongly disagree	(Aheto et al., 2016; Bluwstein and Lund, 2016; Giva, 2016; MICOA, 2014; Mombo et al., 2014; NCP, 2015)
Q.3	Put the current compensation measures in order of importance to the local population	6=most important to 1=least important	
Q.3.1	Limitations with the way that current compensation measures are being delivered	2=strongly agree, 1=agree, 0=undecided, -1=disagree and -2=strongly disagree	(Muarapaz, 2016; NCP, 2015; Tembo et al., 2015)
Q.4	What will be the effectiveness of each new measures below in order to promote the adoption of conservation-friendly practices	2=very positive, 1=positive, 0=no effect; -1=negative and -2=very negative	(NCP, 2015)
Q.4.1	Level of improvement with adoption of new measures	4=76-100%, 3=51-75%, 2=26-50%, 1=1-25% and 0=0%	Authors
Q.4.2	Level of improvement in people behaviours and motivation for conservation	4 =very high, 3 = high, 2= Moderate, 2= low and 0=Null	

Respondents' ratings were first analysed through principal components for dimension reduction and subsequently to detect clusters structures. To understand whether there was any relationship between different views of respondents in all major themes, a crosstabulation between clusters was tested based on Fisher's Exact test and Asymptotic Person's Chi-Square (Chan, 2003; Mehta and Patel, 2011). When a significant relationship was detected, a post-hoc cellwise test (goodness-of-fit) was performed in order to find those attributes most significant for the association, and spell out the meaning of those relationships, based on the adjusted standardized residuals and adjusted alpha (α) (Beasley and Schumacker, 1995; García-Pérez and Núñez-Antón, 2003; Sharpe, 2015). The same technique was applied between clusters of major themes and socio-

economic profile of respondents to understand whether their socio-economic background can also explain the points of views of respondents concerning major themes. Data from the post-hoc test is available in Tables 4-9. For more detailed information about the methodology see Mbanze et al., (2019) (A. Mbanze et al., 2019).

Table 3.4. Post-hoc cellwise tests between clusters of the degree of threat that each of the existing problems in the NNR represents (Q.1), and reasons for local people engagement in threatening practices (Q.2)

			Q.1		
			N1	N2	N3
Q.2	N1	Count	7	0	2
		Expected Count	4.3	2.5	2.3
		% within Ward Method	77.8%	0.0%	22.2%
		Adjusted Residual	2.0	-2.0	-0.2
		P (Z_{ij})	0.0450	0.0446	0.8077
	N2	Count	0	5	3
		Expected Count	3.8	2.2	2.0
		% within Ward Method	0.0%	62.5%	37.5%
		Adjusted Residual	-2.9	2.4	0.8
		P (Z_{ij})	0.0038	0.0155	0.3975
	N3	Count	12	8	6
		Expected Count	12.3	7.1	6.6
		% within Ward Method	46.2%	30.8%	23.1%
		Adjusted Residual	-0.2	0.6	-0.4
		P (Z_{ij})	0.8750	0.5814	0.7015
	N4	Count	1	1	2
		Expected Count	1.9	1.1	1.0
		% within Ward Method	25.0%	25.0%	50.0%
		Adjusted Residual	-0.9	-0.1	1.2
		P (Z_{ij})	0.3542	0.9156	0.2419
	N5	Count	6	1	1
		Expected Count	3.8	2.2	2.0
		% within Ward Method	75.0%	12.5%	12.5%
		Adjusted Residual	1.7	-1.0	-0.9
		P (Z_{ij})	0.0893	0.3102	0.3629

Table 3.5. Post-hoc cellwise tests between clusters of the degree of threat that each of the existing problems In the NNR represents (Q.1) and compensation measures currently in place at the reserve (Q.3)

			Q.1		
			N1	N2	N3
Q.3	N1	Count	26	0	0
		Expected Count	12.3	7.1	6.6
		% within Ward Method	100.0%	0.0%	0.0%
		Adjusted Residual	7.4	-4.3	-4.1
		P (Zij)	0.0000	0.0000	0.0000
	N2	Count	0	15	0
		Expected Count	7.1	4.1	3.8
		% within Ward Method	0.0%	100.0%	0.0%
		Adjusted Residual	-4.3	7.4	-2.7
		P (Zij)	0.0000	0.0000	0.0080
	N3	Count	0	0	14
		Expected Count	6.6	3.8	3.6
		% within Ward Method	0.0%	0.0%	100.0%
		Adjusted Residual	-4.1	-2.7	7.4
		P (Zij)	0.0000	0.0080	0.0000

Table 3.6. Post-hoc cellwise tests between clusters of the degree of threat that each of the existing problems in the NNR represents for conservation and level of improvement of different ecosystem services, after the implementation of new measures.

			Q.4.1		
			C1	**C2**	**C3**
Q.1	**C1**	Count	20	0	0
		Expected Count	9.5	5.5	5.1
		% within Ward Method	100.0%	0.0%	0.0%
		Adjusted Residual	5.9	-3.4	-3.3
		P (Zij)	0.0000	0.0006	0.0011
	C2	Count	0	8	5
		Expected Count	6.1	3.5	3.3
		% within Ward Method	0.0%	61.5%	38.5%
		Adjusted Residual	-3.9	3.2	1.2
		P (Zij)	0.0001	0.0015	0.2179
	C3	Count	6	7	9
		Expected Count	10.4	6.0	5.6
		% within Ward Method	27.3%	31.8%	40.9%
		Adjusted Residual	-2.4	0.6	2.1
		P (Zij)	0.0153	0.5366	0.0317

Table 3. 7. Post-hoc cellwise tests between clusters of reasons for local people being involved with practices that threaten conservation, (Q.2) and compensation measures currently in place at the reserve (Q.3).

			Q.3		
			N1	**N2**	**N3**
Q.2	N1	Count	7	0	2
		Expected Count	4.3	2.5	2.3
		% within Ward Method	77.8%	0.0%	22.2%
		Adjusted Residual	2.0	-2.0	-0.2
		P (Zij)	0.0450	0.0446	0.8077
	N2	Count	0	5	3
		Expected Count	3.8	2.2	2.0
		% within Ward Method	0.0%	62.5%	37.5%
		Adjusted Residual	-2.9	2.4	0.8
		P (Zij)	0.0038	0.0155	0.3975
	N3	Count	12	8	6
		Expected Count	12.3	7.1	6.6
		% within Ward Method	46.2%	30.8%	23.1%
		Adjusted Residual	-0.2	0.6	-0.4
		P (Zij)	0.8750	0.5814	0.7015
	N4	Count	1	1	2
		Expected Count	1.9	1.1	1.0
		% within Ward Method	25.0%	25.0%	50.0%
		Adjusted Residual	-0.9	-0.1	1.2
		P (Zij)	0.3542	0.9156	0.2419
	N5	Count	6	1	1
		Expected Count	3.8	2.2	2.0
		% within Ward Method	75.0%	12.5%	12.5%
		Adjusted Residual	1.7	-1.0	-0.9
		P (Zij)	0.0893	0.3102	0.3629

Table 3. 8. Post-hoc cellwise tests between compensation measures that are currently in place at the Reserve (Q.3) and level of improvement of different ecosystem services, after the implementation of new measures (Q.4.1)

			Q.4.1		
			N1	**N2**	**N3**
Q.3	**N1**	Count	20	0	0
		Expected Count	9.5	5.5	5.1
		% within Ward Method	100.0%	0.0%	0.0%
		Adjusted Residual	5.9	-3.4	-3.3
		P (Zij)	0.000	0.001	0.001
	N2	Count	0	8	5
		Expected Count	6.1	3.5	3.3
		% within Ward Method	0.0%	61.5%	38.5%
		Adjusted Residual	-3.9	3.2	1.2
		P (Zij)	0.000	0.002	0.218
	N3	Count	6	7	9
		Expected Count	10.4	6.0	5.6
		% within Ward Method	27.3%	31.8%	40.9%
		Adjusted Residual	-2.4	0.6	2.1
		P (Zij)	0.015	0.537	0.032

Table 3.9. Post-hoc cellwise tests between the level of education and cluster of level of improvement of different attributes, after the implementation of new measures

			Education		
			Lower & Intermediate	**Upper Secondary School**	**Higher Education**
Q.4.1	**N1**	Count	5	1	14
		Expected Count	5.5	2.2	12.4
		% within Ward Method	25.0%	5.0%	70.0%
		Adjusted Residual	-0.3	-1.1	0.9
		P (Zij)	0.7748	0.2880	0.3451
	N2	Count	4	5	4
		Expected Count	3.5	1.4	8.0
		% within Ward Method	30.8%	38.5%	30.8%
		Adjusted Residual	0.3	3.6	-2.6
		P (Zij)	0.7460	0.0003	0.0084
	N3	Count	6	0	16
		Expected Count	6.0	2.4	13.6
		% within Ward Method	27.3%	0.0%	72.7%
		Adjusted Residual	0.0	-2.1	1.4
		P (Zij)	1.0000	0.0341	0.1739

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Chapter 3

Appendix A

3.A1. Supplementary material.

The on-line survey can be downloaded from Google forms at:
https://goo.gl/forms/ryuvRjl4xF5KDzjm1 (Portuguese) and
https://goo.gl/forms/WUPfWwfDkW1kV0mq1 (English).

3.A2. Survey to the professionals and volunteers involved in the design and implementation of conservation measures in the Niassa National Reserve

The Niassa National Reserve (NNR) is the largest conservation area in Mozambique. The Reserve was created for hunting propose in 1954 and later in 1997 was proclaimed a conservation area. It is one of the few remaining intact savannas in the world, and it's also of global importance due to its biodiversity abundance, mostly endemic. Although efforts are being made to maintain the reserve, there are several problems that threaten biodiversity, mostly anthropogenic.

The present survey aims to collect the sensitivity of the professionals and volunteers involved in NNR conservation, in order to propose sustainable alternatives to improve the conservation. The survey has five sections and it is estimated that the average time to answer all questions ranges from 25 to 35 minutes. Questions marked with asterisk (*) must be answered. If you do not answer the question, the system will report an error alerts (an answer is required for this question), and you will not proceed to the next question before answering the previous one.

Your response to this survey is a valuable contribution to help us to propose consistent solutions to the current problems that threaten the degradation of the Reserve. We appreciate all attention and time you will spend, in order to help us to address this problem. There aren't right or wrong answers to this questionnaire; all answers are important; we just want to know you point of view.

We will ensure total anonymity and confidentiality of your answers in the analysis and publication of all information will be collected.

If you find questions, doubts, comments or suggestions while you fill this questionnaire, you can contact: aires.banze@gmail.com or 26421@novasbe.pt, you can also send this questionnaire if you know people that will be interest to send to them.

We hope you will enjoy it too much

SECTION I - PRACTICES INTERFERING WITH COSERVATION IN THE RESERVE

1. **Could you please identify the degree of threat each of the existing problems in the Reserve represents to conservation?**

	Very high	High	Moderate	Little	Very little
Cut and burn agriculture	□	O	O	O	O
Commercial farming (e.g. tobacco, soy and cotton)	□	O	O	O	O
Sport hunting (Concessions / Hunting Blocks)	□	O	O	O	O
Poaching (e.g. ivory, bones, skin etc.)	□	O	O	O	O
Hunting for eat or sale meat locally (bushmeat)	□	O	O	O	O
Extraction of non-timber products (e.g. honey, fruits and roots)	□	O	O	O	O
Wood fuel (fire wood and charcoal)	□	O	O	O	O
Illegal logging	□	O	O	O	O
Fishing	□	O	O	O	O
Population growth in the reserve with increased pressure to the resources	□	O	O	O	O
Human and wildlife conflicts	□	O	O	O	O
Illegal gold and ruby mining	□	O	O	O	O
Projects and Infrastructures (roads, power poles and communication antennas)	□	O	O	O	O

2. **Could you kindly add two more relevant problems and its respective degree of threats?**
   Threat 1_____
   Threat 2_____

3. **Indicate the main actor responsible for each problem described. In your answer, consider direct (action) or indirect responsibility (omission)**

	Do	Go	ReAd	NoRe	LoPe	PrSc	TrAu
Cut and burn agriculture	□	O	O	O	O	O	O
Commercial farming (e.g. tobacco, soy and cotton)	□	O	O	O	O	O	O
Sport hunting (Concessions / Hunting Blocks)	□	O	O	O	O	O	O
Poaching (e.g. ivory, bones, skin etc.	□	O	O	O	O	O	O
Hunting for eat or sale meat locally (bushmeat)	□	O	O	O	O	O	O
Extraction of non-timber products (e.g. honey, fruits and roots)	□	O	O	O	O	O	O
Wood fuel (fire wood and charcoal)	□	O	O	O	O	O	O
Illegal logging	□	O	O	O	O	O	O
Fishing	□	O	O	O	O	O	O
Population growth in the reserve with increased pressure to the resources	□	O	O	O	O	O	O
Human and wildlife conflicts	□	O	O	O	O	O	O
Illegal gold and ruby mining	□	O	O	O	O	O	O
Projects and Infrastructures (roads, power poles and communication antennas)	□	O	O	O	O	O	O

Where: Do=Donors, ReAd=Reserve Administration, NoRe=Non-residents, LoPe=Local People, PrSc=Private, Sector (PrSc) and TrAu=Traditional Authorities,

4. **There are several reasons for local people to be involved on practices that threaten conservation. Please, indicate your degree of agreement to each of the sentences given below**

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Livelihood Insufficiency	□	O	O	O	O
Conservation does not bring any benefit, instead of restrictions	□	O	O	O	O
People don't know the importance of conservation	□	O	O	O	O
The local people are corrupted to corroborate with infractors	□	O	O	O	O
There are feeling of injustice in benefits sharing (especially 20% of the revenue)	□	O	O	O	O
Conservation only creates problems (e.g. human and wildlife conflict)	□	O	O	O	O
Conservation only benefits foreigners (e.g. visitors, government, NGOs, technicians or researchers)	□	O	O	O	O
The community are not strongly involved on the decision making and its implementation	□	O	O	O	O
Opposition to the restrictions imposed by conservation (e.g. hard rules and zoning)	□	O	O	O	O
Low education	□	O	O	O	O
Lack of infrastructure (e.g. hospitals, schools, transportation and communication)	□	O	O	O	O

SECTION II - EFFECTIVENESS AND LIMITATIONS OF THE COMPENSATION MEASURES
Different compensation measures are currently in place in the Niassa Reserve, to motivate local people in order to participate in the conservation activities

5. **Put the measures listed below in order of importance to the local population, considering 1 = most important and 6 = least important**

	1	2	3	4	5
Jobs for the local population created under the conservation program, (e.g. Forest ranger position)	□	O	O	O	O
Hunting quotas allocated to communities	□	O	O	O	O
20% income from the concessions which are delivered to the local people	□	O	O	O	O
Food allowances which are distributed to local people	□	O	O	O	O
Delivery of 50% of the revenue of the fines from these who detected the infraction in the reserve	□	O	O	O	O
Promotion and respect of culture and beliefs of local communities by government authorities and other actors in conservation (e.g. sacred places)	□	O	O	O	O

6. **Some limitations have been referenced due to the way the compensation measures are being delivered. In this context, please indicate your agreement with the statements below**

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Lack of transparency in the criteria to allocate the jobs position	□	O	O	O	O
The hunting quotas allocated to local people are not enough	□	O	O	O	O
The money allocated to the communities is not enough	□	O	O	O	O
Lack of monitoring and accountability in the use of 20% of concession revenues	□	O	O	O	O
In many cases, the detectors of the offenders do not receive the award	□	O	O	O	O
Weak training and advice to communities in how to use the compensation	□	O	O	O	O
Poor monitoring and evaluation of the results from the projects implemented to the benefit of communities	□	O	O	O	O
The above compensations are not enough to motivate the community	□	O	O	O	O

SECTION III

By improving existing measures and introducing new ones, it would be possible to encourage local people to participate in the conservation by adopting conservation friendly practices. Among these new measures, might be the introduction of individual or collectives' incentives, in cash or in kind, (e.g. improved seeds, assistance in the production of certified products such honey, new techniques to keep away crop raids from farms and communities, as well as performance-based payments), which may lead to the improvement of the conservation performance. More than compensating local people, it's a matter of motivating them to be more active in conservation. In the following questions, we would like to know your opinion regarding to the effectiveness of some of these new measures.

7. In your opinion, what will be the effectiveness of each of the measures described below in order to promoting the adoption of conservation-friendly practices by the household's heads

	Very positive	Positive	Neutral	Negative	Very negative
Create areas for cultivation of high-yield commercial crops (e.g. tobacco, corn, soybeans, cotton, etc.) to reduce pressure on land and obtain greater profits than others crop like cassava, maize etc.	□	O	O	O	O
Assist local people to the use environmentally-friendly cultivation practices (e.g. minimum cultivation, crop rotation, green manuring etc.)	□	O	O	O	O
Assist local people to produce alternative sources of animal proteins (e.g. chickens, pigs, poultry etc.)	□	O	O	O	O
Promoting certification of non-timber products (e.g. honey, fruit, medicinal plants etc.) in order to get higher market prices and encourage sustainable use of natural resources]	□	O	O	O	O
Training the communities for sustainable use of forest resources (timber, non-timber and fishing resources)	□	O	O	O	O
Involve local people in the management and decision-making on issues related to the reserve	□	O	O	O	O

Increase in the percentage of revenues charged to distribute to communities	□	O	O	O	O
Increased employment in conservation and recreation activities (e.g. tour guides, rangers, carpenters, hotels and restoration activities, etc.);	□	O	O	O	O
Attribution of collective conservation performance-based payments for local people	□	O	O	O	O
Provide education for local people (e.g. scholarships)	□	O	O	O	O
Improve services delivery for local people (e.g. health, education, roads etc.)	□	O	O	O	O

8. If you could only choose 4 of the measures mentioned above, what measures would you choose in order to improve the conservation status of the Niassa Reserve? You can mark only those you will be chosen

O	Create areas for cultivation of high-yield commercial crops (e.g. tobacco, corn, soybeans, cotton, etc.) to reduce pressure on land and obtain greater profits than others crop like cassava, maize etc.
O	Assist local people to the use environmentally-friendly cultivation practices (e.g. minimum cultivation, crop rotation, green manuring etc.)
O	Assist local people to produce alternative sources of animal proteins (e.g. chickens, pigs, poultry etc.)
O	Promoting certification of non-timber products (e.g. honey, fruit, medicinal plants etc.) in order to get higher market prices and encourage sustainable use of natural resources)
O	Training the communities for sustainable use of forest resources (timber, non-timber and fishing resources)
O	Involve local people in the management and decision-making on issues related to the reserve
O	Increase in the percentage of revenues charged to distribute to communities
O	Increased employment in conservation and recreation activities (e.g. tour guides, rangers, carpenters, hotels and restoration activities, etc.);
O	Attribution of collective conservation performance-based payments for local people
O	Provide education for local people (e.g. scholarships)
O	Improve services delivery for local people (e.g. health, education, roads etc.)

9. Could you justify the reason for the choice you made above?

Answer_____

_

_____

10. If these 4 measures you selected in the previous question will be adopted in the reserve. What would be the percentage of improvement (on a scale of 0 to 100%), that you would expect to get from each conservation values?

	0%	**1-25%**	**26-50%**	**51-75%**	**76-100%**
Increases of the biodiversity in general	□	O	O	O	O
Increases of forest cover	□	O	O	O	O
Increase of large carnivores and herbivores (e.g. the big fives);	□	O	O	O	O
Increment of fish stocks	□	O	O	O	O
Increase of large aquatic animals (e.g. crocodiles and hippos)	□	O	O	O	O
Reduction of degraded area due to cut and burn agriculture	□	O	O	O	O
Reduction of degraded area due to extraction of non-timber products	□	O	O	O	O
Reduction of local people engaged in illegal activities	□	O	O	O	O

Reduction of unsustainable trophy hunting (sport hunting)]	□	O	O	O	O
Reduction of illegal hunting for eat and sale the meat (bushmeat)	□	O	O	O	O

11. In addition to the conservation values above, what would be the improvement that you would expect to see in relation to these other attributes below?

	Very high	High	Moderate	Low	Null
Knowledge of local communities regarding the importance of NNR conservation	□	O	O	O	O
Motivation of local people to participate in conservation activities	□	O	O	O	O
Disclosure of offenders	□	O	O	O	O
Mutual respect and trustiness among the different conservation actors	□	O	O	O	O
Increase of local people employed in the reserve	□	O	O	O	O
Reduction of human and wildlife conflicts	□	O	O	O	O
Reduction of frequency and forest fires intensity	□	O	O	O	O

SECTION IV - HOW TO CONCILIATE CONSERVATION, DEVELOPMENT AND LOCAL PEOPLE LIFESTYLE

Currently, most of the funding to support conservation activities in the reserve, are from international donors and hunting concessions.

12. Select at least four main sources of funding that can be explored to ensure the future sustainability of conservation activities in the reserve.

O	Donors
O	Government authorities
O	From tourism and ecotourism in general
O	Carbon credits and other related activities
O	Revenues from what is apprehended from illegal activities
O	Hunting concessions

13. Can you suggest at least two other sources of funding that can be explored

One_____

Two_____

14. Below are describe some factors that we believe you've pondered to select the four sources of funding. Could you please put order of importance these factors? In you answer, considers 1 = most important and 7 = least important

	1	2	3	4	5	6	7
Job generation	□	O	O	O	O	O	O
Potential to generate revenue	□	O	O	O	O	O	O
Attracting of investments and its viability	□	O	O	O	O	O	O

Sustainable conservation activities	□	O	O	O	O	O	O
Empowering local communities;	□	O	O	O	O	O	O
Potential to improve local people intellectual and financial capacities	□	O	O	O	O	O	O
Potential to reduce external influence in the conservation policies.	□	O	O	O	O	O	O

15. Can you please mention another important factor that you took in consideration, which was not described above?

_____

_____

SECTION V - SOCIO-ECONOMIC PROFILE OF RESPONDENTS

16. Gender

O	Female
O	Male
O	Prefer not to say

17. Your major field

O	Anthropology
O	Biology
O	Social Sciences
O	Political Sciences
O	Conservation of Natural Resources
O	Rural development
O	Ecology
O	Economics
O	Agricultural Engineering
O	Forest Engineering
O	Environmental Engineering
O	Rural Extension
O	Geography
O	Medicine
O	Others

18. Degree of Education

O	Elementary Education
O	Lower Secondary School
O	Lower Professional Education
O	Intermediate Professional Education
O	Upper Secondary Education
O	BSc/ Graduation Degree
O	Master's degree (M.Sc.)
O	PhD

O	Post-doctoral
O	Other (Indicate please)

19. How many times have you been in the Niassa Reserve?
Never__; 1___; 2____; 3 – 5 ____; > 5 _____

20. For how long time you stayed in the reserve? (sum of all trips) and what was the main objective of your trip to the reserve

O	Any time	O	Tourism
O	Less than a month	O	Research
O	1 – 4 Months	O	Visit friend family
O	5 – 8 Months	O	Just passing through
O	8 – 12 Months	O	Working
O	> 12 Months	O	Others

21. Years of experience in conservation (if applicable)
Any___; 1____; 2 – 5____; 6 – 10____; >10_____

22. Your current institution
_____

23. Position _____

24. Other institutions where you worked before_____

If you find it relevant, provide email contact from two persons who would be relevant to send this questionnaire. You can also send personally. Don't forget to provide full name and the respective institutions where the people work

Thank you for your time

Chapter 4

A Livelihood and Farming System approach for effective conservation policies in Protected Areas of Developing Countries: The case study of the Niassa National Reserve in Mozambique

Aires Afonso Mbanze, Carina Viera da Silva, Natasha Sofia Ribeiro,
Jõao Silva, and José Lima Santos

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A Livelihood and Farming System approach for effective conservation policies in Protected Areas of Developing Countries: The case study of the Niassa National Reserve in Mozambique

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Abstract

Effective conservation requires that conservation policies and management decisions first target local actors who are dependent on natural resource use in Protected Areas (PA) of Developing Countries (DC). In rural areas of DCs, these actors are mainly farmers who also rely on off-farm activities such as harvest of Non-Timber Forest Products (NTFPs) to complement their livelihoods. Here, we propose a novel approach to support the development of policy interventions aimed at achieving conservation goals through the sustainable development of local people in PAs of DCs. The approach consists of identifying the main Livelihood and Farming Systems (LFS) and select those that are more conservation-friendly and that may contribute to solve conservation and development problems such as Human-wildlife conflict. identifying the existing LFS can also helps in searching for conservation-relevant improvements that can contribute for local people wellbeing, considering the existing FS as the starting point for a sustainable development strategy in PAs of DC. Data from the Niassa National Reserve (NNR), the largest PA in Mozambique, were

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used to develop this LFS approach. Measures of effort applied in harvesting NTFPs and in managing agricultural inputs and outputs were collected from 329 households through a structured survey. Cluster analysis was performed to identify and characterise the main LFS in the NNR. Based on the cluster results, we have identified four livelihood systems (LS): gatherers, hunters, farmers and employees; three farming systems (FS) specialized in maize, rice and sorghum, and a mixed FS. A Multinomial Logistic Model was also applied to understand the drivers of LFS choice. Livelihood systems were mainly driven by household-level socio-economic factors, while FS were driven by village-level biophysical conditions. Households who were employed and had diversified farming and off-farm activities were better off and more resilient to climate change and crop-raiding animals. Intensification appears to occur gradually but has found to be limited by rainfall availability. Based on our findings, we propose that conservation experts and policy-makers should use a LFS approach to re-frame the conservation narrative in PAs of DCs and promote the existing practices that can better protect biodiversity while improving livelihood and welfare of local people.

Keywords*: Biophysical and socio-economic drivers, Conservation policies, Crop raiding, Farming and livelihood systems and Protected Areas.*

4.1. Introduction

Efforts to reduce environmental degradation are underway worldwide (Peterman et al., 2013). However, those efforts are even more challenging in Developing Countries (DCs) (Brister, 2016; Cooney et al., 2017), where conservation policies and strategies are frequently focused on reducing biodiversity loss, especially the loss of endangered species (Gaillard et al., 2019; Galvin et al., 2006), rather than on human behaviours that are the core drivers of environmental and ecosystem services degradation (Jew et al., 2019).

In uninhabited Protected Areas (PAs), management efforts toward reducing biodiversity loss have generated the expected results (Beale et al., 2013), unlike in many inhabited PAs, where the local people are the core agents of ecosystem services use (Baral and Heinen, 2007; Bluwstein and Lund, 2016). In these areas, a significant share of the land is managed by small farmers, foresters, hunters, fishers and gatherers of provisioning services (Beale et al., 2013). Thus, management decisions are primarily driven by markets, policies, biophysical and socioeconomic conditions, rather than by the pursuit of conservation goals (Kramer et al., 2009). For conservation strategies and intervention to be more effective, PA managers and policy-makers need to fundamentally shift their focus from directly managing ecosystems to managing the behaviour of economic agents, so that they can choose the available options that deliver both better conservation results and improved human well-being. This requires acquiring knowledge about: (1) the management options available in the area; (2) the key drivers that lead agents to choose between different options (Alemayehu et al., 2018); and (3) those options that can be selected to promote conservation. This knowledge will enable conservation authorities and PA managers to design conservation policies and strategies that act on the drivers of people's choices and thereby promote those options that have the highest conservation value.

A promising approach to identifying existing management options available to local economic agents is to identify the farming systems (FS) occurring within the PA (Ribeiro et al., 2014). For this purpose, a FS is seen as a group of farms that are similar regarding the way they merge inputs (land, labor,

and means of production, e.g. fertilizers), with a similar mix of cropping and livestock activities (sub-systems), to produce a similar bundle of agricultural outputs (Dixon, 2019; Ferraton and Touzard, 2009; Reboul, 2009). A FS approach can be applied to specific farm-level data on inputs and outputs to define a local typology of FS and to select the best available options for local land managers.

Moreover, alongside farming, there are other relevant options (e.g. hunting, fishing, or gathering) to generate income and subsistence (Dixon, 2019). Those alternatives are sometimes even more important than farming, for ecosystem management and conservation, in the case in many PAs of DCs (Dehghani Pour et al., 2017). Thus, FS can be seen as a part (or subsystem) of a broader livelihood system (LS) that comprises all possible income-generating activities (Alemayehu et al., 2018; Dixon, 2019). In this case, we should identify both a broader typology of livelihood systems, for all households, and a more detailed typology of FS, for those who are farmers. These two typologies would provide us with a richer picture of the most dominant management options available for local economic agents within PAs.

Defining existing Livelihood and Farming Systems (LFS) can provide us with a system-based approach that better captures available options for policy proposals rather than defining individual practices, because households practice a specific LFS to achieve a common goal. Management decisions based on individual practices are then best understood as system of strongly inter-related practices that respond to biophysical constraints (Staal et al., 2002) and to environment and socioeconomic opportunities (Dixon et al., 2001; Maru et al., 2018; van de Steeg et al., 2010). For example, if endemic diseases (e.g. animal trypanosomiasis) or potential predation of cattle hinder livestock raising, local people will be more dependent on bushmeat to fufill their protein needs. Likewise, if crop raiding by wild fauna prevents households from strongly investing in crops, they would be expected to rationally shift their effort either to less susceptible crops or to other off-farming practices such as gathering of NTFPs. The prevalence of endemic diseasses and livestock raiding have already been reported in the Niassa National Reserve (NCP, 2017) and in other PAs of DCs (Auty et al., 2016; Kuiper et al., 2015), imposing considerable threat to livestock raising. Furthermore, other authors have reported changes on the type of crop or a shift to other

off-farming practices as a consequence of crop raiding in PAs of DCs (Aylor et al., 2016; Dickman, 2010; Lemessa et al., 2013). Second, choices among individual practices are interdependent on one another. For example: using a genetically improved and more productive variety of rice would entail using more intensive FS. Third, the fact that practices are interdependent within the LFS (Alemayehu et al., 2018) may allow us to identify farm-level management details with important conservation impacts (e.g. harvest dates or use of pesticides). Fourth, the fact that these practices exist implies that the LS and FS are clearly available management options for local households, that one need to take inconsideration when draw conservation policies/strategies. Thus, enhancing the existing practices will be much easier than challenging farmers to abruptly change their longstanding habits.

Four aspects of wildlife conservation and management in PAs of DCs are highlighted in this this paper: First, PAs of DCs are keystones for biodiversity conservation worldwide (Macdonald et al., 2012; Saura et al., 2017; WWF, 2012) as they are crucial for sustainable development strategies, supporting the achievement of the Sustainable Development Goals (Snyman and Bricker, 2016); Second, in the richest biodiversity hotspots, significant numbers of people are dependent on the ecosystem services of those areas (Dewees et al., 2010; Jew et al., 2016) and most of their daily practices contribute to biodiversity loss (Dikgang and Muchapondwa, 2012; Naidu and Kumar, 2016). For instance, the expansion of farmland has been identified to be the main driver of terrestrial biodiversity loss (Meyfroidt and Lambin, 2008), particularly in tropical forests of DCs (Galvin et al., 2006; Twongyirwe et al., 2018). A possible solution would be intensify agricultural production to avoid farmland expansion (the land-sparing option) (Hockings and McLennan, 2012). However, this strategy may be blocked by biophysical constraints (e.g. low rainfall, nutrient-poor soils) (Staal et al., 2002) and lack of appropriate technologies; furthermore, even intensification itself may be a driver of biodiversity loss. The third aspect is that, farmers in PAs of DCs are vulnerable to crop raiding, predation of livestock and endemic diseases affecting livestock, which can be major drivers in the choice among LFS (Aylor et al., 2016; Seiler and Robbins, 2016). Human-wildlife conflicts (HWC), may induce local people to become involved in illegal hunting of the wild animals that

cause crop damages (Moreto, 2019; Rogan et al., 2017) or to cooperate with poachers coming from outside the PA (Dickman and Hazzah, 2015; Mbanze et al., 2019b; Shepherd and Magnus, 2004). These deviations from intended objectives usually occur when PA authorities do not deliver a solution or sufficient levels of benefit to offset uneconomical levels of agricultural output loss from crop-raiding (Moreto, 2019); The last aspect, but not the least, is that, local economic agents in PAs of DCs are among the poorest people on Earth (Bieber-Klemm et al., 2006; Snyman and Bricker, 2016), and acute food insecurity problems persist within these PAs (den Braber et al., 2018; NCP, 2017). This means that no conservation policy or strategy will work without explicitly addressing needs for development and food security, and health challenges.

FS and LS analysis have been used to frame these problems (Dixon et al., 2001). Particular solutions have been put forward, such as diversification of FS into cash crops, intensification of FS (Alemayehu et al., 2018; Aylor et al., 2016; Seiler and Robbins, 2016), and diversification of LS to off-farm activities (Alemayehu et al., 2018; Dickman, 2010; Smith et al., 2017) and non-gathering activities (Lindsey et al., 2017), such as promotion of eco-tourism (Snyman and Bricker, 2016) or public employment in PA-related activities.

In this research, we used the LFS approach to frame the existing conservation problems in the Niassa National Reserve (NNR), which is a typical example of the above contextualized problem in PAs of DCs. By identifying (i) the available management options for local economic agents and (ii) the factors that drive these agents' choice of LS and FS, this approach aims to assist policymakers with appropriate measures, which can be used to design and implement more effective conservation policies and strategies in PAs of DCs.

These problems were addressesd through the following research questions:

Which land management options among the exiting LFS offer a highest potential for diversification and intensification strategies aimed at improving livelihoods and local food security, and which are the factors driving local agents to choose these options?

Which LFS has the potential to mitigate crop raiding and other negative impacts on biodiversity conservation and local resident livelihoods and thereby reduce HWC in the NNR?

Are there any factors that contribute to agricultural intensification or land expansion in the NNR? What are the implications of agricultural intensification and expansion for local agents and biodiversity conservation?

What are the strengths and weaknesses of the LFS approach, and what are its implications for nature conservation policies in the NNR and in other PAs of DCs?

These questions were addressed through a structured survey of households in seven villages located inside the NNR. Householders were asked about several topics related to their LS and FS, losses from crop raiding and their socio-economic and demographic profile.

4.2. Methodology

4.2.1. Site location and characterization

NNR is located in northern Mozambique, between coordinates: 12°38′48.67″S; 11°27′05.83″S and 36°25′21.16″E; 38°30′23.74″E (see Figure 4.1). It is the largest PA in Mozambique and the third largest in Africa (Prin et al., 2014; Ribeiro et al., 2008). The reserve covers 42,200 km^2(Mbanze et al., 2019a; Prin et al., 2014) , of which over 34,000 km^2 are occupied by concession blocks, with additional blocks up for tender in 2019.

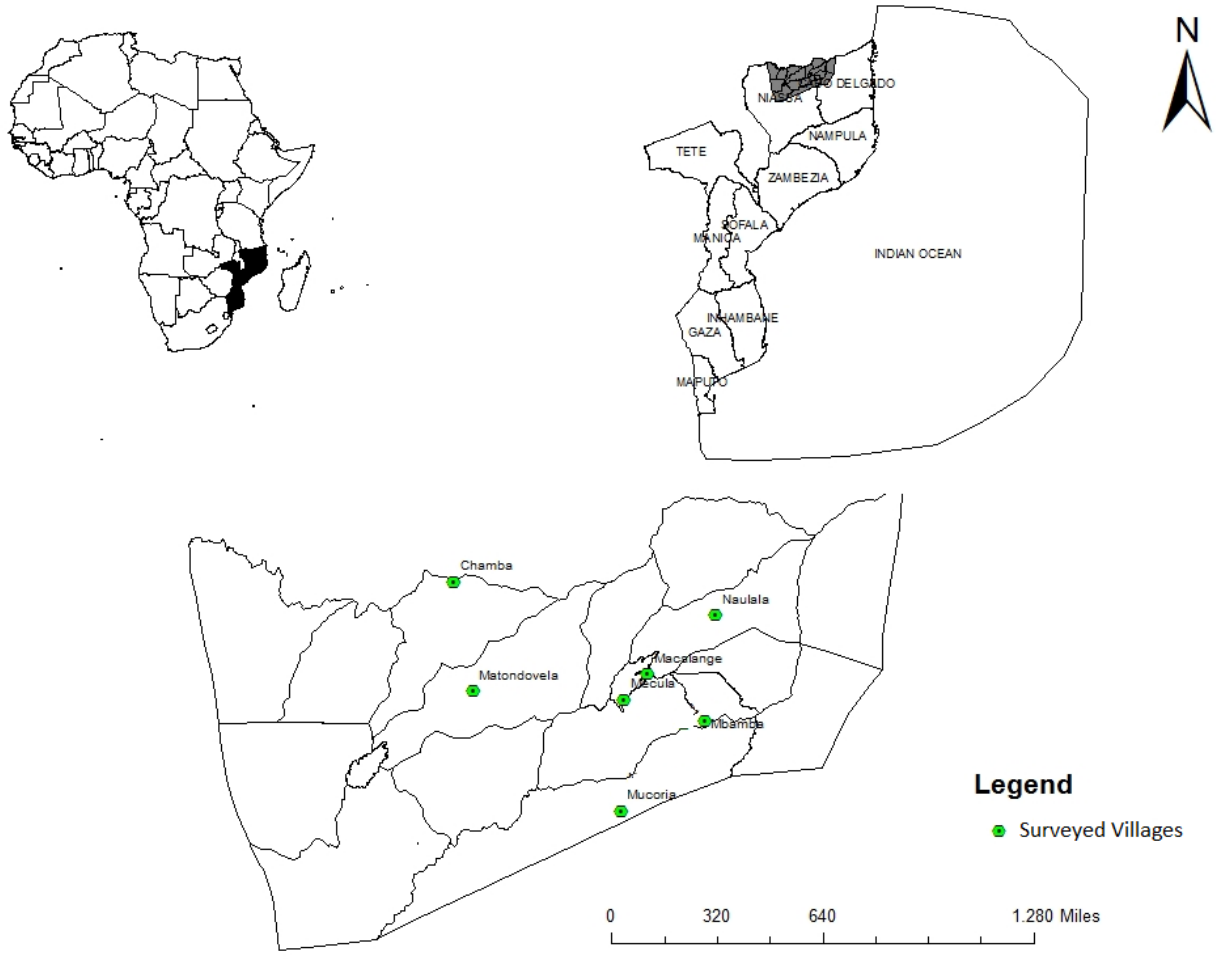

Figure 4. 1. The location of the Niassa National Reserve and the surveyed villages.

The current human population is about 60,000 residents (NCP, 2017), representing a two-fold increase in just ten years (NCP, 2015). Most of the population suffers from chronic food insecurity and limited access to basic social services. They rely primarily on subsistence agriculture, bushmeat hunting and harvesting of NTFPs, including fishing, honey-gathering and illegal trade of natural resources, since there are few legal alternatives (NCP, 2017). Agriculture is practiced in small plots of 0.4 to 2 hectares called "machambas" (Landry and Chirwa, 2011). Soils in the reserve are essentially poor and poorly drained (Campbell, 1996; Dewees et al., 2010). Land preparation includes slash-and-burn practices that exacerbate the soil's impoverishment and reduce productivity. These lands are subsequently abandoned after two to four years of cultivation, due to lack of essential nutrients (NCP, 2017). Land preparation starts three months before the rainy season, which extends from November to April. In this hot, dry period most of the vegetation is dry and prone to wild fires (Mbanze et al., 2015). Rainfall follows a west-east gradient, with about 1200 mm average annually in the west and 600 mm in the east. Temperatures are typically high, with monthly averages reaching around 30^0C in October and November, and dropping to 20-26^0C in the cold dry season or winter (SRN, 2008). Crop and livestock raiding by wild animals is relatively common (Jorge et al., 2013), and the frequency of raids threatens food security of local residents (NCP, 2018).

The network of PAs has increased substantially in the country in the last 20 years (Ministry for the Coordination of Environmental Affairs (MICOA, 2014)), representing about 26% of the country's forets surface (Marzoli, 2007). Within the network, the NNR accounts for 5.3% (ANAC, 2016) of the total area and 44.9% of conservation areas (Ganzin et al., 2010; Prin et al., 2014). The reserve is one of the few intact miombo savannahs remaining in the world (Ribeiro et al., 2013; WWF, 2012). It is home to 1200 lions, one of only seven remaining PAs that each protect more than 1000 African lions (*Panthera leo*), and a substantial elephant (*Loxodonta Africana*) population (Riggio et al., 2013). Unfortunately, poaching and illegal ivory and skin trades represent a major threats to conservation, due to (i) increasing demand for ivory in fast-growing Asian economies, particularly China and Thailand (Booth, Vernon R.; Dunham, 2014; UNEP et al., 2013); ii) retaliatory killing of raiding animals (Mbanze et al., 2019b; NCP, 2017) and (iii) the

increasing of human population (NCP, 2015). For all these above reasons poited out, the NNR is an ideal PA in Mozambique, representative of the Miombo savannas, to conduct this research.

4.2.2. Data collection

Data were collected in seven villages within the reserve (Figure 4.1 and Table 4.1). Villages were selected after review the reserve reports, grey literature and meeting with the NNR administration, the Mecula district government, and the Niassa Carnivore Project to have a more authoritative information and thus select a set of representative villages sample concerning farming and livelihood systems. In this study, a village is defined by the spatial extent of households associated with a village name under the leadership of one village Chairperson (Mackenzie, 2012), which is the lowest administrative unit in Mozambique. The total number of households registered in each village was provided by the NNR administration and Districtal Secretariat of Agriculture and Economic Activities (Secretariado Distrital de Agricultura e Atividades Econômicas - SEDAE), located in the Mecula headquarters. Sample size was uneven among villages, because the main objective was to assure sampling representativeness and preserve the theorem, that for a given random and normally distributed population, sample size does not necessarily increases in the same proportion as the population size (Bartlett et al., 2001; Krebs, 2014). Sampling was taken for convenience. A survey was conducted from July to September 2017. During this period, 339 householders (21.07%) were surveyed in the seven villages. Most of surveyed householders (92.33%) were men, with age ranging from 18 – 86 years (mean = 43; Std. deviation = 16.52).

Table 4.1. Number of households sampled per village

Villages	Number of households in the village	Number of households sampled	Sampling effort (%)
Chamba	50	42	84
Macalange	132	45	34.10
Matondovela	77	52	67.53
Mbamba	141	62	43.97
Mecula	908	56	6.17
Mucoria	131	42	32.06
Naulala	170	40	23.53
TOTAL	1609	339	21.07

Source: National census (2015) available at district level.

4.2.2.1. Household survey

The questionnaire had four sections: 1) general information, which included the location and size of the village; 2) socio-economic background of the household (household size, employment status, income and education); 3) agricultural outputs in the last season (crop harvest and losses for crop raiding), rank of the four top raiding species according to potential loss, proportion of the harvest of each crop that was sold and market prices, and 4) gathering effort related to NTFPs (frequency of harvesting and its final propose, either for use or sale, quantities and prices if households remembered). We did not measure the size of farming area to estimate yield per hectare, as most of the agriculture fields were not close to the villages, and households were not able to show their farming borders within time and logistical constraints. The questionnaire was pre-tested with 10 householders in the Mbamba village, and administered to respondents in collaboration with five field assistants and two young locals, who were familiar with the local languages (Cyao, Emakua and Swahili). In order to avoid external bias and/fear of answering some sensitive questions, each household was individually questioned, mostly at home. Before the administration of the questionnaire, an oral consent was obtained. Only 5 households were unable to participate in the survey, but they were replaced by others to reach the required sample size. No questionnaire was withdrawn from the analyzes. The full questionnaire instrument appears in Appendix A.

4.2.3. Data Analysis

4.2.3.1. Agriculture production and prices

All agricultural outputs and losses were transformed into monetary value and percentage to express the quantities in physical terms and thus allow comparison among farms, LFS and villages (See appendix B). The average price of each crop (in new metical MZN)[6] was estimated based on figures provided by the

[6] New Metical (MZN) is the Mozambican currency. As of 25th November 2019 the exchange rate was: One US dollar ($1) was equivalent to 63.25 MZN. One British Pound (1£) was equal to 81.43 MZN, while one Euro (1€) was equivalent to 69.67 MZN. Source: https://www1.oanda.com/lang/pt/fx-for-business/historical-rates (OANDA – solutions for business)

surveyed households (see section 4 in Appendix A), by dividing the total revenue of crop sold by its respective quantities. This price was subsequently used to derive the Partial Expected Production (PEP) of each crop in monetary values. The PEP was then summed to obtain Total Expected Agriculture Production ($TEAP_i$). We also estimated Actual Crop Production (ACP_i) (by removing losses from crop raiding from the TEAP), and the Proportion of Crop Sold (PCS), which is the amount of crop sold in MZN, divided by the Actual Crop Production (PCS/ACP_i).

4.2.3.2. Typology of Livelihood Systems and Livelihood-System patterns of different villages

Gathering effort and effort by gathering activity

The frequency of participation of the respondent's household in each gathering activity was estimated based on the selection of a specified frequency class option in Section 4 of the questionnaire: 365 days/year were allocated for those that selected the daily option; 52 days/year for the weekly option; 12 days/year for the monthly option; 2 days/year for the semester option; and 1 day/year for the yearly option. This allocation of days/year was done for all 10 gathering activities included in the questionnaire, yielding 10 indicators of yearly gathering effort per activity. By summing frequencies across all activities, we computed the total number of days per year in all gathering activities, which can be interpreted as a rough estimate of total yearly gathering effort. These indicators of gathering effort per activity (GEA_i, where $_i$ is the activity index) and total gathering effort (TGE) were then divided by the total expected agricultural production of the household (TEAP, in metical/year) to express gathering effort in proportion to agricultural output (days/metical); that is $GEA_i/TEAP$ for each gathering activity and TGE/TEAP for all gathering activities. These ratios can be interpreted as the relative importance of gathering as compared to agriculture.

The Crop Raiding Index 1, which predicts the potential damage that is likely to occur at farm level, was based on the top four crop raiding species (elephants, buffalo, baboons and bushpigs), ranked by the surveyed households ($Rank_i$, where i vary from 1 to 4). The class of potential damage to each crop raiding (C), was taken from the literature (Mackenzie, 2012; Tufa et al., 2018) and authors' personal experience.

Elephants and buffalos were considered the most damaging animals (C= 2), followed by baboons and bushpigs (C =1).

$$Crop\ raiding1 = \sum_{i=1}^{4} Rank_i * C_i \quad (eq. 4.1)$$

Crop Raiding Index 1 was then compared to Crop Raiding Index 2, which is the faunal density reported in the NNR management plan at the block level (SRN, 2008). We used both indexes, because (i) Crop raiding index 2 is likely out of date, as the last faunal inventory in our possession was conducted in 2005; (ii) the inventory was not conducted at the village level to cover damages reported by households; and (iii) there are numerous reports highlighting decreases of wild animals in the reserve in the lasts 10 years, especially for elephants (Booth, Vernon R.; Dunham, 2014; Brennan and Kalsi, 2015; Jorge et al., 2013).

Developing a livelihood system typology

To identify different livelihood systems, we classified all surveyed households according to their main sources of income and their relative weights in the total (monetary and in-kind) income of the household. The relative weight of these sources of income was measured in different ways for the different major income-generating activities, depending on data we had access to. First, all households that (1) employed and depended only on wages earned, (2) have not been involved in gathering activities, and (3) had not been running a farm were included in the "Employees" category. All other households were included in a cluster analysis based on ratios of gathering effort per activity (and total gathering effort) to total expected agricultural production, that is GEA_i/TEAP, for each gathering activity and TGE/TEAP for all gathering activities. Only four GEA_i/TEAP variables were used (i = traditional medicines, firewood, edible insects and bushmeat) because many other gathering activities, such as gathering poles, stakes, bamboos or grass for roofing are very much linked to building or repairing activities, which for the same household, can vary very greatly across years and thus, are not good structural indicators of the household economy. A hierarchical cluster analysis was performed using Ward´s method and the Minkowski measure of dissimilarity (Legendre and Legendre, 2003).

Livelihood-system patterns across villages

To describe the LS pattern of each village, a cross-tabulation of LS and villages was performed to verify whether the null hypothesis of similar patterns of LS across villages can be rejected. After detecting any significant relationship, a *post hoc*, cellwise test was performed to find out which livelihood systems were above/below what would be expected by chance in each village (García-Pérez and Núñez-Antón, 2003; Sharpe, 2015).

4.2.3.3. Developing Farming System typology and patterns across villages

The ratio between Partial Expected Production and Total Expected Agriculture Production ($PEP_i/TEAP_i$) *100, was used to develop the typology of FS, based on agricultural crops (see Appendix 1, Section 3). Fish and honey were assigned in the farming system category, despite being NTFPs (see Appendix 1, Section 4) because: (i) we have captured quantities and price at the household level, since a considerable number of households reported selling a part of their production; and (ii) they are very profitable activities, with some households devoting a large portion of their time doing those activities, as there is a local market available. For instance, a litter of honey can bring up to $2 USD dollars in the local market (NCP, 2017).

Development of Farming System typology

The proportion of the dominant crop in the FS was used to assign FS. By convention, we designated specialized FS when the proportion of the dominant crop was approximately equal or greater than to 50% of the $TEAP_i$ while mixed FS were those with no clear dominant crop in the system. FS were assessed through Cluster Analysis on the household data of $PEP_i/TEAP_i$, performed using Ward´s method and the Minkowski index of dissimilarities (Legendre and Legendre, 2003).

Farming System patterns across villages

To describe FS pattern at village level, a cross-tabulation between FS and villages was assembled and tested to verify whether the null hypothesis of similar patterns of FS across villages can be rejected. *Post hoc*

cellwise tests were performed to find out which FS were above/below what would be expected by chance in each village (García-Pérez and Núñez-Antón, 2003; Sharpe, 2015).

4.2.3.4. Predictors and drivers of Livelihood and Farming Systems

Predictors and drivers of LFS were grouped as: (i) socio-economic (size of the family, level of education of the household head, total population per village, distance to the nearest market and crop sold by the household). The Mecula Headquarters was used as the reference for the nearest developed market. Thus household heads living in Mecula are on average 0 hours to the nearest market. Crop sold was coded as a dummy variable (1= if household sold the crop and 0 = otherwise). The Proportion of Crop Lost per Farm (PCLF) was the ratio between total monetary losses and Total Expected Agriculture Production (TEAPi); and (ii) biophysical drivers (availability of flatland for agriculture, average annual rainfall and crop raiding index 1 and 2). The percentage of flatland suitable for rice cultivation (with slope between 0 – 2%) was derived from NNR Digital Terrain Model[7], using a 4 Km buffer from the centre of each village (excludes mountains and rivers). This 4 Km distance range, was selected through satellite images of farming clusters (land use pattern) closer to the village. Some predictors/drivers (age, farm economic size, Crop Raiding Index 1 and 2), with meaningful explanations, but which did not fit in the LS model were used to describe the average size of the LS. Table 4.2 provides detailed information on all predictors and drivers of LFS. Some predictors and drivers were analysed at village level, while other were analysed at household level.

[7] https://www.eorc.jaxa.jp/ALOS/en/aw3d30/

Table 4. 2. Predictors and drivers of Livelihood and Farming System in the NNR

Variable name/code	Type	Unity of measuring/Class	Min-Max	Mean (SD)
Livelihood system				
Household size*†	Numerical	NA	1 - 15	4.93 (2.05)
Education†	Ordinal	7 classes	Illiterate (0) – BSc (6)	1 (1.11)
Age*	Numerical	NA	18 - 86	43 (16.52)
Economic size of the farm*	Numerical	MZN	0 – 246092.46	29558.97 (32350.8)
Crop riding (1)*	Ordinal	NA	13 - 17	15.24 (1.89)
Crop riding (2)*	Ordinal	NA	3 -5	4.17 (0.98)
Crop lost†	Numerical	%	35 – 66.0	45.32 (9.79)
Crop sold†	Categorical	dummy	0 -1	NA
Farming system				
Flatland†	Numerical	%	5.8 - 33.40	18.87 (0.45)
Distance to the market†	Numerical	Hours (h)	0.00 – 7.00	4.52 (3.04)
Total population†	Numerical	NA	234 – 13173	3064.86 (4804.35)
Rainfall†	Numerical	mm	1040.05 – 1867.0	1241.35 (259.81)

*Predictors used to describe LS through Analysis of Variance.
†Predictors/drivers used to describe LFS through the Multinomial Logistic Model

4.2.3.5. Livelihood and Farming Systems Models

A Multinomial Logistic Model was applied to investigate the importance of each predictor and driver of LS and FS. The importance of each of the variables in the fitted model was detected based on the log-likelihood, likelihood ratio, Nagelkerke and Cox&Snell Pseudo R-square. Predictors were selected based on their significance in the model and possible meaningful interpretation. The importance of each predictor included in the model was assessed at $p \leq 0.05$ level of significance.

4.2.3.6. Effect of rainfall and population in agricultural intensification

Since it was not possible to capture the yield of each crop per unit area (hectare), an artifact was applied to have a broad idea regarding the effect of population growth and rainfall in agricultural intensification. The artifact consisted of depicting a diagram of total population at the village level and rainfall *vs* the average number of households fed per hectare of cropland. Agricultural intensity was

measured in people/hectare, as the ratio between the average household size with a farm and the total cropland area. The resort of secondary data from National Agricultural Census (Instituto Nacional de Estatística (INE, 2011)), provided information about the average cropland area per household head at the village level.

4.2.3.7. Losses from crop raiding and their patterns across villages and LFS

The percentage of perceived crop lost was a ratio between crop loss from crop raiding and Partial Expected Production (PEP_i). Those individual ratios were then expanded to FS and village levels in order to understand whether crop raiding influences LFS strategies (e.g. what crop to plant or shift to off-farm activities). To depict the interrelation among LFS, potential damage from crop raiding (Crop Raiding Indexes), losses from crop raiding (actual damage), and the effect of different protective strategies (e.g. electro-fence), at village level. A comparable measure was created by transforming potential and actual damage into ordinal indexes (low, medium and high). These ordinal indexes were built based solely on the information in the present study. Thus, these indexes are strictly relative and do not allow comparison with other works. This procedure was done to allowed us to compare the level of potential and actual damages among villages, as well as have a broader picture of how a set of farms within a village perceive the available options to overcome crop raiding.

4.3. Results

4.3.1. Livelihood Systems and their village-level patterns

Four LS have been identified in the NNR: gatherers, hunters, farmers, and employees (Table 4.3). Gatherers exhibit the highest level of gathering effort in proportion to agricultural output, except for bush meat, and present a relatively low average expected agricultural production per household. They represent a small fraction of households in the sample (8%), but reach a higher proportion (up to 20%) in Mbamba and Naulala villages. Hunters have the highest level of hunting effort in proportion to agriculture and they have levels of gathering effort higher than farmers for all other gathering activities. Hunters have the smallest expected agricultural output and household size; they represent, overall, slightly more than 1/3 of all households, but they reach 70% in Mucoria. Farmers have the lowest levels of effort in each and all gathering activities in proportion to agricultural output. They have the largest average agricultural output and household size. Employees, who depend mostly on wages, are 10 years younger than all other LS types, and they held the highest educational level. These employees predominantly live in the Mecula village and have the lowest level of both crop raiding indexes. They represent less than 5% of the households, except in Mecula where they reach 18%.

All variables used to describe livelihood systems (except age) are significantly different across livelihood types ($\alpha < 0.05$). However, the variance across types is higher than the variance within types ($Eta^2 > 0.50$) only for the proportion of total gathering effort and firewood gathering effort.

Table 4.3. Livelihood systems, their characteristics, and village-level patterns

	Gatherers	**Hunters**	**Farmers**	**Employees**	**Total**		
	8,0%	**35.1%**	**52.2%**	**4.7%**	**N=339**	**Alf (α)**	**Eta^2**
Gathering effort per activity and total gathering effort in proportion of total expected agricultural production (GEA_i/TEAP)							
Traditional Medicines	0.17	0.04	0.01	-	0.036	0.000***	0.075
Firewood	2.83	0.54	0.16	-	0.524	0.000***	0.719
Edible Insects	0.04	0.01	0.00	-	0.006	0.000***	0.072
Bush meat	0.01	0.04	0.01	-	0.018	0.000***	0.051
Total gathering effort (all activities)	3.81	1.06	0.27	-	0.859	0.000***	0.746
Description of average household per livelihood system							
Farm economic size (TEAP in metical/year)	7461	13462	46424	-	29559	0.000***	0.305
Household size	4.9	4.4	5.3	4.6	4.9	0.001***	0.047
Age	43	42	44	34	43	0.057	0.022
Education level	low	low	low	high	low	0.000***	0.195
Distance to the Market	4.6	4.4	4.6	2.1	4.4	0.023*	0.028
Crop riding (1)	15.6	15.2	15.3	13.9	15.2	0.000***	0.066
Crop riding (2)	4.4	4.0	4.3	3.5	4.17	0.001**	0.047
Proportions of different livelihood systems in each village (%)					N		
Chamba	4.8	31.0	59.5	4.8	42		
Macalange	4.4	24.4	68.9	2.2	45		
Matondovela	0.0 -	30.8	65.4	3.8	52		
Mbamba	14.5 +	38.7	45.2	1.6	62		
Mecula	8.9	30.4	42.9	17.9 +++	56		
Mucoria	2.4	69.0 +++	28.6 -	0.0	42		
Naulala	20.0 ++	22.5	57.5	0.0	40		
Total Villages	8.0%	35.1%	52.2%	4.7%	339		

Note: α = ***; ** and * is significant at 0.1%, 1% and 5%, respectively. Low education is primary school, while high education ranges from secondary to graduation school. Proportions of different livelihood systems in each village was performed based on the Person's exact Chi-Square with significance at 0.1% (α = 0. 000). The signals plus (+) and minus (-) indicate relation or no relation between villages and livelihood systems. +|-; ++|- - and +++|---, significant at 5%, 1% and 0.1%, respectively.

4.3.1.1. Predictors of Livelihood System choice

The facts that (1) there are significant differences across LS at household and village-level, attributes that have not been used in the cluster analysis, and (2) there is a clear geographic pattern of LS at the village level suggest that household choice of LS can be associated to household and village-related variables that can be interpreted as either drivers (opportunities and constraints) or consequences of LS choice. Thus, we use here the terms *predictor* or *co-variate* for these variables and, postpone this interpretation for the discussion.

The estimated multinomial logit model of LS choice is presented in Table 4.4. The size of the household and the fact that the head of household sold agricultural output are negatively and significantly ($P < 0.01$) related to Hunters as compared to Farmers. The village-level proportion of crops lost to wild fauna and selling agricultural output are also negative and significant ($P < 0.01$) predictors of Gatherers in comparision to the Farmers. Finally, education is a positive and significant ($P < 0.001$) predictor of the Employees LS.

Table 4.4. Multinomial logistic regression model of livelihood system choice

Livelihood system	Drivers	Coefficient B	Std. Error	Z-values	Alf (α)	Exp(B)
Hunters	Intercept	3.195	0.806	15.735	0.000***	
	Household size	-0.236	0.069	11.775	0.001**	0.790
	Education	-0.096	0.120	0.639	0.424^{NS}	0.909
	Crop lost	-0.027	0.014	3.618	0.057^{NS}	0.973
	Crop sold = Yes	-1.995	0.282	50.146	0.000***	0.136
Gatherers	Intercept	3.606	1.359	7.040	0.008**	
	Household size	-0.100	0.102	0.951	0.330^{NS}	0.905
	Education	-0.293	0.216	1.835	0.176^{NS}	0.746
	Crop lost	-0.079	0.028	7.944	0.005**	0.924
	Crop sold = Yes	-2.242	0.479	21.955	0.000**	0.106
Employees	Intercept	-1.870	2.225	0.706	0.401^{NS}	
	Household size	-0.187	0.153	1.507	0.220^{NS}	0.829
	Education	1.106	0.250	19.601	0.000***	3.022
	Crop lost	-0.021	0.043	0.232	0.630^{NS}	0.979
	Crop sold = Yes	-22.149	0.000			$2.403*10^{9}$

Note: **Farmers is the reference category;** α = *** is significant at 0.1%, ** = 1%, * = 5%, NS = not significant.
Model fit (log-likelihood = 550.28); likelihood ratio test (Chi-square = 157.72, α =0.000). Number of observations = 339; Pseudo R-squared (Nagelkerke = 0.42, Cox and Snell = 0.37).

Reading these results for the reference category in the model (farmers), we verify that the size of the household is positively associated with choosing the Farmers LS as opposed to the Hunters LS. Likewise, being a Farmer as opposed to Hunter or Gatherer LS increases the likelihood of selling agricultural output. Finally, the proportion of crop lost to crop raiding is positively associated to the Farmers LS.

4.3.2. Farming systems and their village-level patterns

Four farming systems (FS) have been identified in the NNR (Table 4.5): (i) Specialized Maize FS, where maize represents nearly ¾ of the total expected production; (ii) Specialized Rice FS, with rice representing approximately 50% of the total expected production; (iii) Mixed Crops FS, where there is no clear dominant crop, but maize represents almost 1/3 of the total expected production, followed by peanuts (12%) and cowpeas (11%); and (iv) Specialized Sorghum FS, where sorghum represents more than half of the total expected production. Approximately 29% of all farms in our sample practice the Specialized Maize FS, a figure that rises to 40% in Chamba and 68% in Matondovela. About 25% of the households are specialized in Rice, which rises to 43% in Chamba and 48% in Macalange. The Mixed Crops FS is the most frequent in the Reserve, 40%, a percentage that rises to 59% in Mbamba and 90% in Mucoria. Only 7% of the farms are Specialized in Sorghum, a figure that rises to 16% in Mbamba and 23% in Naulala.

Table 4.5. Farming systems (FS), their characteristics and village-level patterns

	Specialized Maize	**Specialized Rice**	**Mixed Crops**	**Specialized Sorghum**	**Total**		
Crop	**93 (28.8)**	**80 (24.8)**	**128 (39.6)**	**22 (6.8)**	**323 (100.0)**	**Alf (α)**	**Eta²**
Partial Expected Production of each crop in proportion to the Total Expected Production (PEP/TEAP in %)							
Maize	71.2	31.6	32.0	19.9	42.4	0.000***	0.598
Peanut	1.2	2.0	11.7	8.0	6.0	0.000***	0.212
Cassava	4.0	5.7	4.6	4.6	4.7	0.702^{NS}	0.004
Rice	13.5	48.8	7.5	7.5	19.5	0.000***	0.644
Cowpea	1.9	1.4	10.5	0.7	5.1	0.000***	0.166
Pea	1.4	1.5	5.6	3.6	3.2	0.001**	0.047
Sorghum	1.9	2.6	8.9	53.2	8.3	0.000***	0.670
Millet	0.1	0.1	3.1	0.3	1.3	0.001**	0.050
Sesame	1.3	2.3	5.3	0.9	3.1	0.003**	0.043
Sweet potato	1.2	1.3	2.3	0.1	1.6	0.253^{NS}	0.013
Vegetables	1.9	0.6	3.1	0.0	1.9	0.033*	0.027
Tobacco	0.0	1.2	2.5	0.0	1.3	0.106^{NS}	0.019
Honey	0.4	0.2	2.5	1.0	1.2	0.019*	0.031
Fish	0.2	0.7	0.4	0.0	0.4	0.558^{NS}	0.006
Proportions of different farming systems in each village (%)					N		
Chamba	40.0 +	42.5 ++	17.5 --	0.0 -	40		
Macalange	31.8	47.7 ++	20.5 --	0.0 -	44		
Matondovela	68.0 +++	22.0	8.0 ---	2.0	50		
Mbamba	13.1 --	11.5 --	59 ++	16.4 ++	61		
Mecula	30.4	30.4	39.1	0.0 -	46		
Mucoria	2.4 --	2.4 --	90.5 +++	4.8	42		
Naulala	15.0 -	22.5	40.0	22.5 ++	40		
Total	28.8	24.8	39.6	6.8	323		

Note: α = *** is significant at 0.1%, ** = significant at 1%, * = significant at 5%, NS = not significant. The proportion of each villages and FS were performed based on the Pearson's exact Chi-Square with significance at 0.1% (α = 0. 000). The signals plus (+) and minus (-) indicate positive or negative relation between villages and livelihood systems. +|-; ++|- - and +++|---, significant at 5%, 1% and 0.1%, respectively.

All main variables that characterize FS (proportions of maize, rice, and sorghum in the total expected production) are significantly ($p < 0.001$) different across FS. The proportion of variance across FS for all these three variables is high, representing more than half of total variance (squared ETA ≥ 0.60). Maize and rice are relevant crops in other FS in addition to the ones specialized in these crops.

4.3.2.1. Predictors of Farming System choice

The estimated multinomial logistic model of FS choice is represented in Table 4.6. The availability of flatland and rainfall were the main drivers for choosing either the Specialized Maize or Rice FS as opposed to the Mixed Crops FS (α = 0.000). The increase of population in the village significantly (α = 0.000) reduces the likelihood of choosing the Specialized Maize or Rice FS in relation to the Mixed Crops FS, suggesting that population growth stimulates diversification of activities rather than specialization.

Table 4.6. Multinomial logistic regression model of farming system choice

FS	Drivers	Coefficients (B)	Std. Error	Z-Value	Sig (α)	Exp(B)
Specialized rice	Intercept	-32.463	5.031	41.644	0.000***	
	Proportion of flatland	0.270	0.044	38.426	0.000***	1.310
	Distance to the market	-0.091	0.071	1.643	0.200^{NS}	0.913
	Total population	-0.004	0.001	41.932	0.000***	0.996
	Rainfall	0.025	0.004	41.710	0.000***	1.026
Specialized maize	Intercept	-38.552	4.891	62.131	0.000***	
	Proportion of flatland	0.270	0.044	37.383	0.000***	1.310
	Distance to the market	0.084	0.069	1.480	0.224^{NS}	1.088
	Total population	-0.004	0.001	59.786	0.000***	0.996
	Rainfall	0.030	0.004	62.814	0.000***	1.031
Specialized sorghum	Intercept	12.775	13.455	0.902	0.342	
	Proportion of Flatland	-0.039	0.079	0.249	0.618^{NS}	0.961
	Distance to the market	0.358	0.195	3.369	0.066^{NS}	1.430
	Total population	0.002	0.002	0.780	0.377^{NS}	1.002
	Rainfall	-0.015	0.011	1.784	0.182^{NS}	0.985

Note: **Mixed Farming is the models' reference category;** α = *** is significant at 0.1%, ** = significant at 1%, * = significant at 5%, NS = not significant. Model fit (log-likelihood = 481.35); likelihood ratio test (Chi-square = 167.27, α =0.000) Number of observations = 323; Pseud R-square (Nagelkerke = 0.44, Cox and Snell = 0.40).

Distance to the market has seemingly no significant effect on FS choice, although there is an almost significant positive effect on choosing the Specialized Sorghum FS. Increasing rainfall reduces the likelihood of choosing the Specialized Sorghum FS as opposed to the Mixed Crops FS, an effect that is not statistically significant. There is a significant (α = 0.000) negative effect of rainfall on the likelihood of choosing the Specialized Sorghum FS as opposed to the Specialized Maize or Rice FS. Likewise, population size increases the likelihood of choosing the Specialized Sorghum FS as opposed to the Mixed crops, an

effect that is not statistically significant. However, there is a significant ($\alpha = 0.000$) positive effect of population on the likelihood of choosing the Specialized Sorghum FS as opposed to the Specialized maize or rice FS.

4.3.3. Population size, rainfall levels and agricultural intensity

Figure 4.2 depicts the effects of population size and rainfall on agricultural intensity. It can be observed that in the four villages with higher rainfall (rainfall ≥ 1185 mm), there is a trend suggesting that increased population is pressing for agricultural intensification, that is: raising the number of people fed per hectare of cropland. Mecula, which has by far the largest population size, has also the highest agricultural intensity level, which is additionally supported by the highest rainfall level when compared to other villages in the studied area. However, the demographic pressure for agricultural intensification seems to be also present in Matondovela, with a much lower rainfall level. It is also relevant to note that agricultural intensity seems to increase with population size in a much less than proportional way, suggesting that technology is constraining intensification. In contrast, in the three villages with lower rainfall (rain < 1120 mm), agricultural intensity seems to be more constrained by insufficient water than promoted by population growth.

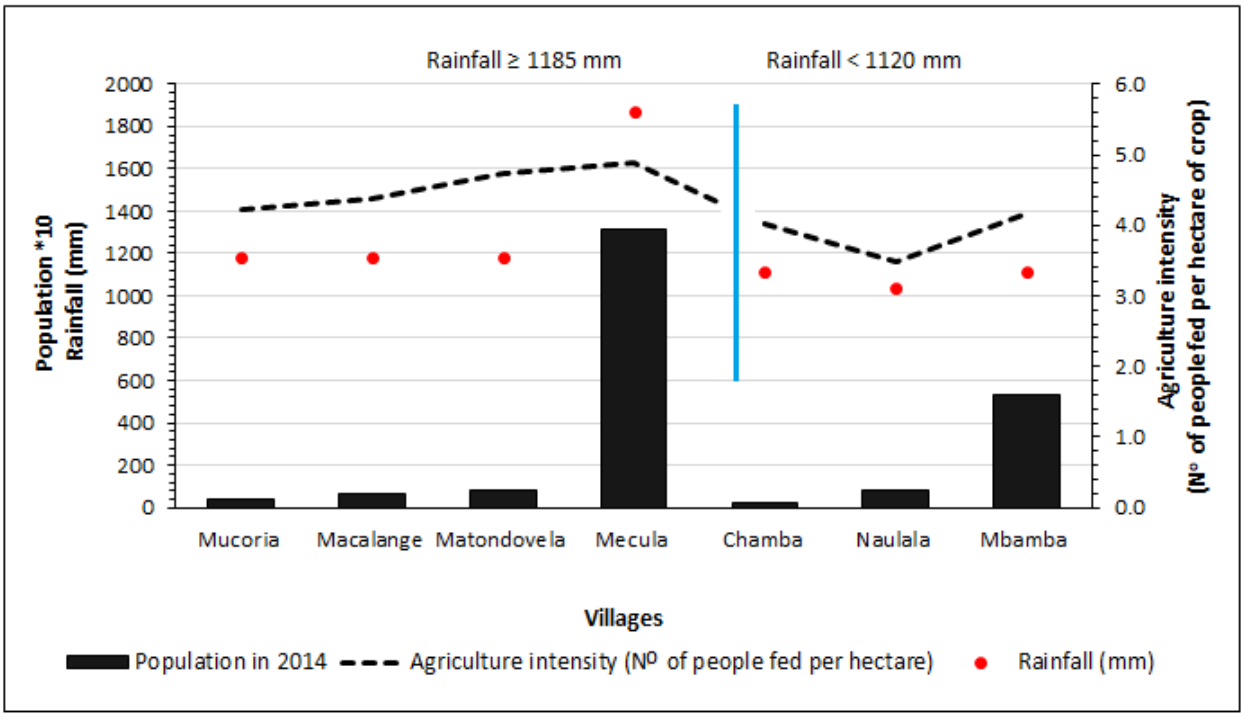

Figure 4.2. Effects of population size and rainfall on agriculture intensity across the seven surveyed villages in Niassa National Reserve. Rainfall is the major limiting factor for intensification, especially for those villages where the predominant FS is Specialized Sorghum.

4.3.4. Proportion of agricultural output lost to crop raiding

Table 4.7 presents the average proportion of agricultural output perceived to be lost to crop raiding for each crop and FS with the results of the ANOVA across FS at the farm level. Overall losses were about 46% of the total expected production. The highest losses correspond to cowpea (62%) and pea (58%), and the lowest to tobacco (21%) and sweet potato (34%). The highest price is also related to the highest crop loss (See Table 4.7 and Appendix 4.B.2) and less output sold (Appendix 4.B.4). The Specialized Rice FS recorded the heaviest average level of loss, almost half of total expected production, while the Specialized Sorghum FS was the one with the lightest average losses (38%). Vegetables (81%) followed by pea (72%) were the most raided crops in the Specialized Rice FS. Cowpea (57%) and rice (49%) were the most raided crops in the Specialized Sorghum FS. The Specialized Maize FS lost more cowpea (60%) and sweet potato (53%) than other crops, while the Mixed Crops FS lost more cowpea (65%) and pea (63.2%). The proportion of output lost varied significantly across FS for some crops such as maize and vegetables.

Table 4.7. Proportion of perceived crop lost to crop raiding per crop and FS (in percentage of total expected production)

	Farming system						
Crops	**Specialized Maize**	**Specialized Rice**	**Mixed Crops**	**Specialized Sorghum**	**Total**	**Alf (α)**	**Eta^2**
Maize	45.7	50.7	47.5	37.9	46.8	0.016**	0.033
Peanut	51.3	38.3	42.5	24.0	41.1	0.352	0.026
Cassava	49.1	36.9	40.7	41.2	42.2	0.262	0.032
Rice	45.2	52.7	52.3	48.5	50.9	0.173	0.024
Cowpea	59.8	46.5	64.6	57.1	62.4	0.869	0.007
Pea	34.0	72.1	63.2	45.3	58.2	0.101	0.091
Sorghum	45.0	31.5	45.5	37.5	40.3	0.492	0.018
Millet	0.0	19.0	56.2	0.0	50.9	0.281	0.122
Sesame	28.8	30.4	41.5	14.7	36.2	0.517	0.042
Sweet potato	53.3	38.9	24.3	25.0	33.8	0.854	0.018
Vegetables	31.5	81.2	37.5	NA	47.4	0.022*	0.156
Tobacco	NA	22.0	19.7	NA	20.6	0.290	0.123
Mean	45.3	48.6	46.9	37.7	46.2		

Note: α = *** is significant at 0.1%, ** = significant at 1%, * = significant at 5%, NS = not significant.

4.3.5. Pattern of losses to crop raiding across villages and its relation to LFS, potential and actual damage, and protective measures

Table 4.8 presents the disposition of LS and FS across villages, the levels of potential and actual damages, average losses and the availability of electric fence, at the village level. The highest overall losses occurred in Macalange (66%) and Mucoria (53%), while the lowest losses occurred in Mbamba (35%) and Naulala (39%).

Table 4.8 – Pattern of losses to crop raiding across villages and its relation to LFS, potential and actual damage and protective measures

	SYSTEMS		POTENTIAL DAMAGE				
Villages	**Livelihood**	**Farming**	**Crop Raiding (1)**	**Crop Raiding (2)**	**Actual damage**	**Losses (%)**	**Fence**
Chamba	------	Maize & Rice	Medium	Medium	Medium	43.6	No
Macalange	------	Rice	Medium	High	High	66.0	No
Matondovela	------	Maize	High	High	Medium	42.6	No
Mbamba	Gatherers	Mixed & Sorghum	High	High	Low	34.8	Yes
Mecula	Employees	-----	Low	Medium	Medium	48.2	No
Mucoria	Hunters	Mixed	Medium	Medium	High	53.1	No
Naulala	Gatherers	Sorghum	High	High	Low	39.3	Yes

Note: Crop Raiding Index (1) ranges from 13 to 17 (≤13 is low; 13<medium<16, and ≥16 is high);
Crop raiding Index (2) ranges from 3 to 5 (≤2 is low; 2<medium<4, and ≥5 is high);
Actual damage, ranges from 35% to 66% (≤40% is low; 40%<medium<50%, and ≥50% is high).

Crop Raiding index (1) ranged from low to high, whereas Crop Raiding Index (2) varied from medium to high. Actual damage ranged from low to medium. Gatherers, which are mostly specialized in Sorghum, are located in Mbamba and Naulala villages and are generally characterized by having high potential damage for both Crop Raiding Indexes, while the actual damage is low. Interestingly, both villages have fenced cropfields. Specialized Maize and Rice are mostly located in Chamba, Macalange, and Matondovela villages. In these villages, actual and potential damage varies from medium to high and none are fenced. In Mucoria village, where most of the households are Hunters, mixed FS is the most predominant, and despite medium potential damage for both crop raiding indexes, the actual damage is high, and the agricultural fields are not fenced.

It was not possible to establish multivariate models that account for the main drivers of these significant losses across FS and villages, despite some efforts in that direction. In the Discussion section, we address possible causes for this limitation in an exploratory way and identify several hypotheses that require more data to be tested.

4.4. Discussion

The three crops that characterize the Specialized FS (maize, rice and sorghum) are also reported to be an important component of all FS in the all study area, regardless of our cluster classification. Maize is regarded as the dominant and most widespread crop, not only in this area (MAE, 2005) but also in all northern and central Mozambique (Dixon, 2019). Likewise, in our FS study, maize is amongst the top two most important crops, accounting for 20% of agricultural production, even in the specialized sorghum, the one FS with lowest proportion of maize.

Employees are clearly the only LS category that does not directly depend on either agriculture or NTFPs harvesting. Farmers showed the least gathering effort, followed by Hunters. We would expect to detect an association between specialized FS and the Farmers LS, but this was not possible, which indicates that specialization within farming does not necessarily mean that the household doesn’t depend on

harvesting NTFPs. In fact, even in the specialized FS there are households that heavily rely on NTFPs to cope with their daily needs. This dependence is also well documented in almost all rural villages and PAs of DCs (Jew et al., 2019; Smith et al., 2017). For instance, firewood and charcoal are the main sources of energy provision for cooking and heating in African rural and urban areas (Baumert et al., 2016; Vollmer et al., 2017; Woollen et al., 2016). Likewise, in our LS, firewood proved to be the most important NTFP, based on harvest effort. Bushmeat and traditional medicines are also in great demand in the NNR, but not necessarily in the same proportion as firewood.

Hunters and Farmers together accounted for over 90% of all households, possibly because the abundance and proximity to NTFPs may lead the household to underreport the effort they commit to harvesting NTFPs, since it is also widespread practice to delegated to young people or carried out by opportunistic harvesting while returning from agricultural fields or water collection. The strong communal relationships that characterized most of rural areas of DCs, with open shared space for the collection of provisioning ecosystem services, especially traditional medicine and firewood (Boafo et al., 2016), which were not documented here in the respondents' answers. However, we are confident that it did not affect our results, as we were more interested in the time/effort that households spend to collect NTFPs, as an alternative for labour used in agriculture.

4.4.1. Interpreting LFS choice and its relationships with agriculture intensification

Based on the estimated Multinomial Logistic Regression Models, LS were driven by socio-economc variables measured at the household level, whereas FS were driven by biophysical variables measured at the village level. This suggests that biophysical constraints, which are mostly out of the households' control, underlie the decision of adoptioning one FS over another. In contrast, LS choice, while responding to household-level variables, seems to be related to the prevalent FS option at the village level. For example, Hunters and Gatherers are largely located in the Mbamba and Naulala villages, where the dominants FS are the Mixed and Specialized Sorghum FS. The Specialized Sorghum FS has, on average, a relatively low agricultural output. In addition, it appears to be the poorest FS, as regards both cash crops, proportion of

the crop sold and nutrition value. This suggests that Specialized Sorghum farmers have intensified gathering effort to offset the nutrition gap and low agricultural productivity. This low productivity is probably related to biophysical constraints (lower rainfall) and fear of crop raiding (high potential for damage). Thus, by adopting the Mixed or the Specialized Shorghum FS and by intensifying hunting and gathering effort, households appear to have developed a clear strategy to deal with these constraints, which probably occurred before the assistance of the private NGO´s (Chuilexi and Luwire Conservancy and Niassa Carnivore Project), with their fencing programmes, which reduced actual damage. According to Guerra et al. (2018) and Ho et al. (2017), agricultural intensification requires vast arable land and technology which are not available in the NNR, not only because of its higher costs of acquisition, diffusion, and adoption, but also because they could have negative environmental and conservation implications, which would not be allowed by the reserve management.

Although both rainfall and availability of flatland are important drivers for the choice of the specialized rice FS, increase in flatland has a stronger effect than rainfall, due to the limiting availability of flatland in the reserve. In fact, the proportion of flatland (slope <2%), ranged from 9.7% to 33.4% (average of 19%). This is even more challenging for traditional rice production that, in addition to flatland, requires wetlands (Dixon, 2019). With increased population in the reserve, which requires more land for agriculture, the availability and accessibility of land will be an even stronger constraint in the future. Regardless the FS type, intensification appears to be driven by population size (Figure 2), an effect that is less clear in drier areas, where rainfall is a strong constraint for intensification.

For all FS, future intensification could be seen as a strategy to deal with population growth in the reserve, by reducing the likely raises in land pressure in the reserve and so saving more land for natural habitats. Our results suggest, according to the literature, this strategy will be easier to adopt in areas with higher rainfall and flatter lands.

Our results also suggest that increases in gathering effort may be interpreted as a response to low agricultural productivity (Tables 3 and 8). This interpretation would be consistent with our finding of a negative association between the size of the household and the choice of a non-Farmer LS.

Contrary to what we expected (at least, based on the Multinomial Logistic Regression), the Mixed Crop FS was seemingly driven by population growth due to the following possible reasons: (i) markets are virtually non-existent in the NNR, so households need to diversify their production for consumption and sharing; (ii) the Mixed Crop FS occurs in agro-ecological zones where there biophysical conditions are not favorable to maize or rice specialization and/or there is a high potential and/or actual damage due to crop raiding (as is depicted in the Figure 2 and Table 8) and (iii) most conservation NGO´s (Chuilexi Conservancy and Niassa Carnivore Project) that developed capacity-building for the local people to improve their agriculture production techniques, business assistance (including credits) and scholarship for their children are confined to Mbamba and Naulala villages, thus a considerable number of household probably moved to these villages to catch up with those benefits.

4.4.2. Incipient markets, diversification of LFS and its implications for food security in PA with high crop raiding levels

All FS in the reserve (including the Specialized ones) are fairly diversified. This is typical of rural and remote areas of miombo, where the connections to external markets are very limited. Hence, households need to diversify their FS and embrace other off-farm practices to cope with all food needs (Jew et al., 2019). Even though market access is insignificant in the NNR, the are some cash crops such as tobacco and sesame, plus partly commercial honey and fish activities (see Appendixes B, D and E), in which case the production appears to be market-oriented, since more than 60% of the output was sold. In addition, these crops and products are amongst the least raided by wildlife. Thus, we suggest that households have adopted these less-raided crops for sale, and by doing so, overcome income shocks and food shortage due to crop raiding. Furthermore, most specialized farming systems are linked to high price volatility (Dixon et al., 2001). We have also noticed that, for those "pivotal" crops that best describe FS (maize, rice and sorghum),

there are also a set of secondary crops (cassava and millet) widespread through all FS. This alternate production plan (primary and secondary crop) is probably aimed at diversifying the risk of crop raiding, climate, market and other umpredictable risks. In fact, there is empirical evidence that agriculture diversification in smallholder farms is a response to nature and market shocks (Ho et al., 2017; Sraïri and Ghabiyel, 2017).

Hunters are mostly located in Mucoria village, where actual crop damage was high (Table 8). This can be interpreted either as an adaptive response or the result of retaliatory killing of provocative crop raiders (Moreto, 2019). The abundance of wild animals in this village seems to increases the likelihood of HWC, as mentioned by Baral and Heinen (2007). Data from the NCP (2018) report 953 incidents of livestock depradation between 2017 and 2018, which represent 11.11% of all HWC events in the NNR.

4.4.3. The Livelihood and Farming System approach: implications for intervention strategies to improve nature conservation and sustainable development in PAs of DCs.

The results of this research led us to identify a set of 6 policies/incentives that are implicit in the previous discussions, but that need to be outlined in a more explicit manner to contribute for the re-framing of conservation narratives towards a sustainable development of people living inside PAs of DCs, whose livelihoods need to be improved.

First, we have demonstrated that employees are, on average, younger, better educated and more wealthy than other LS, and are not or minimally dependent on agriculture or NTFP harvesting. Thus, training and equiping local people with new skills to reduce their dependence on farming, gathering and hunting (e.g. rangers, touristic guides, teachers, etc), and investing in conservation activities such as sustainable tourism and eco-tourism to employ these people, would lower the harvesting effort and agricultural expansion as well as change their LFS towards lower impact levels. Second, Mixed and Specialized Sorghum FS appear to have evolved as a response to crop raiding, biophysical constraints, lack of market, income and food requirements. Diversifying FS (e.g. growth of cash crops and less palatable crops), in addition to small-

scale off-farm activities (e.g. hunting and harvesting of NTFPs), can raise incomes and reduce the risk of households falling into food insecurity due to crop raiding, agricultural pests, diseases and climate hazzards.

Third, in general, all FS in the NNR, especially the Mixed and Specialized Sorghum FS, appear to be struggling with poor soils, lack of fertilizer as well as insufficient water availability. Improving agriculture practicies by implementing conservation agriculture, such as green manure, crop rotation, intercropping, coppicing trees, mulching and traditional soil/water conservation (Bayala et al., 2012) may significantly raise crop yields, simultaneously reducing food insecurity and enhancing environmental services and the resilience of agro-ecosystems (Ajayi et al., 2011). Conservation-friendly agricultural practices, such as parkland trees, soil water conservation and mulching, have provided impressive results in arid zones with poor soils (Bayala et al., 2012), as is the case of areas in the NNR where the Speciallized Sorghum and Mixed FS are predominant. The Niassa Carnivore Project (NCP, 2017) has been working with 19 local farmers in the Mbamba village, in a similar conservation agriculture project (e.g. testing methods of natural manure and mixed cropping), to improve soil nutrition and agricultural yields. This project has achieved considerable success in this pilot phase, which can be replicated throughout whole reserve in the future. Fourth, improving agriculture and livestock practices by assisting local households with drought resistent seeds and livestock breeding resistent to diseases, such as trypanosomosis, as well as helping local people with other protein sources such as poulty breeding will likely reduce unsustainable bushmeat hunting; The Niassa Carnivore Project (NCP, 2017) is also an example of good practice in this respect.

Fifth, the transition from peasant livelihood strategies to specialized or diversified strategies is mainly influenced by natural assets, human assets, social and informational assets (Yang et al., 2018). Therefore, we suggest that central governments, in partnership with PA administrations and NGO managers, should identify agro-ecological zones with better conditions for agricultural intensification, invest in road and agricultural infrastructure in these areas, and reallocate local people to these areas as a solution to overcome biophysical constraints and lack of market access. This would also reduce drastically the costs of providing assistence to local people (e.g. capacity building in conservation agriculture and business entrepreneurship),

regulating some illegal activites such as bushmeat hunting and harvesting NTFPs as well as improving wildlife movement corridors. At the present time, the way that the communities are so widely dispersed throughout the reserve (approximatly 42 villages), with poor road infrastructure and lack of basic services, does not help to implement conservation and development policies. With the rapid growth of the human population within the reserve, which is expected to reach 200, 000 people in 2050 under a *"business as usual scenario"*, no conservation policy/strategy can act effectively without this spatial planning approach.

Last but not the least, enforce PA management standards in the DCs would requere to set a management principles supporting the sustainable development of PA residents, promoting changes in LFS according to the proposals made above, and that could promote sustainable develoment through the certification of PAs as sustainable destinations for eco-tourism. Implementation of these actions may require long-term collaboration and commitment among all stakeholders involved in conservation in the NNR and other PA of DC. More important, it will first need empowerment and transparent involvement of local people who bear the costs of conservation in the NNR (Mbanze et al., 2019b). Effective participation of local people in conservation requires, first, capacity-building, education and awareness.

We have exemplified in the NNR how classifying households by LFS and using Multiple Linear Model to identify the drivers of LFS choice may provide an analytical framework to discuss polcies aimed to improve conservation in the NNR and other PAs in DCs. This framework includes a combination of LFS that can be implemented to enhance biodiversity and ecosystem services provision, this combination of LFS should also reduce HWC, while improving the incomes and livelihoods of the local households, thus enhancing conservation-friendly behaviour and increasing ecosystem resilience and adaptability to climate hazzards. Here we offer a novel and detailed evidence-based framework that can be used to improve conservation in the NNR and in other PAs in DCs elsewhere. Its implementation depends on all stakeholders involved in conservation to understand the material or intangible benefits that can result from each action. However, we believe that conservation managers, donors and decision-makers are in the best position to ensure the implementation of the present proposed framework.

4.5. Conclusions

Based on the survey results, four different LFS were identified in the NNR. The choice of LS is driven by socio-economic factors at household level, more specifically, the household size and the level of education of the household. Employees, who are well educated, are on average wealthier than the other LS we recognized. Gatherers exhibit the highest level of gathering effort and are primarily located in Mbamba and Naulala. Their FS are predominantly Specialized in Sorghum and Mixed FS, in which expansion and specialization are constrained by biophysical conditions (low rainfall and low availability of flatland). The Specialized maize and rice FS are located in areas with better biophysical conditions, thus allowing intensification and specialization of FS. This intensification appears to be indiced by larger household sizes, allowing both agricultural and off-farm activities. However, production in these FS is constrained by higher crop damage by raiding animals.

Households in almost all LFS (except employees) appear to be struggling to cope with their basic needs. Since these FS can be considered an integral part of the conservation area, the required improvement does not necessarily require abrupt changes and can be done through multiple, complementary measures. The most important measures that can be outilined from this research are: (i) provide capacity-building for local people to enhance farming activities, so that they can improve their income and livelihood, hence reducing pressure on the land and ecosystem services; (ii) improve their FS (e.g. improved and drought resistant seeds and conservation agriculture); (iii) implementing mixed FS with cash crops that are subject to less crop raiding and are less sensitive to drought and other climate constraints; (iv) synchronizing FS activities with other important off-farm occupations and training local people in the adoption of effective, sustainable ways to reduce crop raiding.

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Chapter 4

Appendix B

4.B.1. Survey to the household in the Niassa National Reserve

1. General information

a) Name of the interviewer _____ Date: ____/_____/_____

b) Name of the village: _____ Lat _____ Log _____, Alt _____

c) Size of the closest river: small ____, medium ____ and bigger___

d) For how long are you living in the reserve? I was born here ___; > 10 year____;
5 – 10 years ____; < 5 years _____

2. Socio-economic information of the respondent

a) Name (not compulsory) _____, Age_____

b) **Gender** Male ☐Female ☐

c) Number of people in the household _____ Number of wives _____

d) Number of workers in the household _____

Nº	kinship degree	Age	Occupation	Income	School
a)	Household	_____	_____	_____	_____
b)	_____	_____	_____	_____	_____
c)	_____	_____	_____	_____	_____
d)	_____	_____	_____	_____	_____
e)	_____	_____	_____	_____	_____
f)	_____	_____	_____	_____	_____
g)	_____	_____	_____	_____	_____
h)	_____	_____	_____	_____	_____

3. Farming information

Below is the list of most common crops in the NNR. For those that you have planted in the last season, could you please provide total amount harvested, consumption, losses for crop raiders, quantity sold and its respective price

Nº	Crop	Harvested (Kg)	Lost (Kg)	Consumption (Kg)	Sold (Kg)	Price (MZN)
a)	Maize	_____	_____	_____	_____	_____
b)	Peanut	_____	_____	_____	_____	_____
c)	Cassava	_____	_____	_____	_____	_____
d)	Rice	_____	_____	_____	_____	_____
e)	Cowpea	_____	_____	_____	_____	_____
f)	Pea	_____	_____	_____	_____	_____
g)	Sorghum	_____	_____	_____	_____	_____
h)	Millet	_____	_____	_____	_____	_____
i)	Sesame	_____	_____	_____	_____	_____
j)	Sweet potato	_____	_____	_____	_____	_____
l)	Vegetables*	_____	_____	_____	_____	_____
m)	Tobacco*	_____	_____	_____	_____	_____

Note: all products are measured in 20 litters plastic containers, except those marked to asterisks. Vegetable was measured in a big open plastic basket or sachets of 100 litter while tobacco is measures rolls of 2 Kgs. Prices a given for each unity of measurement which was converted for Kg/MZN

3.1. Could you please rank the top four most important crop raiding that have raided you farm and the most important crops each animal prefers

4. Harvesting of non-timber products

Mark all products and materials that you harvest from the forest, rivers, soils, etc. The frequency of harvest, quantities the final purpose and its price if you sell.

Nº	Products	Frequency of harvesting	Propose	Quantities Kg/liters	Price (MZN)
a)	Medicines (roots, leaves, branches and fruits)	day __, week __, month__, semester__ year__	sell __, use __	_____	_____
b)	Grass	day __, week__, month__, semester __ year__	sell__, use __	_____	_____
c)	Stakes	day __, week __, month__, semester__ year__	sell __, use __	_____	_____
d)	Bamboos	day __, week __, month__, semester__ year__	sell __, use __	_____	_____
e)	Firewood	day __, week __, month__, semester__ year__	sell__, use __	_____	_____
f)	Ropes	day __, week __, month__, semester__ year__	sell __, use __	_____	_____
g)	Honey*	day__, week __, month__, semester__ year__	sell __, use __	_____	_____
h)	Fish#	day __, week __, month__, semester__ year_	sell__, use __	_____	_____
i)	Insects	day __, week __, month__, semester__ year__	sell __, use __	_____	_____
j)	Bush meat	day __, week__, month__, semester__ year__	sell __, use __	_____	_____
l)	Others	day __, week__, month__, semester__ year__	sell __, use __	_____	_____

*Honey was measured in litters

#Fish in plastics containers of 20 Kg.

Table 4.B.2. Average selling price for each crop declared by households.

Nº	Crops	Average Price (MZN/Kg)
1	Maize	31.00
2	Shelled Peanut	32.61
3	Dried Cassava	18.35
4	Shelled Rice	41.70
5	Cowpea	66.57
6	Pea	62.37
7	Sorghum	40.59
8	Millet	61.21
9	Sesame	79.22
10	Sweet potato	26.10
11	Vegetables	31.38
12	Tobacco*	315.91
13	Honey*	95.00
14	Fish	85.71

*The price of honey is giving in liters while tobacco is giving in a roll

Table 4.B.3. Total Expected Production (TEP), per crop in each farming System in Metical (MZN)

	Specialized Maize	**Specialized Rice**	**Mixed FS**	**Specialized Sorghum**	**Total**		
Crops	**93 (28.79)**	**80 (24.77)**	**128 (39.63)**	**22 (6.81)**	**323 (100)**	**Alf (α)**	**Eta²**
Maize	24278.89	9898.96	7673.91	7154.85	12970.66	0.000***	0.169
Peanut	322.61	878.88	3217.34	1852.93	1711.76	0.000***	0.108
Cassava	1364.76	1498.70	1129.76	567.08	1250.48	0.584^{NS}	0.006
Rice	4516.41	14589.44	2697.89	2968.74	6185.21	0.000***	0.228
Cowpea	575.47	510.06	3034.46	423.60	1523.38	0.000***	0.060
Pea	572.70	661.86	1187.89	725.72	849.00	0.201^{NS}	0.014
Sorghum	611.49	1079.23	2676.51	19805.03	2852.98	0.000***	0.357
Millet	32.93	65.06	350.77	167.07	175.98	0.001**	0.049
Sesame	591.21	1576.59	2008.49	489.76	1390.00	0.122^{NS}	0.018
Sweet potato	337.35	368.72	614.80	94.76	438.55	0.586^{NS}	0.006
Vegetables	529.06	749.18	975.70	0.00	724.54	0.522^{NS}	0.007
Tobacco	0.00	1492.67	1466.02	0.00	950.66	0.224^{NS}	0.014
Total	33732.89	33369.36	27033.53	34249.54	31023.19		

Note: Number in the brackets is the percentage of household interviewed per villages

α =*** is significant at 0.1%, ** = significant at 1%, * = significant at 5%, NS = not significant

Table 4.B.4. Gross revenue from the Total Crop Sold (TCS) per crop in each farming System in Metical (MZN)

	Specialized Maize	**Specialized Rice**	**Mixed FS**	**Specialized Sorghum**	**Total**		
Crops	**93 (28.79)**	**80 (24.77)**	**128 (39.63)**	**22 (6.81)**	**323 (100%)**	**Alf (α)**	**Eta²**
Maize	5257.23	1298.51	845.58	1300.63	2258.98	0.000***	0.095
Peanut	39.62	140.23	640.51	355.76	324.20	0.002**	0.045
Cassava	110.48	224.75	129.00	33.36	140.87	0.684^{NS}	0.005
Rice	652.95	2335.56	364.93	405.69	938.72	0.000***	0.060
Cowpea	0.00	24.96	293.30	0.00	122.41	0.056^{NS}	0.023
Pea	198.50	35.86	82.83	141.74	108.51	0.659^{NS}	0.005
Sorghum	22.70	101.48	296.19	2996.40	353.13	0.000***	0.124
Millet	0.00	30.60	38.26	0.00	22.74	0.542^{NS}	0.007
Sesame	315.20	796.22	639.99	360.12	566.11	0.620^{NS}	0.006
Sweet potato	36.43	84.69	307.40	0.00	153.28	0.512^{NS}	0.007
Vegetables	269.59	88.65	443.72	0.00	275.42	0.498^{NS}	0.007
Tobacco	0.00	1164.91	1172.32	0.00	753.10	0.223^{NS}	0.014
Honey	117.73	190.41	732.63	908.77	433.28	0.018*	0.031
Fish	215.19	600.38	291.85	0.00	326.32	0.625^{NS}	0.005
Total	7235.61	7117.20	6278.52	6502.46			

Note: Number in the brackets is the percentage of household interviewed per villages

α =*** is significant at 0.1%, ** = significant at 1%, * = significant at 5%, NS = not significant

Table 4.B.5. Proportion (%) of total crop harvested that was sold (PCS) In each farming System in percentage (%)

	Specialized Maize	**Specialized Rice**	**Mixed FS**	**Specialized Sorghum**	**Total**
	93 (28.79)	**80 (24.77)**	**128 (39.63)**	**22 (6.81)**	**323 (100%)**
Maize	39.8	26.6	21.0	29.3	32.7
Peanut	25.2	25.9	34.6	25.3	32.2
Cassava	15.9	23.8	19.2	10.0	19.5
Rice	26.4	33.8	28.4	26.6	30.9
Cowpea	0.0	9.1	27.3	0.0	21.4
Pea	52.5	19.4	18.9	35.7	30.6
Sorghum	6.7	13.7	20.3	24.2	20.7
Millet	0.0	47.1	10.9	0.0	12.9
Sesame	74.9	72.6	54.4	86.2	63.8
Sweet potato	23.1	37.6	66.1	0.0	52.8
Vegetables	74.4	62.8	72.7	0.0	72.3
Tobacco	0.0	100.0	99.6	0.0	99.7
Honey	100.0	100.0	100.0	100.0	100.0
Fish	100.0	100.0	100.0	0.0	100.0
Total	38.5	39.7	40.2	29.2	38.6

Chapter 5

Participation in illegal harvesting of natural resources and the perceived costs and benefits of living within a protected area

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Participation in illegal harvesting of natural resources and the perceived costs and benefits of living within a protected area

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Abstract

In this study, we tested a novel approach for indirectly detecting participation in illegal harvesting of park resources and its spatial distribution. The surveyed respondents were asked about the importance of several threats to biodiversity conservation, including the illegal harvesting in which they may be involved. Non-recognition of these illegal activities as relevant threats to biodiversity is interpreted as the likelihood of household involvement in these activities. We also got evidence from the respondents' about their perceived costs and benefits of living within the Protected Area (PA), and their opinions about conservation measures under implementation, to support our prediction of involvement in illegal resources harvesting. The research was conducted in the Niassa National Reserve (NNR), the third-largest PA in Africa. A survey was applied to 339 households. The results showed that households who are more likely involved in illegal activities are poor, less educated, and mostly located closer to the PA borders; they burden higher costs while receiving fewer benefits of living inside the NNR. Villages respondents were more likely to admit participating in activities that they need to conduct to cope with their daily needs, which is mostly not considered as a serious infraction by the park authorities.

Keywords: *Conservation-threatening practices, Perceived costs, and benefits, Illegal harvesting, Indirect admission, and Protected areas*

5.1. Introduction

Illegal harvesting of environmental goods is recognised as a widespread problem in natural resource management, imposing several threats to biodiversity losses in Protected Areas (PAs) of developing countries (Chang et al., 2019; Free et al., 2015; Gavin et al., 2010; Massé and Lunstrum, 2016; Nelleman, 2012; Petursson et al., 2013; Rogan et al., 2018, 2017; Solomon et al., 2007, 2015). Indigenous people, who seek to secure livelihood are among the main actors of illegal activities in PAs (Loibooki et al., 2002). Shifting cultivation, bushmeat hunting (Rogan et al., 2017), illegal logging (Nelleman, 2012), poaching (Moreto, 2019), and harvesting of non-timber forest products (NTFPs) (Lee et al., 2015) are often reported as the most frequent activities challenging conservation efforts (MacKenzie et al., 2017). Moreover, poaching, bushmeat hunting, and illegal logging are the most widespread illegal activities conducted within PAs due to its higher profitability (Booth, Vernon R.; Dunham, 2014; Massé and Lunstrum, 2016; Rogan et al., 2017; White and Heckenberg, 2014). The increasing of poaching and hunting for bushmeat has threatened most of the savannas large carnivores and herbivores (Booth, Vernon R.; Dunham, 2014; Solomon et al., 2015), while illegal logging disturbs habitat and ecosystem functioning, hence contributing for deforestation and extinction of valuables species (Lee et al., 2015). The volume of wood traded in the global market obtained illegally ranges from 15 to 30 % (Nelleman, 2012).

Poachers, bushmeat hunters, and illegal loggers can be detected through range surveillance or camera traps. However, both methods can be financially prohibitive (Free et al., 2015; Solomon et al., 2007), especially in Developing Countries (DCs), where the majority of PAs include vast inhabited areas. Another constraint with human surveillance is that PAs rangers can be corrupted, and local people paid to collaborate with illegal activities due to their low wages (Gavin et al., 2010; Lee et al., 2015). In addition to direct income generation, the use of poaches as a rational strategy to control the population of wild species that raiding crops or hunt livestock is also widespread practice in PAs of DCs (Vedeld et al., 2012).

Perpetrators of illegal extraction of park resources rarely identify themselves for fear of punishment (Solomon et al., 2007; St. John et al., 2010). PAs residents usually blame outsiders for illegal activities since the confessions of their involvement can also lead to penalties (Mbanze et al., 2019). Different areas of science (e.g., sociologists, anthropologists, psychologists, criminologists and conservationists), have developed methods to measure the degree of participation in illegal resources harvesting (Solomon et al., 2007, 2015). The techniques involving surveys or mixed methods, such as self-reporting, direct questioning and focus groups (Free et al., 2015; Gavin et al., 2010; Rogan et al., 2018), randomized response and nominative techniques (Chang et al., 2019; Solomon et al., 2007; St. John et al., 2010), forensics (Moreto, 2019), modeling, or even direct comparison of multiples methods. Each method has strengths and weaknesses (Gavin et al., 2010; Solomon et al., 2015). Understanding who are the illegal resource users, how many of them exist, and why they behave in such manner (Gavin et al., 2010), is of utmost importance to support effective conservation decisions (Solomon et al., 2007).

Living within a PA brings many direct and indirect benefits, such as infrastructures, the opportunity for business and employment, benefit-sharing schemes, revenue from tourism, sustainable resource extraction, and enjoyment of cultural ecosystem services (MacKenzie et al., 2017). But it can also harm residents through, i) crop and livestock raiding (Fraser-Celin et al., 2018; Hill and Wallace, 2012; Mackenzie and Ahabyona, 2012; Rogan et al., 2018, 2017; Vedeld et al., 2012); ii) risk of injuries and casualties from animal attacks; iii) time lost in crop guarding (Hill, 2000; Mackenzie and Ahabyona, 2012); and, iv) restrictions on resource extraction (Dickman, 2010). Thus, assessing benefits and losses of living inside a PA may help understanding local people's engagement in illegal activities, because those who suffer for greater damages are more willing to embrace illegal harvesting either to offset output lost or for mere retribution (MacKenzie, 2018). This understanding can then support the design of effective policies aimed at engaging local people in conservation-friendly behaviours by enhancing extrinsic motivation (Akers and Yasué, 2017; Mackenzie, 2012).

The assessment of costs and benefits can be done through surveys and direct field observations. For instance, livestock ownership and the house construction standard (e.g., mud and wattle construction or brick construction), are important indicators of household wealth (Hartter et al., 2015; Nube et al., 2016). Regarding costs, crop losses due to wild animals raiding and human and financial efforts to guard the field crops can contribute to food insecurity. Accurate cost and benefit assessments can be done based on Spatially Explicit Population Modeling (Gavin et al., 2010; Mackenzie, 2012; MacKenzie et al., 2017) at the village level; using the village rather than the individual household as the measuring level. It is justified because people living in the same village share views and information that tend to create a common perception of costs and benefits, which then shape individual behaviour (MacKenzie et al., 2017). This shared knowledge can extend to nearby villages. For instance, one village frequently raided by wild animals can learn from a neighbouring village about a preventive strategy that another village is using to reduce crop losses (Hockings and McLennan, 2012).

The present study aims to understand how village-level perceived costs and benefits of living inside a PA lead people to participate in illegal-resource harvesting. We used a spatially-based approach that uses non-sensitive and indirect ways of questioning about participation in illegal activities. The research was conducted in seven villages within the Niassa National Reserve (NNR), the largest PA in Mozambique, and the third-largest in Africa (Mbanze et al., 2019). There, people need to coexist with wild animals, and most of the problems mentioned above occur daily. More specifically, we addressed the following questions: i) Are there significant spatial associations between village-level perceived costs and benefits of living in a PA, opinions regarding conservation policies and incentives in the NNR, and probability of participation in illegal harvesting?; ii) Can local people's undervaluation of the impact of illegal harvesting on conservation (when compared to expert's views on the same subject) be used as an indirect indicator of their involvement in these illegal activities?

We analysed these questions by surveying 339 households living in seven villages inside NNR. Households were asked about the following topics: perceived benefits and costs of living inside a PA;

opinions about the relevance of practices threatening conservation, and main actors responsible for such practices; effectiveness and limitations of the current incentives and the perceived effectiveness of new incentives.

5.2. Methodology

5.2.1. Site location and characterisation

The Niassa National Reserve (NNR) is located in northern Mozambique, between 12°38′48.67″S, 11°27′05.83″S and 36°25′21.16″E, 38°30′23.74″E (Figure 1). It is the largest PA in Mozambique and the third largest in Africa (Mbanze et al., 2019; Prin et al., 2014). The Reserve encompasses 42,200 km^2 (Prin et al., 2014; Zafra-Calvo et al., 2018), of which concession blocks occupy over 34,000 km^2, with an additional block up for tender in 2019. The NNR hosts the highest concentration of wildlife in the country.

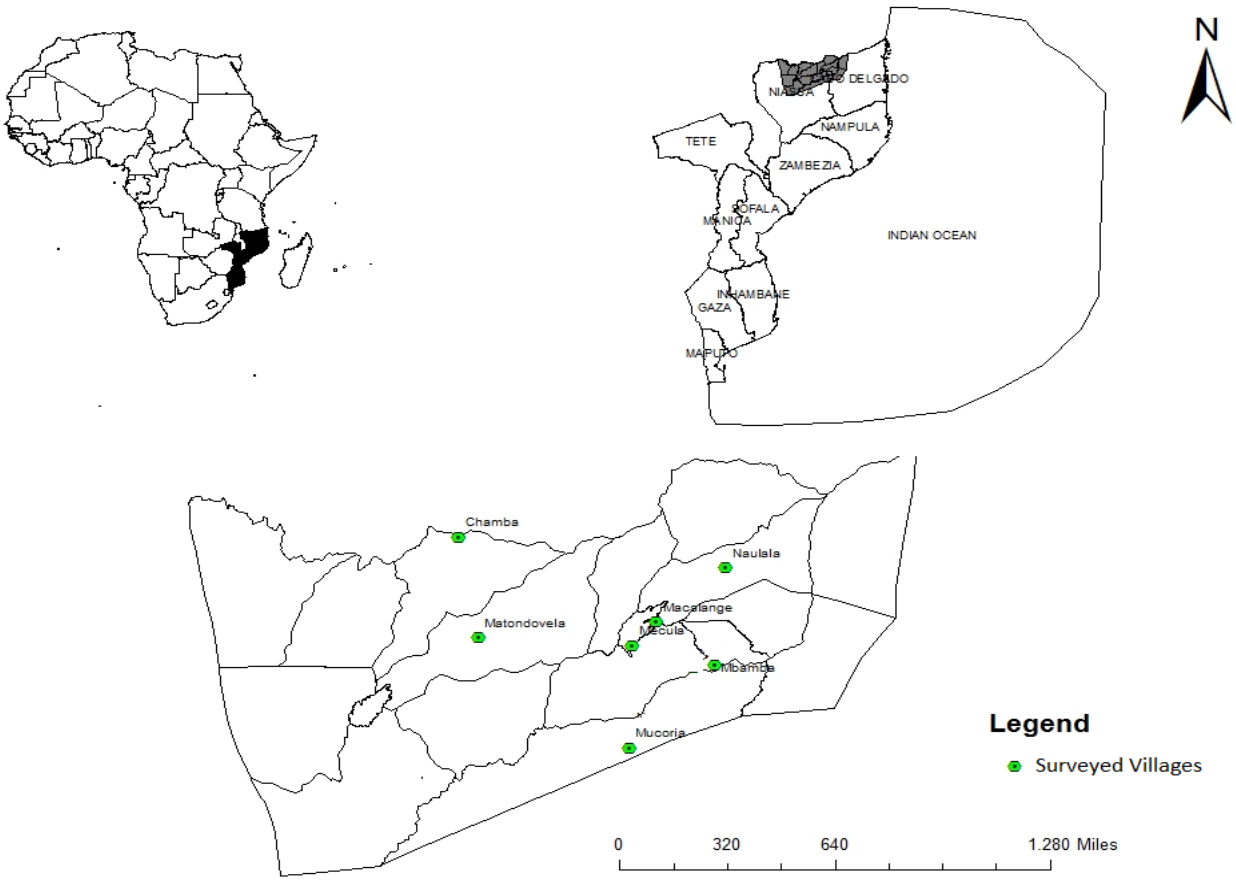

Figure 5. 1. The location of the Niassa National Reserve and the surveyed villages.

The human residents in the Reserve are about 60,000, representing twice as many as ten years ago (NCP, 2017). Food insecurity is of enormous concern, contributing to resident's engagement in illegal activities. People living in the Reserve rely primarily on subsistence agriculture, bushmeat hunting, and harvesting of NTFPs (NCP, 2017; Zafra-Calvo and Moreno-Peñaranda, 2018). Therefore, crop-raiding and livestock attacks, exacerbate food insecurity, and human-wildlife-conflict (NCP, 2018).

The Reserve is managed by the National Administration of Conservation Areas (ANAC), representing the Mozambican Government in partnership with the Wildlife Conservation Society (WCS). There are also some non-government projects, such as the Niassa Carnivore Project (NCP), as well as sport hunting and tourism concessions that assist with conservation management and social development. There is an incentive program currently in place, which consists of sharing with residents 20% of the revenue from hunting fees paid by game concessionaires (Jorge et al., 2013; Massuque, 2013).

5.2.1.1. Infrastructure

People living inside and around the NNR have limited access to essential health and social services (NCP, 2017). In all villages (excluding Mecula), there is only one or two primary schools (from 1st-5th grade and 6th-7th grade), one health centre in bad condition, or even merely under the trees. The network of roads within the Reserve includes roughly 950 km of unpaved and precarious roads, with little or no access during the rainy season. Mecula headquarter is the closest village to the NNR office (Mbatamila main office), (30 Km away, roughly 1 hour by car), while Chamba is the farthest village, at approximately 15 hours by car. Mecula is the only village with decent infrastructures within NNR (Police centre, primary and secondary School, electric power, health centre with maternity clinic, television signal, and communication antenna), holding the maximum value of our infrastructure index (1).

In contrast, Chamba has the weakest infrastructure in the Reserve, with an infrastructure index of 0.08 (see detailed information in appendix A). In the last 10 years, Mbamba and Naulala villages have also been benefited from improved infrastructures such as roads, schools, electric fences, due to work carried out by conservation NGOs and a hunting concessionary operating in these villages. The Marrupa village,

which is approximately 110 Km and 165 Km from Mucoria and Mecula headquarter (SRN, 2008), is the closest and the most developed district with decent infrastructures just outside the Reserve.

5.2.2. Data collection: household survey

5.2.2.1. Survey sample

Data were collected in seven villages (see Figure 1 and Table 5.C.1 in the Appendix) out of approximately 42 villages spread throughout the Reserve (NCP, 2017). Villages were selected after a literature review about the area and meetings held with the NNR administration, the Mecula district government, and the Niassa Carnivore Project (an NGO managing 58,000 hectares of concession area in partnership with the NNR administration and Mbamba community aimed at conserving large carnivores). These were justified to get validated information to select a set of villages representative of the existing diversity within the reserve as it regards the following research topics: i) availability of employment provided by Conservation NGOs or Governmental Institutions; ii) strategic location (e.g., closer to rivers, or the reserve bordering villages); iii) quantity and quality of existing infrastructure in the village, and iv) the predominant livelihood and farming systems. Diversity in these topics was expected to generate different village-level perceptions of costs and benefits of living inside the Reserve. This study defines village by the spatial extent of households associated with a village name under the leadership of one village Chairperson (Mackenzie, 2012), which is the lowest administrative unit in Mozambique. The total number of households registered in each village was provided by the NNR administration and the District Secretariat of Agriculture and Economic Activities (Secretariado Distrital de Agricultura e Atividades Económicas - SEDAE). The number of households sampled was similar across villages (0.65 is the proportion between the smallest and largest village-level samples) because the main objective was to assure representativeness and comparability across villages. While also invoking the theorem, that to get a random sample in a normally distributed population, sample size should increase less than sub-population size (Bartlett et al., 2001; Krebs, 2014). A total of 339 households were surveyed. Using estimated average household size, between 6.71% and 84% of all households in each surveyed village were interviewed;

overall 21% of all households in the selected villages were surveyed (see Table 01). According to Bartlett et al. (2001) and Landry & Chirwa (2011), a 5% sample size is considered sufficient in the household survey research. A convenience sampling was preferred to cover all age groups and variation of other above-referred attributes within the village level. We surveyed households from July to September 2017. Most of the surveyed householders (92.33%) were men, aged between 18 and 86 years (mean = 43; Std. deviation = 16.5). For more details, see Table A in the appendix).

5.2.2.2. Questionnaire

The questionnaire had seven sections (See in appendix 5.C.5):

i) general information of respondents, in addition to the house construction standard (brick construction with (/out) zinc roof, which was confirmed by visual observation in the ground;

ii) the socio-economic and demographic background of respondents (family size, employment status, income, and education), possession or acquisition of each good/service listed in Section 2.e in appendix D, including the cost of purchase if still remember;

iii) estimation of expected agricultural outputs in the last season (crop harvested and losses for crop-raiding), the rank of the four top raiding species according to potential damage, the proportion of agriculture output sold for the main products and corresponding market prices;

iv) gathering effort related to NTFPs (frequency of harvesting and its final purpose, either for use or sale, quantities, and prices;

v) selection of practices that threaten conservation and identification of the actors perceived as main responsible for such practices;

vi) effectiveness and limitations of the current incentives to adopt conservation-friendly behaviors and

vii) effectiveness of newly proposed incentive measures.

The first author conducted an in-depth exploratory survey with a special group of households (villages chairpersons, teachers, healers, and some farmers), to explore questions related to crop-raiding, why some residents are happy or not to live within the Reserve.

We used the first and second parts of the questionnaire (i and ii) to build the household wealth variables within the village level. While the agriculture production variables (iii), gathering effort (iv), and practices perceived as threatening conservation (v) were used to derive other variables used as indicators of participation in illegal activities. The questionnaire was administered in close collaboration with five field assistants and two young locals who were familiar with the local languages (Cyao, Emakwa, and Swahili). The questionnaire was pre-tested with 10 householders in the Mbamba village. To avoid external bias, and fear of answering some sensitive questions, each household head was individually questioned, mostly at home. Before the administration of the questionnaire, we obtained oral consent from respondents.

The practices threatening conservation and the newly proposed incentive measures were taken from a previous survey to experts engaged in conservation in Mozambique (Mbanze et al., 2019). We used only the top four conservation threats pointed by experts to confront local households then. Other potential incentives are under implementation by Niassa Carnivore Project (NCP) in a pilot project in the Mbamba village since 2012. The Mecula administration provided us with information about the quality, quantity, and size of infrastructures available in villages (e.g., schools, hospitals, electricity plants, water storage, marketplaces, mills, mosques, mobile, and TV signals). This information was confirmed through on-ground observations.

5.2.3. Data analysis

Most of the responses were binary (yes or no) and were coded as dummy variables:

i) 1 = if householder declared to have purchased/acquired or repaired each of 12 major goods or services or 0 = otherwise;

ii) 1= if householder recognised each practice as a relevant threat to conservation. And each actor as the main responsible for such practices, or 0 = otherwise;

iii) 1 = if householder knew the effectiveness of each incentive measure under implementation in promoting conservation-friendly practices by local people, and 0 = otherwise;

iv) 1 = if the householder perceived limitations in the way each current incentive measure is applied and 0 = if otherwise, and

v) 1 = if the householder agreed with the effectiveness of each new proposed incentive, or 0 = otherwise.

All raw scores for each of the five-sections pointed out above were counted up to yield a scaled range, from 0 to n_i, were n_i is the number of items in each section coded as 1.

5.2.3.1. Agriculture production and prices

All agricultural outputs (crop harvested and losses from crop-raiding), were transformed into monetary value using the same price (in new metical MZN)[8], to allow comparisons between farms and across villages. The average price of each crop was estimated based on figures provided by the surveyed households (see section 3 in Appendix 5.C.5), by dividing the total revenue of crop sold to its respective quantities. This average price was subsequently used to derivate the Partial Expected Production (PEP = crop harvested + lost for crop-raiding), of each crop into monetary values. The PEP was then summed to obtain Total Expected Agriculture Production ($TEAP_i$) of all crops harvested and lost by each surveyed

[8] New Metical (MZN) is the Mozambican currency. As of 25th November 2019, the exchange rate was: one US dollar ($1) equivalent to 63.25 MZN. One British Pound (1£) was equal to 81.43 MZN, while one Euro (1€) was equivalent to 69.67 MZN. Source: https://www1.oanda.com/lang/pt/fx-for-business/historical-rates (OANDA – solutions for business).

household. After that, we estimated Net Crop Production (NCP_i) (by removing losses from crop-raiding from the TEAP), and the Proportion of Crop Sold (PCS), as a ratio between the amount of crop sold in MZN, by Net Crop Production (PCS/NCP_i).

5.2.3.2. Accounting for benefits and losses incurred by NNR residents

The Flowchart in Figure 5.2. presents the main logical steps followed in data analysis. It can be observed that, all goods and services the household heads declared to own or have access to were used as indicators of the indirect benefits and costs/losses of living inside the NNR. By benefits, we are considering all household wealth, regardless of being generated or not by park-related activities, because we believe that the level of household wealth and access to services may affect each householder's perception of life inside the NNR.

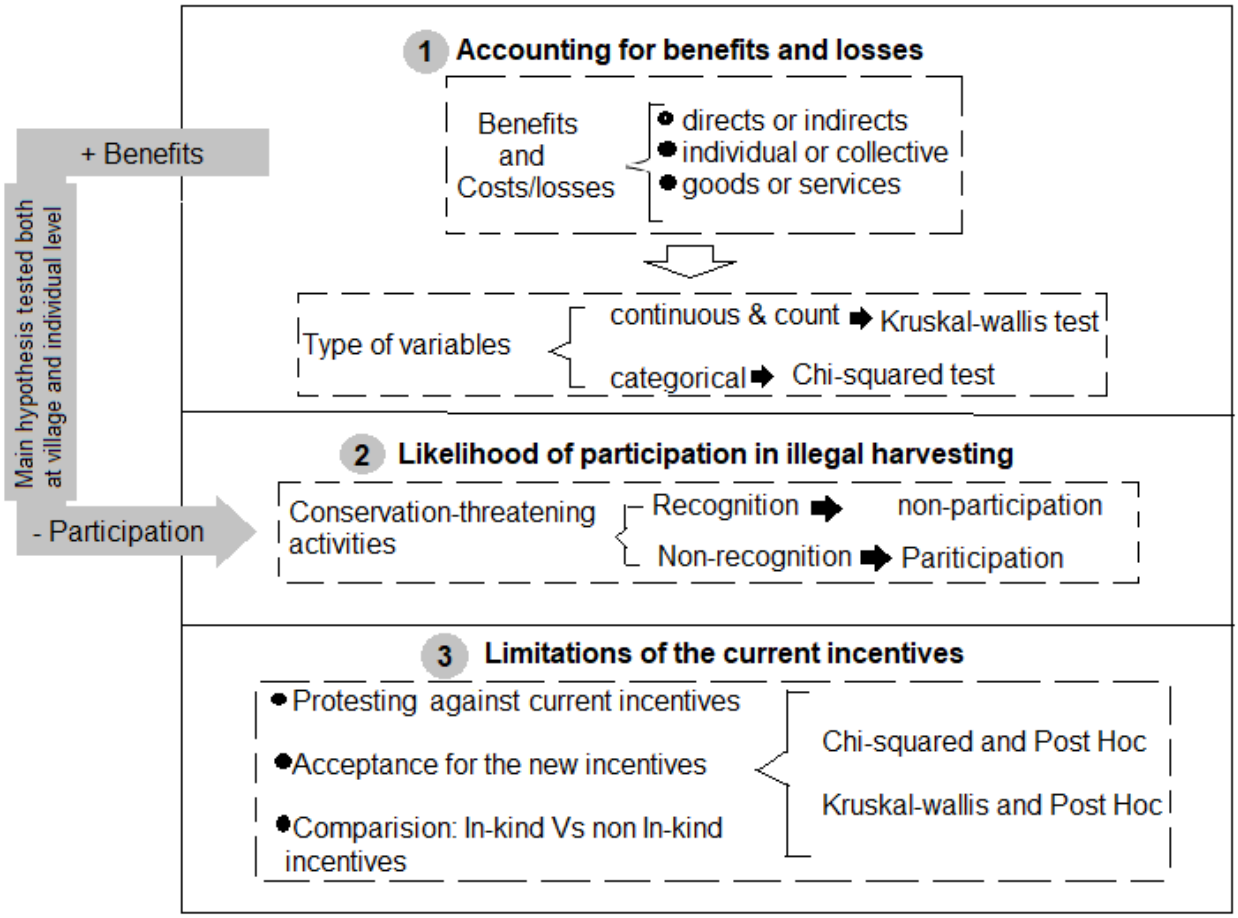

Figure 5.2. Flowchart showing all the logical steps followed for data analysis

We partitioned *total employment* into *general employment* and employment directly related to conservation. To test the hypothesis of equal distribution of household wealth across villages, chi-squared and Post-Hoc cellwise tests were applied for binary variables. For continuous and count variables, a nonparametric test (Kruskal-Wallis) and post-hoc pairwise comparisons with Bonferroni correction were used to investigate statistical differences across villages considering the assumption of equal variances was not verified (see Figure 2).

5.2.3.3. Accounting for loss level variation across villages

Direct losses included the percentage of expected agricultural output directly lost to crop-raiding. Lower levels of Net Crop Production (NCP_i), Total Expected Agriculture Production ($TEAP_i$) and harvest effort related to NTFPs were also considered relative losses. Because if the Reserve did not exist, people would not suffer the existing access restrictions with regards to resource harvest or cropland. The frequency of harvesting each NTFPs was estimated based on the selection of a specified frequency class option in section 3 of the questionnaire: 365 days/year were allocated for those that selected the daily option; 52 days/year for the weekly option; 12 days/year for the monthly option; 2 days/year for the semester option; and 1 day/year for the yearly option. This allocation of days/year was done for all 10 gathering activities considered in the survey.

We estimated the potential losses, based on the crop-raiding index 1, that predicts the potential damage that is likely to occur at the farm level, which was done based on the top four most relevant crop-raiding species (elephants, buffalo, baboons and bush pigs), ranked by the surveyed households ($Rank_i$, where i vary from 1 to 4). The class of potential damage of each crop-raiding species (C) was then taken from the literature (Mackenzie, 2012; Tufa et al., 2018) and the author's personal experience. Crop raiding index 1 was then compared to Crop raiding index 2, which is the fauna density reported in the NNR management plan at blocks level (SRN, 2008). Since all the variables were continuous and count, a nonparametric test (Kruskal-Wallis) and post-hoc pairwise comparisons with Bonferroni correction were used to investigate statistical differences across villages.

5.2.3.4. Assessing the likelihood of participation in illegal harvesting and identifying the drivers for such participation

We developed an indirect approach to estimate the (direct or indirect) likelihood of respondents' participation in illegal activities. The procedure is based on the assumption that people involved in illegal activities will be less willing to recognise these activities as significant threats to conservation. Thus, we used the reluctance of recognition of illegal practices as a proxy for direct or indirect participation in illegal activity. The validity of this association can be tested through cross-tabulating the recognition of shifting cultivation as a threat with participation in this activity where denial is unlikely. Our assumption requires a significant negative deviation of recognition for farmers (see Figure 5.2). Farmers' households used to validate this test was taken from the farming system typology developed in the previous research (Mbanze et al., 2019, under review).

Because this association is only probabilistic, we used the resulting outcome as a random variable to test the following hypotheses:

i) participation in illegal harvesting significantly varies across villages, in a way that reflects differentiated village-level costs and benefits of living within the Reserve;

ii) the individual's perception of the importance of current incentives received by local people significantly reduces the likelihood of participation in illegal harvesting;

We tested the first hypothesis through Analysis of Variance (ANOVA), based on the nonparametric Kruskal-Wallis (KW) test, while the second hypothesis was tested through Spearman's rank correlation. Detailed information about the test used is in Appendix 5.C.2.

We used a table of absolute frequency to depict the relationship between threats to conservation, and the main actors' responsible for each threat. Actors were classified as: Donors (Do), Reserve Administration (ReAd), Non-residents (NoRe), Local People (LoPe), Private Sector (PrSc) and Traditional Authorities

(TrAu). Since admitting responsibility for illegal activities implies admitting involvement in illegal extraction, a chi-squared and post-hoc cellwise tests between villages and actors responsible for each threat to conservation were applied. The objective of these tests was to understand whether villages with illegal activities do not assume local people responsibility. The responses from the household were then compared to experts' response[9].

5.2.3.5. Limitations of current incentives and the need for new proposed incentives as a pretext for involvement in illegal activities

Respondents were questioned about perceived limitations of current incentives and the effectiveness of the newly proposed ones, to test the following hypotheses:

i) in villages where the most surveyed households are likely engaged in illegal activities, these housholds will protest about the way current incentives are delivered;

ii) in general, respondents will be more receptive for the new incentives, if they claim not to receive enough benefits from those under implementation; and

iii) As most of the new proposed incentives are in-kind and in-kind incentives, it has been proved to be more effective in engaging local people with conservation friendly-practices in previous studies (Akers and Yasué, 2017; Mbanze et al., 2019; Narloch et al., 2014). We would expect that the new proposed incentives would have higher acceptance by most of the households, that is, a weak relation will be expected between the limitation of the current incentives and newly proposed ones.

[9] In relation to experts' response, see more in Mbanze et al., (2019): An expert-based approach to assess the potential for local people engagement in nature conservation: The case study of the Niassa National Reserve in Mozambique - https://doi.org/10.1016/j.jnc.2019.125759

We tested the three above hypotheses through chi-square test and Post Hoc cellwise comparison between villages level and respondents' answers for each item related to the limitations of the current incentives and the new proposed incentives. In addition, Kruskal-Wallis (KW) test and Post-hoc pairwise comparisons with Bonferroni correction were also used to test differences between villages for the count of current limitations and new proposed incentives (see Figure 2).

5.3. Results

5.3.1. Distribution of cumulative costs and benefits across villages

Benefits are unevenly distributed across villages ($p < 0.05$), except for poultry ($p = 0.27$) and livestock ($p = 0.085$), which are more uniformly distributed (Table 5.1). Wealthier households are mostly located in Mecula, Macalange and Matondovela villages. Radio, transportation means (motorcycle or bike), mobile phone, and education for dependents, are amongst the few goods/services that most respondents (> 50%) declared to have access. Contrary to the most important benefits, such as payments for agricultural labour, bank account, improved houses, electricity, and infrastructures, which were less reported by respondents, most of them located in Mecula. Mbamba and Naulala also receive important benefits such as electric fences and employment in conservation activities. On average, Macalange accrues more benefits from payments for agricultural labour, investments in small businesses, and acquisition of transport means. Poultry is the only benefit that is, on average, more accrued in Chamba and Mucoria villages.

Costs are also unevenly distributed. Overall, Macalange and Mucoria suffered higher crop losses and recorded the lowest values of agriculture and gathering effort. Potential losses from crop-raiding are more evident in Matondovela, Mbamba, and Naulala. Still, paradoxically, the same villages yield more net agriculture output and have more gathering activities during the year. We will postpone the justification for these results in the discussion section.

Table 5.1. Village-level indicators of diverse types of benefits and costs reported by the surveyed households

	Villages								
	Chamba N=42	**Macalange** N=45	**Matondovela** N=52	**Mbamba** N=62	**Mecula** N=56	**Mucoria** N=42	**Naulala** N=40	**Total N=339**	**P-Value**
Benefits									
Benefits	**Percentage of the households who declared to have acquired each good or service**								
Payment for agricultural labour	14.29	37.78	21.15	35.48	39.29	9.52	47.50	29.79	0.000***
	-		-		+	--	++		
Investing for small business or buying merchandises	9.52	35.56	32.69	25.81	21.43	14.29	27.50	24.19	0.044*
	-	+	+			-			
Motorcycle or bike	38.1	68.89	50	59.68	35.71	52.38	80	54.28	0.000***
	-	+			--		++		
Radio	47.62	62.22	55.77	87.1	50	52.38	85	63.42	0.000***
	-			+++	-	-	+++		
Television	7.1	13.3	7.7	11.3	53.6	0	2.5	15	0.000***
	-		-		+++	--	-		
Mobile phone	33.3	64.4	53.8	51.6	76.4	57.1	47.5	55.6	0.002**
	--				++				
Bank Account	2.4	11.1	9.6	8.1	48.2	4.8	5.0	13.9	0.000***
	-			-	+++	-	-		
Education for dependents	11.9	66.7	38.5	64.5	76.8	35.7	57.5	51.9	0.000***
	---	+	-	+	+++	-			
Poultry	16.7	15.6	28.8	25.8	14.3	31	22.5	22.1	0.269
					-	+			
Livestock	0	0	0	1.6	5.4	0	0	1.2	0.085
					++				
Brick construction	4.76	13.33	5.77	6.45	21.43	0	10	9.14	0.007**
					++	-			
Zinc roof	4.76	22.22	11.54	14.52	37.5	4.76	15	16.52	0.000***
	-				+++	-			
Conservation work	0	6.67	1.92	24.19	14.29	7.14	17.5	10.91	0.000***
	-		-	+++			+		
Formal employment related or not to conservation	2.4	6.7	7.7	27.4	48.2	7.1	22.5	18.9	0.000***
	--	-	-	+	+++	-			

	Villages								
	Chamba N=42	**Macalange** N=45	**Matondovela** N=52	**Mbamba** N=62	**Mecula** N=56	**Mucoria** N=42	**Naulala** N=40	**Total N=339**	**P-Value**
Electricity or solar panel	26.2	26.7	17.3 -	27.4%	60.7 +++	9.5 --	22.5	28.3	0.000***
Wealth accumulation	3.90C	6.16AB	5.02BC	5.69AB	6.88A	4.12C	5.75AB	5.44	0.000***
Infrastructure	2	7	7	10	26.00	11.00	6.00	10.45	NA
Electric fencing	No	No	No	Yes	No	No	Yes	NA	NA
Gross farming output sold	19.07 ABC	17.53 AB	33.07 C	21.57 ABC	11.48 A	15.23 AB	28.68 BC	20.87	0.000***
Costs									
Costs	**Direct and potential (lower agricultural production and gathering effort are interpreted as costs) Value**								**P - Value**
Percentage of agricultural output lost	43.57 D	65.93 G	42.56 C	33.01 A	48.2 E	49.2 F	39.31 B	39.74	0.000***
Crop raiding index 1	15	15	16	16	13	15	17	15.24	NA
Crop raiding index 2	3	5	5	5	3	3	5	4.17	NA
Net agriculture production in $ per household	205.36 A	196.66 A	431.46 C	247.91 AB	165.34 A	115.30 A	389.00 BC	250.56	0.000***
Total gathering effort (days of the year) per household	94.12 AB	78.60 A	123.79 AB	139.89 BC	102.05 AB	116.19 AB	185.50 C	119.81	0.000***

Note: α = *** is significant at 0.1%, ** = significant at 1%, * = significant at 5%, NS = not significant. The proportion of households at village level was performed based on the Person's exact Chi-Square with significance at 0.1% (α = 0. 000). The signals plus (+) and minus (-) indicate positive or negative relation between villages and different questions that household were requested to answer systems. +|-; ++|- - and +++|---, significant at 5%, 1% and 0.1%, respectively.

In Table 5.2. the socioeconomic characteristics of respondents are presented and in which it can be observed that households living in Mecula are on average, more educated, younger, and held a larger family size compared to the rest of the villages. Only 20.4% of respondents declared to have already lived outside the Reserve. Most respondents who have lived outside are in Mucoria, Mbamba, and Mecula. The number of households reported to have lived outside the Reserve for more than two years was smaller, with Mbamba (17.7%) and Mecula (10.7%) being the only villages

above the overall average of 7.1%. More than half of the households (61.7%) declared to feel happy about living inside the Reserve. Chamba was the village with the highest rate of happy people, followed by Mucoria and Matondovela.

Table 5.2. Socioeconomic characteristics of the surveyed respondents

	Villages								
	Chamba N=42	**Macalange** N=45	**Matondovela** N=52	**Mbamba** N=62	**Mecula** N=56	**Mucoria** N=42	**Naulala** N=40	**Total N=339**	**P-Value**
Total population in the village	234	669	340	682	4958	642	855	1294.13	NA
Average education	0.81 A	1.29 A	1.23 A	1.21 A	2.50 B	1.19 A	1.25 A	1.39	0.000***
Age	43.29	44.64	43.56	43.24	39.21	42.86	46.63	43.17	0.500
Size of family	4.67	5.07	4.42	4.82	5.48	4.90	5.03	4.92	0.229
Households who have lived outside the reserve for ≥ 2	2.4 -	0 -	3.8	17.7 ++	10.7 +	9.5	0 -	7.1	0.000***
Households who have ever lived outside the reserve	11.9 -	4.4 --	19.2	29 +	26.8	35.7 ++	10 -	20.4	0.001**
Households who are happy to live inside the reserve	83.3 ++	48.9 -	63.5	53.2 -	55.4	64.3	70	61.7	0.000***

Note: α = *** is significant at 0.1%, ** = significant at 1%, * = significant at 5%, NS = not significant. The proportion of households at village level was performed based on the Person's exact Chi-Square with significance at 0.1% (α = 0. 000). The signals plus (+) and minus (-) indicate positive or negative relation between villages and different questions that household were requested to answer systems. +|-; ++|- - and +++|---, significant at 5%, 1% and 0.1%, respectively.

5.3.2. Illegal harvesting of natural resources

Table 5.3 presents the proportion of people who are likely involved in each illegal activity at the village level. The percentage of households who perceive these activities as not threatening conservation significantly differs across villages ($p < 0.05$), except for illegal logging ($p = 0.127$). The overall percentage of households recognising that each practice represents a threat to conservation in the NNR is above 60%. The likelihood of not being involved in conservation-threatening practices is higher in Mecula, Mbamba, and Naulala. On the other hand, respondents in Chamba and Mucoria are more likely engaged in illegal activities, followed by Matondovela. Poaching is undoubtedly the most recognised threat to conservation (81.6%), with less divergence across villages ($p = 0.021$). Most of the households who are more likely involved in poaching are in Chamba and Matondovela, while people in Mucoria are more likely involved in illegal mining.

Overall, more than half of the households agree with the current compensations under implementation in the Reserve. Only in the case of delivering 50% of the revenue of the fines, the proportion of respondents is below 50%. The percentage of households in agreement to the current compensations significantly varies across villages for all compensation types. The agreement level is lowest in Macalange for all compensation types except for jobs and promotion and respect of culture and beliefs; and the highest in Naulala. There are also higher levels of agreement for employing local people in Mbamba and Mecula. Whereas in Mucoria and Matondovela there is a high agreement regarding delivery of 20% of revenues from concessions to local people. In Mbamba, there is a high agreement for promotion and respect of the culture and beliefs of local communities.

The correlation between the number of illegal practices recognised as threats to conservation and agreement with current compensations is positive ($r_s = 0.121^*$) and $p<0.05$. This positive correlation, while weak, suggests that individuals who agree with current incentives are less likely to participate in illegal harvesting of natural resources.

Table 5.3. The proportion of respondents who recognised different practices as threats to conservation; and percentage of respondents that agree that current compensations are important to engage local people in conservation.
The village-level average number of practices recognised as threats and the average number of incentives that are seen as contributing to engage people in the conservation area in the last lines of each half of the table. Lower levels of recognition of illegal practices (all but shifting cultivation) as threats are interpreted as indirect evidence of household involvement in these illegal practices.
The association between Farming and Livelihood Systems and shifting cultivation as a threat is presented at the bottom.

	Villages								
	Chamba N=42	**Macalange** N=45	**Matondovela** N=52	**Mbamba** N=62	**Mecula** N=56	**Mucoria** N=42	**Naulala** N=40	**Total N=339**	**P-Value**
Practices	**Percentage of respondents who selected each practice as a threat to conservation**								
Shifting cultivation	69	73.3	59.6	53.2	80.4	73.8	52.5	65.8	0.013*
				-	+		-		
Poaching	67.5	83.7	72	83.9	94.2	80.5	86.8	81.6	0.021*
	-		-		++				
Illegal logging	53.8	61	56	62.9	80.8	58.5	60.5	62.5	0.127
					++				
Illegal mining	66.7	61.4	64	71	87.3	42.9	72.5	67.5	0.001***
					++	--			
Average number of illegal practices recognised by the respondents as relevant threats	2.5B	2.69AB	2.44B	2.71AB	3.29A	2.52B	2.65AB	2.71	0.004**
Current incentives	**Percentage of respondents who selected each incentive as relevant to engage local people in conservation**								
Jobs	57.1	73.3	67.3	85.5	89.3	71.4	90	77	0.000***
	--		-	+	+		+		
Hunting quotes allocated to communities	73.8	52.3	80.8	56.5	76.8	54.8	92.5	69.2	0.000***
		--	+	-		-	++		
20% of revenues of concessions delivered	83.3	62.2	92.3	72.6	71.4	90.5	97.5	80.5	0.000***
		--	+	-	-	+	++		
Food allowances	39	32.6	42.3	83.9	36.4	70.7	60	53	0.000***
	-	--	-	+++	--	+			
50% of the revenue of the fines	40.5	34.9	41.2	63.9	38.2	47.6	40	44.6	0.046*
		-		++					
Promotion and respect of culture and beliefs	83.3	82.2	80.8	96.8	78.6	88.1	97.5	86.7	0.016**
			-	++	-		+		

	Villages								
	Chamba N=42	**Macalange** N=45	**Matondovela** N=52	**Mbamba** N=62	**Mecula** N=56	**Mucoria** N=42	**Naulala** N=40	**Total N=339**	**P-Value**
Average number of incentives that respondents perceive as important	3.76AB	3.33B	4.03AB	4.58A	3.89AB	4.21AB	4.78A	4.09	0.000***
Association between Farming and Livelihood Systems and shifting cultivation as a threat									
Livelihood System	____	____	_____	gatherers	employees	hunters	gatherers	65.8	0.244
Farming system	Maize & Rice	Rice	Maize	Mixed & Sorghum	----- +	Mixed	Sorghum --	65.8	0.082

Note: α = *** is significant at 0.1%, ** = significant at 1%, * = significant at 5%, NS = not significant. The proportion of households at village level was performed based on the Person's exact Chi-Square with significance at 0.1% (α = 0. 000). The signals plus (+) and minus (-) indicate positive or negative relation between villages and different questions that household were requested to answer systems. +|-; ++|- - and +++|---, significant at 5%, 1% and 0.1%, respectively.

Results from cross-tabulation between recognition of shifting cultivation as a threat to conservation and farming and livelihood system at the village level suggested that overall, 65.8% of respondents recognise shifting cultivation as a threat. Mecula, is the only village above the expected proportion of respondents, with significant positive deviation. This result suggests that employees mostly living in Mecula, are more willing to view shifting cultivation as a threat. Thus, this result validates the hypothesis that individuals who are not involved in a conservation-threatening practice are more willing to recognise this practice as a threat. Mecula is the village where the level of participation in illegal harvesting is the lowest, while the highest rate observed in Chamba, Matondovela, and Mucoria.

5.3.3. Main actor and its proportion of responsibility for each practice that threatens conservation

The perceptions of respondents on the main factor responsible for each practice threatening conservation in Reserve are in Table 5.4. The non-residents (NoRe) are the main responsible for poaching, illegal logging, and illegal gold and ruby mining, holding more than 95% of all responsibility. The governmental authorities (Go); local people (LoPe); and the reserve administration (ReAd), share the rest of responsibility. The Go share 82% of the responsibility for population growth (population growth should be interpreted as a direct or indirect causes for other conservation-threatening practices); The ReAd share 56% of the responsibility for HWC, followed by LoPe, and the Go. Local people also held 96% of the culpability for shifting cultivation.

Table 5.4. Share of responsibility among different actor, for each cause threats conservation in the NNR.

	Practices threats conservation in the NNR					
Responsible	**Poaching**	**Illegal logging**	**Illegal gold & ruby mining**	**Population growth**	**WHC**	**Shifting cultivation**
ReAd	1	0	0	3	56	2
TrAu	0	0	0	0	0	**0**
Do	0	0	0	0	0	**0**
Go	1	0	1	82	14	**1**
NoRe	97	99	96	1	0	**0**
LoPe	2	1	3	14	27	**96**
PrSc	0	0	0	0	3	**2**
Degree of threat						
Degree of threat	4	2	3	1	4	3

Note: WHC = is human and wildlife conflict, ReAd=Reserve Administration, TrAu=Traditional Authorities, Do=Donors, Go = Government, NoRe= Non-residents, LoPe=Local People and PrSc=Private Sector), and their share of Responsibility in percentage (red to green represents the high to less gradient of the share of responsibility by each actor), represents very high to a little degree of threat each problem represents for conservation.

Local people only accept responsibility for threats that they are directly involved in (see Table 5.C.3 in Appendix), mainly: shifting-cultivation (95,9%), HWC (26.5%) and population growth (13.6%). Besides, there is no consensus among respondents regarding the responsibility of local people for those three threats. All respondents in Chamba, Mecula, and Mucoria believe that local people are the main

responsible for shifting cultivation. For the rest of the illegal activities that threat conservation in the Reserve, they don't accept to share not even 4% of culpability.

5.3.4. Limitations of the current compensations as a need for new proposed incentives.

More than 64% of respondents complained about the current compensations under implementation (Table 5.C.4 in the Appendix). There is more consensus among respondents at the village level concerning the limitations of the current compensations. Respondents consensually perceived the allocation of hunting quotas (81.6%), and lack of an award for the detector of the offender (73.3%), as the more significant limitations for conservation. Chamba and Mucoria are the villages where most respondents agree with the restrictions, while Matondovela held the least proportion of respondents who agree with the current limitations.

The new proposed incentives are better than the existing ones, with an acceptance rate between 95 to 100%, with a clear consensus among village level respondents. On average, the proportion of respondents who perceive the new incentives as necessary are also those who recognise more limitations in the way that the current incentives are delivered to local people.

5.4.Discussion

The distribution of costs and benefits is uneven across villages, which is probably related to the following factors: i) the spatial distribution of villages affects market access for selling and buying goods and services; ii) the distribution of crop-raiding and potential damages leads to very different crop loss levels; iii) different biophysical conditions hinder agriculture production in some villages, and favours others (NCP, 2017; SGRN, 2004); iv) the unfair distribution of infrastructures and conservation projects across villages, leads to attract more skilled and educated workers, increasing the demand for goods and services, hence improving business opportunities in some villages rather than others.

The residents from Naulala, Mbamba, and Macalange seem to invest more in transportation means for carrying their agricultural and NTFP products to sell in the nearest developed villages (e.g., Mecula and Marrupa). On the other hand, there are more people employed in non-agricultural or extractive sectors in Mecula and Marrupa, which increases the purchase power in these two villages. Despite higher agricultural production and its remote location, Matondovela buys fewer bikes and motorbikes, because the residents have invested a proportion of 20% of the revenue paid by hunting concessions to obtain a collective 4x4 car. Besides, they have recently built a new village market to sell agricultural and NTFP products.

Radio and mobile phones are more predominant in villages with higher purchasing power and means of recharge (e.g., electricity and solar panels), except for Mecula where television seems to substitute radio devices. Also, Mecula households own more TVs because it is the only village with a free national television signal. In Chamba, fewer respondents hold mobile phones, not only because they are poorer, but also because they only receive a signal from Tanzania, which requires additional roaming costs for communication in Mozambique.

5.4.1. Costs and benefits, its relation to conservation compensations and the likelihood of involvement in illegal harvesting

Residents in villages that receive more benefits of living within the Reserve tended to recognise illegal harvesting of natural resources as a relevant threat to conservation. This also influences household perception of the effectiveness of current compensations in engaging local people with conservation-friendly practices. In addition to the benefits received, education and access to information also appear to stimulate a more pro-conservation attitude, which is evident in Mecula, Naulala, and Mantondovela. The reverse seems to occur in Chamba and Mucoria villages. Our finds are thus following Espinosa and Jacobson (2012), who asserted that, besides conservation benefits, education and information are also crucial for better understanding the importance of conservation.

Promotion and respect of culture and beliefs are perceived as an essential compensation in almost every village, except in Mecula, likely because most of the current residents came from other areas in the country; hence, they do not identify themselves with the local culture. Besides, most of the households who declared to have spent more years outside the Reserve are more educated and not happy to live inside the Reserve. Probably because they are more educated and better informed, therefore, feeling they have more chances to find better jobs outside. On the other hand, those who only lived inside the Reserve do not have a benchmark reference to assess their degree of happiness on a relative basis. For instance, in an exploratory question, some respondents said enjoying living inside the Reserve for the following reasons*: i) they were born and used to living there; ii) they can grow cops and harvesting NTFPs, which will be difficult outside the Reserve and iii) because they have conservation-related employment. While in the other hand, those who are not happy argued: i) there are too many restrictions; ii) They cannot harvest their production due to crop and livestock raiding; iii) There is no employment; and, iv) Life in the cities is much better.*

Villages closer to the reserve border (Chamba and Mucoria) receive less benefits. Thus, households living in those villages seem to be more reluctant to recognise illegal activities as a threat to

conservation, likely because they are engaged in such activities; these boundary villages also provide local people with more opportunities to assist outsider poachers seeking to conduct illegal incursions into the Reserve. With the cover-up of residents, this border position may also facilitate outsider poachers to escape from range surveillance. Although there is a Selous Game Reserve in Tanzania, adjacent to NNR (Zafra-Calvo et al., 2017), Tanzanian poachers prefer to conduct such illegal incursions in NNR, due to lower penalties they will be subject to if caught and the easy alliances they forge with local residents in the Reserve. It is thus worthwhile to advise the Reserve to provide more benefits in border villages, and not simply increasing ranger surveillance in these locations.

Some studies suggest that households who engaged in illegal activities are better-off than those who are not (Chang et al., 2019; Rogan et al., 2018). However, our Study suggests this is not always the case. Our results are in accordance with previous research conducted by Jorge et al. (2013), who pointed out that lack of direct access to the market hampers local people to get higher profitability from illegal activities, since they act as intermediaries. The following factors can also induce Conservation-threatening practices such as poaching: i) lack of alternative source of animal protein (in Chamba) (Loibooki et al., 2002); ii) higher potential damages (in Matondovela) and iii) higher actual losses from crop-raiding (in Chamba and Matondovela), (Rogan et al., 2018).

5.4.2. Threats to conservation, responsible and illegal harvesting

Based on this methodology of using the non-recognition of certain activities as conservation threats as a way to detect village-level involvement, we noticed that village-level respondents only recognised to participate in illegal activities in which they were directly involved, namely: population growth, HWC, and shifting cultivation, especially in villages where their involvement is undeniable. This is also probably because, in many PAs (including the NNR), such activities are either not illegal or are only considered minor infractions. Nevertheless, when we requested them to point out who bears significant responsibility for such threats, they find a room to blame the government authorities (Go) for population growth and the reserve administration (ReAd) for HWC (see Table 4). These results contrast

to the previous survey to conservation experts who clearly point out local people as the main response for both threats (Mbanze et al., 2019b).

In the exploratory responses, some residents complained that *the Reserve prefers to protect crop-raiding animals than the residents and their belongings. Thus, poaching is sometimes good because they shrink crop-raiding. Concerning* population growth, other respondents claim that *the animal population is growing more than the human population, and the (human) population is growing because the governmental authorities allow outsiders to settle within the reserve*. Identifying local people as responsible for HWC has proved to be highly controversial (Fraser-Celin et al., 2018; Gaillard et al., 2019; Marker and Boast, 2015). For instance, one can argue that "*I killed the same buffalo or lion who killed my mother or was trying to kill me, when I tried to expel him from raiding my crops or attacking my livestock*."

Respondents blamed outsiders for all activities that constitute major threats to conservation for the following possible reasons: i) they do not want to be found guilty, as penalties are severe; and, ii) they are likely involved in such activities in indirect ways that they try to hide by blaming outsiders as the direct actors. For instance, local people share more responsibility for HWC in villages where they perceived poaching as irrelevant. Thus, we may infer that householders claim to poach the provocative raiding animals, which is also in accordance with Moreto, (2019) and Dickman and Hazzah, (2015). According to the surveyed experts, outsiders hold 55% of culpability for poaching, while local people hold 20% (Mbanze et al., 2019). Whereas in this Study, the household do not accept even 3% of guilt for poaching, and they tended to put all the blame on the outside (97%), especially in villages where their involvement in conservation-threatening activities is more difficulty to denied.

5.4.3. Strengths and limitations of this methodology: the need for further advancement research

Our results suggest that supporting conservation costs without receiving the corresponding benefits affects local 'residents' perceptions of the importance of conservation, which leads to more involvement in illegal resource-extraction activities. On the other hand, under-valuing the negative effects of such activities on conservation may be seen as a way of hiding their participation in these activities, and thus can be used as an indicator of involvement in illegal activities. Those who carry the conservation burdens, while not receiving any benefits out of it, will be more willing to participate in illegal activities, either for mere revenge, necessity, or rationality (reducing populations of crop-raiding animals). All these hypotheses were better verified at the village rather than at an individual level. This has already been noted by several authors quoted in the introduction (for instance, Mackenzie, 2012 and Mackenzie et al., 2017).

To make the point clearer, we should note that when we tested the hypothesis that the 'individual's perception of the importance of current incentives received by local people reduces the likelihood of participation in illegal harvesting through the Spearman's rank test, the correlation was positive, but only slightly significant. This suggests that people's perceptions of costs and benefits of living within the Reserve or of the fairness of conservation incentives is probably built at the village as opposed to the individual level, and thus its relationship with behaviour is also better captured collectively at the village level.

One limitation to highlight is that the methodology was not yet validated, to the extent that it requires extra and reliable data: i) either from the NNR database (e.g., infraction/occurrences of illegal harvesting at the village level conducted by residents and outsiders); unfortunately, as far as we are aware of, the NNR does not yet have this information; or ii) by conducting more in-depth ethnographic interviews in each village where the survey was carried out. Despite this limitation, this methodology seems to move in the right direction, as any other referred village-level spatially modelling for detecting

illegal resource harvesters. However, we are taking the necessary cautions to not overselling it, as a more thorough validation is still needed.

5.5.Conclusions

This research aimed to understand whether the perceived costs and benefits of living inside a PA may affect 'residents' levels of participation in conservation-threatening activities, and if undervaluation of threats (and incentives under implementation) can be used, at the village level, as an indicator of the likelihood of participation in illegal activities. The results showed that costs and benefits were unevenly distributed across communities, due to natural, socio-economic and policy/management factors, including the conservation dynamics in Reserve. Householders who perceived to receive few benefits and high conservation costs tend to be less educated and have no or inadequate access to information and are mostly located in villages closer to the reserve borders.

This research suggests that some costs and benefits can be changed to improve the pro-conservation attitude of local communities in those villages where people tend to undervalue conservation threats and participate more in conservation-threatening activities. The percentage of agriculture output lost to crop-raiding appears to be the most obvious cost to be tackled, since it seems to induce poaching and WHC, which are important threats to conservation. This can be done through enhancing some benefits such as improve or provide additional infrastructure (e.g., electro fence to protect against crop-raiding and improve roads accessibility), to boost communication, business opportunities, provide education to keep village dwellers better informed, and to have more opportunities of better employments and conservation work to offset crop-raiding indexes and dependence out of agriculture and harvesting NTFPs.

This requires that the NNR managers and NGO operating in the Reserve put more effort to attract conservation projects that increase conservation benefits in those villages where households

support the highest costs and lowest benefits, while simultaneously improving 'people's access to education and information, and increasing range surveillance in the villages located near to the PA borders.

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Chapter 5

Appendix C

Table 5.C1. General characteristics of each sampled village: geographical location, the total household in the sampled village, sample size, Infrastructure and distance from each village to the Reserve headquarter in Mbatamila.

Villages	Coordinates	No. of households in the village*	No. of households sampled	Sampling effort (%)	Index of Infrastructure	Distance to Mbatamila (h)
Chamba	11º36´29”S; 36º55´49”E	50	42	84	0.08	15.0
Macalange	12º00´17”S; 37º46´05”E	132	45	34.10	0.27	2.3
Matondovela	12º04´28”S; 37º00´59”E	77	52	67.53	0.27	8.5
Mbamba	12º12´01”S; 38º01´00”E	141	62	43.97	0.38	8.0
Mecula	12º08´34”S; 37º40´16”E	908	56	6.17	1	1
Mucoria	12º36´27”S; 37º39´38”E	131	42	32.06	0.42	10
Naulala	11º49´57”S; 37º54´28”E	170	40	23.53	0.25	6
TOTAL		1609	339	21.07	NA	NA

Note:* Data from the national census (2015) available at the district level.
The Index of infrastructure is the ratio between the quantity of infrastructure existing on a village given village and the maximum quantity of infrastructures which was observed in Mecula village.
Distance from a given surveyed village to Mbatamila (the reserve main office), is an average time in hours (h) spent travelling by a 4x4 car

Appendix 5.C.2. Testing the hypotheses of participation in illegal harvesting

For the first type of hypotheses, an ANOVA between the number of harvesting activities recognised by respondents as threats, as well as the number of such illegal practices across villages was carried out. When an association was detected, post hoc cellwise tests were performed to find those villages in which households were involved in illegal activities. A nonparametric Kruskal-Wallis (KW) test and post-hoc pairwise comparisons with Bonferroni correction were used to investigate the differences in average recognition levels across villages.

To test the second hypothesis, a Spearman's rank correlation between the number of illegal harvesting activities (poaching, illegal logging, and illegal mining), and the number of current incentives that the respondent perceives as effective in promoting conservation-friendly attitudes. The Spearman's rank correlation coefficient (Spearman's rho) was used because both variables are counts and the hypothesis of normal distribution was rejected (Kumar and Abirami, 2018).

Table 5.C.3. Share of responsibility of local people for each threat to conservation in the NNR according to respondents' views.

		Villages								
Threats	**Main Responsible**	**Chamba N=42**	**Macalange N=45**	**Matondovela N=52**	**Mbamba N=62**	**Mecula N=56**	**Mucoria N=42**	**Naulala N=40**	**Total N=339**	**Sig.**
Shifting cultivation	LoPe	100 +	95.6	96.2	85.5 ---	100 +	100 +	97.5	95.9	0.002**
Poaching	LoPe	0	2.2	0	3.2 +	1.8	0	0	1.2	0.554
Illegal logging	LoPe	0	0	0	3.2 ++	0	0	0	0.6	0.174
Population growth	LoPe	11.9	22.2 +	11.5	14.5	5.4 -	2.4 -	30 ++	13.6	0.003**
Human and wildlife conflicts	LoPe	42.9 ++	33.3	34.6	17.7 -	21.4	26.2 -	12.5 -	26.5	0.015*
Illegal mining	LoPe	2.4	6.7 +	0	3.2	3.6	0	5	2.9	0.451

Note: LoPe=Local People, α = *** is significant at 0.1%, ** = significant at 1%, * = significant at 5%, NS = not significant. The proportion of households at village level was performed based on the Person's exact Chi-Square with significance at 0.1% (α = 0. 000). The signals plus (+) and minus (-) indicate a positive or negative relation between villages and responsibility of households with each practice threatening conservation. +|-; ++|- - and +++|---, significant at 5%, 1% and 0.1%, respectively.

Table 5.C.4. Respondents´ answers concerning the limitations of the current incentives under implementation and the effectiveness of the new incentives to engage local people with conservation in the NNR.

	Villages								
	Chamba N=42	**Macalange N=45**	**Matondovela N=52**	**Mbamba N=62**	**Mecula N=56**	**Mucoria N=42**	**Naulala N=40**	**Total N=339**	**Sig.**
Limitations of current incentives	**The proportion of respondents who pointed limitations**								
Lack of transparency in the job attribution	97.6	55.8	82.4	67.7	54.5	92.9	62.5	72.5	0.000***
	+++	--	+		--	++	-		
The hunting quotas allocated are insufficient	92.9	69.8	78.4	85	83.9	78	77.5	81.1	0.168
	+	-							
The money allocated is insufficient	83.3	66.7	60	67.2	78.8	85.7	77.5	73.6	0.038*
	+		-			+			
Lack of monitoring and accountability of revenues (20%)	71.4	61.9	53.1	67.2	57.1	83.3	57.5	64.3	0.052
			-			++			
In many cases, the detectors of the offenders are not awarded	88.1	68.3	76.5	61.7	71.7	70.7	81.6	73.3	0.083
	+			-					
Weak training and advice in how to use the incentives	54.8	54.8	44.9	75.8	69.4	80.5	67.5	64.3	0.002**
			--	+		+			
Poor monitoring and evaluation of the results from the projects implemented in NNR	61.9	67.4	54	75.8	70.9	81	67.5	68.6	0.106
			-			+			
The above compensations are not enough to motivate the community	71.4	77.8	58	74.2	78.6	66.7	72.5	71.5	0.282
			-						
Cluster of total limitations	73.8	43.2	42.6	66.7	64.4	77.5	60.5	(188)61.4	0.003**
	+	-	-			+			
Average number of limitations	6.21AB	5.27BC	5.02C	5.75ABC	5.8ABC	6.43A	5.66ABC	5.7288	0.002**
New incentives	**The proportion of households who agrees with the effectiveness of the new proposed incentives**								
Help local people to adopt conservation agriculture practices	100	100	100	98	100	100	100	100	0.612
Provide local people with alternative sources of animal proteins	100	100	100	98.4	96.4	100	100	99.1	0.325

	Villages								
	Chamba N=42	**Macalange N=45**	**Matondovela N=52**	**Mbamba N=62**	**Mecula N=56**	**Mucoria N=42**	**Naulala N=40**	**Total N=339**	**Sig.**
Help local people with practices to enhance the sustainable use of forest resources	100	100	100	96.8 -	100	100	100	99.4	0.335
Involve local people in the management and decision-making	100	100	100	93.5 --	98.2	100	97.5	98.2	0.082
Increased employment in conservation and recreation activities;	100	100	100	96.8 --	100	100	100	99.4	0.174
Provide education for local people (e.g. scholarships)	100	100	100	100 --	100	100	100	100	**a**
Improve services delivery for local people	100	100	100	100	100	100	100	100	**a**
Create areas for cultivation of high-yield commercial crops	100	100	98.1	98.4	98.2	100	100	99.1	0.804
Promoting certification of non-timber products	97.6	95.6	100	100	100	100	95	98.5	0.144
Increase in the percentage of revenues charged to distribute to communities	97.6	95.6 -	90.4	95.2	96.4	97.6	92.5 -	95	0.632
Attribution of collective conservation performance-based payments	97.6	95.6	96.2 -	90.3 -	98.2	100 +	92.5	95.6	0.220
Sum of all new incentives	10.93	10.87	10.85	10.68	10.88	10.98	10.78	10.84	0.11

Note: α = *** is significant at 0.1%, ** = significant at 1%, * = significant at 5%, NS = not significant. The proportion of households at village level was performed based on the Person's exact Chi-Square with significance at 0.1% (α = 0. 000). The signals plus (+) and minus (-) indicate a positive or negative relation between villages and different questions that households were requested to answer. +|-; ++|- - and +++|---, significant at 5%, 1% and 0.1%, respectively.

a = Test as not computed because only one group of people who agrees with the new incentives exists.

Appendix 5.C.5: Survey to the household in the Niassa National Reserve

1. General information

e) Name of the interviewer _____ Date: ____/_____/_____
f) Name of the village: _____ Lat _____ Log _____, Alt _____
g) For how long are you living in the reserve? I was born here ___; > 10 years____;
5 – 10 years ____; < 5 years _____
e) Have you ever lived out of the reserve before? Yes _____ No_____,
g) If yes, why did you decided move to the reserve? _____
_____
h) What kind of home do you live in? Cement____ Clay ____ Grass roof ____ Zinc roof___ Other___
If other, could you describe it, please?
_____
_____
_

2. Socio-economic information of the respondent

a) Name (not compulsory) _____,
Age_____
b) **Gender** Male☐ Female☐
c) Number of people in the household _____ Number of wives
_____
d) Number of workers in the household _____
e) Could you please fill the table below which is related to the general family spend for acquisition of some goods and services? (you should consider the most recent from the two last years).

Nº	Activities/Acquisition	Total spend (MZN*)	Year
a)	Rebuilding or construction of the house	_____	_____
b)	Rebuilding or construction of the storehouse	_____	_____
c)	Acquisition of transportation (motorbike/bike)	_____	_____
d)	Acquisition of radio	_____	_____
e)	Acquisition of TVs	_____	_____
f)	Acquisition of mobile phone	_____	_____
g)	Investing in a business (small shop)	_____	_____
h)	Opening of bank account	_____	_____
i)	Pay for agricultural labour and inputs	_____	_____
j)	Kids' education	_____	_____
l)	Electricity	_____	_____
m)	Home appliances	_____	_____
n)	Clothes	_____	_____

* Mozambican currency (new family metical)

3. Farming information

Below we provide the list of most common crops that households grow in the NNR For those that you have planted in the last season, could you please provide total amount harvested, consumption, losses for crop raiders, quantity sold and its respective price

Nº	Crop	Harvested (Kg)	Lost (Kg)	Consumption (Kg)	Sold (Kg)	Price (MZN)
a)	Maize	_____	_____	_____	_____	_____

b)	Peanut	_____	_____	_____	_____	_____
c)	Cassava	_____	_____	_____	_____	_____
d)	Rice	_____	_____	_____	_____	_____
e)	Cowpea	_____	_____	_____	_____	_____
f)	Pea	_____	_____	_____	_____	_____
g)	Sorghum	_____	_____	_____	_____	_____
h)	Millet	_____	_____	_____	_____	_____
i)	Sesame	_____	_____	_____	_____	_____
j)	Sweet potato	_____	_____	_____	_____	_____
l)	Vegetables*	_____	_____	_____	_____	_____
m)	Tobacco*	_____	_____	_____	_____	_____

Note: all products are measured in 20 litters plastic containers, except those that are in asterisk. the vegetable was measured in a big open plastic basket or sachets of 100 litter while tobacco is measures rolls of 2 Kgs. Prices a given for each unity of measurement which was converted for Kg/MZN.

a. Could you please rank the top four most important crop-raiding that have raided your farm and the most important crops each animal prefers?

4. Harvesting of non-timber products

Mark all products and materials that you harvest from the forest, rivers, soils, etc. The frequency of harvest, quantities the final purpose and its price if applicable.

Nº	Products	Frequency of harvesting	Propose	Quantities Kg/litres	Price (MZN)
a)	Medicines (roots, leaves, branches and fruits)	day __, week __, month__, semester__ year__	sell __, use __	_____	_____
b)	Grass	day __, week__, month__, semester __ year__	sell__, use __	_____	_____
c)	Stakes	day __, week __, month__, semester__ year__	sell __, use __	_____	_____
d)	Bamboos	day __, week __, month__, semester__ year__	sell __, use __	_____	_____
e)	Firewood	day __, week __, month__, semester__ year__	sell__, use __	_____	_____
f)	Ropes	day __, week __, month__, semester__ year__	sell __, use __	_____	_____
g)	Honey*	day__, week __, month__, semester__ year__	sell __, use __	_____	_____
h)	Fish#	day __, week __, month__, semester__ year_	sell__, use __	_____	_____
i)	Insects	day __, week __, month__, semester__ year__	sell __, use __	_____	_____
j)	Bush meat	day __, week__, month__, semester__ year__	sell __, use __	_____	_____
l)	Others	day __, week__, month__, semester__ year__	sell __, use __	_____	_____

*Honey was measured in litres

#Fish in plastics containers of 20 Kg.

5. Practices Interfering with Conservation in the Niassa National Reserve

a) Could you please tell if each of the existing problems threatens conservation in the NNR?

	Yes	No	I don't know
Slash-and-burn agriculture	□	O	O
Poaching (e.g. ivory, bones, skin etc.)	□	O	O
Illegal logging	□	O	O
Population growth in the Reserve with increased pressure to the resources	□	O	O
Human and wildlife conflicts	□	O	O
Illegal gold and ruby mining	□	O	O

b) Could you please indicate the main actor that is responsible for each threat described below? In your answer, consider direct (action) or indirect responsibility (omission)

	Do	Go	ReAd	NoRe	LoPe	PrSc	TrAu
Slash-and-burn agriculture	□	O	O	O	O	O	O
Poaching (e.g. ivory, bones, skin etc.	□	O	O	O	O	O	O
Illegal logging	□	O	O	O	O	O	O
Population growth in the Reserve with increased pressure to the resources	□	O	O	O	O	O	O
Human and wildlife conflicts	□	O	O	O	O	O	O
Illegal gold and ruby mining	□	O	O	O	O	O	O

Where: Do=Donors, ReAd=Reserve Administration, NoRe=Non-residents, LoPe=Local People, PrSc=Private,
Sector (PrSc) and TrAu=Traditional Authorities,

6. Effectiveness and limitations of the current incentives that are placed in the Niassa National Reserve

a) Could you please tell if each incentive that is currently under implementation in the Reserve are effective to engage local people with conservation-friendly practices in the Reserve.

	Yes	No	I don't Know
Jobs for the local population created under the conservation program, (e.g. Forest ranger position)	□	O	O
Hunting quotas that are allocated to local people	□	O	O
20% of concessions revenues that are delivered to the local people	□	O	O
Food allowances which are distributed to local people	□	O	O
Delivery of 50% of the revenue of the fines from these who detected the infraction in the Reserve	□	O	O
Promotion and respect of culture and beliefs of local communities by government authorities and other actors in conservation (e.g. sacred places)	□	O	O

b) Some limitations have been referenced due to the way that the compensation measures are being delivered to the local people. Do you agree or disagree?

	Agree	I don't know	Disagree
Lack of transparency in the criteria that have been used to allocate the jobs position	□	O	O
The hunting quotas allocated to local people are not enough	□	O	O
The money allocated to the communities is not enough	□	O	O
Lack of monitoring and accountability in the use of 20% of concession revenues	□	O	O
In many cases, the detectors of the offenders do not receive the award	□	O	O
Weak training and advice to communities in how to use the compensation	□	O	O
Poor monitoring and evaluation of the results from the projects implemented to the benefit of communities	□	O	O

The above compensations are not enough to motivate the community	□	O	O

7. New proposed compensation measures.

a) In your opinion, what will be the effectiveness of each of the measures described below to promoting the adoption of conservation-friendly practices by the household's heads

	Positive	**I don't know**	**Negative**
Create areas for cultivation of high-yield commercial crops (e.g. tobacco, corn, soybeans, cotton, etc.) to reduce pressure on land and obtain greater profits than others crop like cassava, maize etc.	O	O	O
Assist local people to the use environmentally friendly cultivation practices (e.g. minimum cultivation, crop rotation, green manuring etc.)	O	O	O
Assist local people to produce alternative sources of animal proteins (e.g. chickens, pigs, poultry etc.)	O	O	O
Promoting certification of non-timber products (e.g. honey, fruit, medicinal plants etc.) to get higher market prices and encourage sustainable use of natural resources]	O	O	O
Training the communities for sustainable use of forest resources (timber, non-timber and fishing resources)	O	O	O
Involve local people in the management and decision-making on issues related to the Reserve	O	O	O
Increase in the percentage of revenues charged to distribute to communities	O	O	O
Increased employment in conservation and recreation activities (e.g. tour guides, rangers, carpenters, hotels and restoration activities, etc.);	O	O	O
Attribution of collective conservation performance-based payments for local people	O	O	O
Provide education for local people (e.g. scholarships)	O	O	O
Improve services delivery for local people (e.g. health, education, roads etc.)	O	O	O

Chapter 6

General considerations and management implications

6.1. General conclusions

This research aimed to propose policies to improve the conservation status of NNR by investigating: i) the practices that threaten biodiversity conservation; ii) the drivers for local people involvement in such practices and, iii) possible incentives and compensations that can be used to promote conservation-friendly behaviors. The main objective was divided into three specific objectives, addressed in four chapters (chapter 2 to 5 of this thesis).

The first objective was to understand the role of local people in major threats to conservation and the underlying drivers for their involvement in conservation-threatening practices. This objective was addressed based on surveying of experts engaged in conservation in the NNR. The results showed high degree of agreement among experts as regards the practices that mostly threaten biodiversity conservation in the reserve: poaching, illegal logging and mining. Most of these practices are carried out by illegal outsiders, acting with support of local people. According to the experts, local people cooperate with outsiders who conduct illegal activities due to the following possible reasons: i) insufficient livelihoods, which are possibly related to weak compensation schemes and higher levels of crop-raiding and, ii) local people do not have the skills and minimum investment required to conduct such illegal activities, so they can only collaborate with outsiders that have those resources and lead the activities. The results also showed that most answers of the expert were related to the general narrative of PAs in DCs (e.g. insufficient livelihood and higher level of crop-raiding, can lead to retaliatory killing of raiding animal or cooperation with outsiders poachers), and that most of their views in relation to conservation-threatening practices with were also in accordance to

many existing studies conducted in PAs of DCs in general and some in Mozambique in particular.

In order to identify the available possible management options for local people (economic agents), in the reserve and the factors that drive their choices among different LFS, a household survey was applied in seven villages within the NNR. Based on the cluster results of 339 surveyed households, we have identified livelihood systems of gatherers, hunters, farmers and employees, and three specialized farming systems (FS) of maize, rice and sorghum, and one mixed FS. A Multinomial Logistic Model was used to investigate the drivers of Livelihood and Farming System choice, and it was possible to understand that Livelihood System choice were mainly driven by socio-economic factors (e.g. education of the household and the family size of the family), while Farming System choice were mostly driven by biophysical conditions (e.g. the availability of flat land for cultivation and average annual rainfall). People who had diversified farming and off-farming activities were better off and more resilient to meteorological events and crop-raiding animals and intensification was constrained by biophysical conditions, namely rainfall.

A more in-depth household survey was conducted with the same 399 households in the NNR to understand how perceived costs and benefits of living inside a PA at the village-level can lead people to participate in illegal-resource harvesting by using a spatially-based approach, that uses non-sensitive and indirect questioning of local residents about participation in illegal activities. The results showed that costs and benefits were unevenly distributed across villages, due to biophysical and socio-political factors, including the conservation dynamic in the reserve (e.g. the location of most conservation NGO´s, the size of population in villages within the

reserve and location of some villages closer to the PA borders). Most of the households who receive more conservation benefits were less likely involved in conservation-threatening practices. These households were located in villages with higher agriculture outputs (mixed farming system or farming system of sorghum), and more conservation-related employments (Mecula, Mbamba and Naulala). Households who were more likely involved in illegal activities were poor, less educated, and mostly located closer to the PA borders. These villages tend to perceive higher costs and lower benefits of living inside the NNR. Respondents were more likely to admit their participation in activities not considered as serious infraction by park authorities, such as shifting cultivation, to conduct to cope with their daily needs and which are.

6.2. Management implications for PAs of developing countries

Management decisions in most PAs of DCs are based on general information from other PA cases of success, often locked within specific spatial and temporal contexts, and localized network of conservation experts´ and PA managers. Thus, resulting in some mistakes that are replicated elsewhere in other PAs (Beale et al., 2013). Since carry out research that provides more detailed and accurate information for a specific PA is time and resource consuming. Such inconsistent decision often does not provide the desired results due to the peculiarities of each PA, that can only be captured through specific information obtained using a ground survey. This PAs diversity, includes the type of fauna and flora, culture difference and identities, hard or soft borders (Beale et al., 2013; Wegmann et al., 2014). Even in Mozambique, the existing networks of PA from south to north cover different ecosystems (e.g. Miombo and Mopane) (MICOA, 2014), where residents show distinct cultures and identities. Thus, accurate and consistent conservation policies and decisions require more context-specific field information.

As we have demonstrated, relying on expert advice, without crosscheck with ground information, can sometimes lead to management mistakes, since experts seem to draw their views based on the general narrative of conservation in DCs, as most of the PAs in developing countries appear to share the same problems by far. Even if we assume similar problems, digging deeper, the right solutions may not be necessarily the same. In the case of the NNR, we observed that both experts and local people appear to agree that outsiders are the main responsible for the major conservation-threatening practices, and local people may cooperate with them due to poverty and lack of livelihoods. The livelihood constraint can be addressed by improving and promoting the adoption of the existing environmental-friendly and more sustainable livelihood systems (of gatherer and employees), as well as the mixed and sorghum farming systems. At the same time, the reserve managers and all relevant actors need to monitor and set strategies to control the unsustainable growth rate of human-population, because no conservation policies can deal with the needs of the projected population of approximately 200, 000 living inside the NNR in 2050 under a growth ratio of "*business as usual scenario*". If the population continues to grow in an unsustainable way, poaching and illegal logging by outsiders may no longer be considered priority problems, because all lions and elephants may be extinct in the reserve (by the current decline ratio). Poaching and illegal logging will more likely replaced by shifting cultivation and harvesting of NTFPs as the top conservation-threatening practices, as the densely populated villages will struggle for land for agriculture and resources harvesting. In fact, there are studies showing that most of non-fenced PAs in Africa are challenged whit high population density which increase pressure on Ecosystem Services, imposing significant challenges for decision-makers and conservation managers (Wegmann et al., 2014).

Providing local residents with in-kind incentives such as the adoption of highly productive cash crops and environmentally friendly agriculture practices, conservation related employment, capacity-building to discover and secure business and other opportunities, and providing their kids with scholarships seems to have significant potential to improve conservation in the NNR. To accomplish this goal, considering that the reserve suffers for lack of financial resources, part of 20% of funding from concession taxes, already under implementation, could be allocated as in-kind payments. In addition to in-kind payments, the Reserve also needs to set consistent buffer zones to avoid human-wildlife-conflicts and work in closer collaboration with the local households to prevent crop and livestock incursions, because compensations for crop-raiding and livestock deprivation are not easy to implement and highly subject to fraudulent claims and purposeful induced conflict to claim compensation (Mackenzie and Ahabyona, 2012), especially when offsets are too high.

The research also shows that the conservation problem in the NNR is too complex and multifaceted, so no single compensation scheme can address all problems. As already noted by Travers et al. (2019), a broader, holistic and sustainable approach should be used instead. This includes the use of a policies mix including: education and empowerment of local people in conservation (improving community relationships); sustainable use of common pool resources, especially in the context of meteorological adversities; increasing law enforcement, especially closer to the park borders; consistent buffer zones and wildlife corridors implementation to reduce HWC; improving the quality of infrastructures and services in the reserve (e.g. good road quality and planning); and improving communication between conservation researchers and practitioners.

6.3. Limitations for the present study and recommendations for further research

The lack of basic socio-economic data related to PAs in Mozambique, especially in the NNR, was the great gap we used as an opportunity to conduct a relevant research that provided valuable information related to conservation in Mozambique and other PA in DCs. However, to carry out credible and high-quality research, one needs a starting point, which includes, at least, the availability of basic and indispensable data which will help to delineate the problem. In this specific study, most of required data were unavailable. So, we started by questioning experts to help framing our approach by understanding whether what we considered relevant problems were really relevant or not. We devoted one year of the Ph.D. project doing this exercise. This procedure was relevant and indispensable for the quality of the research. Although Mozambique has been putting a lot of effort to catch up with international standards of information collection and availability in the last years. This is not reflected in many important sectors. This is why we suggest that the Mozambican National Direction of Conservation Areas (DNAC) and the Niassa National Reserve need to put some effort to create a digital and accessible database where researchers and any other ordinary citizen can view and download basic information. This information should include: number and size of PAs in Mozambique, their location; data from the census of fauna and flora over annual or 5-years periods; human resident census; basic shapefiles to be used to develop GIS data bases; annual budget and allocation of compensation schemes for local communities, infrastructures including tourism operators and accommodations. This information is important to attract donors, investors, researchers and other relevant stakeholders. The Niassa Carnivore[10] project

[10] http://niassalion.org/

is an example in terms of data collection and accessibility which should be followed by other conservation agencies in Mozambique. And it is impressing to see how they devote efforts to improve their data collection process and reports over years.

As future research, we aim to select those compensations and commitments options that both experts and local people agreed as relevant to improve conservation in the reserve and conduct a choice-experiment (a stated preference technique to assess individual preferences), to come up with a more refined set of policies that can be easily implemented in the reserve, due to the resources constraints (time and money), this task, which was initially in our plans, will be postponed as our next priority for the upcoming research.

By using an indirect and non-sensitive approach to assess the likelihood of household participation in illegal activities and relating this with village-level variables, it was possible to find out that most people engaged in illegal activities were located in villages closer to the PA boarders (Chamba and Mucoria). The validation procedure of association between the recognition of shifting cultivation as a threat with the participation in the same activity, did somewhat not showed the desired results. This is because both methods are indirect. The easiest way to validate the results would be the use of a registration database of illegal activities in each village in the reserve. Unfortunately, so far as we are aware, the Reserve does not have this information and the improvement of this method in the future study is required. Another way for validation, would be the use of more in-depth interviews with reliable informants in each village where the survey was conducted, but this would be possible only in future research. It is also important to highlight that this methodology of assessing the likelihood of direct or indirect participation in illegal harvesting was not in the priorities of this research, and we only

found it relevant in the middle way of the research, and so its full validation still requires further research work.

6.4. References

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