KU LEUVEN

FACULTY OF BIOSCIENCE ENGINEERING

Payments for ecosystem services: an assessment of existing and possible reward mechanisms for ecosystem services in the Pendjari Biosphere Reserve, Benin

Betalingen voor ecosysteemdiensten: een evaluatie van beloningsmechanismen voor ecosysteemdiensten in het Pendjari Biosfeer Reservaat, Benin

Promotors:
Dr. Bruno Verbist
Department of Earth and Environmental Sciences
Division of Forest, Nature and Landscape

Prof. Liesbet Vranken
Department of Earth and Environmental Sciences
Division of Bioeconomics

Dissertation presented in
Fulfillment of the requirements
for the degree of Master of Bioscience Engineering:
Agro- and Ecosystems Engineering

Anton De Ryck

September 2018

KU LEUVEN

FACULTY OF BIOSCIENCE ENGINEERING

Payments for ecosystem services: an assessment of existing and possible reward mechanisms for ecosystem services in the Pendjari Biosphere Reserve, Benin

Betalingen voor ecosysteemdiensten: een evaluatie van beloningsmechanismen voor ecosysteemdiensten in het Pendjari Biosfeer Reservaat, Benin

Promotors:
Dr. Bruno Verbist
Department of Earth and Environmental Sciences
Division of Forest, Nature and Landscape

Prof. Liesbet Vranken
Department of Earth and Environmental Sciences
Division of Bioeconomics

Dissertation presented in
Fulfillment of the requirements
for the degree of Master of Bioscience Engineering:
Agro- and Ecosystems Engineering

Anton De Ryck

September 2018

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my promotor Bruno Verbist for his constant help, efforts and inputs through the entire process. I would like to thank my supervisor, Anne-Julie Rochette, for the support and guidance. Above all, helping me start the project in Benin is very appreciated. Thanks to my co-promotor Liesbet Vranken to keep me on track. I want to express my gratitude towards the professors of the Laboratory of Biomathematics and Forest Estimations (LABEF) from the University of Abomey-Calavi (UAC) for their hospitality and expertise during the fieldwork, especially towards Jean-Didier.

Helmut, thanks for accompanying me in the (far) north. Besides your hard work in the field, you made me become familiar with the 'true' Beninese culture. I wish Belgium had won the world cup, so I could prove you wrong. Thanks Thomas for guiding me through Pendjari with a big smile. Your work and efforts are amazing and should be more appreciated!

Lastly, I am grateful for all the support of my family and for giving me the opportunity to experience this. I thank my friends who provided distraction at appropriate times. Sam and Nele, I feel honored that I could show you – for the first time in your life – wild animals in the beautiful setting of Pendjari.

Anton De Ryck

ABSTRACT

Payments for ecosystem services (PES) have become a well-known concept in the field of nature conservation. The idea is to close the gap between the real value of ecosystem services (ES) to human well-being and the value reflected by conventional markets, which often neglect negative effects of economic activities on ecosystem services. PES projects mainly focus on the protection and restoration of natural resources, but at the same time often linked to poverty alleviation in developing countries. The study area of this thesis concerns the Pendjari biosphere reserve in northern Benin. The riparian population living along two roads bordering the reserve pose a (long-term) threat to the provisioning of several ES. This study checks whether PES schemes can already be identified here and which ES have potential to develop one in the future. First, the local context is sketched based on literature and interviews with local experts. The results are presented coherently using the DPSIR framework. In this way, a cause-effect chain is established for the study area. This is complemented by focus groups organized with local communities, which allowed us to identify the priority ES in the study area. In general, cultivated goods obtained by agriculture are considered the most important. The vast majority of the population also value domestic water and tourism more than other ES. In the next part of this thesis four ES are fully assessed: agriculture, water, tourism and carbon. If possible a rough estimate of the value of the ES is given. Thereafter, all aspects of a PES project concerning improved cooking stoves are evaluated. Our findings indicate, on the one hand, the impressive efficiency of the wood consumption and, on the other hand, the major shortcomings of the project which largely nullify the outcome. Finally, the potential of the four previously mentioned ES is discussed based on all available information. Above all, tourism and carbon seem to have the most potential. Some promising PES chains could be identified and the perspectives for the future look rather good. However, the two ES face great challenges. The long chain between buyers and providers causes problems and is a major disadvantage for carbon PES. Tourism is currently undergoing major changes by the replacement of the park management and the future is uncertain. Our findings suggest that PES schemes are less likely to develop in the field of water and agriculture. Little progress has been made and the PES chains are very local. Agriculture is, moreover, not very suitable for PES according to literature, since it is often an alternative for PES systems.

SAMENVATTING

Betalingen voor ecosysteemdiensten (PES) zijn uitgegroeid tot een geaccepteerd concept binnen het domein van natuurbehoud. Het idee is om de kloof te overbruggen tussen de werkelijke waarde van ecosysteemdiensten (ES) voor het menselijk welzijn en de waarde die de conventionele markten hier aan geven. Deze laatsten durven de negatieve effecten van economische activiteiten op ES wel eens te verwaarlozen. PES-projecten richten zich voornamelijk op bescherming en herstel van natuurlijke rijkdommen, maar zijn tegelijkertijd vaak gekoppeld aan armoedebestrijding in ontwikkelingslanden. Het studiegebied van deze masterproef betreft het biosfeerreservaat Pendjari in het noorden van Benin. De lokale bevolking die voornamelijk aan twee wegen aan de rand van het reservaat woont, vormt op de lange termijn een bedreiging voor het behoud vanverschillende ES. Deze studie gaat na of hier reeds PES-concepten terug te vinden zijn en welke ES er mogelijkheden bieden voor de toekomst. Eerst wordt de lokale context geschetst op basis van literatuur en interviews met experts. De resultaten worden coherent gepresenteerd met behulp van DPSIR. Op deze manier wordt een oorzaak-gevolg-keten opgesteld voor het studiegebied. Dit wordt aangevuld door focusgroepen met lokale gemeenschappen, waardoor de prioritaire ES geïdentificeerd konden worden. Geteelde landbouwproducten komen als belangrijkste naar voor. De overgrote meerderheid van de bevolking hecht duidelijk meer waarde aan watervoorziening en toerisme dan aan andere ES. Vervolgens worden vier ES volledig beoordeeld: landbouw, water, toerisme en koolstof. Waar mogelijk wordt een ruwe schatting van de waarde van de ES gegeven. Daarna worden alle aspecten van een PES-project rond verbeterde kookvuren geëvalueerd. De bevindingen wijzen enerzijds op een efficiëntere houtconsumptie maar anderzijds op de grote tekortkomingen van het project die de resultaten grotendeels teniet doen. Ten slotte wordt het potentieel van de vier eerder genoemde ES besproken op basis van de beschikbare informatie. Toerisme en koolstof lijken het meeste potentieel te hebben. Sommige veelbelovende PES kunnen worden geïdentificeerd en de perspectieven voor de toekomst zijn redelijk positief. De twee diensten staan echter voor grote uitdagingen. De lange keten tussen kopers en aanbieders veroorzaakt problemen en is een groot nadeel voor koolstof PES. Het toerisme ondergaat momenteel ingrijpende veranderingen door de vervanging van het parkbeheer. De toekomst blijft vooralsnog onzeker. Onze bevindingen suggereren dat PES minder waarschijnlijk is op het vlak van water en landbouw. Er is vooralsnog weinig vooruitgang geboekt. Bovendien is landbouw volgens de literatuur niet erg geschikt voor PES, omdat het veeleer een concurrerend alternatief kan zijn voor PES.

LIST OF ABBREVIATIONS

AP	African Parks
AVIGREF	Association Villageoise de Gestion des Réserves de Faune
Belspo	Belgian Science Policy
CARDER	Centres d'action régionale pour le développement rural
CENAGREF	Centre National de Gestion des Réserves de Faune
CPL	chasseurs professionnels locaux
DEHWA	Department of Environment, water, Heritage and Arts
DFRN	Direction des Forêts et des Ressources Naturelles
DPSIR	Drivers, Pressures, State, Impacts, Responses
DWAF	Department of Water Affairs and Forestry
ES	Ecosystem service
EVAMAB	Economic valuation of ecosystem services in Man and Biosphere reserves
FONAFIFO	Fondo Nacional de Financimiento forestal
GEF	Global Environmental Facility
LABEF	Laboratory of Biomathematics and Forest Estimations
LULC	Land Use Land Cover
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organization
NWFP	Non-Wood Forests Products
PA-BAT	Protected Area Benefit Assessment Tool
PAGAP	Projet d'Appui à la Gestion des Aires Protégées
PBR	Pendjari Biosphere Reserve
PES	Payments for Ecosystem Services
PNP	Parc National Pendjari
ProFAEB	Promotion des Foyers Améliorés Erythréens au Bénin
PROWAD	Promotion des foyers Wanrou dans la région de l'Atacora et Donga
PSA	Pago por Servicios Ambientales
RES	Rewards for Ecosystem Services
RUPES	Rewarding Upland Poor for Environmental Services
TESSA	Toolkit for Ecosystem Services Site-based Assessment
UAC	University of Abomey-Calavi
UNESCO	United Nations Educational, Scientific and Cultural Organization
WAP	W-Arly-Pendjari
WfW	Working for Water
WHO	World Health Organization
ZOC	Zone d'Occupation Contrôlée

LIST OF FIGURES

Fig. 1: The basic concept of payments for ecosystem services 4
Fig. 2: The Pendjari biosphere reserve and its adjacent villages 12
Fig. 3: Zones in the Pendjari biosphere reserve 15
Fig. 4: Pendjari river basin 20
Fig. 5: The establishment of the cause-effect chain using the DPSIR framework 42
Fig. 6: Mean and median of the value of importance for the 10 focus groups 44
Fig. 7: Value of importance of domestic water, tourism and wood for the 10 focus groups 45
Fig. 8: Values of importance for agriculture, livestock and hunting for the 10 focus groups 46
Fig. 9: Value of importance for fishing, beekeeping, medicinal plants and non-wood forest products for the 10 focus groups 48
Fig. 10: Results focus groups Tanongou. 49
Fig. 11: Results of 4 focus groups with the 'local communities' in different villages. 50
Fig. 12: Normalized Difference Vegetation Index (NDVI) image of the Pendjari Biosphere Reserve 51
Fig. 13: Yields of different crops per hectare 57
Fig. 14: Yields of different crops per household 58
Fig. 15: Profit of different crops per household 58
Fig. 16: Profit of different crops per hectare 59
Fig. 17: The Wanrou project as PES scheme 60
Fig. 18: Comparison wood consumption of different types of stoves 62
Fig. 19: Comparison cooking time between improved and traditional stove 63
Fig. 20: Examples of cardboard signs used during the focus group discussions. 88
Fig. 21: Ecosystem services cited during the focus groups discussions. 93
Fig. 22: Normalized Difference Vegetation Index (NDVI) image of the Pendjari Biosphere Reserve 100
Fig. 23: Distribution of land classes in the Pendjari biosphere reserve 100
Fig. 24 : Field size of different crops in the ZOC 104
Fig. 25: Subsistence farming around the Pendjari biosphere reserve 104
Fig. 26: Comparison amount of wood collected between improved and traditional stove. 106
Fig. 27: Comparison values wood consumption between participants of the project and others 106
Fig. 28: Comparison of the amount of wood collected between participants and non-participants of the project. 107
Fig. 29: Time spent on wood collection in the dry season 107

LIST OF TABLES

Table 1: Ecosystem services (Millenium Ecosystem Assessment, 2005, p. 28) 2
Table 2: Annual number of visits Pendjari Biosphere Reserve (2013-2017) 53
Table 3: Estimation total touristic expenses in and around the Pendjari Biosphere Reserve. . 54
Table 4: Cultivated area for the five most important crops in Tanguiéta (annex 3.5). 55
Table 5: Field size, yield, subsistence and profits of different crops 56
Table 6: List of actors interviewed during the fieldwork 87
Table 7: Focus groups 87
Table 8: Interviews conducted regarding cultivated goods 88
Table 9: Interviews Foyer Wanrou 88
Table 10: Mean, median and standard deviation of importance value 93
Table 11: Lesson learnt agriculture 94
Table 12: Lesson learnt water 95
Table 13: Lessons learnt eco-tourism 96
Table 14: Lessons learnt hunting 96
Table 15: Lessons learnt beekeeping 97
Table 16: Lessons learnt fishing 98
Table 17: Results water use 101
Table 18: Lessons learnt organic cotton 105
Table 19: Lessons learnt conventional cotton 105
Table 20: Advantages improved stoves Eco-Benin according to the users 108
Table 21: Evaluation of the relationship between Eco-Benin and the users 108
Table 22: Results conditionality of the project. 108
Table 23: The reasons people not use an improved stove 109
Table 24: Lessons learnt group discussion Tiele 109
Table 25: Some passages from the interviews with ‘formatrices’ of Eco-Benin 110

TABLE OF CONTENTS

ACKNOWLEDGEMENTS .....
ABSTRACT .....
SAMENVATTING .....
LIST OF ABBREVIATIONS .....
LIST OF FIGURES .....
LIST OF TABLES .....
1. INTRODUCTION 1
1.1. Ecosystem services 1
1.2. Payments for ecosystem services 2
1.2.1. Basic approach 3
1.2.2. Current approach 6
1.2.3. Main domains 6
1.2.4. Examples 7
2. CONTEXT, AIMS AND STRUCTURE 10
3. METHODOLOGY 12
3.1. Study area: the Pendjari biosphere reserve 12
3.1.1. General context 13
3.1.2. Ecosystem services 18
3.1.3. Main threats and challenges 23
3.2. Rapid assessment tools 26
3.2.1. The Toolkit for Ecosystem Service Site-based Assessment 27
3.2.2. The Protected Area Benefit Assessment Tool 28
3.3. Identification of priority ecosystem services 29
3.3.1. Interviews with local experts 29
3.3.2. Focus groups 30
3.4. Full assessment of priority ecosystem services 31
3.4.1. Carbon sequestration and storage 31
3.4.2. Water 32
3.4.3. Tourism 32
3.4.4. Agriculture 32
3.5. Evaluation of payments for ecosystem services schemes 33
3.5.1. Carbon sequestration and storage 33
4. RESULTS 36

4.1. 4.1. Identification of priority ecosystem services 36
4.1.1. Interviews with local experts 36
4.1.2. Focus groups 43
4.2. Full assessment of priority ecosystem services 51
4.2.1. Carbon sequestration and storage 51
4.2.2. Water 52
4.2.3. Tourism 52
4.2.4. Agriculture 55
4.3. Evaluation of payments for ecosystem services schemes 60
4.3.1. General scheme 60
4.3.2. Strengths 61
4.3.3. Weaknesses 63
4.3.4. Perspectives 67
5. DISCUSSION 68
5.1. Carbon sequestration and storage 68
5.1.1. Improved cooking stoves 68
5.1.2. Reforestation and carbon credits 69
5.2. Water 70
5.3. Tourism 71
5.3.1. Tourism under CENAGREF 71
5.3.2. Tourism under African Parks 74
5.4. Agriculture 75
5.4.1. Organic agriculture 75
5.4.2. Land tenure 78
6. CONCLUSION 79
REFERENCES 81
Annexes 86
Annex 1. Methodology 86
Annex 1.1. Temperature and precipitation Natitingou (Tiomoko, 2014) 86
Annex 1.2. List of local experts 87
Annex 1.3. Basic information focus groups 87
Annex 1.4. Cardboard signs focus groups 88
Annex 1.5. Basic information full assessment agriculture 88
Annex 1.6. Basic information improved cooking stoves 88

Annex 1.7. Surveys Full Assessment 89
Annex 1.8. Survey Improved cooking stoves 92
Annex 2. Focus groups 93
Annex 2.1. Cited ecosystem services during the focus groups 93
Annex 2.2. Mean, median and standard deviation of importance value focus groups 93
Annex 2.3. Lessons learnt concerning agriculture, water, tourism, hunting, beekeeping and fishing during focus groups 94
Annex 3. Full Assessment 99
Annex 3.1. Aboveground biomass densities (Mg. ha^{-1}) and total biomass stocks (Mg) for different land classes 99
Annex 3.2. NDVI image Pendjari biosphere reserve 100
Annex 3.3. Land classes Pendjari biosphere reserve 100
Annex 3.4. Lesson learnt full assessment concerning water 101
Annex 3.5. Interview CARDER 102
Annex 3.6. Field sizes different crops in the ZOC. 104
Annex 3.7. Subsistence farming around the Pendjari biosphere reserve 104
Annex 3.8. Lessons learnt concerning organic cotton 105
Annex 4. Improved cooking stoves 106
Annex 4.1. Results Wanrou figures 106
Annex 4.2. Results surveys Wanrou tables 108
Annex 4.3. Lesson learnt Operational plan. 111
Annex 5. Images 113
Annex 5.1. Improved cooking stoves 113
Annex 5.2. Image Focus groups 114

1. INTRODUCTION

1.1. Ecosystem services

Ecosystem services have taken a prominent place within the research domain of the environmental sciences over the past decade (Fisher et al., 2009). The concept was first introduced in the Millennium Ecosystem Assessment in 2005 by the United Nations, although the phenomenon itself already exist as long as mankind (Millenium Ecosystem Assessment, 2005). The remarkable increase in the recent interest can be easily explained. Humanity now puts such a pressure on several natural resources, which until recently were taken for granted, that its provision is jeopardized (Veeneklaas, 2012). One realizes that nature delivers these valuable services free of charge and that this might stop in the near future (Veeneklaas, 2012).

First and foremost, it may be useful to define what ecosystem services exactly are. It is generally known that ecosystems provide a large amount of goods and services. Many common products like food, fuel wood and medicinal products are obtained from nature. But ecosystems provide also less obvious – but at the same time very valuable - services like purification of water, stabilization of climate through carbon sequestration and mitigation of floods and droughts. These services are more difficult to understand and distinguish, but not less important. However, literature does not provide a clear definition and, therefore, a few definitions are commonly cited. Costanza et al. (1998) described ecosystem services as all kinds of benefits humans obtain, directly or indirectly, from ecosystem functions. At their turn, an ecosystem function refers to the habitat, biological property or process of a particular ecosystem (Costanza et al., 1998).

In order to be able to understand and assess ecosystem services properly, it seems appropriate to go deeper into certain underlying concepts. The Australian Department of Environment, Water, Heritage and the Arts (2009) states that an ecosystem can be seen as a functional unit consisting of interacting populations of plants, animals, microorganisms and the non-living environment and is strongly influenced by environmental factors, such as soil type, climate and water availability which determine the presence and distribution. Sunlight, soil, nutrients and water are considered as inputs for the system, while biomass is an important output (DEWHA, 2009).According to the DEWHA (2009), biodiversity has a fundamental role in the provision of ecosystem services. It is not only the direct source of many services, such as food and fiber production, but it is also an essential factor in the provisioning of clean water and air (DEWHA, 2009). “Changes in and the loss of biodiversity directly influences the

capacity of an ecosystem to produce and supply essential services, and can affect the long term ability of ecological, economic and social systems to adapt and respond to global pressures."(DEWHA, 2009, p. 4).

Historically, because a wide range of ecosystem services exists, a clear classification system is needed. The Millennium Assessment's classification system is one of the most widely used and divides the ecosystem services in the following four categories: supporting, regulating, provisioning and cultural services (Millenium Ecosystem Assessment, 2005).Table 1 gives a brief overview of possible ecosystem services subdivided per category (Millenium Ecosystem Assessment, 2005, p. 28).

Table 1: Ecosystem services (Millenium Ecosystem Assessment, 2005, p. 28)

Provisioning	Regulating	Supporting	Cultural
Food, fibre, fuel	Pollination	Nutrient cycling	Education
Biochemical's	Climate regulation	Water cycling	Recreation
Fresh water	Disease regulation	Provision of habitat	Aesthetic values
Genetic resources	Erosion control	Soil formation	Spiritual values
	Water purification	Primary production	

The provisioning of ecosystem services largely depends on the landowners who manage their property. Recently, land uses that provide valuable services, such as forests, decrease rapidly (Pagiola, et al, 2005).An essential reason for this loss is that land users have little incentive to continue providing these services, because they normally do not receive any compensation for the environmental services they generate for others (Pagiola et al., 2005). To counter this, Payments for Ecosystem Services (PES) were introduced.

1.2. Payments for ecosystem services

Ecosystem services – and especially more complex services such as carbon sequestration – are difficult to evaluate and the real value of these services are rarely shown correctly in market economies (Leimona et al., 2015). Moreover, conventional markets rarely include or even neglect negative consequences of economic activities on ecosystem services (Leimona et al., 2015). Therefore, interest has grown in market-based instruments, such as Payments for Ecosystem Services (PES) schemes, to compensate at least a part of the true value of these services through the monetization of ecosystem services (Gómez-Baggethun et al., 2010; Leimona et al., 2015).

1.2.1. Basic approach

The principles of Payments for Ecosystem Services are simple: the ecosystem service providers should be rewarded by the ecosystem service users (Pagiola et al., 2005). The benefits land users obtain from environmentally-conducive activities, such as forest conservation, are often less than the benefits they would receive from alternative land uses (Pagiola et al., 2005). Conversion into another land use (e.g. agricultural land) seems to be the best option for the individual landowner. However, e.g. deforestation can have negative consequences on downstream populations, who receive less or no benefits of certain ecological services (Pagiola et al., 2005). A payment – which has to be more than the additional benefits of the alternative land use – by the beneficiaries can convince landowners to conserve the forest (Pagiola et al., 2005). At the same time, it must be less than the value of the benefit to the downstream population, otherwise they would not be willing to pay for it(Pagiola et al., 2005). An additional advantage of this system is that it supports poor land users in an effort to improve their livelihoods (Pagiola et al., 2005). The concept is presented graphically in Fig.1. Conversion to pasture seems to be more beneficial for the landowner than forest conservation, but this causes at the same time a reduction in water provisioning, a loss of biodiversity and an increase of carbon emissions, which can be seen as a cost to downstream populations. Therefore, a payment, which it makes it more beneficial than conversion (more than minimum payment), could convince the service provider to conserve the forest. However, the payment will logically be lower than the maximum payment, which equals the costs to the downstream population.

PES mechanisms are used to translate non-market values of nature into real economic incentives, emphasizing the economic efficiency advantages of sheer market transactions, well-defined property rights and absence of intermediaries(Gómez-Baggethun et al., 2010).

1.2.1.1.Definition

Because the concept of Payments for Ecosystem Services is quite extensive and the term may be used for any kind of market-based mechanism for conservation, it may be useful to define a clear definition in order to distinguish it from other mechanisms such as eco-certification or entrance fees for tourists (Gómez-Baggethun et al., 2010). Wunder (2005, p3) proposed a definition to describe the PES concept: ”a *voluntary* transaction where a *well-defined* ES (or a land-use likely to secure that service)is being ‘bought’ by a (minimum one) ES *buyer* from a

(minimum one) ES *provider* if and only if the ES provider secures ES provision (*conditionality*)."

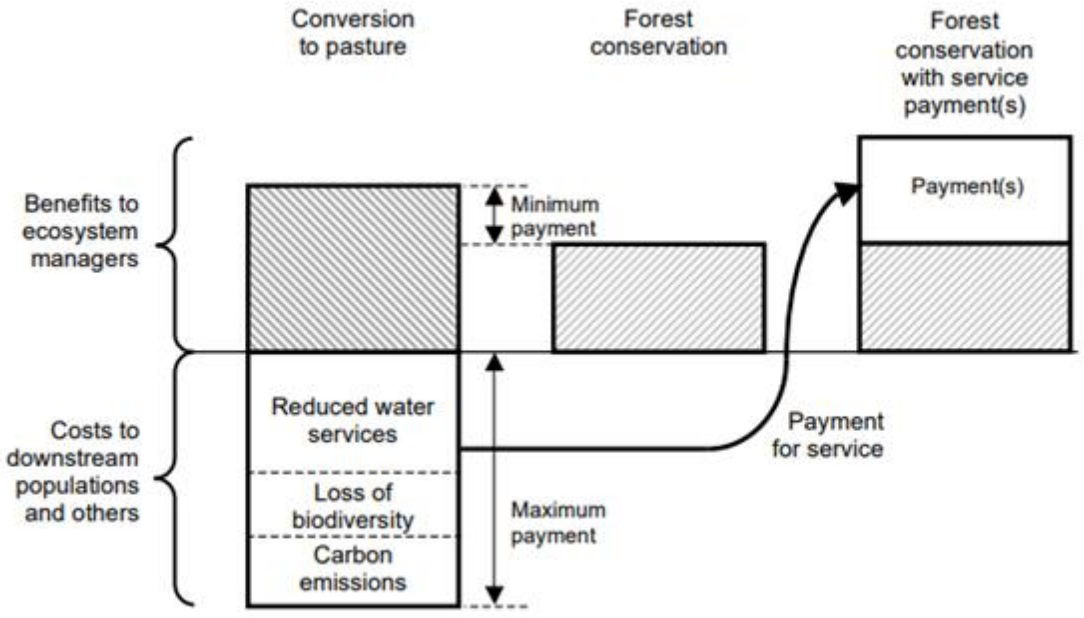

Fig. 1: The basic concept of payments for ecosystem services
(Engel et al., 2008).

1.2.1.2.Who are the service users?

In PES programs two different types of users or buyers occur: buyers who actually use the ES or buyers who act on behalf of the users such as the government, NGO's or international agencies (Engel et al., 2008). The 'user-financed' PES scheme – buyers are the actual users – would be most efficient, since the actors are directly involved, can observe directly whether the service is delivered and have a clear incentive to make the system work (Pagiola & Platais, 2007; cited by Engel et al., 2008). In 'government-financed' PES programs are the buyers governmental or international institutions or organizations which do not directly use the ES (Engel et al., 2008). Pagiola & Platais (2007) argue that these systems may be less efficient, but would be more cost-effective than user-financed PES because of the reduced transaction costs (Engel et al., 2008).However, the distinction between these two options is not always clear. Which type of actor occurs in a PES project depends on the particular situation, sometimes user-financed programs are more suitable to emerge, while in other cases the only option is a 'government-financed' PES system(Engel et al., 2008). Engel et al. (2008, p7) further describes the user-financed PES system as follows: " if PES benefits a small number of actors, incentives to free ride and transaction costs of coordinating a joint PES

program are relatively low. User-financed PES is also likely to emerge […] if users have a sufficiently large share of total ES benefits that it would be unrealistic for them to expect to free-ride on the efforts of others." So, there is no such thing as an ideal number or type of buyer(s), but this largely depends on the local circumstances of the specific PES scheme.

1.2.1.3.Who are the service providers?

The actors who are able to safeguard the provisioning of a particular ecosystem service are the potential providers or sellers and they are typically private landholders, although it should be noted that governments can also be landholders(Engel et al., 2008). PES projects tend to choose for the low-costs providers, who on their turn do not accept a compensation lower than the cost of providing the ES (Engel et al., 2008).Providers receive these payments in exchange for conditionality of the provisioning, in other words, that they comply with their contracts (Engel et al., 2008).

1.2.1.4.What are the obstacles?

A critical factor in the decision of a landowner to participate in a PES project is the expectation that the program will be profitable and – as mentioned above – at least receiving more benefits than an alternative land use (Pagiola et al., 2005). Payments are more likely to go to – often poor – owners of low-productivity land, as opportunity costs are lower (Pagiola et al., 2005). However, according to Pagiola et al. (2005), the reverse can also be true and, therefore, care must be taken with a generalization. Only the will of a particular landowner to participate in a PES program is not enough to make the project succeed (Pagiola et al., 2005). The study shows that tenure issues, investment costs and technical obstacles may cause that households are not able to participate. If tenure is insecure – especially the case for long-term investments - , the installation of a PES program is often not possible, because PES payments target particular land uses (Pagiola et al., 2005). Pagiola et al. (2005) argue that adopting a particular land use – which a participation in a PES program implies – sometimes requires costs and forces the land users to undertake investments, such as reforestation. If – often poor – participants cannot afford these additional investment costs, landowners may be unable to adopt it (Pagiola et al., 2005). In some cases, land users need substantial technical knowledge in order to make a PES project work, which is often lacking due to a limited access to education and technical assistance (Pagiola et al., 2005). Implication of numerous, dispersed households in a particular PES project is usually associated with high transaction costs and

these costs form an extra obstacle for the poor participants (Pagiola et al., 2005). The authors state that this transaction cost consist of costs to the PES program itself regarding contracting each participant and costs for the participants themselves. These costs are mostly per contract (rather than per unit area) and, therefore, PES program often opt to contract larger farms, which reduces the total transaction costs (Pagiola et al., 2005).

1.2.2. Current approach

Other approaches to PES have developed over time. As described in the paragraphs above, PES schemes were initially only considered as market-based policy instruments to conserve nature in the most efficient way (Engel et al., 2008; Leimona et al., 2015; Pagiola et al., 2005). In their opinion, efficiency means producing the greatest social value for the least cost (Leimona et al., 2015). "The idea is that ideal PES schemes should integrate ecosystem services into markets, and should be like any other market transaction."(Farley & Costanza, 2010, p4).Recent literature, however, is convinced that the pure market approach is not enough to implement a PES scheme in practice (Muradian et al., 2013). The current approach of effectiveness and fairness differs from that of authors in the past. Leimona et al. (2015, p17) puts it as: " […] efficiency refers to ES additionally gained by clearly linking land-use practices contracted under a PES scheme and ES provisions and the cost effectiveness of the scheme. Fairness refers to pro-poor aspects of PES, where marginalized actors of the potential scheme, be they men or women, have non-biased (or preferential) opportunities in participating, planning, designing, implementing and monitoring the scheme, and getting benefits from it." A broader concept is introduced: Rewards for Ecosystem Services (RES), which not only focuses on financial transactions between actors but also includes in-kind rewards, such as access to land and markets, capacity building and the recognition of identity and rights (van Noordwijk et al., 2004).

1.2.3. Main domains

In terms of PES projects, four different types of ecosystem services are characterized as promising (Wunder, 2005, p2):

1. *Carbon sequestration and storage* (e.g. Northern electricity company paying farmers in the tropics for planting and maintaining trees)
2. *Biodiversity protection*(e.g. conservation donors paying local people for setting aside or naturally restoring areas to create a biological corridor)

3. *Watershed protection* (e.g. downstream water users paying upstream farmers for adopting land uses that limit deforestation, soil erosion, flooding risks, etc.)
4. *Landscape beauty* (e.g. a tourism operator paying a local community not to hunt in a forest being used for tourists' wildlife viewing)

Although some PES programs focus on biodiversity conservation, carbon sequestration and recreational activities, PES initiatives are commonly related to water services (Pagiola et al., 2005). Turpie et al. (2008) suggest project planners to primarily focus on the most valuable services such as water provisioning. This service can be used as an 'umbrella service' and, by restoring or conserving it, other ecosystem services revive as well and a variety of conservation goals can be achieved (Turpie et al., 2008).

1.2.4. Examples

The concept of Payment for ecosystem services may be promising in all its simplicity, but the reality in the field does look different. According to the organization for economic co-operation and development(2010), some pre-requisites are of great importance to ensure environmentally effective PES programs. To make a project succeed, it is essential that the goals and objectives of the project are unambiguous and property rights are clearly defined and enforced (OECD, 2010). Moreover, a well-functioning monitoring and reporting framework, which makes an assessment of the PES program possible, is needed and should be done on multiple levels (OECD, 2010). Baselines should be established to project a business-as-usual scenario in order to make correct payments (only for additional ES) and leakage, which occurs when an increase of an ES causes the decrease of the ES in another region, should be addressed (OECD, 2010). In this section, a few case studies of PES programs will be briefly discussed.

2.2.4.1 PSA Costa Rica

One of the pioneers of payments for ecosystem services in developing countries is the *Pago por Servicios Ambientales* (PSA)program in Costa Rica, which includes mechanisms to charge users of environmental services and compensate providers of these services(OECD, 2010). The program started in 1997 and compensated more than 4400 farmers and forest owners for reforestation, conservation and sustainable forest management (Pagiola, 2008). However, long before this date, a system of payments for reforestation and forest management was already in use in Costa Rica (Zbinden & Lee, 2005). Since the beginning of the project, two major changes were implemented: change of justification for payments (from support for

the timber industry to the provision of environmental services) and change of the source of financing (from government to taxes and payments from beneficiaries) (Pagiola, 2008). The *Fondo Nacional de Financiamiento Forestal* (FONAFIFO), an agency with independent status, manages the PSA Program (Pagiola, 2008).

Initially it was intended that ecosystem service users would finance the program, but this objective was only partially realized over time (Pagiola, 2008). The program recognized and targeted four ecosystem services provided by natural forests: water services, carbon sequestration, biodiversity conservation and ecotourism (Pagiola, 2008). FONAFIFO negotiated with hydroelectric power producers and other water users in the region to pay for the water services they receive and some agreements were reached (Pagiola, 2008). Service beneficiaries typically compensate upstream landowners to maintain the forest ecosystem and, by consequence, water provisioning in lower areas (Pagiola, 2008). The exact payment depend on the local opportunity cost of the service and differed both over time and location (Pagiola, 2008). Moreover, the PSA program is among others financed by the revenues of a fossil fuel tax, a loan from the World Bank and a grant from the Global Environment Facility (GEF) (Pagiola, 2008). The fossil fuel tax can be considered as a compensation from the carbon users for carbon sequestration and the GEF grant covers the financing part of the biodiversity conservation (Pagiola, 2008). Although significant progress was already made, until today only a part of the PSA program is paid by the services beneficiaries (Pagiola, 2008).

Although the Costa Rican's PSA program is one of the most successful PES schemes in a developing country over the last decades, the program still has its shortcomings and lessons can be drawn for future projects (Pagiola, 2008). Initially poor targeting characterized the program and undifferentiated payments were often used, but these problems were gradually addressed over time (Pagiola, 2008). However, lack of monitoring data to measure the impact of the activities on ecosystem services is another major weakness of the PSA program (Pagiola, 2008).

2.2.4.2.Sumber Jaya, Indonesia

About half of the Sumber Jaya region (Indonesia) consists of protected forests (40%) and national parks (10%), but only 10% of this area is forested (Pagiola, 2008). In the neighborhood of these forests, a hydropower company has established and provides electricity to the region, but water deficit and sedimentation due to activities in upstream regions cause

problems for the company (Fauzi & Anna, 2013). With the support of the Rewarding Upland Poor for Environmental Services (RUPES) program in 2004, the private company provided incentives for the local population to conserve the protected forests in the region (Fauzi & Anna, 2013). In this way, both water flow to the dam and the sustainable livelihood of the local population is ensured (Fauzi & Anna, 2013). The amount of payment made is based on the turbidity reduction which is a consequence of the conservation actions, but also non-monetary compensations are included in the PES scheme (Fauzi & Anna, 2013). On the one hand, funds are provided to plant trees and create a coffee agro-forestry system which is beneficial for the local community(Fauzi & Anna, 2013). Moreover, the purchase of goats is stimulated in the hope that goats will increase tree or grass planting (this would reduce soil erosion and, thus, sedimentation) (Fauzi & Anna, 2013). On the other hand, incentives are given by government agencies in the form of tenure rights which provides a legal basis to use the land for economic and conservation purposes (Fauzi & Anna, 2013).

2.2.4.3.South Africa

Grassland catchment areas in South-Africa catch and slowly release summer rainfall which ensures the water provisioning in the dry season (Fauzi & Anna, 2013). However, not only management practices like overgrazing and burning regimes threaten this services, but the grassland is also often replaced with alien plant species such as *Pinus* and *Eucalyptus*(Turpie et al., 2008).Large parts of the country were invaded by these alien species (approximately 10 million hectares) and water runoff and base flows are affected (Turpie et al., 2008). The Working for Water program (WfW), established in 1995, addresses these threats by clearing mountainous and riparian zones of invasive plants to restore the ecosystem(Turpie et al., 2008). First and foremost, one focuses on the water provisioning service, but this will influence other services as well(Turpie et al., 2008). Poverty relief programs and the Department of Water Affairs and Forestry (DWAF) mainly finance the project(Turpie et al., 2008). The DWAF charges water consumers based on the WFW's cost estimates of the restoration actions, although this is not fully operational yet(Turpie et al., 2008). Moreover, WfW reached some payment agreements with a couple of municipalities to overcome water shortage in the area(Turpie et al., 2008).

2. CONTEXT, AIMS AND STRUCTURE

This research was conducted in the framework of the EVAMAB project, which addresses the evaluation of the economic value of ecosystem services in UNESCO-MAB sites from a regional perspective. The Pendjari biosphere reserve is one of the study sites, besides sites in Tanzania, Uganda and Ethiopia. In total, the EVAMAB project lasts 30 months (2017-2019) and is financed by Belspo and UNESCO (European Communities, 2018).The fieldwork was organized in partnership with the Laboratory of Biomathematics and Forest Estimations (LABEF) from the University of Abomey-Calavi (UAC).

The main objective of this master thesis was to evaluate existing and possible Payments for Ecosystem Services (PES) schemes of four different ecosystem services in and around the Pendjari biosphere reserve, Benin. Or, in other words, to assess both the recent developments within these ecosystem services and the potential for the implementation of new PES schemes in the future. The following four ecosystem services were thoroughly examined: carbon sequestration and storage, water, tourism and agriculture. As explained in the introduction, four ecosystem services are characterized as promising in terms of PES. In this study, however, biodiversity was left out and replaced by agriculture. Agriculture turned out to be – by far – the most important ES for the local population in the exploratory stage and was, therefore, included (see below). The PES concept was, however, widely interpreted in this master thesis. Not only monetary rewards were looked at, like the term suggests, but non-monetary rewards were included as well. The study area was assessed based on this broader term, also referred to as Rewards for ecosystem services (RES) as mentioned in section 1.2.2.

To realize our main objective, the master thesis was divided into three major consecutive phases:

1. the identification of the priority ecosystem services (or the exploratory stage)
2. the full assessment of the priority ecosystem services
3. the evaluation of existing PES projects

This was a step-by-step process starting from a broad view to end up more detailed. It was intended that this would enable us to draw meaningful conclusions regarding the four ecosystem services.

The identification of the priority ecosystem services (phase 1) served to explore the study area to be able to sketch the local context properly, mainly focusing on ecosystem services. Thus,

the aim was to gain insight in the local perceptions concerning ecosystem services The objectives for the first phase were:

- Establishment of a cause-effect chain using the DPSIR framework
- Identify the priority ecosystem services using rapid assessment tools
- Expose differences between groups living around the Pendjari biosphere reserve

Section 3.1 summarizes basic information available in literature. It was intended that the qualitative information from the interviews with local experts during the fieldwork both complements this and provides more detailed information and insights. The results are presented in a clear and understandable way in section 4.1.1. A cause-effect chain of the study area was established using the DPSIR framework. The results were also used as a solid basis for further stages of the research project.

Furthermore, the focus groups with inhabitants of the study area investigated the impressions at the lowest level, using two rapid assessment tools as a guide. These tools were selected in advance and tested in the field. Participants ranked ecosystem services according to importance and major threats and challenges were addressed (section 4.1.2).

The objective of the full assessment of the priority ecosystem services (phase 2) was to fully assess the four main ecosystem services. Hereby, attention was paid to the economic value of a service and – if possible – an estimate was made. Results are presented in section 4.2. This phase is essential because understanding the value of an ecosystem service is crucial to develop – in a later stadium – a PES project, which can contribute in safeguarding the service using reward mechanisms. The ecosystem services provided by the biosphere reserve are of both global, national and local value. A proper valuation may lead to greater interest, more investments and better preservation of the biosphere reserve.

In the last part, the objective was to expose both the strengths and weaknesses of a selected PES project to draw useful conclusions for the future. During the fieldwork, a project of Eco-Benin concerning improved cooking stoves was selected. Both interviews with Eco-Benin and a survey in the field were carried out in order to examine all aspects of the project. The project is evaluated in section 4.3.

In the discussion (chapter 5) all this information was put together to assess the four selected ecosystem services. The progress already made within the ES and the potential are discussed in detail. In this way, the main aim of this master thesis was realized. Chapter 6 concludes the most important findings.

3. METHODOLOGY

3.1. Study area: the Pendjari biosphere reserve

The Pendjari biosphere reserve is located in the *Atacora* department in northwest Benin (Fig.2) (Turpie et al., 2008). It is part of the W-Arly-Pendjari (WAP) complex, which is a concatenation of protected areas shared between the Republic of Niger, Burkina Faso and the Republic of Benin (UNESCO/WHC, 2018)

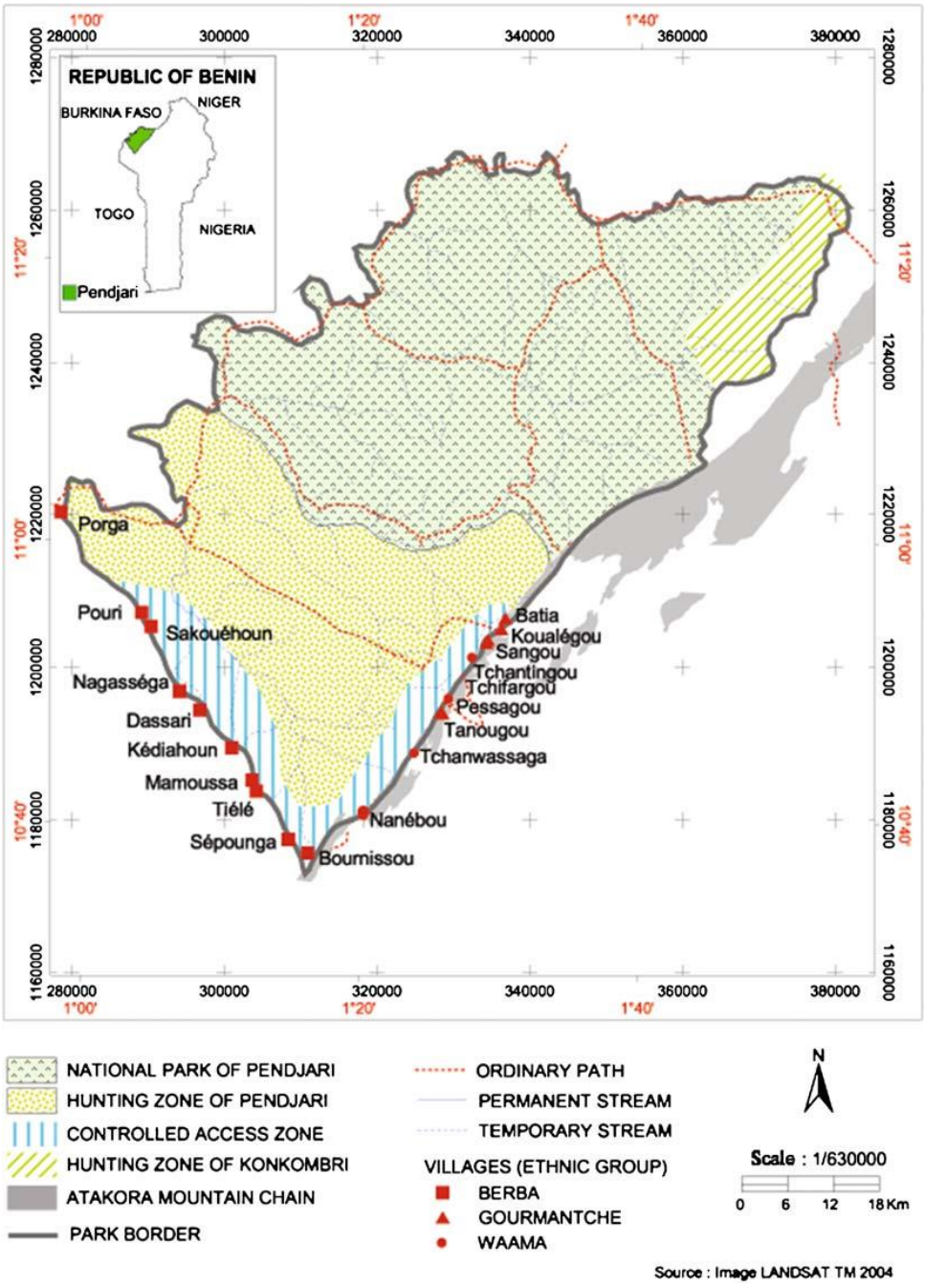

Fig. 2: The Pendjari biosphere reserve and its adjacent villages

(UNESCO, 2013)

The surveys with the local population were conducted in the various villages along the two roads bordering the biosphere reserve in the south during the fieldwork of this master thesis (Fig.2). The following sections provide a detailed overview of the Pendjari biosphere reserve.

3.1.1. General context

The Republic of Benin is a country of Western Africa and is bordered to the west by Togo, to the east by Nigeria and to the north by Niger and Burkina Faso (Encyclopædia Britannica, 2018). The official capital is Porto Novo, although Cotonou is the largest city and is considered as the economic and administrative center of the country (Encyclopædia Britannica, 2018). In the north, the land is dominated by grass and park savannahs, although gallery forests occur along rivers and dry forests in areas protected from fire (Floquet, 2011a). The initial vegetation is often replaced by typical park savanna consisting of, among other things, baobab and locust trees (Floquet, 2011a). The Pendjari Biosphere reserve is located in this region.

3.1.1.1.Protected areas

One fifth of the surface of Benin is officially under protection, although this statement must be nuanced because the degree of protection depends on the status of the protected area (Floquet, 2011a). In Benin, a distinction is made between three types of protected areas: national parks (north), forests of the state domain (mid-belt) and commons under community regulation (south) (Floquet, 2011a). After being classified as Partial Wildlife Reserve and National Park in respectively 1956 and 1961, Pendjari National Park and its adjacent reserves joined the list of biosphere reserves of the UNESCO Program on Man and the Biosphere in 1986 (UNESCO, 2013). Biosphere reserves, which may comprise different kind of ecosystems, are protected areas with special attention for biodiversity conservation by focusing on interactions of social and ecological systems (UNESCO, 2017).The reserves are organized in three interrelated zones: (1) the core area (a zone under total protection), (2) zones surrounding the core areas, known as the buffer zone (used for activities compatible with ecological practices) and (3) the transition zone, where other activities are allowed (UNESCO, 2017).

3.1.1.2.Climate

The climate of the Pendjari biosphere reserve – which is located in a tropical bioclimatic area of the Sudanese type – is described by Tiomoko (2014) as:

- The dry season (October to May) consists of a cool period (October to February) associated with the harmattan[1]and a warm period (March to May)
- The rainy season lasts from May to October

Annex 1 shows the average temperature and precipitation during the year in *Natitingou*, a village close to the park. From March to May the highest temperatures are noted and reach 40°C, while during the winter months (December and January) the lowest temperatures can be recorded (UNESCO, 2013). Precipitation varies during the year, in the summer months the highest amounts of rainfall are recorded with in August and September an average monthly rainfall greater than 250 mm (CENAGREF, 2009).

3.1.1.3.Institutional Framework

(i) Zones

The Pendjari biosphere reserve is an extensive area – where not everywhere the same rules and laws apply – and, as shown by Fig.3, consists of three main categories (CENAGREF, 2009):

- Central zones: classified as fully protected areas
- Buffer zones: surrounding the central areas
- Transition areas: development zones where activities must be compatible with the interest of the buffer zones

There are three main central zones, represented by dark green in Fig.3: core area 1 (center), core area 2 (eastern center) and core area 3 (northeast) represent 28 % of the biosphere or 1 028 km²(CENAGREF, 2009). *Le plan d'aménagement participatif et de gestion* of CENAGREF (2009) states that these zones follow the guidelines of the Man and Biosphere program of UNESCO. The Pendjari river valley and the *Bondjagou* forest also belong to this category (CENAGREF, 2009). Most activities are forbidden – in order to benefit from long-term protection and conservation of biological diversity – and ecosystems are monitored(CENAGREF, 2009). Therefore, according to the development plan, the number of visitors is strictly limited and only a few activities, such as scientific research, are allowed. This category was awarded to the least disturbed areas and development activities, beside for

[1] The harmattan is a dry, dust-laden continental wind which blows from the Sahara Desert into the Gulf of Guinea (Lyngsie et al., 2011). This dry and cold wind, loaded with sand and dust, quickly dries the ponds and rivers and reduces the visibility (UNESCO, 2013).

anti-poaching and research infrastructure, must be restricted to guarantee conditions as natural as possible (CENAGREF, 2009).

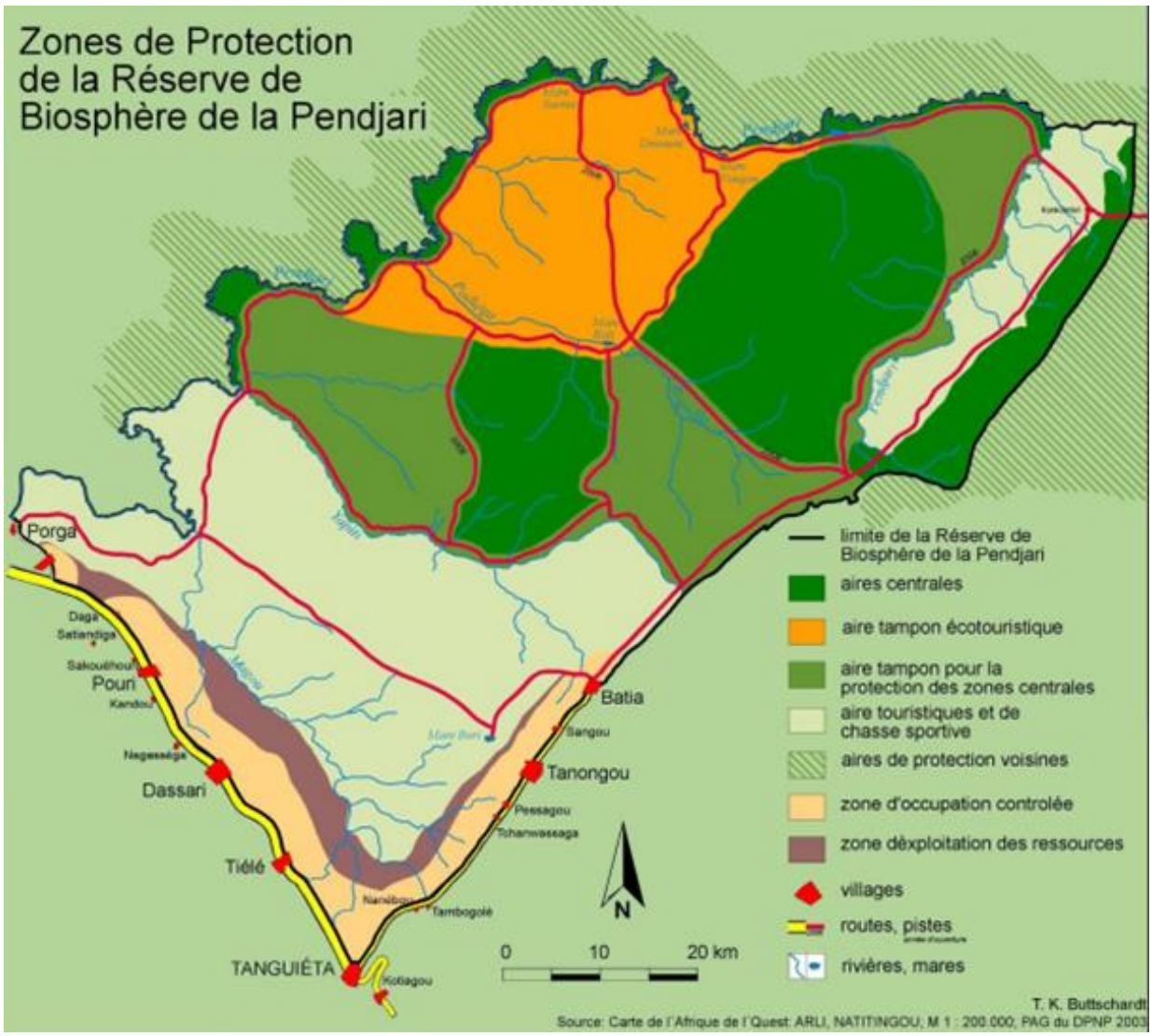

Fig. 3: Zones in the Pendjari biosphere reserve
(CENAGREF, 2009)

Buffer zones, where certain activities (such as recreation, education, research or tourism) are allowed, are located around and near central areas (CENAGREF, 2009)The light green areas in Fig.3represent buffer zones with the purpose of protecting the core area. Even the use of resources (hunting, agriculture or fishing) is not always restricted and five categories can be distinguished according to the degree of protection(CENAGREF, 2009). In this way, there are zones created for ecotourism purposes (orange color)or zones where game hunting (grey zones) is allowed. One of the most important zones in this category is *la zone d'occupation contrôlée* (ZOC), which is located inside the limits of the Biosphere along the two roads (Tanguièta-Porga and Tanguièta-Batia) (beige color Fig.3). The width of this zone fluctuates

between three and five kilometers(CENAGREF, 2009). Because the lack of (agricultural) land in the area, agriculture is allowed in the ZOC to the riparian population, but clear rules are needed to ensure sustainable agriculture compatible with neighboring areas(CENAGREF, 2009). Strictly speaking, *le plan d'aménagement* indicates that these measures exclude cotton, which is present in the area(CENAGREF, 2009). The limits of this zone should be clear for the villagers and in no case exceeded(CENAGREF, 2009). Therefore, according to the development plan, a system of internal control has been set up. Traditional hunting on a few small species is also permitted in the ZOC(CENAGREF, 2009).

In transition zones, it is allowed to do agriculture, other economic activities and even establish villages(CENAGREF, 2009). Although it is still appropriate to do this in line with objectives of conservation, because people in this zone have a direct influence on the buffer zone and – to a lesser extent – on the central areas. According to the development plan of CENAGREF, many projects are – or have been – in operation to reduce the local population's pressure on the resources of the buffer zone. Moreover, improvements on farming techniques are needed both in the transition zone and the buffer zone, as the executors are the same(UNESCO, 2013). Within this theme, sustainable farming with organic manure is an option in order to reduce the pressure on the land(CENAGREF, 2009).

(ii) Management

Formerly, local communities were not involved in the management of the park resources, which regularly resulted in conflicts between local population and the management (Idrissou et al., 2013). When the park was created in 1954 during the colonial period, land was taken away from the local populations and, in the following years, the park has been managed with power and repression with little or no involvement of the local population (Idrissou et al., 2013). Since 1993, the park management tries to include the local population in the decision-making process of the park and its resources (Vodouhê et al., 2010). Therefore, the *c*, commonly known as AVIGREF, was created in many villages near the Biosphere (Vodouhê et al., 2010). The goal of this association is that villagers become more involved in the management and benefit as well from revenues of tourism, game hunting, etc. (CENAGREF, 2009).

In 1996, *Centre National de Gestion des Réserves de Faune* (CENAGREF), created by the government, replaced the DFRN (*Direction des Forêts et des Ressources Naturelles*) which managed the park since the beginning (Vodouhê et al., 2010). This autonomous institution

took charge of the conservation and management of the protected area in collaboration with AVIGREF (CENAGREF, 2009). This power transfer follows the global trend of a modern management of Protected Areas, which is nowadays more often entrusted to offices, NGO's or the private sector (CENAGREF, 2009). As described by CENAGREF itself in 2009, the tasks of CENAGREF are multiple: development of protected areas, strengthen both wildlife reserve management and biodiversity conservation, value natural resources and participatory management with AVIGREF (CENAGREF, 2009).

The riverside villages established AVIGREF in order to combat consequences of deep anthropogenic degradation of the Biosphere reserve due to activities like poaching and land clearing (CENAGREF, 2009). Beside a membership fee and an annual contribution, the association is open to every person living in one of the riverside villages on a voluntary basis (Vodouhê et al., 2010). It is the intention of AVIGREF to guarantee: proper education on the necessity to preserve the fauna, awareness about regulations and the sustainable management of fauna (Vodouhê et al., 2010). Moreover, CENAGREF is assisted by AVIGREF to carry out control and surveillance activities (CENAGREF, 2009). In return, members of AVIGREF can profit from numerous benefits. AVIGREF receives 30% of the revenues of game hunting and can sell the – game hunting – meat in the villages, which is an additional income (CENAGREF, 2009). Moreover, AVIGREF provides technical services as well. For these activities, members receive 1500 FCFC per day (African Parks, 2017).

Recently, the management of Pendjari Biosphere Reserve has been taken over by African Parks. This non-profit organization was founded in 2000 due to a decline in protected areas and currently manages15 national parks (and protected areas) across Africa, among others in Rwanda, Zambia and the Democratic Republic of Congo (African Parks, 2018) .African Parks functions according to the principle of Public-Private Partnerships (PPP's) which implies that the state remains the owner of the park and is responsible for legislation and policy, but African Parks itself executes management functions and is accountable to the state of performance (African Parks, 2018). First and foremost, long-term agreements are negotiated, financial support is ensured and good governance and management is ensured by registering separate legal entities in the host country(Vodouhê et al., 2010). Once these three factors are in place, African Parks mainly focuses, according to the organization itself, on five aspects: law enforcement, management and infrastructure, biodiversity conservation, community development and economic impact (African Parks, 2018). Revenues are partly generated through tourism and enterprises associated with conservation, but African Parks also still

depends on donations (African Parks, 2018). To achieve long-term conservation, African Parks normally secures 20-year management contracts and a clear mandate to take operational responsibility is needed (African Parks, 2018).

3.1.1.4.Human environment

Two roads border the reserve, along which nearly 30 000 people live in 20 villages (UNESCO, 2013). Looking to the three districts surrounding the park (Dassari, Tanongou and Tanguièta), population has grown from circa 45 000 people in 1992 to 47 000 in 2012 (CENAGREF, 2009). The activities of the populations living in these area, also referred to as "riparian zone", have an impact on the natural resources of the Biosphere Reserve (CENAGREF, 2009). In a sense, the villagers are in their right to exploit the resources of the area based on historical, cultural and political reasons (CENAGREF, 2009). Among the poorest people in Benin live around the National Park, but the population density is rather low (Vodouhê et al., 2010). The literacy rate in the region is low, inhabitants still largely depend on their traditional lifestyle and have a lot of wildlife expertise (Vodouhê et al., 2010).

The population consists of three main ethnic groups: *Berba*, *Gourmantche* and *Waama* (CENAGREF, 2009). The Fulani, who guard the cattle of other ethnic groups in the region, are another important group (CENAGREF, 2009). Besides the Fulani, the majority of the population –almost every ethnic group – have strong hunting traditions (Vodouhê et al., 2010). The main activity of the local population to sustain themselves remains subsistence agriculture (CENAGREF, 2009).

Recently, modern administrative institutions are established in the region, although traditional offices still play an significant role(CENAGREF, 2009). Communal councils support the socio-economic development of municipalities (CENAGREF, 2009). In almost all villages, social organizations are active, of which the most important is AVIGREF (CENAGREF, 2009). But other initiatives, such as *les groupements villageois*, *les groupements féminins* and *les groupements de pêcheurs*, exist as well (CENAGREF, 2009). The network of social services is relatively well in the region (Floquet, 2011a).

3.1.2. Ecosystem services

3.1.2.1.Carbon sequestration and storage

In protected areas in the northern part of the country, woody and grass savannahs and unaffected areas of dry forests still occur (Floquet, 2011a). CENAGREF (2009) states in its

plan d'aménagement that the vegetation of the PBR and its adjacent areas consists of a mixture of herbaceous, shrubby, wooded and woody savannas. The wooded savanna – where the landscape largely consists of – is alternated with forest formations of which 5% shrub savannah and 80% forests (CENAGREF, 2009). According to CENAGREF (2009), the grassy savannas, mainly found in de floodplains of the Pendjari, represent 17% of the parks' vegetation. Along the Pendjari river and its tributaries gallery forests are located (4 % of PNP) and, at higher altitudes, forests can be found (12% of PNP)(CENAGREF, 2009).

Both the savannah and the different forest types offer multiple ecosystem services. Timber production, firewood extraction, charcoal production and carbon sequestration are important services delivered by the ecosystem. The major part of timber production is owned and exported by the state, while local production is rather low (Floquet, 2011a). However, less than 10% is produced in plantations and more than 90% is harvested in natural forests in Benin (Bertrand & Agbahunga, 2009 cited by Floquet, 2011). Moreover, Floquet (2011a) reports that, in 2017, the vast majority of the rural population (92%) depend exclusively on fuel wood for cooking. Charcoal is the most popular way of consumption (yearly 13.3 million tons of wood processed into charcoal) , while firewood is less used in Benin (1.1 million tons) (Floquet, 2011a). The charcoal industry is well established, especially in the southern parts of the country, but such activities occur also more frequently in the north (Floquet, 2011a). Charcoal production offers a steady (mostly low) income for the poor local population (Floquet, 2011a).

3.1.2.2.Water

The only permanent watercourse in the biosphere reserve is the Pendjari river (CENAGREF, 2005, cited by UNESCO, 2013). The river, often drying up in several places, flows over 200 kilometers through the reserve and permanent ponds form at the secondary arms of the river because of its low slope. The main river limits the reserve in the north and eventually flows southwards (CENAGREF, 2009). Circular ponds exist, but usually dry up before January (UNESCO, 2013). Only Bali pond, located on open savannah ground, can hold the water longer and attracts animals and – by consequence – tourists (UNESCO, 2013). The Pendjari river has several tributaries (*Magou, Yatama, Yabiti, Tandjali, Podiega, Bonkada*, etc.) which form together a hydrographic network, although only the Yatama river is permanent (UNESCO, 2013). Fig.4 gives an overview of the Pendjari river basin, which includes the

Pendjari biosphere reserve. The villages are – for logical reasons – located where the most important aquifers are found or areas crossed by rivers (UNESCO, 2013).

The Pendjari River basin, located in north west Benin, originates in the Atacora mountains and flows – right through the Atacora cliffs – over a distance of 420 km through Benin (Ahouansou et al., 2015). Unfortunately, few studies has been done in terms of hydrological processes and information is lacking (Ahouansou et al., 2015). However, Ahouansou et al. (2015) assessed the water availability in the Pendjari river basin, taking into account both runoff, groundwater and evapotranspiration. To meet their goals, the study used a J2000 model, which offers an appropriate basis parameterization with poor data availability, to analyze the hydrological budget. The outcome of the study is that annual rainfall largely (86.94%) returns to the atmosphere. This is caused by canopy interception (28.27%) and evapotranspiration (58.67%), which supports natural vegetation and farmland production (Willaarts et al. 2012 cited by Ahouansou et al., 2015). The study estimated the water yield, the sum of surface runoff (12.53%) and groundwater recharge (9.92%), in the Pendjari river basin at 21.45% of the annual rainfall.

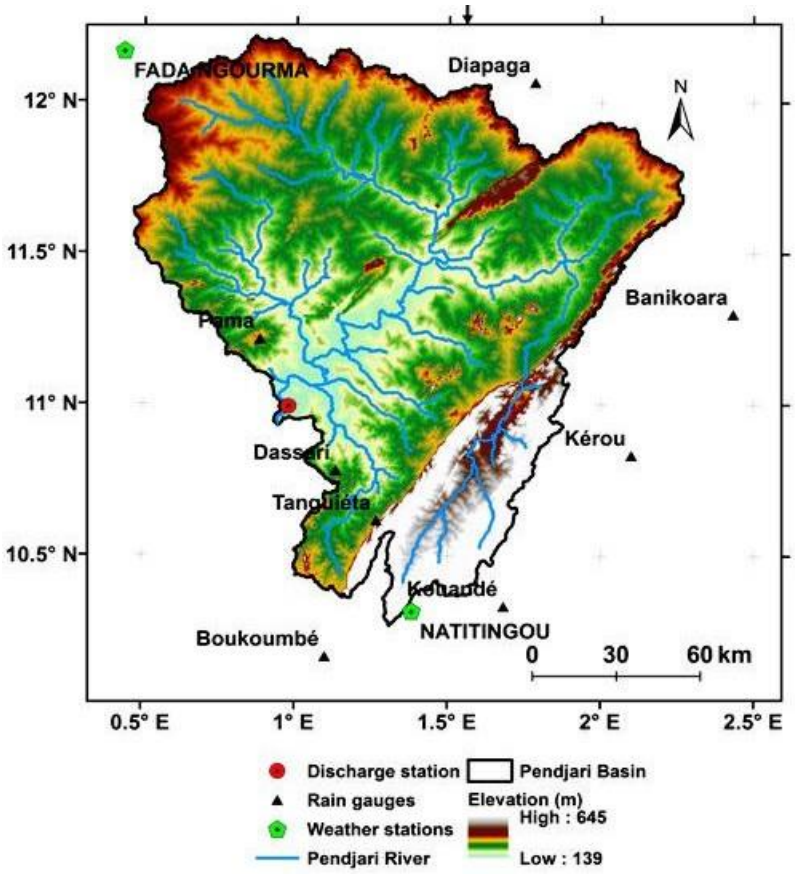

Fig. 4: Pendjari river basin

The Pendjari biosphere reserve is a part of the basin (Ahouansou et al., 2015)

3.1.2.3.Tourism

Recently, the government of Benin made of sustainable tourism development a top priority and began to put a set of projects, known under the name 'revealing Benin', into operation to achieve this objective (African Parks, 2017). Six of these projects have tourism purposes and – more importantly – one project focuses on the revitalization of the Pendjari Biosphere Reserve(African Parks, 2017). Therefore, in January 2018, the new park management African Parks has started a collaboration with National Geographic to protect and restore the park's landscape (National Geographic Society, 2018). National Geographic reports that 23.5 million dollar would be distributed over several years. In 2017, around 6000 tourists visited the national park, but there is need for new infrastructure (African Parks, 2017). According to African Parks, some improvements were already realized: a new safari vehicle was purchased, the main entrance was refurbished, trainings were organized for the tourist guides and walking and boat safaris were tested.

3.1.2.4.Agriculture

Agriculture is the main activity and often the only source of income of the local population (CENAGREF, 2009). Beside food crops like maize and sorghum, cotton and rice are cultivated as well (CENAGREF, 2009). CENAGREF (2009) reports that agriculture near the biosphere is essentially for subsistence purposes, food products are almost exclusively sold on local markets. According to the inhabitants of the riparian villages, there is a serious shortage of land (CENAGREF, 2009). People near the Tanguièta-Batia road are stuck between the mountain range and the limits of the park and, have got access to the ZOC (CENAGREF, 2009). On the other axis (Tanguièta-Porga), there is less shortage of land, but spaces are cultivated extensively (CENAGREF, 2009). CENAGREF (2009) writes that the fertility of the majority of soils is low and the agriculture extends in the *Zone Cynégétique de la Pendjari*. The allocation of the *zone d'occupation contrôlée* (ZOC) to the local population was therefore unavoidable (CENAGREF, 2009).

Livestock keeping, the second economic activity, is often a coping mechanism to deal with setbacks by selling their animals in difficult times (CENAGREF, 2009). Only for special occasions, animals are slaughtered and consumed by their owners (CENAGREF, 2009). According to CENAGREF (2009), one ethnic groups in particular completely focuses on this activity: the Fulani.

3.1.2.5.Others

(i) Biodiversity

In total, 241 plants species occur in the Pendjari biosphere reserve and the large variation of plant formations provide an habitat for different wildlife species(CENAGREF, 2009).A variety of mammals, such as large antelopes, can be found in this areas (Floquet, 2011a). In general, most of the large mammal species – typical for this region – can be observed in the National Park (CENAGREF, 2009).The biosphere is especially known for the presence of populations of elephants (*Loxodonta africana*), buffalos (*Syncerus caffer*) and lions *(Panthera leo*) (Floquet, 2011a). According to CENAGREF (2009), carnivores are a good biological indicator, because they are on top of the food chain. At least 70 individual lions (*Panthera leo*) are recorded in the National Park (CENAGREF, 2009). In addition, there are also cheetahs (*Acinonyx jubatus*) , leopards (*Panthera pardus*), wild dogs (*Lycaon pictus*) and hyenas (*Crocuta crocuta*) (CENAGREF, 2009). Without the creation of this protected areas, these species would probably not be there due to anthropogenic pressure (Floquet, 2011a).Of course, there is also a large variety of non-mammalian fauna such as a huge variety of bird and fish species(CENAGREF, 2009). The gallery forests on the banks of the Pendjari River contain many typical gallery forest species of the Sudanian region (Oumorou et al., 2011). In total, Oumorou et al. (2011) identified 350 valuable plants species in this type of forest.

(ii) Non-wood forest products

The local population gathers a lot of non-wood forest products (NWFP) – often just for home consumption – in protected areas (Floquet, 2011a). Beside food like fruits and nuts, many other products are collected in forests to use as construction material or to process into handicrafts (Floquet, 2011a). Vodouhê et al. (2009) report that the local population living near the Pendjari Biosphere Reserve uses a total of 118 plant species, most of which had multiple uses. Moreover, especially medicinal and food plant species were highly appreciated by the inhabitants (Vodouhê et al., 2009). Parts of some plants are used as a remedy for many diseases and disorders (Floquet, 2011a). In this study, Vodouhê et al. (2009) listed 60 important medicinal and 48 food species, as mentioned by the participants. *Parkia biglobosa*, *Adansonia digitata* and *Vitellaria paradoxa* are considered as the most important species (Vodouhê et al., 2009). Both the seeds (food), the bark(medicine) and the leaves (ceremonies) of *Parkia biglobosa* are used (Vodouhê et al., 2009). Butter is often produced using the seeds of Sheatrees (*Vitellaria paradoxa)* (Vodouhê et al., 2009). Traditional agro-forestry systems often occur in sub-Saharan Africa (Djossa et al., 2008). Among others by these systems, the

Sheatrees dominate with a few other species the Pendjari region and serve as an important source of income for women in the study area (Djossa et al., 2008). A distinction in the value assigned to certain plant species by different ethnic groups could be observed, trees were also valued more (Vodouhê et al., 2009). Vodouhê et al. (2009) argues that species available throughout the year become important to the households and are likely to be exploited regularly.

In addition to the frequent exploitation of many plant species, the harvest of wild honey is an important traditional activity as well (Floquet, 2011a). According to Floquet (2011a), honey harvesters often smoke and kill bee swarms in order to obtain their product. Therefore, this destructive activity is prohibited and the Park administration tries to convert harvesters into beekeepers (Floquet, 2011a). However, Floquet (2011a) indicates that the majority is still honey harvester and the amount of honey produced by the beekeepers remains rather low.

3.1.3. Main threats and challenges

3.1.3.1.Agriculture

A consequence of the growing cotton production is the application of pesticides (Paré et al., 2014). Both the central zone, buffer zone and the ZOC were investigated in 2008 and 2009 by Paré et al. (2014) in order to determine the impact of this activity on the natural environment. Therefore, the amounts of pesticides residues were measured in soils and sediments of seasonal residues (Paré et al., 2014). Paré et al. (2014) report that no residues could be found inside the central zone, some pesticides occurred on agricultural fields and in the buffer zone. In addition, residues were only found at the end of the growing season and is was mainly endosulfan that was discovered (Paré et al., 2014).

Simultaneously, a similar study was carried out about insecticides in bats in the Pendjari Biosphere Reserve. In particular, bats are considered as providers of valuable ecosystem services and insecticides may affect their population (Stechert et al., 2014). Stechert et al. (2014) detected residues of DDT[2] and endosulfan in bats in the region. In 2008, low concentrations of endosulfan residues were found in bats, however, in 2009, this was not the case (Stechert et al., 2014). Low concentrations of DDT residues were found as well (Stechert et al., 2014).

[2]bis(4-chlorophenyl)- 1,1,1-trichloroethane or DDT is a chemical compound of certain insecticides (Stechert et al., 2014).

Although both studies detected rather low concentration of chemical inputs and suggest a limited distribution, this problem can absolutely not be considered as solved. The increased use on a larger scale of these inputs may affect certain species, such as bats (Stechert et al., 2014). Of course more studies have to be done on effects of pesticides.

3.1.3.2.Land clearing for agriculture

In Benin, agriculture is still an essential source of income and many households rely on it for their livelihoods (Floquet, 2011a). Available fertile land is becoming scarce and families try to secure their future by occupying new areas after forest clearing (Floquet, 2011a).This seems appropriate for the local population, because this is how farmers used to obtain rights on new areas in ancient times (Floquet, 2011a). In the Pendjari Biosphere Reserve, specific part of the land – *la zone d'occupation contrôlée* – is allocated to the farmers for agriculture (CENAGREF, 2009). The question is whether or not these limits will be respected in the future.

3.1.3.3.Grazing in protected areas

Livestock farming remains an important activity for the local population as well (Floquet, 2011a). Cattle, often under the supervision of the Fulani, move around in order to find fodder, grass and water around the Pendjari National Park (Floquet, 2011a). Consequences of high concentrations of livestock – such as overgrazing or soil compaction – can have a serious impact on protected areas (Floquet, 2011a). Recently, it has been observed that even livestock keepers in the Sahel, accompanied by hundreds of thousands of cattle, come to northern Benin in their search for grazing land (Ecopas, 2004). Ecopas (2004, p11) summarizes the concept as : "transhumance is an animal production system characterized by cyclical seasonal movements of variable amplitude." The difficult conditions in regions north of Benin force the livestock keepers to move to favorable areas more south (Ecopas, 2004). Convers et al. (2004) considers transhumance as one of the major threats to conservation in the W-Park. Since 2001, the ECOPAS program started to manage the illegal grazing inside the park(Convers et al., 2007). The Pendjari Biosphere reserve, together with the W-park part of the WAP-complex, also attracts cattle from other regions (Floquet, 2011a). However, according to CENAGREF (2009), large transhumance is not yet a problem in the biosphere. Nevertheless, in the current times of climate change, it is a possibility that animal grazing will cause more implications in the Pendjari National Park as well.

3.1.3.4.Carbon

The growing local population and its associated increased consumption puts natural forests under pressure (Floquet, 2011a). The majority of timber production still originates from illegal logging activities (the legislation is often circumvented by obtaining permits from neighboring countries) in protected areas (Floquet, 2011a). By consequence, some species are currently endangered and are about to disappear replacing them with less valuable species (Floquet, 2011a). As mentioned above, most people largely depend on fuel wood as energy for cooking, although the amount has been decreasing recently due to the introduction of gas and fuel wood saving cookers (Floquet, 2011a). Bush fires are an important phenomenon in Benin and occur more frequently (Alimi, 2010). The fires, often induced by humans, can easily spread throughout the landscape and affect forest stands (Floquet, 2011a). To avoid damage to the vegetation, one encourages the local population to set early fires (not in the dry season) and the management of classified forests anticipate bush fires by implementing fire protection in their management plan (Floquet, 2011a). Moreover, national parks use bush fires to increase visibility for tourism purposes (Floquet, 2011a).

3.1.3.5.Game hunting and poaching

Traditional hunting is still an essential activity for rural population in order to obtain some meat and protect their agricultural fields and mostly concerns rodents (Floquet, 2011a). Hunters are often organized in groups and are difficult to regulate (and certainly to forbid) due to strong cultural ties (Floquet, 2011a). The increase of valuable animal species in protected areas attracts other types of hunters: poachers. Floquet (2011a) reports that a considerable part of the local population depends on poaching for their income and threatens many species. In this way, e.g. the amount of lions in West-Africa has decreased drastically (Henschel et al., 2010) and low lion densities are recorded in the Pendjari biosphere as well (Sogbohossou et al., 2014). The authors argue that the lion population – and more specifically the social structure – is disturbed. Besides poaching, game hunting would play a role in this too (Sogbohossou et al., 2014). In some zones of the Pendjari biosphere reserve hunting is allowed under the control of the administration (Floquet, 2011a). The former park management organized legal hunting activities taking into account both ecological quota and touristic revenues of the high-income trophy hunting (Floquet, 2011a).

3.1.3.6.Cohabitation problems with the wild

Migrating animal species, such as elephants, cause problems for the local population while moving from one area to another (Floquet, 2011a). The animals often destroy agricultural fields of the villages bordering the reserve (Floquet, 2011a). However, the population is rarely compensated for their losses (Floquet, 2011a) and this may lead to poaching. Moreover, carnivore species (mainly hyenas, baboons and lions)cause some problems as well (Sogbohossou et al., 2011). The wildlife predates the livestock (sheep, goats, pigs and even cattle) of the local population (Sogbohossou et al., 2011)

3.1.3.7.Gathering activities on non-wood forest products

People around the Pendjari Biosphere Reserve largely depend on non-wood forest products. The most used or valuable plant species not necessarily match the most abundant species in the Pendjari Biosphere Reserve (Vodouhê et al., 2009). Therefore, it is even more appropriate to think about methods to avoid the overexploitation of non-wood forests products, which can have a negative impact on the local population. Especially, this may have a serious impact on the species which are gathered in its entirety, for its roots or barks (Floquet, 2011a). The collection of honey is also a destructive activity, because wild bee hives are often destroyed (Floquet, 2011a).

The traditional agro-forestry systems in the region already include some important species and can be seen as a conservation strategy (Vodouhê et al., 2009). In this way, the local population creates a buffer against an excessive utilization and contribute to the conservation of many valuable plant species (Vodouhê et al., 2009). Shea(*Vitellaria paradoxa*) and locust trees (*Parkia biglobosa*) are often planted in the fields (Floquet, 2011a). Nevertheless, improvements are still needed in order to harvest non wood forests products sustainably (Vodouhê et al., 2009). Hereby, one has to focus particularly on the species valued most by the inhabitants of the region (described in section 1.3.5) to secure a proper management and conservation.

3.2. Rapid assessment tools

As a reaction on the growing interest in ecosystem services, many decision-support tools have been developed recently to support a systematic ecosystem service assessment (Bagstad et al., 2013). The authors argue that the analytical tools enable replicable and quantifiable ecosystem services analyses. On the one hand it is the intention that these tools add credibility to the decision process, so that stakeholders are more confident using them (Bagstad et al., 2013).

On the other hand it's important that these tools are both flexible (can be used in different decision contexts) and affordable, so they can be incorporated into decision making on a routine basis (Bagstad et al., 2013).There is a large variation between the different tools, some are place-specific, while others are applicable to any location in the world (Bagstad et al., 2013). The tools differ also in their approach to economic valuation, spatial and temporal representation of services and incorporation of existing biophysical models (Bagstad et al., 2013).

Prior to the field work, several rapid assessment tools were compared on the basis of a selection of evaluative criteria. The criteria test each tool to determine whether or not it is quantifiable, replicable, credible, flexible and affordable (Bagstad et al., 2013). Time requirements, uncertainty, scalability, affordability and technical expertise are examples of the criteria used in the assessment. The analysis enabled us to determine which tools are appropriate for this research project and can contribute to the right assessment of the ecosystem services in the study area. Eventually, two rapid assessment tools were selected: the toolkit for ecosystem service site-based assessment (TESSA) and the protected area benefit assessment tool (PA-BAT). The methodology of the two first stages of this master thesis was mainly based on TESSA supplemented with some aspects of PA-BAT. Thus, a combination of the two was used. Both tools will be briefly discussed in the following paragraphs.

3.2.1. The Toolkit for Ecosystem Service Site-based Assessment

Although assessing the impact of perturbations on ecosystem services is essential for planning decisions, relatively little research was done into this study area due to high costs and technical difficulties (Peh et al., 2015). The Toolkit for Ecosystem Service Site-based Assessment (TESSA) overcomes this obstacle and provides practical guidance on how to asses and monitor ecosystem services without substantial technical expertise or financial resources(Peh et al., 2015). The authors argue that the toolkit was designed to support users throughout the whole process of ecosystem evaluation from identifying significant services at a site of interest and measuring the necessary data to the communication of the results. It allows users to understand the benefits, which are received from nature, and assess their value in order to generate information for decision making (Peh et al., 2015).

One often focuses on a global level, but TESSA uses information gathered locally to bring the work down to an operational level, and requires less technical skills and resources than other

projects working on similar approaches(Peh et al., 2015). The toolkit is accessible, low cost and relevant for local decision-makers and, moreover, delivers scientifically robust results, which are often based on real field measurements, rather than theoretical scenarios (Peh et al., 2015). To date, methods for assessing global climate regulation, water-related services, harvested wild goods, cultivated goods and nature-based recreation are included(Peh et al., 2015). The toolkit consists of two consecutive stages: the preliminary rapid appraisal and the full assessment.

The preliminary scoping appraisal is designed to capture the full range of services that are relevant for the site of interest and gives the researcher a general overview of the ecosystem services provided by the site and how they may change under plausible future changes (Peh et al., 2015). To obtain the necessary data, Peh et al. (2015) suggest to organize group discussions with different stakeholder groups. The first step of the TESSA toolkit (rapid appraisal) consists of two parts: identifying habitats and activities impacting the site and identifying ecosystem services.

3.2.2. The Protected Area Benefit Assessment Tool

The Protected Area Benefit Assessment Tool (PA-BAT) helps to provide information on the full range of current and potential benefits of individual protected areas (Dudley & Stolton, 2009). It is primarily designed to work with stakeholders to identify important values and the associated benefits on both a local and global level(Dudley & Stolton, 2009). According to the authors, The PA-BAT tool is an assessment tool and not a monitoring tool, but it can help guide future monitoring. The tools provides guidance to help think logically about the types of benefits, who benefits and by how much, and the degree to which particular benefits are linked to protection strategies(Dudley & Stolton, 2009). Dudley & Stolton (2009) propose to carry out the assessment in the form of workshops with different stakeholders and the tool consists of two sections: the background information datasheet and the benefits to protected area stakeholders datasheet.

The background information datasheet provides a general overview of the protected area by gathering information on basic protected area data, ownership and governance, management objective, population, well-being and biodiversity values (Dudley & Stolton, 2009). The benefits to protected area stakeholders datasheet identifies the important values to stakeholders and focuses on nine main groups of value: nature conservation, protected area management, food, water, culture and spirit, health and recreation, knowledge, environmental

benefits; and materials(Dudley & Stolton, 2009). For each value, the assessment considers seven issues: the stakeholder group which benefit, type of benefit, amount of protected area involved and period it is exploited, economic value, conservation impact, management issues and additional notes (Dudley & Stolton, 2009).

3.3. Identification of priority ecosystem services

The research process started with meeting different actors operating in the region (local experts) and organizing group discussions – also referred to as focus groups - with the local communities living near the park. Both approaches were combined in order to identify the essential ecosystem services in the study area.

3.3.1. Interviews with local experts

Prior to departure, a list was created with several interesting parties, such as governmental organizations, park managers, NGO's, etc. In consultation with some specialists with knowledge in the study area, like professors of the university of Abomey-Calavi and (ex-) park managers, this file was completed during the first days of the fieldwork. A list of actors who were eventually interviewed is included in annex 1.2. General questions were asked about the operation, vision and goals of their organization. Furthermore, their professional opinion on ecosystem services (and the associated threats and challenges) was asked as well.

Because the amount and nature (qualitative) of information required an appropriate strategy to present the results, the information was structured according to the DPSIR framework. The DPSIR framework is a functional analysis scheme and consist of five factors which are interrelated: driver, pressure, state, impact and response (Ness et al., 2010). Ness et al. (2010) indicate that, beside structuring information, the tool identifies important relations and reveals the underlying problems. However, ecosystem services and their corresponding value to human population are currently not yet included in the DPSIR framework (Collins et al., 2011). The focus lies upon drivers paying less attention to the needs of local human communities (Kelble et al., 2013). Therefore, Kelble et al. (2013) proposed a conceptual model which merges ecosystem services directly with DPSIR. In this case, impact is replaced by ecosystem services in the scheme. This merged framework was used in this master thesis to establish the cause-effect chain in the study area.

3.3.2. Focus groups

The methods of the focus groups show great similarities with the scoping appraisal part of the TESSA toolkit, although some ideas of the PA-BAT tool were included as well.

3.3.2.1.Selection Villages

First and foremost, it was the intention to get a general idea of which ecosystem services the local population as a whole considers important in the study area. It was, therefore, necessary to spread the group discussions across the two roads limiting the biosphere. Secondly, it was intended to check to what extent preferences differed between villages (geographical location) and whether or not it depended on the activities a particular group carries out. Thus, the selection process of the focus groups was based on location, profession and activity. Rather homogeneous groups were created in order to reduce the variability within each focus group. In this way, results can be linked to a specific profession and/or activity in the analysis.

In total, ten separate groups were selected spread over seven villages: four local communities, trackers, beekeepers, fishermen, park guards, communities active in the field of medicinal plants and people working in tourism (see annex 1.3). A group was considered as a local community when there was no common profession. However, this does not necessarily mean that these groups did not include e.g. beekeepers or fishermen. The number of participants varied greatly between the different villages. Originally, it was the intention to bring together larger groups and, if possible, an equal distribution in terms of gender of the participants. However, this could not - or only partially - be realized during the fieldwork due to a shortage of participants or particular circumstances in a certain village. The size of the focus groups ranges, therefore, between four and nine participants. Only in three villages women participated in the discussion.

3.3.2.2.Content

After a brief explanation of the research project, the area that is considered for the exercise was shown on a map to make sure the participants answer the questions correctly regarding the study area. In the first place, the participants discussed in group the different ecosystem services and name – in their own words – the services which have a great value for them. For this group discussions, pictures of possible ecosystem services were provided (see annex 1.4). In total, twenty services were visualized using cardboards signs with a figure on it. Before the next stage of the exercise starts, each symbol and its corresponding service was briefly explained to make sure participants understand what it is. Given the time pressure, it maybe

seems unnecessary for certain services. However, services such as climate change, erosion control and flooding prevention need a little explanation. At the same time, after a particular service was explained, it was asked whether this ecosystem services was considered important by the participants. This was useful to introduce the participants to ES this way, but the results are not reported (also to avoid confusion with what follows).

In the next step, the participants were asked to prioritize the ecosystem services according to their own experiences. For this, use was made of seeds. Inspiration for the approach was based on the method of pebbles (Floquet, 2011a). Each group received an amount of seeds and had to divide them over the quoted services. The assigned number of seeds reflected the importance of each ecosystem service. In this way, each ecosystem service obtained a certain value of importance. When time allowed it, the group was asked why they value a certain service more than another. Thus, the motives for their choices could be figured out.

The next part of the exercise mainly focused on those services considered most important by the whole group. In most cases, a clear distinction could be noted since participants had no difficulties making a ranking. Two or three ecosystem services were elected by the interviewers to acquire additional information about them. Some questions were asked about the problems with these services and possible activities threatening those ecosystem services in the present or the future. Moreover, participants gave their opinion on how they experienced changes of this services in the last couple of years and, if appropriate, where in the study area the service increased or decreased. Eventually, it was asked if there are certain projects active in their neighborhood promoting some services in order to conserve or improve them.

3.4. Full assessment of priority ecosystem services

Four ecosystem services were further investigated in this research project: carbon, water, tourism and agriculture. As described in chapter 2, this was based on the major study fields of PES and the results of the first stage. These services largely corresponded. For agriculture and water a survey was carried out in the field, while the evaluation for tourism and carbon was purely based on literature. The TESSA toolkit was used as a guide for the field surveys, but also in the analysis of the results.

3.4.1. Carbon sequestration and storage

The service was assessed using, on the one hand, maps provided by an assignment of fellow students and, on the other hand, the results of a previous study close to our study area. Using

the maps, an overview was provided of the vegetation types and more specifically the location of the forests. Furthermore, an attempt was made to estimate the aboveground biomass in the study area based on data in literature (Chabi et al., 2016). Chabi et al. (2016) estimated the mean dry biomass density values for the different LULC classes in the Dassari basin, located next to Pendjari (see annex 3.1). The surface of the ZOC was known. In this way, the total biomass stock of the ZOC was estimated .

3.4.2. Water

A survey was carried out with regard to water use in the villages. Nine women were interviewed individually and this was supplemented by four group discussions. Five different villages were included. The survey addressed the origin, availability, the amount and problems of water in the study area (see annex .1.7).

3.4.3. Tourism

Data on touristic activities in and around Pendjari were examined in detail. Use was made of reports provided by the local touristic organization Eco-Benin, because no tourists were present at the time of the fieldwork and it was, therefore, not possible to conduct a survey. One report (DPNP, 2016) summarizes the analysis of information obtained from suggestion sheets completed by visitors in the period July 2015 - June 2016. In this study, a total of 407 sheets were collected, out of a total of 4 394 visitors. This is a sample rate of 9.26%. The annual total income from tourism and recreation was estimated. The survey of Eco-Benin divided the visitors into classes (100 000 FCFA) according to their expenses. The distribution of the visitors over these expense classes was used. So, the number of visitors per expense class was multiplied with a suggested expense per visit (mean of the expense class). By adding up the different classes, a total income was obtained. This was done for both the year 2016 (least visitors) and 2017 (most visitors). Thus, minimum and maximum annual income were estimated. In this way, a range of annual total income was obtained.

3.4.4. Agriculture

A first important step in the assessment was meeting a group of agricultural extension officers, government officials or representatives of a farmer cooperation. In this case, it was chosen to conduct an interview with a well-informed individual, namely a representative of*les Centres d'action régionale pour le développement rural* (CARDER).This section was included to collect general information on cultivation in the assessment site in an efficient

way. It was decided to focus only on a few important products, because the evaluation of all existing cultivated goods would take a significant amount of time and would be difficult to conduct. Based on the answers of the informed individual and in consultation with our guide Mr. Thomas, the five most important cultivated goods in the assessment site were selected.

The interviews with individual cultivators were conducted in ten different villages and in total 56 farmers participated (see annex 1.5). Due to practical reasons, there was opted to conduct individual interviews, but organized in group. In this way, the project had to be presented only once and the questions could be explained to a number of cultivators at the same time. Although a group session was organized, the questions and their responses were asked and answered individually. This had the advantage that participants had already time to think about their answer, while another cultivator was answering the question. However, a possible disadvantage of this method is that the cultivators may be influenced by each other. The questions were individually asked, but the responses were given in the name of his/her household. Although the interviews were not always conducted with the head of a certain household, the results can be considered reliable because the questions were of this nature that they could be easily answered by any member of the family, who represents a certain household.

The selection of the farmers was random, but the survey only comprises the five main crops and farmers were thus only included as they grew at least one out of five. There was asked for cultivated area, yields, amount sold, prices, use of fertilizers, etc. (see annex 1.7). In this way a simple economic evaluation of the different crops could be estimated. One crop, namely cotton, consisted of two types: conventional cotton and organic cotton. The major differences between these two types was investigated as well. Finally, a few questions about the possible changes of agriculture in the future were implemented into the survey as well. This brief section took place at the end of each session and was mostly answered in group by the participants, although in some cases we also noted individual answers.

3.5. Evaluation of payments for ecosystem services schemes

3.5.1. Carbon sequestration and storage

According to the exploratory stage, one of the most promising (PES) projects in the study area was *les foyers Wanrou* of the NGO Eco-Benin. In 2013, the NGO Eco-Benin started a project

regarding improved cooking stoves: *La Promotion des Foyers Améliorés Erythréens dans les communes riveraines du Parc national de la Pendjari au Bénin* (la ProFAEB).Currently, these stoves are known under another name : Wanrou stoves. The project took place in five communities in the Atacora region in the north of Benin: *Boukombé, Tanguièta, Cobly, Materi*and *Kerou*. Officially, the project ensured the construction of 12 000 improved stoves spread over 3500 households.. In the meantime the project ProFAEB – what was foreseen for three years – has already come to an end in 2016. The follow-up project, le ProWAD, focuses on another region in Benin. However, this study only focuses on the first project (ProFAEB) largely located around the Pendjari biosphere reserve. All aspect of this project were assessed in this section. This was based on surveys in the field with users of the stove (the providers), interviews with the broker Eco-Benin and the operational plan of CO2-logic (The Gold Standard, 2017). First, the general context was sketched. Thereafter, the strengths and weaknesses of the project were examined. Broker, provider and buyers are shortly introduced below:

(i) broker

A couple of organizations, like the Gold Standard Foundation and the NGO CO_2 logic, were involved in this project. However, Eco-Benin was the most important factor in this project. This NGO came up with the idea for the stoves and started their first project in 2013. In the meantime there is already a follow-up program which Eco-Benin continues to organize. In a way the NGO can be seen as a broker between the users of the stoves and the buyers of the carbon credits who finance the project. Therefore, it was important to contact the NGO to learn more about the project. Three informal conversations took place with representatives of Eco-Benin.

(ii) Buyer

This project has one Belgian buyer : the Walloon agency for Air and Climate. .

(iii) Providers

a survey was done in the villages around the biosphere reserve. In this case, there was opted to interview women, because, according to the Beninese culture, cooking belongs to one of the tasks of women. On the one hand, this questionnaire focused on the general operation of the project, the communication between Eco-Benin and the users of the cooking stoves, possible shortcomings or improvements of the project, etc. On the other hand, the survey checked to what extent the promised results of Eco-Benin match the actual results in the field. Therefore,

questions were included about the amount of wood consumed by the cooking stoves, required cooking time, etc. in order to see if the project achieves its intended purpose (see annex 1.8).

In total, 41 inhabitants were interviewed, of which thirteen did not use the cooking stoves at that moment (see annex 1.6). This took place in six different villages along the two axes around the Biosphere reserve: *Tiele, Kani, Wanteou, Tanongou, Bourgninsou*and*Sangou*.

4. RESULTS

4.1. 4.1. Identification of priority ecosystem services

4.1.1. Interviews with local experts

As explained in section 3.3.1., the results of the interviews with the local experts are organized according to the (merged) DPSIR framework. This section includes therefore six parts. A coherent summary of the results of ecosystem services, state, pressures, drivers and responses (which are the different components of the framework) is given. Finally, all aspects are combined in the last section providing a general overview of the study area. In this way, a cause-effect chain was established.

4.1.1.1.Essential ecosystem services around the Pendjari biosphere reserve

Tourism can be valuable for the local population in the riparian villages around the biosphere reserve. Especially, Tanongou has great potential to attract tourists and make a decent income with it. The village is located close to a waterfall near the park entrance. The north of Benin is the source of **water** for the rest of the country The local population intensively uses the water for many rural activities such as water for agriculture and cattle or even laundry. **Non-wood forest products** (NWFP) are essential for the inhabitants of the study area. Therefore, to meet the need for these products, *la zone d'exploitation des ressources naturelles* was created, where it is allowed to harvest non-wood forest products. The reserve offers also a **cultural** service. Formerly, most people had cult sites inside the park to worship and, until today, access is allowed to enter the park for cultural purposes. The local population still depend on **medicinal plants** for health issues. Normally, people enter the park to look for appropriate plants. Only if it is really necessary, inhabitants buy expensive modern medicines. **Fire** is an important service. It renews the grazing and allows tourism. A lot of other ecosystem services are considered important as well: food provisioning by **agriculture**, **wood** (construction material), **fishing, pollination, wildlife and flora, fodder**.

4.1.1.2. State

Although there is potential for **tourism** in the study area, too little is done with it. The local population can profit more from tourism, especially in Tanongou. The services offered are sometimes poor. All the arms of the **river dry up** for some time in the year. The local population depends more and more on water from the pumps in the villages. The destruction

of a considerable part of the gallery forests has led to the drying up of some rivers. An increased amount of **bee mortality** has been reported on cotton fields. In the past, a lot of beehives were destroyed. The local population has to collect **wood** further and further away. Recently, they already have to go to the mountains. In addition, people start **to cut valuable trees** for non-wood forest products (e.g. Shea tree), because there is no specific species for energy consumption

4.1.1.3. Pressures

Large – higher than the WHO standards – amounts of chemicals, such as insecticides, were measured in the ZOC and even in the park. The production of cotton (which is often associated with large amounts of chemical inputs) is possibly the cause of this **agricultural pollution**. Water can flow from the ZOC inside the park and animals will drink it. Recently, it has been observed that a couple of hippos died. One of the possible causes could be pesticides. Originally, the Pendjari biosphere reserve consisted of many gallery forest. Major parts of these forests were, however, destroyed. By consequence, rivers dry up. In this way, **deforestation** threatens the regular supply of water in the region. The growing population constantly expand its land, but it has to share the land with wildlife which is also living in the area. Wild animals, such as elephants, come close to the villages and destroy agricultural fields. Thus, **conflicts** emerge between **human beings and wildlife**. A study was conducted on the economic value of elephant damage in order to compensate agricultural losses and prevent the killing of wildlife. AVIGREF can perhaps intervene to provide a compensation caused by elephants, lions, etc. In this way, wildlife is more protected. **Poaching** and **logging** also pose a huge threat on the environment destruction of beehives by **illegal harvesting**. Bees are often smoked during these activities. **Grazing**, **fire** and **insecurity** were considered as a threat as well.

4.1.1.4. Drivers

The main driver that causes the threats on ecosystem services is the **population growth**. Sustainable land use need to be developed and finding new alternative incomes is a must. Because of their level of **poverty**, households near the reserve highly depend on resources provided by the biosphere. By consequence, a lot of resources are exploited by the local population. **Land tenure** around the Pendjari National Park is a difficult matter as well. The colonial administration expelled the population and installed them on the two roads limiting the biosphere. It was only after the independency of Benin, it became a national Park. But,

people still consider the area as their land, and definitely not the state's property. This is a difficult situation and short-term changes are unlikely. People have even set up a system where the state does not have the rights to expel them if they want. Recently, the government is trying to change that. Alcoholism is a serious **socio-cultural** problem. E.g. the local population in Tanongou has a very strong alcohol culture. Although they are well supported and facilities are all right (even accommodations to spend the night), the provided services are not of a high level. **Illiteracy** and **corruption** at higher levels can also be identified as drivers as well.

4.1.1.5. Responses

La zone d'occupation contrôlée (ZOC) was granted to the population as a **compensation** of the government. The intention is to restrict the increase in agricultural land. In *La zone d'exploitation des ressources naturelles* it is allowed to harvest non-wood forest products in order to meet the needs of the population. **Co-management** is very advanced in Benin. 30% of the revenues from tourism and game hunting flow to the local population through AVIGREF. So, the association is involved in management and primarily invests in patrol and sensitization. Nevertheless, only 6-7% of the local residents are member of the association. Thus, in fact, 6% of the people benefit from 30% of the revenues. Moreover, when CENAGRREF needs help to do work in the field, members of AVIGREF are contacted and hired for the job. In this way, there is a double benefit for the people of AVIGREF. In comparison, the town hall receives only 6% and represents much more people. Meat from game hunting also goes to AVIGREF and they can manage the sale, but often the meat ends up at the members of AVIGREF. This situation creates tension in the villages and people who do not benefit from these revenues sometimes go to get their meat themselves. In addition, the revenues also include fines and some groups of the population consider these fines as a cost of use, since staying out of the park is no option for them. For a large part, this means that in order to prevent people entering the area, the money of fines caused by people entering the area is needed. This creates a vicious circle.

An appropriate **strategy** to make the importance of the conservation clear to the local population is **lacking**. They must be convinced that by conserving the resources they will benefit more than by destroying it. The park management has the essential task to lead everything in the good direction, but in order to accomplish their goals they have to be supported by higher authorities. The **link** between the **local** management and the **government**

is missing. Even employees of the partners, such as CENAGREF, are not paid by the government. A consistent source of wages has to be found, but on the moment the government pays not even half of the wages. It is PAGAP and the world bank who provide the wages. In this way, employees are not motivated. This creates a **management problem.** A fundamental problem is the **bad cooperation** between the ministry of agriculture and ministry of environment in Benin. So, strategies to increase yields can be implemented without taking into account the possible negative consequences for other services such as water, soil, wildlife or even humans, since people drink this water directly. In order to reduce the pressure on natural resources, the **right part** of the population has to be **targeted**: the people who have a significant impact on the resources. Today, many projects focus on schools and women, but these people have less impact. Therefore, 'big consumers' should be accompanied and financially supported.

The decision has been made to **allow** the Fulani, a certain ethnic group, to enter the park to the *Magou* river with their **cattle** for water. The problem is that the animals linger on the way back and graze. The management of the hunting areas is done by the *amodiateurs*. They arrange contracts with **sport hunters** to secure species and amount of animals hunted and the meat is redistributed to AVIGREF. One tries to combat poaching by providing activities which occupy the local population and, so, prevent them from poaching. E.g. this took place in Tanongou, where presumably poachers can be found, certainly in the dry season. In the beginning, this did work, but in the meantime the contact is blurred. The introduction of **income generating activities** can reduce the pressure on other ecosystem services as well. One should try to combat poverty by providing these activities.

Improved cooking stoves are promoted in the area by several NGO's. These fireplaces consume less wood and would reduce the pressure on forests in the region. A **reforestation project** is in operation of the NGO Jura Afrique to restore the watercourse of the Pendjari river. Committees has been setup in the villages and they reforest the gallery forests in the region and this already for 4-5 years. Beekeepers and market gardeners are members of these committees to ensure the actions can continue for a long time. Reforestation programs were initiated in Porga and Matéri, but failed. However, the projects continue in Tanguièta and Boukombe. Participants of the projects are trained to produce plants and resell them to Jura Afrique. There are also supported during the activity of planting. Little projects support nursery schools in the area where students learn how to produce seedlings. In addition, the committees have to recreate the bed of the stream again.

Beekeepers are trained by Jura Afrique in order to generate an income and preventing them from fire the hives. This project is in operation since three years and the NGO is looking for customers. The director indicates that it is the intention to double or triple the price of honey. In 2008, an initiative regarding **biological cotton** was launched (project Alafia), but until 2012 is was merely experimental. There was investigated how to produce cotton without the necessity of chemical inputs, trainings were organized etc. There was chosen for a rotation system of cotton with soy and sesame in order to be organic. Some cooperatives and projects were active in the past, but the payment deadlines and/or certification were not good, so did not work out.

Feu de correction is lighted to provide on the one hand at all times pasture for wildlife, and, on the other hand and more importantly, to provide a good vision for the tourists. Hunters benefit as well. **Agricultural innovations** are investigated that can reduce the use of pesticides and fertilizers. **Agro-forestry** is promoted as well to diversify the production. Some projects are active to diversify the nutrition of the local population. Part of these projects are e.g. planting useful tree species in the home gardens.

4.1.1.6. DPSIR-framework

The main trends and responses around the Pendjari biosphere reserve are summarized using the DPSIR-framework and will be discussed starting from the main identified drivers: population pressure and poverty. Fig.5 shows a global overview of the drivers, pressure, state, ecosystem services, responses and how they influence each other.

Population growth is considered as one of the main drivers around the Pendjari Biosphere Reserve and has at least two direct consequences which are a threat to the natural environment: deforestation and lack of agricultural land. However, literature indicates a population growth around 4% which is still acceptable in comparison with other parts of the country (section 1.3.4). Besides the obvious effect of a reduction in forest area (which influences the ecosystem service carbon sequestration), deforestation has an impact on the hydrological cycle as well and, currently, arms of the Pendjari river dry up early in the year. In this way, water provisioning in the study area becomes insure and the local population asks for help. NGO's try to combat deforestation by implementing several projects regarding improved cooking stoves and reforestation. Although it was suggested that projects often do not focus on the right groups, 'big' consumers are rarely targeted, while such response is actually needed to reduce pressure on forests in the region.

Another consequence of the growing population is that this creates a lack of agricultural land. Which in turn leads to a human-animal conflict and the disappearance of valuable tree species. The *zone d'occupation contrôlée* (ZOC) was allocated to the local population, but land still remains scarce and people share more and more the same space with wildlife. The problem is that these animals sometimes damage agricultural fields of the farmers. It may happen farmers kill these wild animals to protect their assets. This can have negative consequences for the ecosystem services biodiversity and tourism in the Park. A study was done on economic damage, but for the time being there is no compensation system in operation. A NGO tried to reduce this conflict by providing materials to fence the home garden of the local population. Moreover, because the availability of land is low, farmers want to optimize the agricultural system by removing trees from their fields. Furthermore, it was said that there is not a specific tree species for energy consumption and trees valuable for other purposes like non-wood forest product are often used. A possible response from the administration can be to convince the local population that they will profit a lot more in the future by conservation than the rapid profits they obtain now. However, such conservation strategy is lacking. Mainly, NGO's try to make them aware of it. Moreover, projects of NGO's also focus on implementing agro-forestry systems.

Poverty in the study area leads to poaching and illegal harvesting of beehives. People do not have another option and these activities generate very fast profits. Poaching in turn causes a reduction of animal population which may influence tourism around the Pendjari Biosphere Reserve. The park administration tries on the one hand to keep the population busy by offering them income generating activities to prevent them from poaching, and on the other hand, to catch the poachers. The former park administration tried to combat poverty by implementing a co-management system with AVIGREF. 30% of the revenues of vision tourism and game hunting flow to AVIGREF in order to improve the livelihoods of the riparian population. However, it seems that mainly members of AVIGREF itself profit from these measure which creates tension between members of the organization and other villagers.

Poverty in combination with population growth lead to the need for increasing agricultural needs. This is usually accomplished by the use of chemical inputs such as fertilizers and pesticides. Chemical components of these inputs are already detected in and around the water of the Pendjari biosphere reserve. Due to a bad cooperation between the department of agriculture and environment, application of these products can go on without taking into account effects on others services. High concentrations can have negative consequences for

wildlife and humans, since they drink the water. Moreover, a high bee mortality has been observed near conventional cotton fields where many chemical inputs were used. So, in the end, ecosystem services like water provisioning and pollination can be disturbed. Ngo's try to answer these threats by train beekeepers and promoting organic farming.

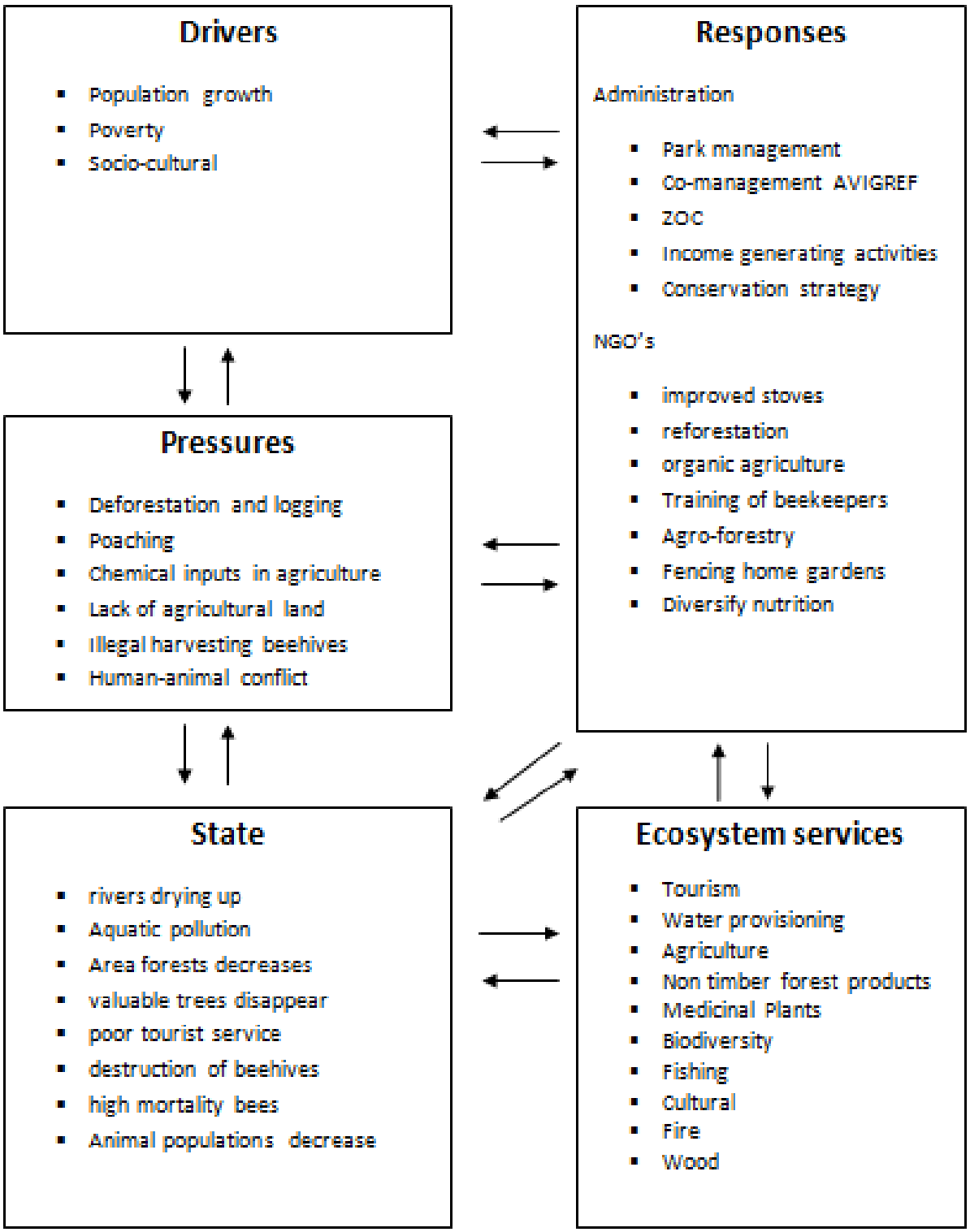

Fig. 5: The establishment of the cause-effect chain using the DPSIR framework

Some experts considered alcoholism as a growing socio-cultural problem on the local level, especially in Tanongou. This sometimes results in poor services offered to the tourists and leads to a reduction of visitors. Which in turn reduces the benefits of tourism on a local level and poverty increases. Another socio-cultural problem is the idea about land tenure. The local population considers it their land and this may cause deforestation and exploitation of other services.

4.1.2. Focus groups

Analyzing the prioritization (where participants attach a value to each service), it can be observed that agriculture is considered the most important ecosystem service, as what could be expected in advance (Fig.6). The mean attached value of importance is 0.17. Also not entirely against expectations, this is directly followed by domestic water use (0.13). Fig. 6illustrates that education, tourism and fishing occupy respectively places three, four and five based on mean value of importance. Beekeeping and drinking water for animals just exceed a mean value of 5%. Hunting, fodder and surveillance are considered less important by the ten surveyed groups. Erosion control, flood protection and climate regulation were the least appreciated.

However, the mean value does not show the whole picture. Annex 2.2 lists the mean, median and standard deviation for the different ecosystem services. The median value of importance for agriculture (Mdn=0.16), domestic water (Mdn=0.13), tourism (Mdn=0.09) and education (Mdn=0.08) are the highest and do not differ much from the mean value. The values of importance of livestock, wood and non-wood forests products are lower in comparison with previously mentioned services. Nevertheless, it seems that these ecosystem services are important for a larger part of the population, in contrast with e.g. fishing and beekeeping. Each focus group consistently valued these services – admittedly rather low – and standard deviation is, therefore, low (see annex 2.2). The results of the ecosystem service fishing based on the mean value are a bit misleading. The value for fishing of the fishermen in Porga are, logically, really high and have a strong influence on the general result. This can be observed from the median, which is zero (Fig. 6). The median of beekeeping also differs considerably from the mean value (Mdn=0.02). This indicates that certain focus groups attach more value to this service than others. Of course, this results are within expectations. Logically fishing and beekeeping play an essential role as ecosystem service for respectively fishermen and

beekeepers. Differences between focus groups will be more thoroughly discussed in the following paragraphs.

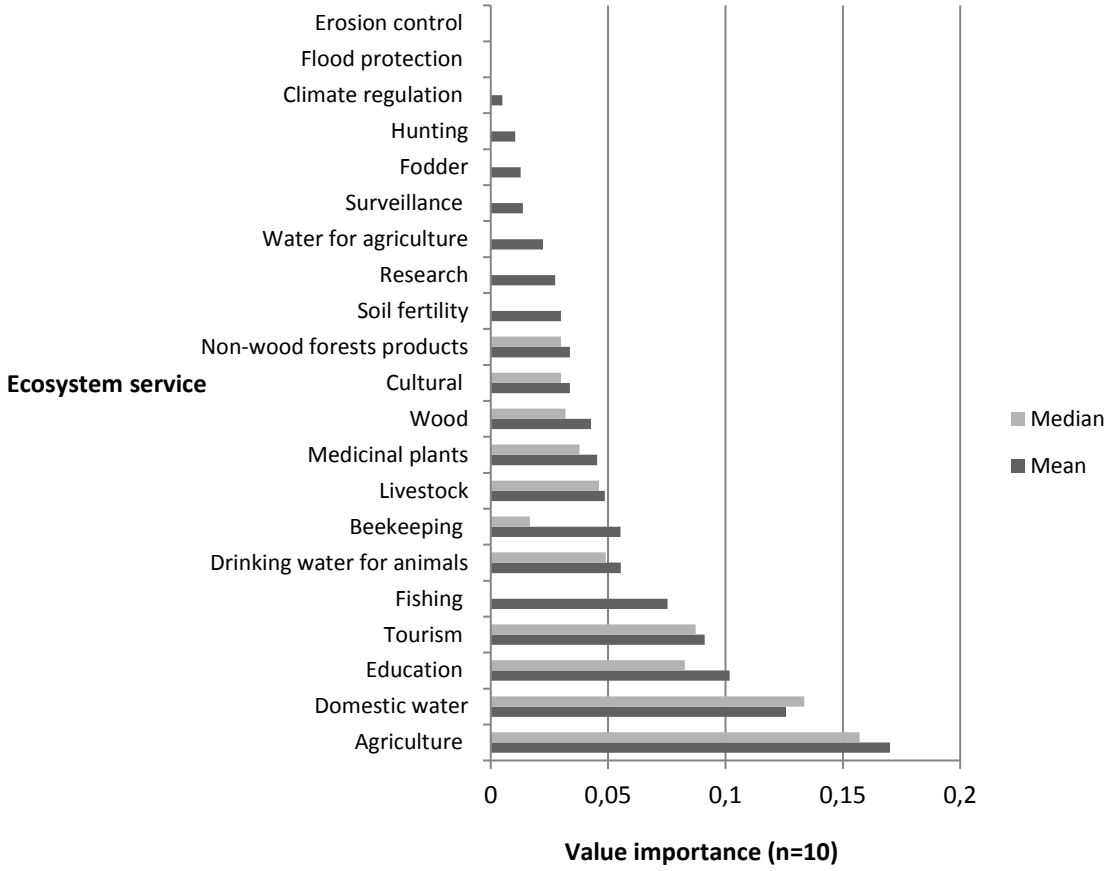

Fig. 6: Mean and median of the value of importance for the 10 focus groups

Each focus group attached a certain value to each ecosystem service by allocating an amount of seeds to it.

In order to keep an overview, the ecosystem services will be discussed in detail separately. Domestic water has clearly a value for every group, although there is some variation between the different focus groups (Fig. 7). Of course, tourism is extremely important for the people active in the touristic sector, but the other groups in Tanongou indicated as well that tourism has a certain – relatively high – value for them. The high values for tourism are not really surprising for the inhabitants of Tanongou, because of the touristic activities in the area (e.g. waterfall of Tanongou). In the local communities of Batia, Dassari and Sepounga tourism is also appreciated. Beekeepers in Batia, however, value tourism less, although they are located at the entrance of the Park. People in Tschassawanga, Porga and the CPL do not profit from touristic activities in the area. The difference between the villages for this ecosystem services

is considerable. Wood is, in general, less valued by the participants, some groups do not even include it. Nevertheless, in some villages, such as Dassari, this service is almost equally valued as water and tourism.

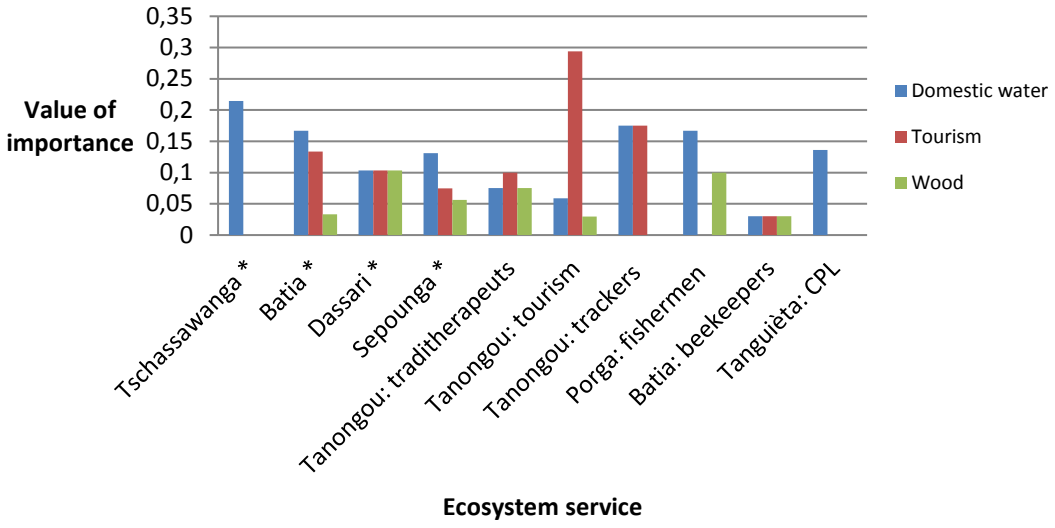

Fig. 7: Value of importance of domestic water, tourism and wood for the 10 focus groups

Annex 2.3 provides the shortened version of the discussion concerning water. Besides that traditional fishing and use of herbicides would pollute water in the region, gardening and livestock consume a lot of water. Moreover, there is a lack of material to repair pumps which are ruined and water dries up in the dry season (as a consequence cattle enter the park and are killed by the foresters). However, some communities indicate that there are no or few problems regarding water. Population growth can threat water provisioning in the future, just like an increase in use of construction material, which requires a great amount of water.

In some villages water provisioning has recently increased, while other participants indicate a decrease. In Sepounga, this is due to the construction of a dam near the village. There are often no measures active in the villages, although once it was indicated that the town hall intervenes in the water management. According to the interviewees, they are the ones who benefit in the first place, but also the people working in the park and – on a larger level – people living much further form the park.

In three focus group, tourism was further investigated (see annex 2.3). The main problem is that there are not enough tourists for the number of guides living in the small villages. Due to their rather limited experience and unprofessionalism, clients often choose to hire guides from well-known organizations. One of the most important observations in the result was

mentioned by the trackers in Tanongou. They consider hunting – and especially poachers – as the main threat for tourism in the area. In recent years, tourism has decreased in the region. This was caused by the Lassa virus[3], even though this was rather a temporary phenomenon. The disease scared people away. Some of the income of touristic activities ends up with the local communities (10%).

Fig. 8 illustrates the results of agriculture, the most important service in the study area, and its traditional economic counterparts livestock and hunting. It seems that hunting is not a main source of income and only two groups assigned a certain value to it. Livestock is mostly included in the list of the groups, but the values are relatively low.

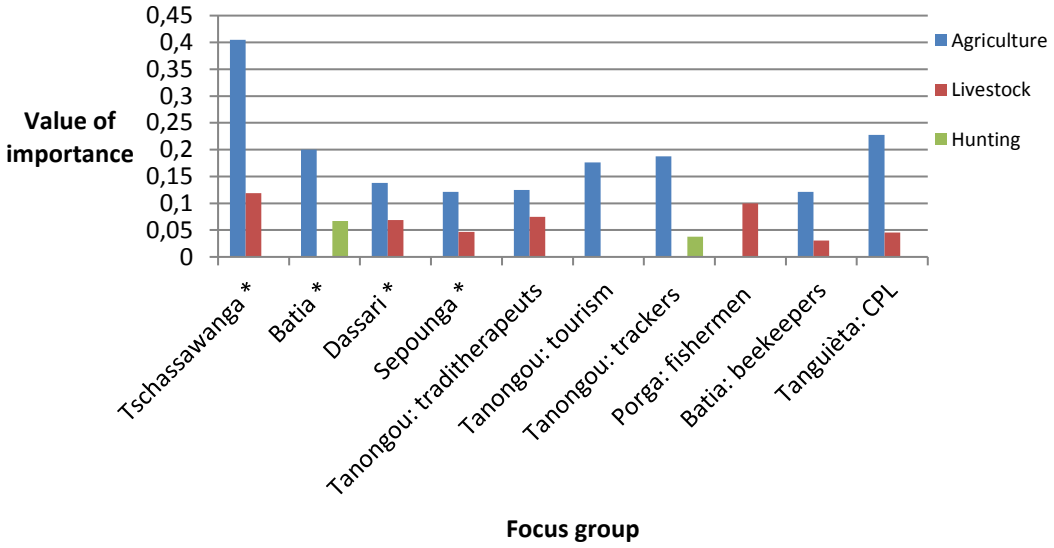

Fig. 8: Values of importance for agriculture, livestock and hunting for the 10 focus groups

In seven focus groups additional questions were asked about agriculture (see annex 2.3). The same trend can be observed across the entire study area. Beyond the fact that land is scarce along the two roads around the Pendjari biosphere reserve, different interviewed groups indicate as well that the soil is poor and infertile. The local communities often ask the authorities to increase their land, but in vein, because no land is available anymore outside the national park. The traditional healers in Tanongou also added :"*Nous avons un problème d'infertilité du sol. Même avec l'utilisation répétée d'engrais sur les terres, ça ne fonctionne plus*." One of the other problems that is frequently mentioned by the participants is the

[3] Lassa fever is a viral disease which causes thousands of deaths in West Africa per year (Olayemi et al., 2016). In February 2017, there was a Lassa fever outbreak in Benin and most cases are situated near the Pendjari Biosphere Reserve (WHO, 2018).

growing conflict between wild animals and agriculture. Monkeys disturb the local population and the elephants leave the park in their search to food and can destroy several hectares of the farmer's land. According to the trackers in Tanongou, however, inhabitants pay a considerable amount of money to AVIGREF to control their activities. But this does not seem to work. Lack of appropriate material, insect pests and irregular precipitation are common problems in the region.

Wild animals, population growth and treatments with fertilizers and herbicides are possible threats and can cause serious problems in the future. Although there is less consensus amongst the participants. On the contrary, everyone agrees that agricultural yields decrease. According to the traditional healers in Tanongou, however, the amount of cultivable land increases. The production focus on the local market, only the cotton is sold to the state. There are a couple of management measures to maintain or improve this ecosystem service. Both CARDER, CENAGREF as AVIGREF intervene.

From the conversation with a group of trackers in Tanongou, it becomes clear that there are some problems associated with game and/or illegal hunting in the study area (see annex 2.3). It is indicated that there is a lack of financial resources to ensure a proper operation of the group of trackers. Currently the trackers work on voluntary basis and their manager seems to be a weak figure in the battle against poachers. Moreover, the park management created a traditional hunting association in Tanguièta that kills certain species excessively. Another consequence is the current presence of cattle in the park which bring diseases. According to this group of trackers, the future doesn't look good either. The conversion system of poachers into *chasseurs professionnels locaux* (CPL) need to be ensured in the future, because when this stops, the poachers will start again and kill all animals in less than two years.

It is noticeable that the four services represented in Fig. 9 not occur consistently in all focus groups. Clear outliers can be observed. So, fishing is obviously extremely important for the fishermen in Porga. It seems that they totally depend on it. However, fishing is for many other groups not important at all, except for the beekeepers in Batia and the local communities in Dassari and Sepounga. The same applies for beekeeping. Only the beekeepers in Batia assign a high value to this service, which is logical. It is surprising that the non-wood forests products score so badly. But is must be said that medicinal plants are in fact a part of the NWFP. Probably combined they would score higher on the importance list. Nevertheless, a lot of focus groups just let these services out of assigned a relative low value.

The group of beekeepers in Batia indicated that, in the recent past, some projects were introduced to help them professionalize the beekeeping activity (see annex 2.3). However, instead of improving the system, these measures have had negative consequences. New hives were delivered by the project, but the bees do not stay. The group states that it used to be better. Moreover, according to the beekeepers, use of herbicides of the cotton farmers in the region is a main threat for the beekeeping activities. On a social level, stealing remains a problem. In this case, a part of the production of honey is often stolen by other villagers.

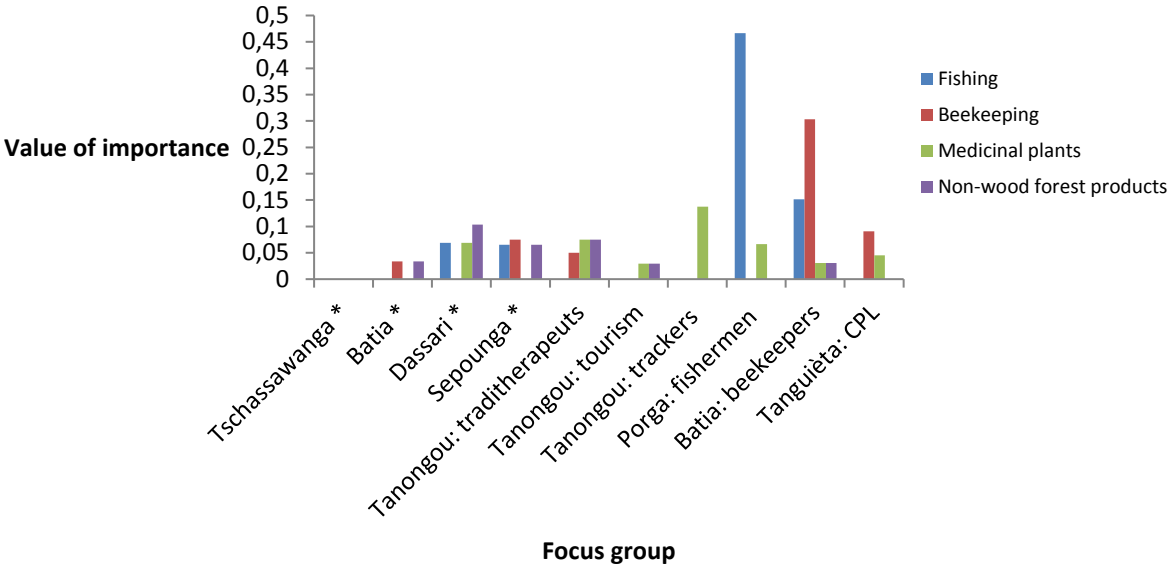

Fig. 9: Value of importance for fishing, beekeeping, medicinal plants and non-wood forest products for the 10 focus groups

Fishing still remains a frequent activity for the local communities around the biosphere reserve. Additional questions were asked to the fishermen in Porga, where a fishing community is active (see annex 2.3). Some fishermen used to penetrate the park following the river. Currently the park is closed and fishermen are forbidden to enter and perform their activities. However, according to the group discussion in Porga, people from Burkina Faso can still enter the park. Another problem is that herbicides end up in the water and a lot of fish die. Some NGO's in the area encourage the local fishermen to concentrate on other activities like *pisciculture*.

Fig. 10 compares the three focus groups in *Tanongou*. A focus group consisting of animal trackers is compared to a group of traditional healersand one of people involved in tourism. There can be observed that agriculture, tourism and education are for the three groups essential, which is similar to the general results. Of course, tourism is the most important

service for the group active in the touristic sector. There can be observed that the traditional healers value a lot more services than the other groups. It is questionable whether there is a good reason for that. Beside some outliers, the results of these groups are quite similar. However, it is premature to state that the type of group, and thus the main activity, has no influence on the importance of ecosystem services.

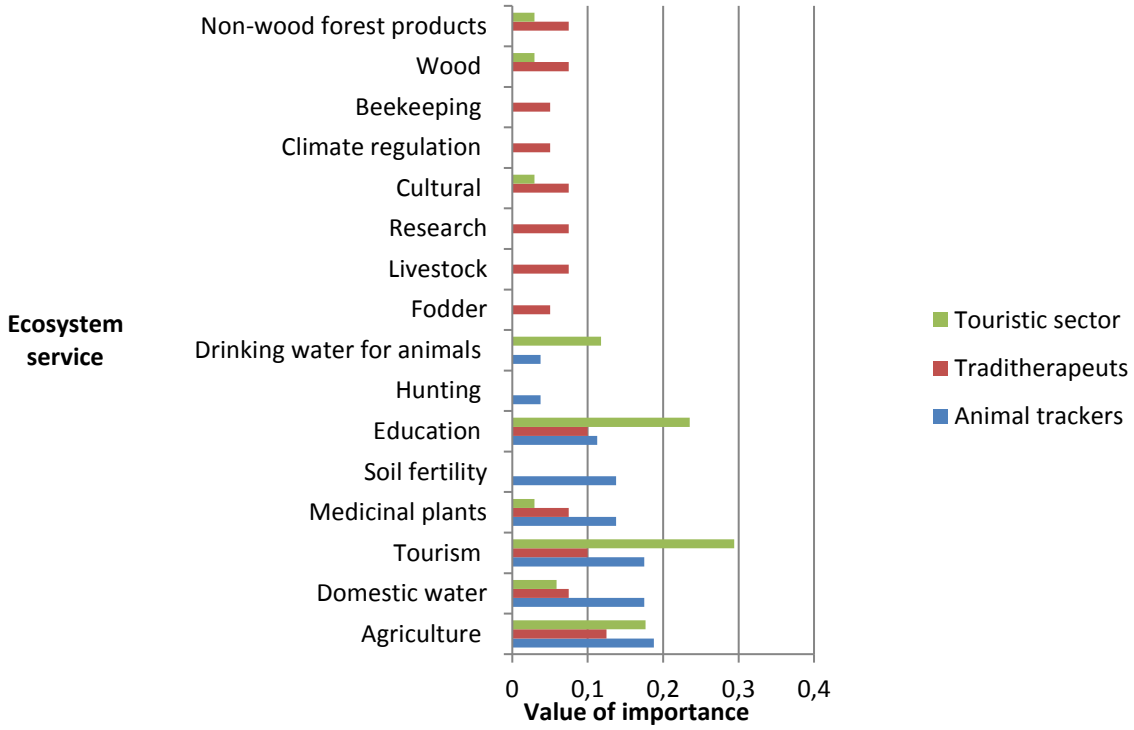

Fig. 10: Results focus groups Tanongou.
(Three groups with different main activity)

To exclude the 'activity effect' and to check whether a spatial effect can be observed, the results of the four focus groups defined as 'local community' are compared in Fig. 11. To keep it clear, only the most important services are shown. Agriculture is the most important ecosystem service for the local communities in Dassari, Tschassawanga and Batia.Soil fertility (not included in Fig. 11.) is on the first place in the community of Sepounga. However, inhabitants in this village attach almost the same value to agriculture, which takes second place. Moreover, soil fertility is strongly related to agriculture and there is actually no clear distinction. Logically, domestic water use is also considered as ecosystem service from which they benefit most. Unlike the villagers of Tschassawanga, inhabitants of Batia, Dassari and Sepounga value tourism a lot.

Villagers of Tschassawanga and Batia attach a great value to education. In Tschassawanga, it takes second place. This demonstrates that some differences can be distinguished between the focus groups, because in the other two local communities is valued less, even no importance in Dassari. As discussed in the paragraph above, generally speaking tourism and education seem to be relatively valuable for most of the inhabitants in the study area. However, these local communities indicate that they profit little from education. It also worth mentioning that it is not clear whether the participants mean all the same when they say education is important or not. It often became clear from further questions that they were talking about education in general – which is of course important, but not an ecosystem service – instead of the possibility to learn more about nature, because these people are in a privileged position to learn about their environment. Therefore, this ecosystem services was added by the researchers to have an idea of their appreciation for something like that. An attempt was made to explain this rather difficult concept to participants, but this probably not always succeed. This can be another reason for the differences in results between the groups. All this observations are in line with the results discussed above. However, small differences with the general results can be observed. E.g. livestock takes a prominent place in the local communities.

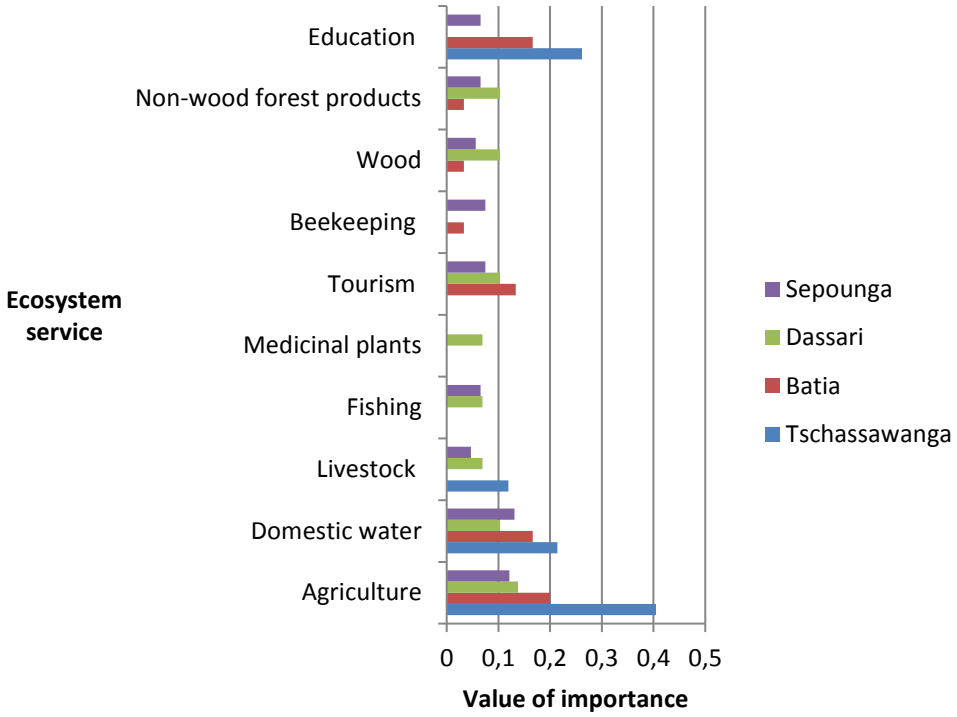

Fig. 11: Results of 4 focus groups with the 'local communities' in different villages.

4.2. Full assessment of priority ecosystem services

4.2.1. Carbon sequestration and storage

Processed and classified Landsat images, provided by Gaillard & Knoops (2018), provide an overview of the spatial distribution of the vegetation. A Normalized Difference Vegetation index (NDVI) image of the study area for the dry season 2017 is illustrated in Fig. 12. It should be noted that the overall NDVI is rather low, because it is an image of the dry season(Gaillard & Knoops, 2018). Using this image, forest areas (higher densities) can be distinguished and separated from the savannah. In this way, the gallery forest on the banks of the Pendjari River can be easily observed, due to high density values. According to the images, most forests are located in the southeast and at higher altitudes, outside the borders of the Biosphere Reserve. A classified image of the different land classes across the biosphere of the dry season in 2017 is given by annex 3.3. The green areas represent forests and mainly correspond with the high density zones in , although a much larger area is classified as forests in this image, especially inside the borders of the reserve. The study area is dominated by savannah (annex 3.3).

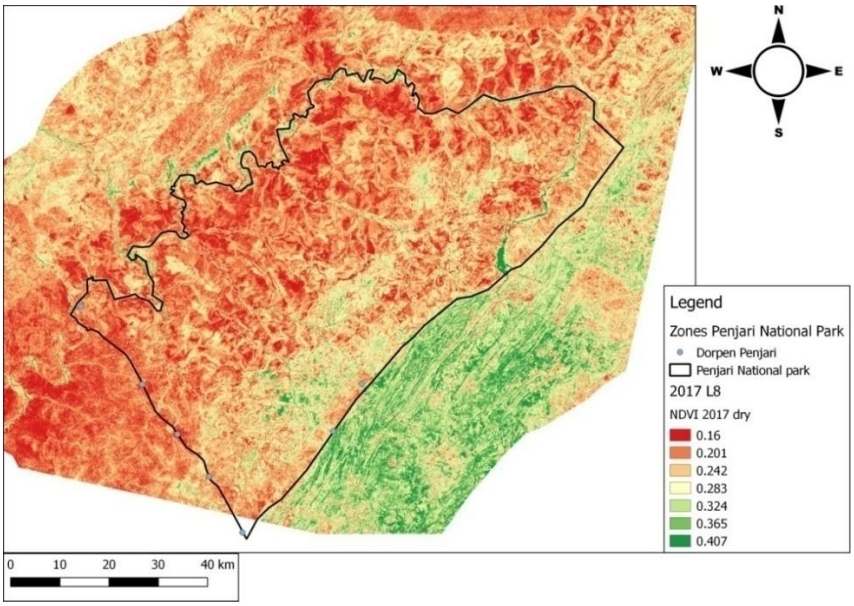

Fig. 12: Normalized Difference Vegetation Index (NDVI) image of the Pendjari Biosphere Reserve

(june 2017) Red colors represent low vegetation densities, while green colors represent high vegetation densities. (Gaillard & Knoops, 2018)

The two classes riparian forest and woodland and woodland savannah have a relative high mean dry biomass density, respectively 94.58 and 45.29 Mg. ha^{-1} (Chabi et al., 2016). But, from section 2.1.3., it becomes clear that these vegetation types occur almost exclusively

within the boundaries of the national parks (the zones were some or all activities are restricted).However, in our specific study area (the *zone d'occupation contrôlée*or ZOC), land has been cleared and currently used for agriculture. The vast majority of this area can, therefore, be considered as cropland (and fallow) or settlement. The values for the dry biomass density are considerably lower, respectively 3.28 and 4.86 Mg. ha^{-1} (Chabi et al. 2016). Only some small areas could be classified as shrub savannah and savannah grassland, of which the mean biomass is not much higher (14.05 and 3.62 Mg. ha^{-1}). The area of the ZOC is 305 km^2 or 30 500 ha (CENAGREF, 2009). The total biomass stock in the ZOC roughly ranges between 100 000 and 150 000 Mg, if all area was cropland or settlement. In reality, this value is probably higher because the occurrence of forests and savannah. However, in comparison with the national park itself and other regions (in the world), these values are very low.

4.2.2. Water

Some results concerning the origin, amount and problems of water use are listed per village in annex 3.4. The same trends can be distinguished across the entire study area. Normally, women get the water from the water pumps in or near the villages. The biggest problems arise when these pumps are broken. Most participants indicated that there is not always enough water available. This is the case for *Kani*, *Tanongou* and *Sangou*. However, people from *Sepounga* have more water than they need all year long. The results of the amount of water used in the different villages confirms this. People in *Sepounga* use remarkably more water than people in other villages. The main problems associated with water are that the water becomes white when it rains and that a lot of insects live in the pumps.

4.2.3. Tourism

In general, tourism in the Pendjari Biosphere Reserve can be subdivided into two main branches: vision tourism (safari's) and game hunting (CENAGREF,2009). Both components generate revenues and will be discussed in this section. To estimate the value of the nature-based recreation in the Pendjari biosphere reserve, the annual total number of visits is essential. There should be noted that this is not the same as the total number of visitors, because it includes repeat visits (one visitor can visit the region more than once). Last year 6688 visits were registered in the National Park (Table 2).

Table 2: Annual number of visits Pendjari Biosphere Reserve (2013-2017)
(Adapted from DPNP, 2016)

Year	2013	2014	2015	2016	2017
Number of visits	6161	6257	4933	4394	6688

Moreover, it can be observed that 2017 was the most successful year in terms of Eco-tourism in the region (Table 2). Similar numbers were reached in 2013 and 2014, when respectively 6161 and 6257 tourists visited the national park. However, in the period 2015-2016, there was a clear drop in the number of visits. It is, therefore, not possible to conclude that the number of tourists – and thus by extension the number of visits –increases year by year. If you go further back in time, it can be observed that the number of visits has increased gradually, starting from circa 2000 tourists in 1996 to approximately 7000 tourists in 2009 (CENAGREF, 2009). This grow seems to be stagnated since then.

Beninese (~40%) and French (~25%) are the two nationalities that visit the reserve the most. Tourists from Germany, Belgium, the United States and Canada were registered in a much smaller proportion. Nationalities of countries bordering Benin are almost non-existent. The main reason – approximately 60% – to visit the biosphere reserve is tourism. Missions (~23%), family visits (~8%) and business (~4%) are also given as reason. On average, visits of the Pendjari national park were rather short. In 2016, more than 80% of the visits were trips of two nights or less. In comparison with the touristic season in 2011, there can be observed that visits have also become shorter and shorter. Last year, the majority of the visits lasted only one night (~45%), while six years ago (2011) circa 8% of the visitors stayed one night and almost 35% percent two nights. Tourists often spend the night in the park itself (~55%) or in Tanguièta (~25%). Only some spend the night somewhere else.

Revenues are divided over three levels: national level, regional level and local level (Floquet, 2011b) Floquet (2011b) reports that 27% of the expenditures of tourists flow to the local level, good for a total added value on local level of approximately €450 000. At least 111 operators are active around the Pendjari Biosphere Reserve in the touristic sector: 63% specialized in business and 37% wage labor (Floquet, 2011b). Accommodation and catering activities create most jobs (62%) on local level and 67% of the added value is allocated to this kind of activities (Floquet, 2011b). Floquet (2011b) states that 31% is for the transport sector and only a small part for local guides or handicrafts. However, tourism is a part-time activity, since tourists are lacking from June to December (Floquet, 2011b).

Table 3 shows the distribution of visits based on total expenses ordering them in four classes. In 2016, approximately one fifth of the visitors spent less than 100 000 F CFA[4] and 16% invested more than 400 000 F CFA. Almost 40% spent between 100 000 and 200 000 F CFA and 10% of the visitors are in the expenses category 300-400 000 F CFA. In comparison with previous years, the number of visitors in the category 300-400 000 F CFA has reduced, just like the category less than 100 000 F CFA. However, number of people spending between 100 and 200 000 F CFA has increased.

According to the evaluation report of Eco-Benin, the results of the data collected in the tourist season 2015-2016 are generally in line with those of previous seasons. Although there can be observed a significant increase in number of visits in 2017 (Table 2) there can be assumed that the other variables –nationalities, nights spent, expenses, etc. – remain more or less the same as before.

In order to get an idea of the total economic value of the ecosystem service tourism, the total revenues resulting from tourism are estimated. The annual total income from nature-based tourism in the study area can be estimated between 880 million FCFA and 1,3 billion FCFA. Taking into account the current exchange rate (12/04/2018), this corresponds to a range of €1,4 million to €2 million. Of course this is only a rough estimate of reality. E.g. for the category of visitors, who spent more than 400 000 F CFA, there was continued to calculate with a value of 450 000 F CFA. This mean expense for this group could be much higher. Nevertheless, this result gives a conservative idea of the revenues of tourism in the study area.

Table 3: Estimation total touristic expenses in and around the Pendjari Biosphere Reserve.

An estimation of expenses is done for the worst (2016) and best (2017) year. Expenses for the non-available data is calculated by multiplying the proportion of this class with the total expenses of the other classes combined.

	Class expense (1000 FCFA)				
	0 - 100	**100 - 200**	**300 - 400**	**>400**	**Not available**
Distribution visits	0.21	0.38	0.1	0.16	0.15
Suggested expense per visit (1000 FCFA)	50	150	350	450	
Expenses 2016 (1000 FCFA)	46 137	250 458	153 790	316 368	115013
Expenses 2017 (1000 FCFA)	70 224	381 216	234 080	481 536	175 058
Total expenses 2016 (1000 FCFA)	881 766				
Total expenses 2017 (1000 FCFA)	1 342 114				

[4] 1euro=628 F FCA

4.2.4. Agriculture

As shown by the results of the interview with the agricultural agency CARDER, the following five crops are the most important in the community of *Tanguièta*: cotton, maize, rice, sorghum and soybean (Table 4). This concerns an area much larger than the study area of this thesis. There can be observed that the cultivated area for each crop increased last year. Most likely the same trend applies to the study area, even though this is not necessarily the case. In 2017, maize was the most important crop (6774 ha) in the region, immediately followed by cotton (6750 ha). However, in 2018, it is the other way around. The total cultivated area of cotton grew more than 30% last year. The same happened for soybean, admittedly on a smaller scale. Approximately 4500 households are involved cultivating these crops (see annex 3.5). For each crop, farmers cultivate only once a year, which takes three or four months (see annex 3.5). So, the fallow period is eight or nine months a year and people use it to rest (see annex 3.5). For cotton, rice and soybean there exist a cooperation (see annex 3.5). Organic cotton will also be discussed in this section, especially in comparison with conventional cotton.

Table 4: Cultivated area for the five most important crops in Tanguiéta (annex 3.5).

Crop	Cotton	Maize	Rice	Sorghum	Soybean
Area 2016-2017 (ha)	6750	6774	3300	2106	1212
Area 2017-2018 (ha)	8800	7752	3645	2430	1615
Increase (%)	30,37	14,44	10,45	15,38	33,25

Table 5 shows the results of the surveys conducted in the field. A ‘typical’ conventional cotton field is clearly the largest, namely 3 hectares. Maize and sorghum fields are already a lot smaller, respectively 1,25 and 1 hectare. However, the field size of conventional cotton fields (and to lesser extent of maize fields) varies quite a lot, in comparison with field sizes of others crops such as sorghum or soybean (see annex 3.6). The values range roughly between 2 and 5 hectares, while the values of field sizes of others crops are rather concentrated around a certain – lower – value. The median field size of the two types of cotton differ greatly (Table 5): organic cotton fields measure 0.5 hectares, which is rather small in comparison with the much larger conventional cotton fields (3 hectares).

Table 5: Field size, yield, subsistence and profits of different crops

c. cotton=conventional cotton; o. cotton=organic cotton; hh=household; the median is used because it is less affected by extreme values.

	c. cotton	o. cotton	maize	sorghum	rice	soybean
Median field size (ha)	3	0.5	1.25	1	0.5	0.375
Median yield per hh (kg/yr. hh)	2000	180	1000	250	300	100
Median yield per ha (kg/yr. ha)	700	333	866	400	1200	250
Median proportion used for subsistence (%)	0	0	0.966	1	1	1
Median profit per hh (1000 FCFA/yr. hh)	249375	17900	98906	45125	27417	16778
Median profit per ha (1000 FCFA/yr. ha)	88188	35800	83400	84375	60400	28636

Moreover, a difference in production rate can be observed between the various crops (Fig. 12). For rice, a median yield of more than a ton is obtained per hectare (1200kg/yr. ha). Annually, a typical farmer harvest 866 kilograms of maize per hectare. The amounts produced on fields of sorghum ad soybean are considerably lower. Per hectare, the yield of sorghum is less than half of the yield of maize and not even a third is obtained for soybean. The production rate for conventional cotton is 700kg per hectare. As illustrated by Fig. 12, it looks like for rice there are many farmers with a high yield and some farmer with a much lower yield (median>mean).In comparison, the situation for maize is a bit the reverse: relative many farmers with a lower yield and some farmers with a high yield (median<mean). The variance of rice and maize yields is also higher in comparison with the other crops. Yields differ between farmers and mainly range between 1000 and 2000 kg. The use of fertilizers, pesticides and herbicides leads to double the yield for the cotton production: households, who grow cotton on a conventional way, produce 700 kilograms per hectare per year, while the median yield per hectare per year for a biological farmer is 333 kilograms. From Fig. 12, it appears that the variance in yields that organic farmers harvest per hectare is smaller, although it is concentrated around a lower value.

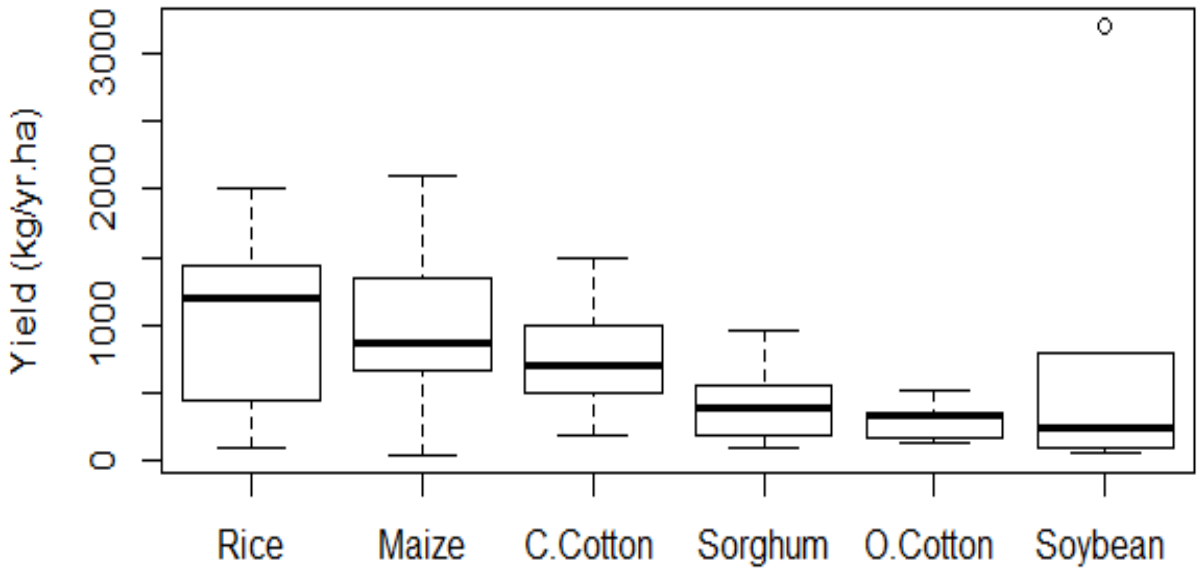

Fig. 13: Yields of different crops per hectare

(c. cotton = conventional cotton; o. cotton = organic cotton)

Farmers in the study area produce the largest amounts of cotton and maize, since both yield and size of fields is high for those two crops. This combination leads to a relatively high production per household in comparison with the other crops (Fig. 13), which indicate that families largely depend on maize and cotton. However, it should be noted that, in general, yields per hectare for these crops are rather low (Jones & Thornton, 2003).

Maize, sorghum, rice and soybean are – for the most part – cultivated for own consumption (Table 5). Families around the Pendjari Biosphere Reserve largely depend on them for their subsistence. For these four products, it can be observed (from the very high median) that the majority of farmers sell almost nothing and keep the harvest for themselves (see annex 3.7). In the study area, conventional cotton is the cash crop par excellence.

It appears, from Table 5, that farmers profit by far the most from conventional cotton, leaving the other crops far behind. A household that cultivates conventional cotton benefits approximately for 250 000 FCFA. This corresponds approximately with €380. Maize takes second place (circa 100 000 FCFA) with still a value twice as high as the other crops. In the case of cotton, this corresponds with the actual amount of money they earn on an annually basis. Although, it should be noted that there are large differences between the individual farmers for the production of conventional cotton (Fig. 14). Many farmers benefit, but cultivation of conventional cotton is not necessarily equal to making a profit. Unfortunately,

there is also a considerable part where the benefit is limited and some farmers even lose money by cultivating this crop.

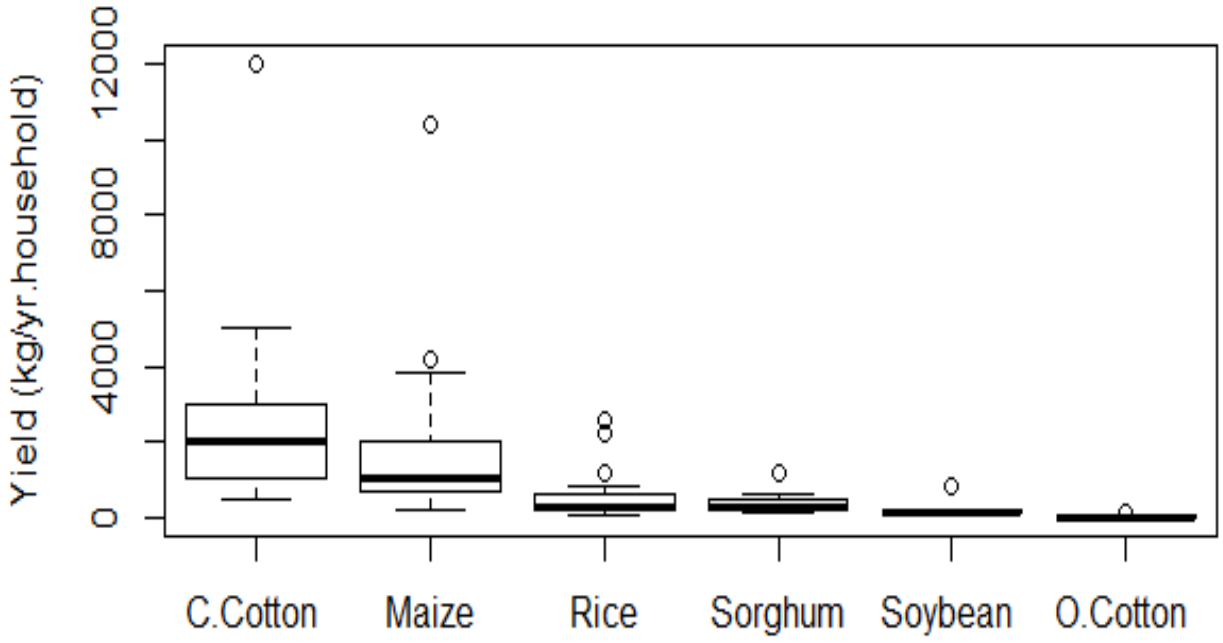

Fig. 14: Yields of different crops per household

(c. cotton = conventional cotton; O. Cotton = organic cotton)

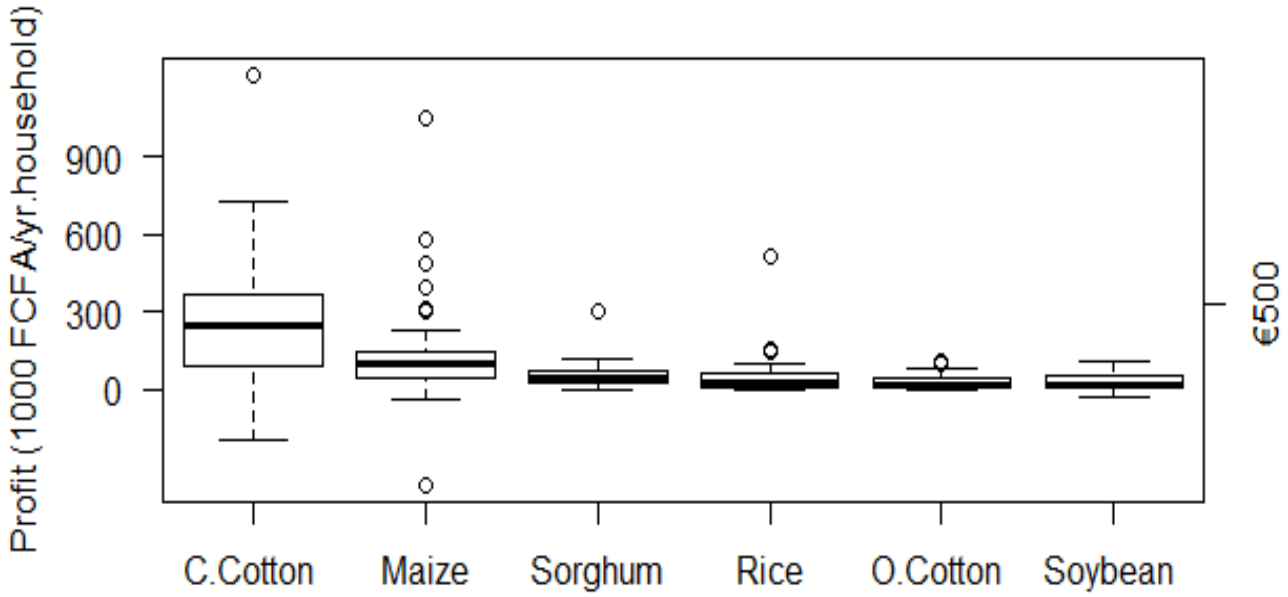

Fig. 15: Profit of different crops per household

(c. cotton = conventional cotton; o. cotton = organic cotton; €1=653FCFA)

The median profits obtained per hectare for conventional cotton, maize and sorghum only differ slightly from each other, although conventional cotton still remains the most profitable (Table 5). The median profit per hectare exceed for the three crops 80 000 FCFA, which

roughly corresponds to €120. The total profit of conventional cotton per hectare is around 88 000 F CFA and per household 250 000 F CFA (Table 5). The profits are significantly lower for organic cotton, respectively 36 000 and 18 000 F CFA. From Fig. 14 and 15, it can be observed that the variance of profits for conventional cotton is high. The extreme values are far from each other. So, a farmer can both win and lose a relatively large amount of money, while this is less the case for organic cotton farmers, because the costs are minimal.

As long as the price or the yields of biological cotton does not increase, most farmers will be inclined to continue with the conventional cotton, since this is the most beneficial. According to a lot of interviewees, they really need the profits to pay for the costs of the other crops, which they use to eat. Farmers realize that the chemical inputs they use can cause serious problems for the environment and human health, however for most farmers this does not outweigh the benefits of the conventional cotton. From the conversations with the farmers on the field (see annex 3.8), the mean reason to grow cotton on a conventional way is that it ensures that farmers can buy fertilizers for the maize production. A group in *Wantehoun* declared that is not allowed to buy fertilizer on credit if you only own biological cotton fields.

Finally, using a weighted average, the benefits people obtain from cultivated goods in the study area are estimated to be at least 62 000 FCFA per hectare per year (or more or less €90). However, this is very rough estimation of reality. In the first place because, as described in chapter 3, an important part of the agricultural system, livestock, was left out of the calculation. This value, therefore, represent the absolute minimum.

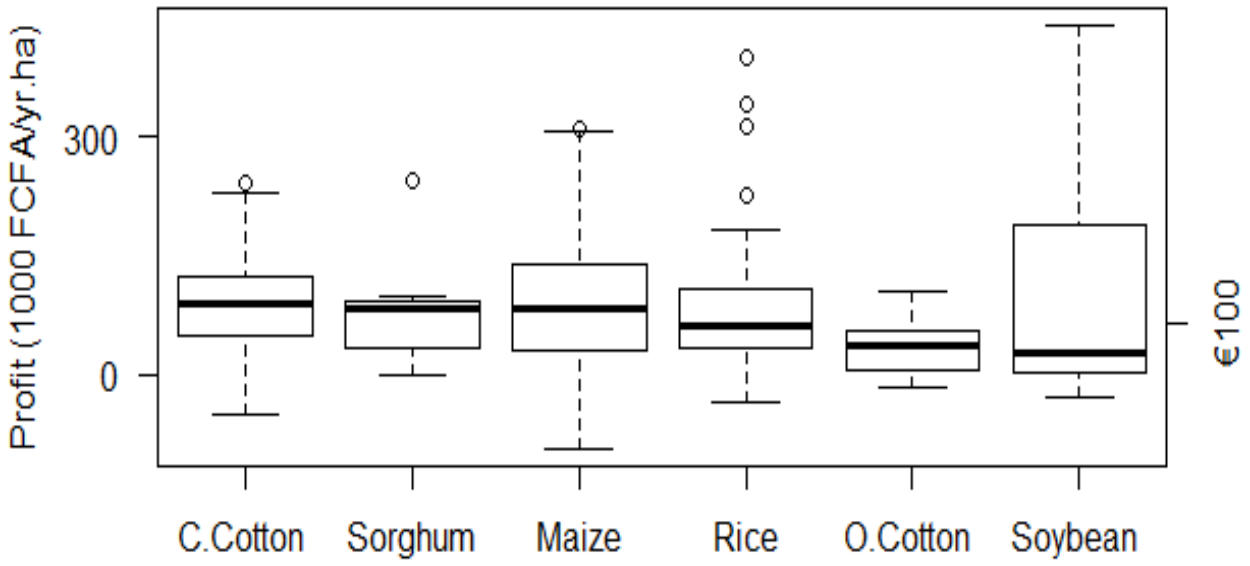

Fig. 16: Profit of different crops per hectare

(c. cotton = conventional cotton; o. cotton = organic cotton; €1=653FCFA)

4.3. Evaluation of payments for ecosystem services schemes

4.3.1. General scheme

Officially, there are 3500 households involved in the Wanrou project (spread over 40 villages) and more than 12 000 stoves were build, the amount which was planned before the project started (pers. Com. Eco-Benin, 2017). The project of Eco-Benin has quite a few similarities with the concept of PES. A couple of actors are involved in designing, planning, financing and putting into practice of this project. Like other PES projects, it consists of three main components: the providers, the buyers and the brokers (Fig. 16). As explained in section 3.5, the project was evaluated based on three sources of information: surveys in the field with users of the stove (providers), interviews with Eco-Benin (broker) and the operation plan of CO_2 logic.

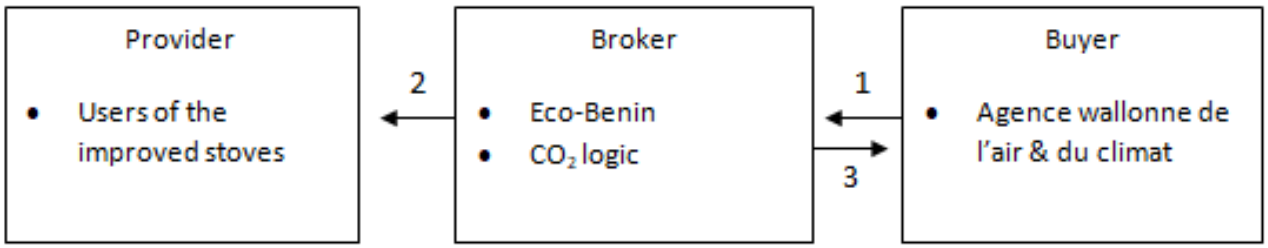

Fig. 17: The Wanrou project as PES scheme

(1). Monetary transaction (2) Non-monetary reward (3) certification/carbon credit

The operation is coordinated by two organizations or brokers: Eco-Benin and CO2 logic. They have to make sure that the reduction in CO_2-emission is realized and, in order to do so, they are financed by the buyer (Walloon agency for air and climate). Therefore, the project should receive a certification. For this, the NGO 's consult the Gold Standard Foundation who controls and evaluates the operation of projects. In this way, it is the intention to obtain the gold standard certificate, needed to convince buyers to invest. Therefore, a strategy was designed by CO_2 logic to fulfill the demanded criteria. An operation plan was drawn up. A reduction of 2 ton wood and 3 tons of CO_2 per year would be realized per household. So, if the project went well, the 3500 households involved should have realized a total reduction of 10 000t/CO_2 per year.The average price for a clean cooking stove offset in Africa is \$5.1/t CO_2(Hamrick & Gallant, 2017). Therefore, it can be estimated that, if successful, the credits obtained by the project are worth a total of \$50 000/yr. To what extent this will be effectively

achieved depends on several factors. The strengths and weakness of the projects will be discussed in this section.

4.3.2. Strengths

4.3.2.1.Stove efficiency

The providers are the participants of the project in the study area. By using an improved stove, they are supposed to consume less wood and, in this way, reduce deforestation and CO_2 emissions. Fig. 17. compares the wood consumption of participants of the *Wanrou* project before (traditional stove) and during (improved stove) the project, based on our survey. In this way, the efficiency of the stoves can be estimated. It can be observed that the improved stoves of Eco-Benin consume considerably less wood in comparison with the traditional stoves. During the project, households of participants used 7 m^3 wood per year, while the median wood consumption with a traditional stove (before the start of the project) was 23 m^3 per family on an annually basis. Our results suggest that the improved stoves of Eco-Benin consume approximately 70% less wood than the 'old' traditional stoves. The results of the improved stoves show some clear outliers, but the variance is rather low. The variance of the traditional stoves is higher. During the interview, Eco-Benin stated that tests were performed which indicated that the improved stoves have an increased efficiency (thermal efficiency of at least 22 %, while this is considerably lower for the three-stone fire). Our results confirm the actual efficiency of the improved stoves in the field in terms of wood consumption and suggest that the stoves work intrinsically very well and have the potential to reduce the pressure on forests in the region.

The amount of wood participants gathered during the project is also lower than before the start of the project (see annex 4.1). According to the results of this research, villagers using the improved stove collect approximately 42% of the amount they used to collect. Mostly, households indicated that they collect exactly the same amount of wood in the dry season and they store the extra wood, because the improved stove consumes less, around their houses. In this way, women do not have to look – or in any case less – for wood in the rainy season. Eco-Benin itself indicated that 50% of wood is saved using the improved *Wanrou* stoves (pers. Com. Eco-Benin, 2017), which corresponds to our findings.

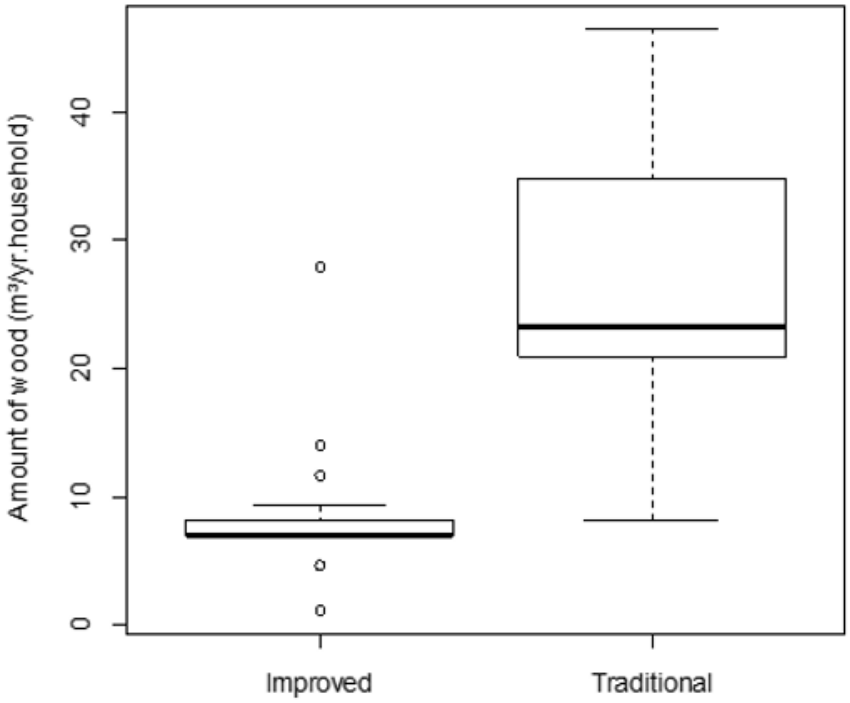

Fig. 18: Comparison wood consumption of different types of stoves

Median amount of wood consumed by improved stove = 7 m³/ yr. household; median amount of wood consumed by traditional stove = 23m³/ yr. household. (Improved: n=27; Traditional: n=23)

4.3.2.2.Additional benefits

Eco-Benin mentioned the variety of advantages for the user. In the mindset of PES, it are the benefits providers receive in exchange for their efforts to protect the environment. In this case, it concerns a non-monetary reward. Our surveys verify that the general impression of the project is positive. No less than 92% indicated to be satisfied about the improved cooking stoves (see annex 4.2). The users often quote the same reasons for this. *Les foyers wanrou* provide a better general hygiene (the cooking pots are cleaner), are good for health (less smoke) and consume less wood (annex 4.2). As shown in Fig. 18, women spend, moreover, less time on cooking when they use the *Wanrou* stoves. Cooking time is reduced by 30 minutes for each meal. Originally, households spent circa 21 hours a week to gather wood when they were using the traditional stoves. This became a seasonal activity with the introduction of the improved stoves. When the project was running, households did not have to gather wood at all in several months of the rainy season (often not the entire season). This is also a major advantage.

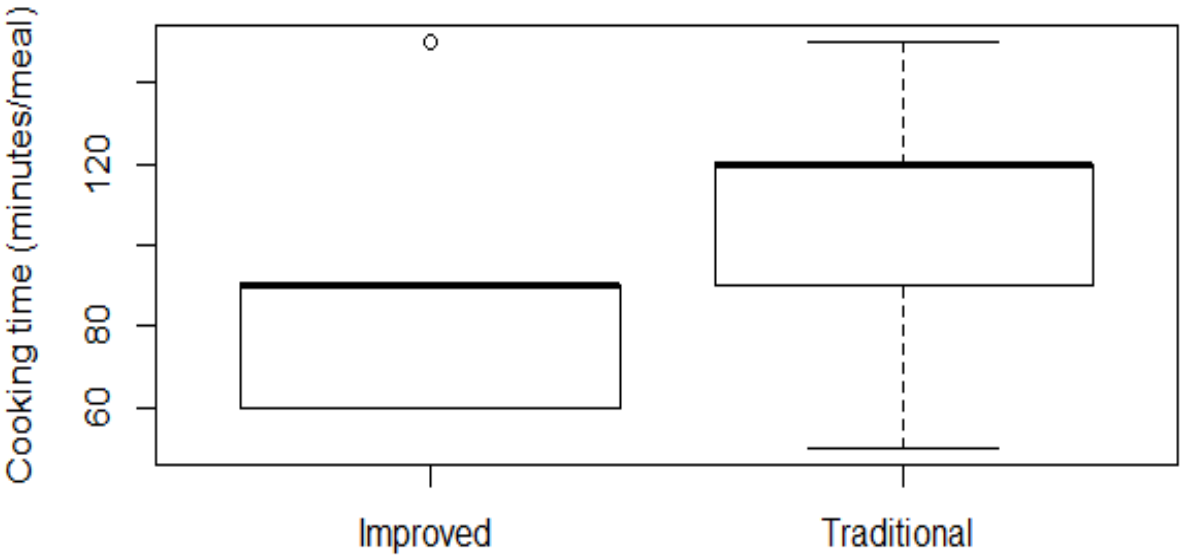

Fig. 19: Comparison cooking time between improved and traditional stove

Median cooking time improved stove=90 minutes; median cooking time traditional stove=120minutes, reduction=30minutes. (Improved: n=16; Traditional :n=16)

Furthermore, 86 % of the users never had a problem with her stove and approximately 58% do not think improvements are needed. However, the group of people who believed there are improvements needed gave some excellent suggestions (see annex 4.2).

4.3.2.3.Continuation

The NGO works with a committee of instructors in each village. This committee consists of available women who show some commitment to the project. These volunteers are responsible for the local diffusion of the Wanrou stoves. Eco-Benin teaches them how to build and maintain the stoves. Approximately, 400 women were trained by the NGO. It was the intention they worked for three years as long the project was running. These women build and help others for free and the project brings all the material. They are not paid, but the NGO is able to mobilize all the instructors, for one or two weeks, to spread the stoves in the villages.

4.3.3. Weaknesses

4.3.3.1.Lifespan stove

At the moment of our survey, almost 70% of the stoves were broken, mainly due to heavy rain (73%) (see annex 4.2). These stoves are not yet repaired and are, on average, five months out of use. These people currently use the traditional stoves again. The stoves which are still operational (32.14%) are mostly located inside (86%) and, thus, protected from the rain. The

group of women in Tiele sees it even more bleakly thinking that only two per cent of the stoves still works. The project started three years ago and this is also the lifespan of a *Wanrou* stove, because the efficiency decreases throughout the years (pers. Com. Eco-Benin, 2017). However, in the design of the project, it can be read that each stove should be replaced once every three years and every time it is broken (see annex 4.3).

4.3.3.2.Follow-up and monitoring

From our survey, It can be observed that forty percent never received a visit from a representative of the NGO and one fifth just once in the three years while the project was running (see annex 4.2). Only one out of five experienced active support of the NGO. Approximately 7% indicate that the NGO intervenes actively and offers the villagers help. However, 50% of the interviewees mentioned that they receive help, but not from Eco-Benin. According to the surveyed users Eco-Benin controlled approximately one fourth of the stoves regularly. Women, in Tiele, declared, during a group discussion, that they never received any kind of support from Eco-Benin (see annex 4.2).

The design of the project included a monitoring plan. In order to prove a real CO2 reduction in the field, it was intended to monitor three factors annually: the usage rate of the improved stoves, a discount factor to account for efficiency loss and a discount factor to account for the baseline stoves which are still in use. Therefore, a sample has to be taken from each size of cooking stoves once a year (annex). It is not clear to what extent this happened.

The plan states that every stove owner has to be visited at least once per year by Eco-Benin (see annex 4.3). Eco-Benin itself confirms following up the project to check if instructors really built the stoves and if the households indeed use the stoves (pers. Com. Eco-Benin, 2017). The follow-up happens through community relays and facilitators who were recruited for the project and, normally, each household should be checked almost daily by the community relay (pers. Com. Eco-Benin, 2017). Restricted by their budget, only three facilitators have been appointed to follow up the project in 45 village and this is not enough (pers. Com. Eco-Benin, 2017).

4.3.3.3.Rewards

A group of women is convinced that others – people who were trained directly by the NGO – receive money and support. The group in Tiele claimed that a lot of women, who also work hard helping the others and constructing the stoves, do not get recognition. Moreover, unlike

them, women in other villages would receive compensations. This creates tension in the village. Although the group is not happy with the attitude of Eco-Benin, they declared to be motivated to start again. However, this time it would be different, they would build it for themselves and not in the name of Eco-Benin. In the future, they would also consistently cover the stoves against the rains.

Normally, users had to pay around 1500 F CFA for having the stoves, but because the project took place in a relative poor rural area, this measure was abolished (pers. Com. Eco-Benin, 2017). In this way, the women who build the stoves do not receive anything from the users and, therefore, Eco-Benin gives small bonuses to motivate them to keep on working during and after the project (pers. Com. Eco-Benin, 2017). Therefore, Eco-Benin introduced a reward system for the instructors, but this was not systematically in all villages (pers. Com. Eco-Benin, 2017). Instructors received ducks, which they had to raise in order to give the ducklings to another family after a certain period (pers. Com. Eco-Benin, 2017). The idea is that finally everyone benefits from this small initiative of Eco-Benin.

Moreover, 92 % never received any kind of reward for using the stoves. One person received seven ducks – which she had to raise and return the ducklings – and one woman received once two thousand *franc CFA.* However, both women are not sure of the origin of this reward. So, it does not necessarily have to be from Eco-Benin.

4.3.3.4.Bad targeting

It should be noted that the project only targets a particular part of the population who puts pressure on the forests in the region and big consumers, like people making the transformation to wholesale, are left out (pers. Com. Eco-Benin, October 2017). Moreover, the local brewed beer in the region is very popular, the production is an important economic activity and demands a huge amount of wood , but these people are also not included in the project, since the stoves are too small for their activity (pers. Com. Eco-Benin, October 2017). Also people in town are not targeted, because they need a removable model (personal communication, 2017). It is therefore questionable whether such projects can actually make a difference in the global picture.

According to our surveys, the values of wood consumption of traditional stoves given by participants of the project – thus values of four years ago – slightly differ from those of villagers who still have a traditional stove until the day of the interview (Annex). The median is more or less the same for both groups, but the mean wood consumption for non-participants

is lower than for participants and a difference in variance can be observed as well. Values of households participating in the project are further apart. The fact that the project was already running for more than three years – so participants had to give values from several years ago – is perhaps a factor here.

Finally, it should be noted that there is a huge discrepancy between the collected and the consumed amount of wood. This may indicate that villagers use wood for other purposes as well, presumably for construction or to sell on the market in Tanguièta.

4.3.3.5.Conditionality

End-users do not have to meet any conditions, are not obligated to use the stoves and can in any moment start using the traditional stoves again (see annex 4.2). Not a single user indicated that there exist conditions for either the construction or the use of the stoves. Moreover, nobody paid for *les foyer Wanrou*. The conditionality factor which is needed for a real PES is lacking here. Nevertheless, the intention is that the benefits the end-users obtain are sufficient to ensure conditionality and in fact this is more the responsibility of the broker in this case.

4.3.3.6.Leakage

Approximately 60 % of the participants solely used the improved stove while the project was running (see annex 4.2). Although a considerable part (40%) continued to use the traditional stoves simultaneously. One of the reasons is that the villagers brew their own local beer (see annex 4.2), for this they need big cooking pots that do not fit the improved stoves. 40% indicated that they used the traditional stove on a daily basis during the project (see annex 4.2).

4.3.3.7.Why not participating

There are multiple reasons why households still not use the improved stoves (see annex 4.2). Absence at the beginning of the project and lacking knowledge of the project at the time were given as reasons. According to other women, there is a lack of support and they indicated they did not find enough help at the moment of installation. One person from Sangou declared she had to deal with some conditions, she had to pay 3000 F CFA for support. Although these women still do not have a *Wanrou* stove three years after the project started, almost everyone is interested to join the project (92%). According to the four women joining the small group discussion in Sangou, they lack the resources to construct the stoves. They

declare that during the first three months of the project they simply did not know the project existed. Afterwards they had to pay for installation.

4.3.4. Perspectives

The willingness among the population to construct the stoves again even without the support of Eco-Benin is high (92%) (section 4.4.1). This is probably because the majority is more than happy with the stoves (section 4.4.1). On the one hand, this suggest the project can continue without the intervention of a NGO and there are signals that the local population can maintain the project itself. On the other hand, many stoves are currently broken and people do not repair it themselves, which can indicate the local population need Eco-Benin more than they show. Moreover, from the interviews with women who still use the traditional stoves, it appears that many locals are willing to join the project and construct an improved stove themselves. However, they still do not have it because they depend on other women for the construction. This may also be a signal for the need of a broker.

5. DISCUSSION

5.1. Carbon sequestration and storage

In our specific study area (zone d'occupation contrôlée), both the amount of forest and savannah was greatly reduced due to anthropogenic activities. Mainly cropland and settlements occur in the zone along the two roads bordering the biosphere. To a limited extent, savannah and forest can still be found and the biomass densities are many times higher, but across the whole area values are low in general (section 4.2.1.). Furthermore, local experts indicated that wood is gradually becoming scarce in the zone and deforestation has destroyed significant parts of (gallery) forests as well. However, wood provisioning did not really emerge as an important ES (or a service associated with many problems) during the focus groups with the locals. Nevertheless, recently, one tries to address the growing threat of deforestation and logging and reverse the situation. Two kind of projects concerning carbon are currently in operation in the study area: improved cooking stoves and reforestation.

5.1.1. Improved cooking stoves

At least two NGO's designed stoves to reduce wood consumption and carbon emissions. The *Wanrou* stoves of Eco-Benin, which could be considered as a PES-like scheme, were selected and thoroughly evaluated in this master thesis. Based on our findings, it may be clear that – intrinsically – such projects have an enormous potential. Users of the improved stoves consume up to 70% less wood and the amount of wood collected is halved according to our surveys. Users receive the material for free and can attend meetings to learn the know-how of constructing a stove. Other advantages are: reduced cooking time, reduced gathering time, more hygiene in the kitchen, etc. Thus, these can be seen as non-monetary rewards for the service providers in the mindset of a PES scheme.

Nevertheless, this is no guarantee of success and this downside came up as well in the analysis of the project. Stoves broke prematurely, traditional stoves were still used, the monitoring (network) is weak and insufficient, etc. In short, the follow-up of the project largely failed. This is probably due to the large distance (both literally and figuratively) between buyers/brokers and providers. Buyers are located on the other side of the world and have zero contact with providers. The contact with the broker turned out to be very limited as well and Eco-Benin was, in fact, located relatively far from the intervention zone. A long chain with several intermediaries can be observed. Eco-Benin indicated not have enough resources to cover the whole area of the project. This could be an indication that the costs of

the intermediaries are too high to eventually run the project properly. In this case, the reality often did not match the predetermined design.

Even though it is not yet – or will never be – a real PES, future similar projects certainly has potential to improve the livelihoods of the local population and in the same time protect the environment. Although the first part of this project may not have been that successful, the second part can do better with adjustments and better organization. But, at least, the major shortcomings should be solved.

Furthermore, it should be noted that the project only targets a particular part of the population who puts pressure on the forests in the region leaving big consumers out , like people making the transformation to wholesale, and people in town (pers. communication, October 2017). The local beer brewers[5]are also not included in the project, since the stoves are too small for their activity (pers. communication, October 2017). It is, therefore, questionable whether such projects can actually make a difference in the global picture.

5.1.2. Reforestation and carbon credits

On the other hand, the NGO Jura Afrique is currently engaged in a couple of reforestation projects. Committees are active for almost five years and mainly consist of a mix of beekeepers and gardeners. This is necessary to ensure activities for a longer time. The first reforestation program failed, but the NGO continued the project in other villages. It concerns small-scale projects which experience a lot of difficulties. "New Tree", the broker of this project, states that about 7.5 km along the river has been reforested (width 25m) and 860 ha of parcels regenerated and protected (new Tree, 2018).The broker is also funded by carbon credits buyers and donations. In this case, the providers are compensated by a monetary reward. More specifically, they are trained by the NGO to grow plants and can then eventually sell it to the same NGO.

However, these projects do not take place in the study area of this study, but in neighboring areas. It is likely that such projects are not feasible in the *zone d'occupation contrôlée*. A conflict with agriculture would arise. Both experts and local communities indicated the acute shortage of available land. Since the local population values agriculture clearly more, reforestation projects are unlikely to succeed. In the case that land would become available here, the chance is great that inhabitants will immediately claim and convert it into

[5]the local brewed beer in the region is very popular, the production is an important economic activity of a major part of the population. It demands a huge amount of wood (personal communication, October 2017)

agricultural land. A possible new PES project would then be confronted with such high opportunity costs required to convince the countless farmers in the area. Moreover, as mentioned above, the main land classes (savannah types) in which the zone could be converted have low biomass densities (the forests with relatively higher biomass densities occur especially along the river). Only a small amount of carbon would be sequestered per hectare, which is less interesting for projects. One often prefers projects that realize better results in shorter time.

Purely from the point of view of carbon sequestration and storage, not much potential can be attributed to reforestation projects in the study area. It should be noted, however, that the added value of such projects cannot be captured in this one service only. Reforestation could indirectly cause the revival of other services as well, such as the restoration of the watercourse in the long term or habitat for valuable animal species. Furthermore, another solution to the conflict with agriculture may be the implementation of (more) Agro-forestry systems. This will be less of a problem for farmers. .

5.2. Water

As shown in Fig. 4, the villages bordering the biosphere are located in the watershed of the Pendjari river. During the focus groups, water emerges – fully understandable – as an essential ES across the whole study area. Water availability is scarce across the study area, especially when water pumps are broken. The quality of water is often not optimal. As mentioned in section 1, PES initiatives are often related to the provision of water services. Many projects all over the world were launched regarding this ecosystem service. Mostly, one of more users are identified (often a water company) and landowners are paid to conserve their land and provide the service. No PES(-like) schemes could be identified in and around the biosphere with regard to the ecosystem service water.

In the first place, inhabitants of the *zone d'occupation contrôlée* can be seen as users of the water service. Water pumps were installed in almost all villages. Then, inhabitants often paid for the maintenance of the pumps. So, when something was wrong, they were able to solve the problem as a community. This concerns a very short local system. Once, a project constructed the pumps and since then the community ensures that it continues to function. In fact, the strong social control forces everyone to participate.

Secondly, because the villages are located in the watershed of the Pendjari, the inhabitants can be considered as the providers or sellers in a PES scheme as well. The buyers or users of the

service must probably be sought elsewhere, since the Pendjari river flows almost directly in Togo, returning to Benin more southerly. Local experts indicated that the use of herbicides and fertilizers of farmers in the ZOC threatens the quality of the water provisioning service. The reduced quality of the water does not only affects the residents along the two roads (focus groups and full assessment confirm the bad quality of the water), but has also impact on a large group of people who live further from the park. However, these people have not the right profile as a buyer. But wildlife living in the park is also threatened. In this context, a water PES project has perhaps some potential. The touristic sector could be considered as a buyer of the water service, since wildlife drinks the contaminated water in the park. The management could then compensate the inhabitants to keep the water clean in order to maintain the population size of the different animal species. This would be an interesting PES chain to investigate in the long term. However, here too, a conflict would arise with agriculture, due to the high yields obtained with conventional cotton (and other cultures associated with fertilizers and herbicides). It is clear that further research is needed.

5.3. Tourism

End 2017, the former park management CENAGREF was replaced by the non-profit organization African Parks. Above all, this switch of power will have an impact on the touristic sector. Both literature and our findings from interviews still describe tourism under the former management, since the fieldwork took place during the transition period. This section consists, therefore, of two parts. Firstly, the ecosystem service tourism will be fully assessed and discussed under the old regime. Secondly, attention will be paid to possible changes that are on the way. The perspectives of the new policy will be explained and an attempt will be made to estimate what the future holds, because it is likely that quite a few things will change under African Parks.

5.3.1. Tourism under CENAGREF

Inhabitants of the study area consider tourism as one of the most essential ecosystem services provided by the park. According to our estimations, the total economic value generated by the tourism industry in and around the park can be estimated between €1.4 and €2 million on an annual basis (2016-2017). Floquet & Lawani (2009) estimated total touristic expenditures at $2.5 million (circa €2 million) in 2009, which correspond to our findings. Since 2009, the number of visits has stagnated and shorter trips were registered. Subtracted by the costs, the total added value of vision tourism is estimated at €1.5 million per year (Floquet, 2011a).

It appears that the local level profits from tourism in the region, since the share of the local level is relatively high in comparison with total revenues. The results of the focus groups of this research project confirm this hypothesis attaching a relatively high value to tourism as an ecosystem service. Nevertheless, according to the inhabitants, the number of guides exceeds the amount of tourists in the villages and clients often choose for well-known organizations. The largest part of revenues flows to a select group who have access to sufficient resources like bar infrastructure or a car (Floquet, 2011a). The actual profit of the local population in the villages located along the two roads around the biosphere reserve is, therefore, not clear, since they are generally lacking the resources. Activities where the local population is eligible for, such as guiding and handicraft sales, receives only 2% of the total revenues on local level (Floquet, 2011a).

Data of Floquet (2011a) did not include revenues of the park management. Park entrance fees (and the associated expenditures of tourists for accommodation and transport in the park) were not considered as a benefit for the local level. CENAGREF (2009) estimated that the total revenues from vision tourism for the park management itself (CENAGREF) are 82 750 000 FCFA (circa €125 000) in 2008. Revenues from the game hunting activities exceed those from vision tourism and, e.g. were estimated at 115 500 000 FCFA by CENAGREF(2009) in 2008. This included slaughter fees (45%), hunting permits (18%) and a permit to access the land (36%). It should be noted that an important part of these revenues (30%) generated by game hunting and entrance fees flows to AVIGREF and, so, by extension to the local level (personal communication). Moreover, the meat obtained by the hunting practices also go to AVIGREF who can offer it for a low price to the local population around the park (personal communication).

(Eco-)tourism has undeniably a great potential in the study area both on local and global level. During the interviews, several stakeholders indicated the value of tourism and its potential locally, but, at the same time, the need to exploit the service more. Especially Tanongou is excellently located with a waterfall nearby and close to the entrance of the park. Moreover, the village has the facilities and is well supported. However, despite the mentioned factors, the inhabitants of Tanongou are –for the time being – not capable to take full advantage of the touristic sector and attract enough tourists to make a decent living. Recently, the suitability of the Pendjari national park for ecotourism purposes was tested and eventually confirmed (Olaniyi et al., 2018). More than 75% of the land is suitable for Eco-tourism based on eight

criteria (Olaniyi et al., 2018). Moreover, the recent study states that the moderate naturalness is a major asset for the region to properly develop (mass) tourism.

To get an idea of the magnitude of the tourist industry in Pendjari, the data are compared with another national park in West-Africa: the Mole national park in Ghana. The number of tourists in this park increased steadily throughout the years. In 2007, more than 13 000 visitors entered the park (Wuleka, 2012) and the number went up to 16 000 in 2011 (Acquah et al., 2016). This is more than twice as many visitors as in Pendjari. It shows that the Pendjari National park is not able to lure as many tourists as parks with similar characteristics and geographical location in neighboring countries. Even though Kruger national park in South-Africa belongs to a completely different category, data of both parks are compared. Last year, almost two million people (1 817 724) visited Kruger national park (South African National Parks, 2017). Touristic revenues are probably ten times higher. Perhaps it is not entirely appropriate to compare Pendjari with this kind of famous national parks, but it shows once again the enormous growth opportunities of national parks in Africa and the great potential of the recreation service in the study area.

In this research project, one PES-like scheme concerning tourism was identified in the study area. Co-management is advanced in Benin and, as mentioned above, it is said that 30% of park revenues flow back to the inhabitants of the region through AVIGREF. Meat obtained from game hunting is handed out as a reward to the locals. This seems to tend towards a real PES system, although there are still some challenges. Firstly, the agreements are too vague. One could say that inhabitants do not enter the park in return, but experts indicated that some groups e.g. see this as a cost of use and still enter the park. The money flow is not immediately suspended when certain people violate the rules. This puts the conditionality of the project at risk. Secondly, it seems that only a small part of the population (members of AVIGREF) benefits from it. This creates tension between villagers and puts a large group aside on which the park management could lose it influence. There was a local benefit system under the former management CENAGREF, but it is not clear what the money was exactly spent on. The general perception is skeptical and the integrity of AVIGREF is questioned. Both experts and the local communities expressed their doubts during the interviews. Whether or not the money is well spent, this perception is essential. A well-functioning PES requires in the first place a transparent communication.

5.3.2. Tourism under African Parks

The Beninese government recognizes the potential value of the Pendjari biosphere reserve as a tourist attraction. Recently, a set of projects were launched ('revealing Benin') to, among others, develop sustainable tourism. As mentioned in the introduction, one project in particular focuses on the revitalization of Pendjari national park. In 2017, the new management (African Parks) concluded an agreement with the Beninese government for a 10-year management mandate. The Government will spend US$6 million over five years, which is additional to the Wyss Foundation's funds of US$10 million. The National Geographic Society invests US$7 million as well for the protection and restoration of the park.

Furthermore, a new law enforcement strategy was already introduced: the management was centralized from a new operational base inside the park, new rangers were trained (and are operational) and a special brigade was established(African Parks, 2017). African parks reports that in the first month (December 2017) already 31 arrests were made. It gives the impression that a big chance is coming and supervision will strengthen. The innovation of the touristic compartment of the park has been started as well: vehicles were purchased, the entrance renewed and alternative tours (walking and boat) were tested. The new management itself indicates the importance of the relationship with AVIGREF and meetings were organized in all 23 villages bordering the biosphere. Moreover, community tourist guides received a refreshment training .

The new management's vision and objectives are certainly promising. It seems that the management will professionalize, supervision will strengthen and tourism will be upgraded. First and foremost, large amounts of money were invested recently. Through this investments in both infrastructure and media campaigns, it may be possible to attract more tourists and develop a profitable sustainable (eco-)tourism industry in the future. Moreover, it looks like the local population will be part of it. According to our findings, tourism already turned out to be an important service across the study area. But, in the same time, locals experienced difficulties and the feeling prevailed that the potential was not fully exploited. Something seems to be done about that now and the local population is part of the new management's plans. However, it remains the question to what extent the vision can be put into practice.

When talking about tourism, sustainability must also be taken into account, since tourism can have a serious impact on the environment and, thus, be an important cost of the service. However, literature does not report large-scale negative consequences of tourism in the Pendjari Biosphere Reserve and there is no reason to assume that this would change in the

future. The possible changes do not seem to be of such nature that tourism will develop in such drastic way which can cause serious damage to the environment.

It is likely that the co-management system is maintained (at least in the short term) and may evolve towards a PES scheme. This could offer a solution for the many threats the park faces nowadays. Deforestation, poaching, chemical inputs in agriculture, human-animal conflict, etc. affect the tourism industry as well. An improvement can be that only the providers (or protectors) of a certain ecosystem service share in the park revenues. Possibly difficult to implement, but, at least, it focuses on a larger group of the population and can motivate people to do something or not. In Kenya, a tourism-based PES program was introduced including herders of the Maasai ecosystem (Osano et al., 2013). In return for direct payments, the landowners have agreed to keep their livestock away from areas destined for tourism activities (Osano et al., 2013). Osano et al. (2013) report that five commercial tourism operators compensate the participants. Similar projects could also be started up around Pendjari. However, it is questionable if the tourism industry is big enough to accomplish it, since a large group of possible providers need to be compensated.

5.4. Agriculture

5.4.1. Organic agriculture

Agriculture in the *zone d'occupation contrôlée* (ZOC) is mainly dominated by conventional cotton and maize. The yields per hectare are also higher in comparison with other crops (such as sorghum, rice and soybean). However, it looks like the results presented in this study are an underestimate of the long-term average, because yields are usually higher (Kloos & Renaud, 2014). E.g. yields for conventional cotton in the period 2009-2012 exceeded every year 1 ton per hectare (Kloos & Renaud, 2014), while our results are considerably lower. Food crops, generally used for subsistence purposes, are often replaced by the cash crop cotton. In 2017, the total area of cotton fields in the community of Tanguièta has increased with 30%.Local farmers largely depend on the cash crop, since profits per household, generated by cotton production, are relatively high. However, it appears that profits per hectare are higher for maize and sorghum. Moreover, it should be noted that cultivating conventional cotton involves risks, because profits of cotton production seem to vary a lot between individual farmers. Some farmers even lose money cultivating conventional cotton. This is less the case for other crops.

In 2008, AVIGREF launched a first project (ALAFIA)to promote the conversion of conventional cotton into organic cotton (U-AVIGREF, 2016). This was a reaction on the discovery of high concentrations of chemicals inputs associated with conventional cotton, threatening natural resources in and around the Pendjari Biosphere Reserve (ALAFIA, 2008). Moreover, local farmers consider shade as a negative factor (it decreases yields) and trees are, therefore, removed from the fields (Kloos & Renaud, 2014). Practical considerations also play a role, since tractors often plough the large cotton fields (Kloos & Renaud, 2014). Besides the purpose to reduce the impact of agriculture on the environment, ALAFIA and later projects attempt to improve profits for local farmers (U-AVIGREF, 2016). Lower costs and a higher price obtained per unit should effectuate this (U-AVIGREF, 2016). However, our findings suggests that, despite higher prices obtained per kilogram, profits of organic cotton are considerably lower in comparison with profits of conventional cotton due to lower yields per hectare (section 4). Nevertheless, according to AVIGREF (2016), the cultivated area of biological cotton in the ZOC has increased from 54 hectares in 2008 to approximately 250 hectares in 2016, but conventional cotton still covers around 1000 hectares.

Thus, there has to be another reason why farmers still cultivate biological cotton, since profits are lower. Unlike conventional cotton, organic cotton production does not imply high costs associated with chemical inputs and, so, no need to use credit to purchase them (Kloos & Renaud, 2014). Cooperatives organize cotton production in the study area providing inputs (received from agricultural offices) to the farmers on credit and can play an important role in the decision of a farmer to change to organic cotton (Kloos & Renaud, 2014). When a particular farmer has a negative balance due to a bad harvest and cannot pay his debts, profits of other members of the group decrease as well and the farmer is, therefore, usually excluded from the cooperation (Kloos & Renaud, 2014). Organic cotton production offers a way out and the possibility to still earn a cash income (Kloos & Renaud, 2014). This hypothesis is supported by the results of this study. Profits of conventional cotton seem to differ considerably between individual farmers and some farmers even lose money. This high economic risk associated with this type of cotton can force farmers to convert their land in biological cotton, where risks are lower, since only natural inputs are required (often free).

Another important factor which can explain an increase in organic cotton in the ZOC is that organic cotton production is particularly attractive for small producers, especially women who do not have the same opportunities to access land (U-AVIGREF, 2016). AVIGREF (2016) reports that the number of women involved in organic cotton farming has increased since

2008. In 2016, 63% of the biological cotton farmers would be women, against 33% in 2008(U-AVIGREF, 2016). Culturally, the local population considers conventional cotton as an activity for men and women stay away from these cotton fields, because the used pesticides threat their health and of their children (Kloos & Renaud, 2014). Generally, food crops are also the responsibility of men, who are often not willing to reduce them to offer land to women to grow biological cotton (Kloos & Renaud, 2014). Therefore, marginal of infertile lands are typically used for organic cotton production in the study area (Kloos & Renaud, 2014). It is shown in section 4 that organic cotton fields are indeed smaller in comparison with other crops. However, Kloos & Renaud (2014) reported that these lands and, thus, the production of organic cotton are of great benefits for women, because it generates an additional income for them. In this way, women are able to cover educational costs, improve food diversity and increase access to health care facilities (Kloos & Renaud, 2014). So, only taking account the net profits per hectare does not cover the total impact of organic cotton farming on the local population, since the livelihood of a particular group of the population (women) seem to improve by this practice.

The largest part of land is still used for production of conventional cotton (U-AVIGREF, 2016). Besides higher profits, one of the reasons farmers cultivate conventional cotton is that it gives them access to fertilizers and pesticides, which they can apply on fields of food crops (such as maize) as well in order to increase their yields (section 4.2.). However, biological manure and other practices associated with organic farming, such as crop rotation, may improve land fertility in the long-term. By consequence, agricultural yields will increase. Moreover, organic farming can improve resilience against climate fluctuations caused by climate change, because of increased biodiversity in agriculture.

Furthermore, it can be concluded that conventional cotton and maize associated with extensive use of fertilizers and pesticides still dominate the agricultural system around the Pendjari Biosphere Reserve. As long as it remains more beneficial to grow conventional cotton, it will be hard for NGO's and government agencies to motivate local producers to convert their land into biological cotton fields. Nevertheless, it should be noted that organic farming probably generates an extra income for a particular part of the population, improving their livelihoods. Although organic farming still faces a lot of obstacles, the system has potential to reduce agricultural impact on the environment, reduce economic risks and, moreover, improve at the same time revenues for – at least a part of – the local population.

Monetary or non-monetary rewards may convince farmers in the future to change to organic crop production. However, the support (and therefore the prices) of organic agriculture will certainly have to increase to offer a full-fledged alternative to the conventional market of today. In-kind rewards are, therefore, perhaps more suitable in this case. The allocation of more land could be an option, but may lead to the systematic shift of the limits in the long term. In Uganda, a study was carried out to test the potential of PES projects in adopting more sustainable agricultural practices (Nalukenge et al., 2009). Nalukenge et al. (2009) suggests that PES can be an appropriate alternative to conventional environmental regulations. Therefore, reasonable contracts need to be negotiated with farmers by local institutions and beneficiaries need to be willing to pay for the protection of the land.

5.4.2. Land tenure

Agriculture is often the alternative for PES schemes, since landowners have the choice to either conserve/restore their land or convert it into agricultural land. The study area is almost entirely agricultural land. It should be noted that the study area, *le zone d'occupation contrôlée,* was granted to the riparian population as a compensation of the government. A clear delineated area which inhabitants can use as agricultural land was provided. It was then the intention that the inhabitants farm in the ZOC only and stay within the limits. Moreover, it is allowed to hunt to a limited extent and harvest non-wood forest products in an extra zone (*la zone d'exploitation des resources naturelles*). These in-kind rewards should make sure that the central zones of the biosphere reserve are protected. The local population, however, does not consider it as a nice gesture of the government and find it evident that the land is rewarded and often do not understand why they cannot take other parts. Therefore, it can perhaps not convince the population to stay out of the park. Of course, this has to do with the past. Originally, the land belonged to the population, since they lived there. At least, this is how the population sees it. In 1954, the land was taken away when the park was created. The park was managed with power and repression leading to social unrest and tensions. When CENAGREF started in 1996, the local population became more involved through AVIGREF and over time the ZOC was granted. Nowadays, it seems that, in general, the population complies with the agreements, although there are always exceptions. Another compensation was granted to the Fulani, to whom was allowed to water their cattle inside the park area.

6. CONCLUSION

The Pendjari biosphere reserve delivers a varied cluster of ecosystem services to society and in particular to the local communities living along the two roads bordering the park. Nowadays, the natural resources are being put under pressure and various threats may jeopardize the provisioning of some ecosystem services in the near future. PES systems may offer an appropriate solution to deal with this problem. During this research project, no true well-functioning PES schemes could be identified in the study area. However, various PES-like systems could be distinguished. For some ecosystem services far-advanced systems are already running, while for other ecosystem services very little has happened in this area. Our findings, therefore, suggest that there is quite some potential for some ecosystem services to develop such PES chains in the future. Nevertheless, a clear distinction can be made between the different ecosystem services assessed in this thesis.

Some projects focusing on carbon are active around the PBR. The improved cooking stoves distributed in the villages have *in se* a great potential. Our results confirm both the increase in efficiency and the additional benefits for the users. Nevertheless, the projects face many challenges. The long chain between buyer, broker and providers was assessed as a major disadvantage. Increased transaction costs by intermediaries, a stiff communication and too high expectations threaten the proper functioning and follow-up of the project. It will certainly not be easy to solve these shortcomings. Reforestation projects have little potential in the study area, due to the conflict with agricultural land and the difficult conditions.

According to our results, tourism is perhaps the ecosystem service which has the most potential in the study area. Local communities already consider tourism as an essential ecosystem service. The park still receives, however, relatively little visitors in comparison with other parks in (west-)Africa. Very recently, the management has been taken over by African Parks, offering many opportunities for the future. The prospects for the future are rather positive both for the board and the communities. It is likely that tourism will undergo a renewal and get a boost. Of course, nothing has been proven yet and the difficult transfer from vision to practice still has to be done. Under the former management, an advanced co-management system was in operation. A nice concept, but the good (fair) functioning was difficult to assess. This is perhaps a local PES-like chain that could be further elaborated under the current management.

A lot of problems are associated with water and the proper provisioning of this ecosystem service is threatened. The distribution is very local and there are little perspectives for the future. Agriculture is a bit different. In general literature, it is not considered as a promising ecosystem service in terms of PES. In our study area – and in many places in the world – it remains the most important economic activity for the local communities near the biosphere. A conflict may arise with other ecosystem services.

REFERENCES

Acquah, E., Dearden, P., & Rollins, R. (2016). Nature-based tourism in Mole National Park, Ghana. *African Geographical Review*, *35*(1), 53–69. https://doi.org/10.1080/19376812.2015.1088389

African Parks. (2017). *Restoration: Nature's Return*.

African Parks. (2018). Pendjari national park Benin. Retrieved August 02, 2018, from https://www.africanparks.org/the-parks/pendjari

Ahouansou, D. M. M., Agodzo, S. K., Kralisch, S., Sintondji, L. O. C., & Fürst, C. (2015). Analysis of the Hydrological Budget using the J2000 Model in the Pendjari River Basin , West Africa. *Journal of Environment and Earth Science*, *5*(19), 14. https://doi.org/ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)

ALAFIA. (2008). *Coton biologique et equitable dans la reserve de biosphere de la Pendjari*.

Alimi, M. (2010). *Diagnostic participatif des feux de forêts au Bénin et recommandations pour une stratégie nationale de gestion des feux de forêts*.

Bagstad, K. J., Semmens, D. J., Waage, S., & Winthrop, R. (2013). A comparative assessment of decision-support tools for ecosystem services quantification and valuation. *Ecosystem Services*, *5*, 27–39. https://doi.org/10.1016/j.ecoser.2013.07.004

CENAGREF. (2009). *Plan d 'Aménagement Participatif et de Gestion de la Réserve de Biosphère de la Pendjari 2004 – 2013*. Retrieved from www.pendjari.net/IMG/pdf/pag_pendjari_2009.pdf

Chabi, A., Lautenbach, S., Orekan, V. O. A., & Kyei-Baffour, N. (2016). Erratum : Allometric models and aboveground biomass stocks of a West African Sudan Savannah watershed in Benin. [Carbon Balance Manage, 11, (2016), (16)] Doi: 10.1186/s13021-016-0058-5. *Carbon Balance and Management*, *11*(1). https://doi.org/10.1186/s13021-016-0064-7

Collins, S. L., Carpenter, S. R., Swinton, S. M., Orenstein, D. E., Childers, D. L., Gragson, T. L., … Whitmer, A. C. (2011). An integrated conceptual framework for long-term social-ecological research. *Frontiers in Ecology and the Environment*, *9*(6), 351–357. https://doi.org/10.1890/100068

Convers, A., Chaibou, I., Binot, A., & Dulieu, D. (2007). La gestion de la transhumance dans la zone d'influence du parc régional du w par le programme ecopas. *VertigO-La Revue Électronique En Sciences de L'environnement,, Hors-Série*, *4*, 1–9. Retrieved from http://vertigo.revues.org/index761.html (10/11/2015)

Costanza, R., D'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., … van den Belt, M. (1998). The value of the world's ecosystem services and natural capital. *Nature*, *387*(6630), 253–260. https://doi.org/10.1038/387253a0

DEWHA. (2009). *Ecosystem services: key concepts and applications*.

Djossa, B. A., Fahr, J., Wiegand, T., Ayihouénou, B. E., Kalko, E. K., & Sinsin, B. A. (2008). Land use impact on Vitellaria paradoxa C.F. Gaerten. stand structure and distribution patterns: A comparison of Biosphere Reserve of Pendjari in Atacora district in Benin. *Agroforestry Systems*, *72*(3), 205–220. https://doi.org/10.1007/s10457-007-9097-y

DPNP. (2016). *Rapport synthèse de l ' analyse des fiches de suggestion des visiteurs du Parc*

National de la Pendjari.

Dudley, N., & Stolton, S. (2009). *The Protected Areas Benefits Assessment Tool*. *Assessment*. Retrieved from http://wwf.panda.org/what_we_do/where_we_work/amazon/publications/?174401/PABAT

Ecopas. (2004). Réunion extraordinaire du Conseil d ' Orientation du Programme Régional Parc W / ECOPAS relative à l ' adoption de mesures urgentes pour la gestion de la transhumance dans la région du W, (00 226), 58.

Encyclopædia Britannica. (2018). Benin. Retrieved March 8, 2018, from https://www.britannica.com/place/Benin

Engel, S., Pagiola, S., & Wunder, S. (2008). Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological Economics*, *65*(4), 663–674. https://doi.org/10.1016/j.ecolecon.2008.03.011

European Communities. (2018). Project outline. Retrieved August 10, 2018, from http://www.biodiv.be/evamab/

Farley, J., & Costanza, R. (2010). Payments for ecosystem services: From local to global. *Ecological Economics*, *69*(11), 2060–2068. https://doi.org/10.1016/j.ecolecon.2010.06.010

Fauzi, A., & Anna, Z. (2013). The complexity of the institution of payment for environmental services: A case study of two Indonesian PES schemes. *Ecosystem Services*, *6*, 54–63. https://doi.org/10.1016/j.ecoser.2013.07.003

Fisher, B., Turner, R. K., & Morling, P. (2009). Defining and classifying ecosystem services for decision making. *Ecological Economics*, *68*(3), 643–653. https://doi.org/10.1016/j.ecolecon.2008.09.014

Floquet, A. (2011a). Benin: Developing Protected Areas For and With People. In C. R. Heredia (Ed.), *The Contributions of Protected Areas to the Economic and Social Development in Bhutan, Costa Rica and Benin* (pp. 89–114). Program of South-South Cooperation.

Floquet, A. (2011b). Contributions of the Existence of Protected Areas in Benin. In C. R. Heredia (Ed.), *The Contributions of Protected Areas to the Economic and Social Development in Bhutan, Costa Rica and Benin* (pp. 299–350). Program of South-South Cooperation.

Gaillard, J., & Knoops, J. (2018). Land use changes in and around Pendjari National Park (North-Benin), 1–19.

Gómez-Baggethun, E., de Groot, R., Lomas, P. L., & Montes, C. (2010). The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. *Ecological Economics*, *69*(6), 1209–1218. https://doi.org/10.1016/j.ecolecon.2009.11.007

Hamrick, K., & Gallant, M. (2017). *Unlocking potential State of the Voluntary Carbon Markets 2017*.

Henschel, P., Azani, D., Burton, C., Malanda, G. U. Y., Saidu, Y., Sam, M., & Hunter, L. (2010). Lion status updates from five range countries in West and Central Africa. *CATnews 52*, 34–39.

Idrissou, L., van Paassen, A., Aarts, N., Vodouhè, S., & Leeuwis, C. (2013). Trust and hidden conflict in participatory natural resources management: The case of the Pendjari national park (PNP) in Benin. *Forest Policy and Economics*, *27*, 65–74. https://doi.org/10.1016/j.forpol.2012.11.005

Jones, P. G., & Thornton, P. K. (2003). The potential impacts of climate change on maize production in Africa and Latin America in 2055. *Global Environmental Change*, *13*(1), 51–59. https://doi.org/10.1016/S0959-3780(02)00090-0

Kelble, C. R., Loomis, D. K., Lovelace, S., Nuttle, W. K., Ortner, P. B., Fletcher, P., … Boyer, J. N. (2013). The EBM-DPSER Conceptual Model: Integrating Ecosystem Services into the DPSIR Framework. *PLoS ONE*, *8*(8). https://doi.org/10.1371/journal.pone.0070766

Kloos, J., & Renaud, F. G. (2014). Organic cotton production as an adaptation option in north-west Benin. *Outlook on Agriculture*, *43*(2), 91–100. https://doi.org/10.5367/oa.2014.0166

Leimona, B., van Noordwijk, M., de Groot, R., & Leemans, R. (2015). Fairly efficient, efficiently fair: Lessons from designing and testing payment schemes for ecosystem services in Asia. *Ecosystem Services*, *12*, 16–28. https://doi.org/10.1016/j.ecoser.2014.12.012

Lyngsie, G., Awadzi, T., & Breuning-Madsen, H. (2011). Origin of Harmattan dust settled in Northern Ghana - Long transported or local dust? *Geoderma*, *167–168*, 351–359. https://doi.org/10.1016/j.geoderma.2011.07.026

Millenium Ecosystem Assessment. (2005). *Ecosystems and Human Well-Being: Biodiversity Synthesis*. *Wild Resources Institute*. Washington, DC. https://doi.org/10.1057/9780230625600

Muradian, R., Arsel, M., Pellegrini, L., Adaman, F., Aguilar, B., Agarwal, B., … Urama, K. (2013). Payments for ecosystem services and the fatal attraction of win-win solutions. *Conservation Letters*, *6*(4), 274–279. https://doi.org/10.1111/j.1755-263X.2012.00309.x

Nalukenge, I., Antle, J., & Stoorvogel, J. (2009). Assessing the Feasibility of Wetlands Conservation: Using Payments for Ecosystem Services in Pallisa, Uganda. In D. Zilberman (Ed.), *Payments for environmental services in agricultural landscapes* (pp. 239–254). Food and Agriculture Organization of the United Nations and Springer ScienceþBusiness Media, LLC. https://doi.org/10.1007/978-0-387-72971-8

National Geographic Society. (2018). Once on the Brink, This African Park Is Making a Comeback. Retrieved August 1, 2018, from https://news.nationalgeographic.com/2018/01/pendjari-national-park-conservation-west-africa-spd/

Ness, B., Anderberg, S., & Olsson, L. (2010). Structuring problems in sustainability science: The multi-level DPSIR framework. *Geoforum*, *41*(3), 479–488. https://doi.org/10.1016/j.geoforum.2009.12.005

new Tree. (2018). REBOISEMENT. Retrieved August 8, 2018, from https://newtree.org/fr/projet/reboisement/

OECD. (2010). *Paying for Biodiversity: enhancing the cost-effectiveness of payments for ecosystem services*. Paris. https://doi.org/10.1787/9789264090279-en

Olaniyi, O. E., Akindele, S. O., & Ogunjemite, B. G. (2018). Ecotourism suitability of Okomu

and Pendjari National Parks. *Anatolia*, *0*(0), 1–12. https://doi.org/10.1080/13032917.2018.1486329

Olayemi, A., Cadar, D., Magassouba, N., Obadare, A., Kourouma, F., Oyeyiola, A., … Fichet-Calvet, E. (2016). New Hosts of The Lassa Virus. *Scientific Reports*, *6*(March 2009), 1–6. https://doi.org/10.1038/srep25280

Osano, P. M., Said, M. Y., de Leeuw, J., Ndiwa, N., Kaelo, D., Schomers, S., … Ogutu, J. O. (2013). Why keep lions instead of livestock? Assessing wildlife tourism-based payment for ecosystem services involving herders in the Maasai Mara, Kenya. *Natural Resources Forum*, *37*(4), 242–256. https://doi.org/10.1111/1477-8947.12027

Oumorou, M., Natta, A. K., Adomou, A. C., & de Foucault, B. (2011). Caractéristiques écologiques et phytosociologiques des galeries forestières de la Réserve de biosphère de la Pendjari (nord-ouest du Bénin). *Acta Botanica Gallica*, *158*(1), 125–139. https://doi.org/10.1080/12538078.2011.10516260

Pagiola, S. (2008). Payments for environmental services in Costa Rica. *Ecological Economics*, *65*(4), 712–724. https://doi.org/10.1016/j.ecolecon.2007.07.033

Pagiola, S., Arcenas, A., & Platais, G. (2005). Can Payments for Environmental Services help reduce poverty? An exploration of the issues and the evidence to date from Latin America. *World Development*, *33*(2 SPEC. ISS.), 237–253. https://doi.org/10.1016/j.worlddev.2004.07.011

Paré, S., Kaboré, B., Stechert, C., Kolb, M., Bahadir, M., & Bonzi-Coulibaly, L. Y. (2014). Agricultural Practice and Pesticide Residues in Soils and Pool Sediments from the Pendjari Biosphere Reserve Area in Benin, West Africa. *Clean - Soil, Air, Water*, *42*(11), 1593–1603. https://doi.org/10.1002/clen.201200371

Peh, K. S.-H., Balmford, A. P., Bradbury, R. B. ., Brown, C. ., Butchart, S. H. M. ., Hughes, F. M. R. ., … Birch, J. C. (2015). *Toolkit for Ecosystem Service Site-based Assessment*. (D. Pritchard, Ed.).

Sogbohossou, E. A., Bauer, H., Loveridge, A., Funston, P. J., De Snoo, G. R., Sinsin, B., & De Iongh, H. H. (2014). Social structure of lions (Panthera leo) is affected by management in Pendjari Biosphere Reserve, Benin. *PLoS ONE*, *9*(1), 1–4. https://doi.org/10.1371/journal.pone.0084674

Sogbohossou, E. A., De Iongh, H. H., Sinsin, B., De Snoo, G. R., & Funston, P. J. (2011). Human-carnivore conflict around pendjari biosphere reserve, northern benin. *Oryx*, *45*(4), 569–578. https://doi.org/10.1017/S0030605310001109

South African National Parks. (2017). *Annual Report 2016/2017*. https://doi.org/10.1017/CBO9781107415324.004

Stechert, C., Kolb, M., Bahadir, M., Djossa, B. A., & Fahr, J. (2014). Insecticide residues in bats along a land use-gradient dominated by cotton cultivation in northern Benin, West Africa. *Environmental Science and Pollution Research*, *21*(14), 8812–8821. https://doi.org/10.1007/s11356-014-2817-8

The Gold Standard. (2017). *THE GOLD STANDARD MICRO-PROGRAMME OF ACTIVITIES DESIGN DOCUMENT TEMPLATE*.

Turpie, J. K., Marais, C., & Blignaut, J. N. (2008). The working for water programme: Evolution of a payments for ecosystem services mechanism that addresses both poverty and ecosystem service delivery in South Africa. *Ecological Economics*, *65*(4), 788–798.

https://doi.org/10.1016/j.ecolecon.2007.12.024

U-AVIGREF. (2016). *Promotion des cultures biologiques pour la protection de la biodiversité et l ' amélioration du bien-être des populations résidentes à la périphérie de la Réserve de Biosphère de la Pendjari*.

UNESCO. (2013). *Examen périodique de réserve de biosphere: Reserve de biosphere de la Pendjari*.

UNESCO. (2017). Biosphere Reserves – Learning Sites for Sustainable Development. Retrieved July 25, 2018, from http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/

UNESCO/WHC. (2018). W-Arly-Pendjari Complex. Retrieved July 25, 2018, from https://whc.unesco.org/en/list/749/

van Noordwijk, M., Chandler, F., & Tomich, T. P. (2004). An introduction to the conceptual basis of RUPES : rewarding upland poor for the environmental services they provide.

Veeneklaas, F. (2012). Over ecosysteemdiensten. *Wettelijke Onderzoekstaken Natuur & Milieu*, 1–6.

Vodouhê, F. G., Coulibaly, O., Adégbidi, A., & Sinsin, B. (2010). Community perception of biodiversity conservation within protected areas in Benin. *Forest Policy and Economics*, *12*(7), 505–512. https://doi.org/10.1016/j.forpol.2010.06.008

Vodouhê, F. G., Coulibaly, O., Greene, C., & Sinsin, B. (2009). Estimating the local value of non-timber forest products to pendjari biosphere reserve dwellers in Benin. *Economic Botany*, *63*(4), 397–412. https://doi.org/10.1007/s12231-009-9102-7

WHO. (2018). Weekly bulletin on outbreaks and other emergencies. *Health Emergency Information and Risk Assessment*, 1–18.

Wuleka, K. C. (2012). Tourism potentials of Mole National Park in Northern Ghana. *African Journal of Hospitality, Tourism and Leisure*, *2*(1), 1–21.

Wunder, S. (2005). *Payments for environmental services: some nuts and bolts* (No. 42).

Zbinden, S., & Lee, D. R. (2005). Paying for Environmental Services: An analysis of participation in Costa Rica's PSA program. *World Development*, *33*(2 SPEC. ISS.), 255–272. https://doi.org/10.1016/j.worlddev.2004.07.012

Annexes

Annex 1. Methodology

Annex 1.1. Temperature and precipitation Natitingou (Tiomoko, 2014)

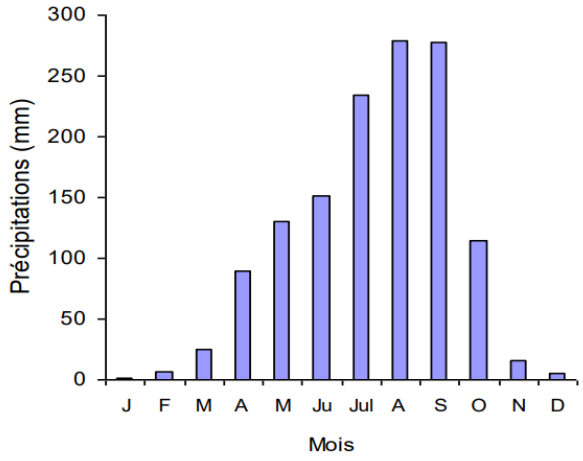

Figure 3 : Pluviosité moyenne mensuelle de 1960 à 2010

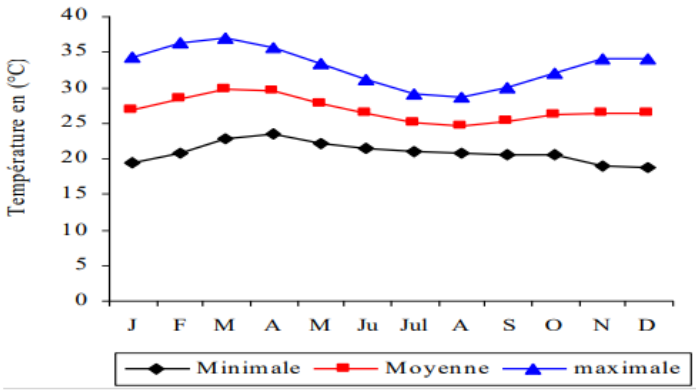

Figure 2 : Variations saisonnières des températures moyennes de 1960 à 2010

Annex 1.2. List of local experts

Table 6: List of actors interviewed during the fieldwork

Name	Function
Azandjeme, A.	Belgian Ambassy
Kouton, M.	Former director Pendjari national park
Tehou, A.	Cenagref (Unseco map commity)
Castro	University of Abomey-Calavi
Amoussou, G.	National coordinator Eco-Benin
Terjanian, J.	Director Pendjari (African parks)
Agnoro, M.	Director Jura-afrique
Yoakassa, A.	Organic agriculture Avigref
Nsera, P.	Ecological monitoring Cenagref
Kpadonou, C.	Eco-tourism specialist Pendjari
Van Nieuwenhuyzen, G.	Cooperation technique belge
Toni, A.	Louvain cooperation
Koda, A.	Guichet d'economie locale
Behrens, R.	Director ProSAR
Samba, A.	Representative Protos
Anonymous	Representative Planète urgence
Anonymous	Representative Eco-Benin (Natitingou)
Anonymous	Representative GIZ
Anonymous	La mairie
Anonymous	Representative CARDER

Annex 1.3. Basic information focus groups

Table 7: Focus groups

Village	Number of people	Number of women	Characteristic
Tanongou	4	0	Trackers
Tanongou	7	5	Eco-tourism
Tanongou	4	0	Traditional healers
Batia	5	0	Local community
Batia	4	0	Beekeepers
Tschassawanga	6	0	Localcommunity
Dassari	9	6	Local community
Sepounga	4	1	Local community
Porga	8	0	Fishermen
Tanguièta	5	0	Park guards

Annex 1.4. Cardboard signs focus groups

Fig. 20: Examples of cardboard signs used during the focus group discussions.

From left to right they suggest the following ecosystem services : fishing, ecotourism and medicinal plants.

Annex 1.5. Basic information full assessment agriculture

Table 8: Interviews conducted regarding cultivated goods

Village	Number of farmers	Number practicing bio-cotton
Batia	1	1
Koulehou	1	1
Sangou	14	2
Wantehoun	1	1
Dassari	7	7
Wanterou	1	1
Tanongou	12	1
Sepounga	4	0
Kouhourou	11	0
Bourgninsou	4	0
Total	**56**	**14**

Annex 1.6. Basic information improved cooking stoves

Table 9: Interviews Foyer Wanrou

Village	Number of people	Number of people using Foyer Wanrou
Tiele	10	10
Kani	8	1
Wanteou	3	3
Tanongou	11	10
Bourgninsou	3	0
Sangou	6	4
Total	**41**	**28**

Annex 1.7. Surveys Full Assessment

- **Water**

Nom :

Âge, genre, occupation :

nombre des gens du ménage :

lieu, date :

---

1. D'où vient l'eau que vous utilisez ?
   A. La rivière, le mare, le barrage, etc.
   B. L'eau de pluie
   C. Une source, forage, puits
   D. Robinet
   E. Others
2. Quelles sources utilisez-vous pour les usages suivantes? Pour saison sèche et saison humide
   Irrigation
   Boire
   Cuisine & laver
   Sanitaire
   Autre usage
3. Pour chaque source de l'eau : pour chaque mois
   +plus l'eau que j'ai besoin
   -pas suffisant
   0 suffisant
4. Si la source normal de l'eau n'est plus disponible, quelle est l'alternative ?
5. Quelle est la source la plus important de l'eau et pourquoi vous l'utilisez ? Pourquoi c'est la plus important ?
6. Vous savez combien litre de l'eau vous utilisez pour chaque l'usage différent dans la saison humide (chaque mois ou chaque jour)?
7. Combien de temps ça prend chaque fois pour obtenir de l'eau ?
8. Combien de l'eau utilisez-vous pour chaque service ? un pourcentage
9. Votre ménage utilise moins l'eau dans la saison sèche ? Combien moins ? pourcentage
10. Vous payez quelque chose pour l'eau ? Combien ? le prix est fixe ou vous payez par mois ?
11. Vous avez eu des périodes quand il n'y avait pas suffisant de l'eau ? Qu'est-ce qu'était la cause, selon vous ? Quelle était l'impact ?
12. Vous avez eu des périodes quand il y avait trop l'eau ? Qu'est-ce qu'était la cause, selon vous ? Quelle était l'impact ?
13. Si la quantité de l'eau dans les rivières augmenterait, quelle impact aurait sur toi ? ça prenait plus/moins de temps pour obtenir l'eau ou il y avait autres activité supplémentaires pour avoir d'accès à l'eau (augmentation des dépenses) ?
14. Si la quantité de l'eau dans les rivières chuterait, quelle impact aurait sur toi ? ça prenait plus de temps pour obtenir l'eau ou il y avait autres activité supplémentaires pour avoir d'accès à l'eau ((augmentation des dépenses) ?
15. Depuis vous vivez ici, avez-vous eu des problèmes avec la qualité de l'eau ? odeur, goût, des maladies ou autres? Quand, combien de temps ? Qu'est-ce qu'était la cause, selon vous ? Quelle était l'impact ? ça prenait plus de temps pour obtenir l'eau ou il y avait autres activité supplémentaires pour avoir d'accès à l'eau (augmentation des dépenses) ?
16. Avez-vous vu un changement de couleur ou la quantité des sédiments dans l'eau, depuis vous vivez ici ? Qu'est-ce qu'était la cause, selon vous ? Quelle était l'impact ? ça prenait plus de temps pour obtenir l'eau ou il y avait autres activité supplémentaires pour avoir d'accès à l'eau (augmentation des dépenses) ?

17. Si la quantité des sédiments dans les rivières augmenterait, quel impact aurait sur toi ? ça prenait plus de temps pour obtenir l'eau ou il y avait autres activité supplémentaires pour avoir d'accès à l'eau (augmentation des dépenses) ?
18. Si la quantité des sédiments dans les rivières chuterait, quel impact aurait sur toi ? ça prenait plus de temps pour obtenir l'eau ou il y avait autres activité supplémentaires pour avoir d'accès à l'eau (augmentation des dépenses) ?
19. Avez-vous vu un changement dans disponibilité dans l'eau depuis vous vivez ici ? Qu'est-ce qu'était la cause, selon vous ? Quelle était l'impact ? ça prenait plus de temps pour obtenir l'eau ou il y avait autres activité supplémentaires pour avoir d'accès à l'eau (augmentation des dépenses) ?

- ## Tourisme

Nom :

Fonction :

Date, lieu :

---

1. Combien de touristes recevez-vous chaque année ?
2. Combien gagnez-vous par touriste?
3. Est-ce que vous-même ou des membres de la famille ont travaillé concernant le tourisme ? Combien de jours et combien de personnes ? Nous cherchons un valeur 'person-days'.
4. Avez-vous loué des personnes pour vous aider quand il y a des touristes ?
5. Combien de jours par an et combien de personnes ?
6. Quelle est le salaire moyen que vous payez ces personnes ?
7. (Si ce n'est pas le cas et ils font tout le travail eux-mêmes) Si vous ne pouvriez pas faire le travail eux-mêmes, combien vous payerez les personnes qui viennent pour travailler ?
8. Avez-vous des coûts ? (la nourriture, boissons, l'essence, etc.) C'est combien ?
9. Quels outils, matérielle ou équipements avez-vous besoin ?
10. Combien de temps attendez-vous que chacun de ces outils durent ?
11. Combien cela a-t-il coûtait pour acheter ces outils ?
12. Recevez-vous autres retenues du tourisme, sauf directe des touristes ? Quelque chose de l'AVIGREF? Comme la viande ou quelque chose d'autre ? Quelque chose de la commune ?
13. Si c'est la cas ? qu'est-ce qu'est et combien ?
14. Avez-vous autres activités ? combien de vous retenues viennent du tourisme ?
15. Selon vous, comment va le nombre des touristes changer en général à la future en savent qu'African parks gère le parc maintenant ? Il y aura certains changement :comme la construction d'un aérodrome, meilleur infrastructure, meilleur encadrements, etc. Un pourcentage ?
16. Pensez-vous que les touristes vont payer plus, moins ou le même ? un pourcentage ?
17. Selon vous, comment va le nombre des touristes changer en général à la future en savent que certaines espèces importants comme les éléphants, les lions, les hypothames, etc. sont diminué ?
18. Pensez-vous que les touristes vont payer plus, moins ou le même ? un pourcentage ?

- **Agriculture**

Nom:

Genre, âge, taille du ménage, éducation, ethnicité, statu matrimonial :

Lieu, date :

Les questions sont répondu par : individuel ménage entreprise

1. Quelle est votre taille totale du terrain que vous cultivez dans la région ?
2. Quels produits (des cinq plus important) cultivez-vous ?
3. Quelle est la proportion pour chaque produit ?
   (Les questions suivantes doivent être répondues pour chaque produit)
4. Quelle unité utilisez-vous pour ce produit ?
5. L'année passée, combien de ce produit avez-vous produit ?
6. L'année passée, qu'est-ce qu'était le prix moyen que vous avez obtenu pour chaque unit ? (si Ils ne vendent pas, nous ajoutons le prix moyen d'autres cultivateurs après)
7. Le pourcentage qu'ils utilisent eux-mêmes ?
8. Le pourcentage qu'on vend ?
9. Est-ce que vous-même ou des membres de la famille ont passé du temps (travaillé) pour cultiver, planter, récolter ou traiter ce produit ? (travail pas payé)
10. Si c'est le cas, combien de jour par an et combien de personnes ? (nous cherchons un valeur 'person-days' . Si 5 personnes travaillent 20 jours par an, ça veut dire 100 person-days)
11. Est-ce que vous avez loué quelqu'un pour cultiver, planter, récolter ou traiter ce produit ?
12. Si c'est le cas, combien de jour par an et combien de personnes ? (nous cherchons un valeur 'person-days' . Si 5 personnes travaillent 20 jours par an, ça veut dire 100 person-days)
13. Quelle est le salaire moyen que vous payez ces personnes par jour ?
14. (Si ils n'ont personnes loué: Combien vous devriez payer une personne par jour pour faire le travail ? un prix moyen) .
15. Quel est le coût pour autres intrants de ce culture ? (semences, engrais, pesticides, l'eau, l'essence pour machines)
16. Quels outils ou équipements vous avez besoin pour cultiver, planter, récolter ou traiter ? (outils, des machines, …)
17. Combien de temps attendez-vous que chacun de ces outils durent ?
18. Combien cela a-t-il coûtait pour acheter ces outils ?
19. L'année passée, combien vous avez payé pour le transport de ce produit ?
20. Comment (Quoi) pensez-vous que la culture de ces produits va changer à la future ?
    20.1. Pensez-vous que vous allez produire plus, moins ou le même à la future? un pourcentage ?
    20.2. Pensez-vous que vous devrez travailler plus, moins ou le même à la future ? un pourcentage ?
    20.3. Pensez-vous que le coût des certains intrants va augmenter, diminuer ?

Annex 1.8. Survey Improved cooking stoves

1. Quels sont les flux de revenues importants pour ton ménage ?
   □agriculture □ PFNL □bétail □tourisme □ commerce □ autres
2. Demande de la richesse de ménage (Thomas va le formuler)
3. Vous êtes actuellement en possession de ?
   □ télévision □ radio □ internet □voiture □moto □vélo
4. Utilisez-vous les foyers améliorés? □ oui □ non
5. Vous êtes content des foyers améliorés? □ pas du tout □plutôt pas □ neutre □ content □très content
6. Pourquoi? □temps de cuisson réduit □temps pour obtenir du bios réduit □maladies respiratoires □brûlures réduites (protection)□conserver l'environnement □autres
7. Le foyer est actuellement usable? □ oui □non pourquoi ?
8. Combien de temps vous avez le foyer?
9. Combien de temps n'était pas usable pendant ce période ?
10. Pendant la période que le foyer était usable avez-vous eu autres problèmes avec le foyer ?
    □jamais □ une fois □ plusieurs fois □ très souvent
    7.1. Si oui, quel problème ?
11. il y a des choses qui peuvent être améliorées ? □ oui □ non
    8.1 si oui, lesquelles ?
12. Comment décririez-vous la relation avec Ecobenin ? (monitrices)
    (□pas de communication)
    9.1. il y a une personne qui peut t'aider quand vous avez une problème/question avec le foyer ? (Par exemple maintenant pour réinstaller le foyer) □oui□non
    9.2. il existe une certaine forme de contrôle de l'utilisation (correcte) ? il y a de suivi ? à quelle fréquence ?
    9.3. Vous souhaitez plus de communication avec Ecobenin (plus de suivi) ? □oui □non Comment ?
    9.4. Vous allez continuer utiliser le foyer même s'il n'y pas d'intervention de Ecobenin ? □ oui □ non
13. Il y a des conditions pour obtenir le foyer ? □oui □ non
14. Est-ce vous avez payé quelque chose pour le foyer ? (installation, etc.) □oui □non
    14.1 si oui, combien ?
15. Avez-vous reçu un soutien financier pour l'installation ? □ oui □ non
    15.1 si oui, de qui ?
16. Avez-vous payez quelque chose pour la construction (argile, paille, brique) ? □ oui □ non
    13.1. Si oui, Combien ?
17. Utilisez-vous actuellement uniquement le foyer ? □ oui □ non
18. Combien de fois par semaine cuisinez-vous ? □14 □21 □….
19. Combien de temps dure-t-il en moyenne pour cuisiner une fois ?
20. Combien de temps durait-t-il en moyenne pour cuisiner avec le feu traditionnelle une fois?
21. Le bois : long= périmètre=
22. Environ combien de bois vous utilisez pour cuisiner une fois ?
23. Environ combien de bois vous utilisiez avant sans foyer amélioré pour cuisiner une fois?
24. Comment vous obtenez le bois ? □acheter □aboyer
    20.1. Si on achète le bois. Quel est le prix ?
25. Combien de bois vous collectez par semaine ?
26. Combien de bois vous collectiez par semaine auparavant sans foyer amélioré?
    22.1. Si c'est environ la même quantité : Qu'est-ce que vous faites avec le bois extra ?
27. Combien de temps ça prend par semaine?
    (Transport : combien bois/transport : temps/transport :)
28. Combien de temps ça prenait sans foyer par semaine ?
    (Transport : combien bois/transport : temps/transport :)
29. Avez-vous actuellement plus de temps pour faire d'autres choses ? □oui □non
    29.1 Si oui, qu'est-ce que vous faites ?

Annex 2. Focus groups

Annex 2.1. Cited ecosystem services during the focus groups

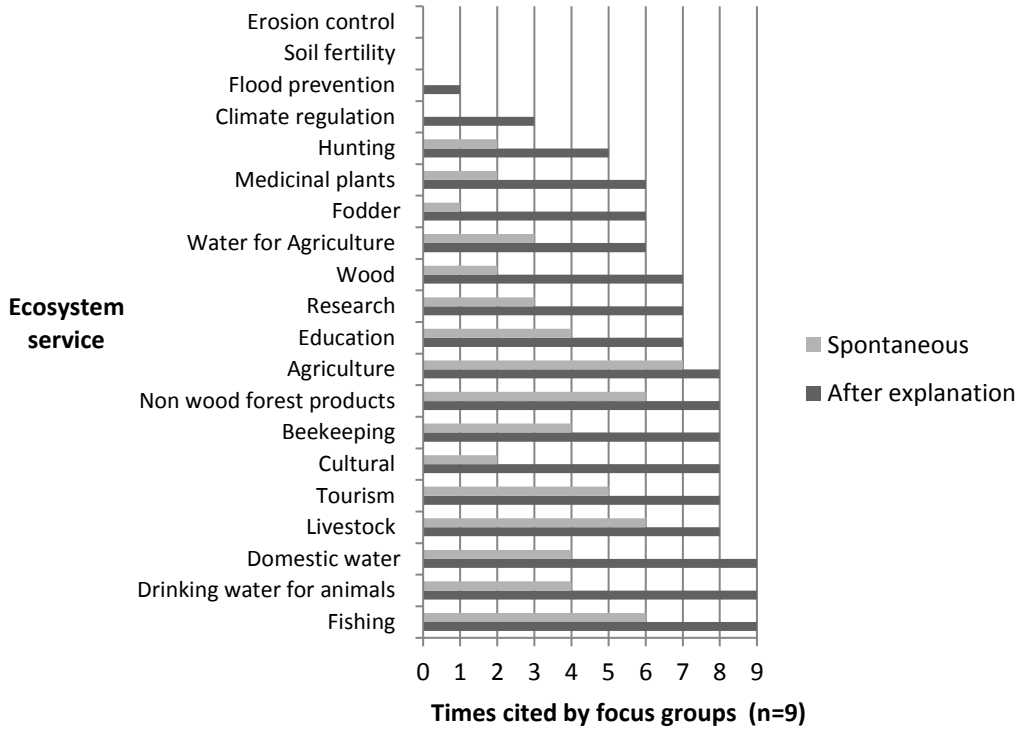

Fig. 21: Ecosystem services cited during the focus groups discussions.

Both spontaneously citing and citing after a little explanation of all existing services are shown. This exercise was done with 9 different groups. A value 5 means that in 5 out of 9 focus group discussions a particular service was cited.

Annex 2.2. Mean, median and standard deviation of importance value focus groups

Table 10: Mean, median and standard deviation of importance value

Only the most important ecosystem services are shown.

	Agriculture	Domestic water	Education	Tourism	Fishing	Drinking water for animals	Beekeeping	Livestock	Medicinal plants	Wood	Cultural	Non-wood forests products
Mean	0.17	0.13	0.10	0.09	0.08	0.06	0.06	0.05	0.05	0.04	0.03	0.03
Median	0.16	0.13	0.08	0.09	0.00	0.05	0.02	0.05	0.04	0.03	0.03	0.03
Σ	0.10	0.06	0.09	0.09	0.14	0.05	0.09	0.04	0.04	0.04	0.03	0.03

Annex 2.3. Lessons learnt concerning agriculture, water, tourism, hunting, beekeeping and fishing during focus groups

Table 11: Lesson learnt agriculture

Y-a-t-il des problèmes avec le service?	La terre cultivable ne suffit pas, on doit cultiver toujours sur les mêmes parcelles. (7) Le sol n'est pas fertile, elle est pauvre et fatiguées. (7) Il y a un conflit entre le faune et l'agriculture. Les singes et les éléphants sont des menaces, ils détruisent les champs. (7). On n'a pas de matériel de travail. (4) Il y a des insectes qui attaquent nos cultures. (4) Il manque de pluie et/ou la pluie est irrégulier. (3)
Quelles sont les menaces ? Quelles activités l'impactent négativement ?	Traitement des produits chimique, des herbicides, les engrais. La famine est une menace. Les animaux qui viennent détruire les champs. La croissance démographique est l'une des causes de problèmes du secteur agricole pour le manque de terre.
Est-ce que le service a chuté ou augmenté ?	Les rendements d'agriculture chutent. (6) L'agriculture a augmenté en termes de superficie, mais le rendement est faible. (Focus group tradithérapeutes,Tanongou)
Y a-t-il des mesures de gestion permettant de conserver ou améliorer ce service ?	Les herbicides, des engrais. On doit utiliser les engrais, parce qu'il n'y a pas suffisante de terre pour faire la jachère. (3) Nous avons des accompagnements du CARDER pour améliorer notre agriculture. L'AVIGREF nous apprend à faire l'agriculture biologique en faisant le compost. Mais ce n'est pas encore développé chez nous. Ils ont dit que tous les membres de l'AVIGREF doivent faire l'agriculture biologique pour la prochaine saison. (Focus groupDassari) Les gens du CENAGREF viennent pour nous encadrer pour faire le coton bio mais ils n'apportent pas assez de matériels pour qu'on le fasse bien. C'est nous qui fabriquons notre compost (Focus group pisteurs Tanongou) Nous avons des techniques de nos jours pour l'amélioration de notre agriculture, avant on devait beaucoup sarcler mais avec les herbicides on arriver à cultiver de plus grande superficie. L'AVIGREF vient pour nous exhorter à faire le coton biologique mais on ne le fait pas trop.
Qui bénéficie de ce service ?	On vend le coton à l'état.(4) Nous vendons nos produits vivriers si c'est beaucoup. D'ici jusqu'à Tanguièta.(6)

Table 12: Lesson learnt water

Y-a-t-il des problèmes avec le service ?	Local community in Sepounga : « Nous n'avons pas de problème au niveau de l'eau, seulement quand il y a une pompe qui est gâtée. Depuis qu'il y a le barrage, il y a une nette amélioration. » Local community Batia : « Le maraichage et l'élevage prennent beaucoup d'eau et les traitements des champs polluent l'eau. » Local community Tschassawanga: «Quand le pompe se gâte, ils n'ont pas matérielles pour réparer. Il n'y a pas assez l'eau potable. » Local community Dassari: « […] en saison sèche le petit marigot tarit et (nos) bœufs vont dans le parc, mais les forestiers les tuent. La pêche traditionnelle et les herbicides polluent l'eau [...] » Fishermen in Porga : « Mais (quand) une seule pompe est fonctionnelle, les femmes se battent souvent pour ça et d'autres préfèrent aller prendre l'eau du marigot. »
Quelles sont les menaces ? Quelles activités l'impactent négativement ?	Local communitySepounga : « Il n'y a pas de menace. Seulement dans de rares cas certains font la pêche en empoisonnant l'eau et ce sont des cas sévèrement punis. » Local community Batia : « La croissance démographique […] peut entrainer le manque d'eau, (juste comme) la pisciculture. » Local communityTschassawanga : « La construction a besoin beaucoup de l'eau. »
Est-ce que le service a chuté ou augmenté ?	Local communitySepounga : « Le service en eau a augmenté, la disponibilité en eau a augmenté depuis le barrage. » Local community Batia : « L'eau dimunie à cause de la croissance démographique, pisciculture et autres. » Fishermen in Porga : « La disponibilité de l'eau s'est accrue récemment. »
Y a-t-il des mesures de gestion permettant de conserver ou améliorer ce service ?	Local communitySepounga : « […] des techniciens sont souvent envoyés par la mairie mais ils ne connaissent pas leur provenance. » Local communityTschassawanga : « il n'y a pas. » Fishermen in Porga : « Nous cotisons par famille pour l'entretien des pompes. »
Qui bénéficie de ce service ?	-Local communitySepounga : «Tout le monde bénéficie […], pas seulement Tanguiéta, plus loin aussi. […] Les Peuls viennent abreuver les bêtes dedans (le barrage) […]. » Ici on en profite ainsi que ceux qui travail dans le parc. (fishermen Proga and local communtiyBatia) seul le village lui-même (Tschassawanga et Dassari)

Table 13: Lessons learnt eco-tourism

Y-a-t-il des problèmes avec le service ?	Il y a beaucoup de jeunes qui sont des guides, mais quand les clients qui viennent ont déjà leur guide. C'est pour ça que le nombre de guide dépasse les touristes et les guides ici manquent des clients. (3) La prestation est mauvaise et fait fuir les clients, il y a une absence de formation professionnel. (2)
Quelles sont les menaces ? Quelles activités l'impactent négativement ?	Il y a de la concurrence entre les hôtels. (Focus group Eco-tourism Tanongou) il y a parfois des gens, qui viennent et sont déjà malade, qui disent qu'ils sont malade de la nourriture ou des conditions de l'hôtel. (Focus group Eco-tourism Tanongou) La chasse et les braconniers (Focus group pisteurs Tanongou)
Est-ce que le service a chuté ou augmenté ?	Les services ont chuté. Mais l'espace d'accueil reste toujours le même : cinq habitations. (Focus group Eco-tourismTanongou) Le tourisme a chuté à cause des problèmes de virus lassarécents (lassa) (Focus group pisteurs Tanongou)
Y a-t-il des mesures de gestion permettant de conserver ou améliorer ce service ?	Focus groupe Eco-tourismTanongou : « Nous n'avons pas vraiment de mesures de gestion. Quelques rares séance de formation. Le plus récent était une de la Burkina Faso. » Focus groupe pisteurs Tanongou : « Nous n'avons aucune mesure pour améliorer notre tourisme, nous voulons de l'aide de l'état pour la lutte contre les virus pour rassurer les touristes. »
Qui bénéficie de ce service ?	10 % pour la communauté et 10 % pour la mairie.(Focus group Eco-tourismTanongou)

Table 14: Lessons learnt hunting

Quels sont les problèmes, menaces et activités nuisibles actuelles et dans le futur ?	« […] avant c'était mieux, on faisait la chasse et la lutte anti braconnage, mais notre actuel amodiateur n'a pas de moyens financiers. […] nous sommes bénévoles. […] La direction a créé une association de chasse traditionnelle qui vient de Tanguiéta[…] et tuent tout. C'est une faute à la direction. Ils ont tué presque tous les aulacodes, lièvres et autres. Ils rentrent même dans la zone cynégétique car notre amodiateur est faible. Avec ça nos enfants ne pourront plus voir certaines espèces en grandissant. […] Ce qui nous dérangeait c'était le braconnage, mais beaucoup sont reconvertis en CPL (Chasseurs Professionnels Locaux) et sont payé 40.000 F en 10 jours.Les peuhls Bouviers viennent avec les bœufs dans le parc et apportent des maladies […] On en tue des milliers mais chaque jour ils sont encore plus nombreux, les bœufs. Cette année on ne fait pas la lutte anti braconnage car l'actuel amodiateur n'as pas de moyens et les bœufs sont dans le parc impunément actuellement. »
Est-ce que le service a chuté ou augmenté ?	« Notre chasse locale ici a augmenté »

Y a-t-il des mesures de gestion permettant de conserver ou améliorer ce service ?	« Non, pas vraiment mais il faut assurer la pérennité du système de reconversion car si ça s'arrête, les anciens braconniers vont recommencer et tuer tout les animaux en moins de deux ans. »
Où se trouve votre zone de chasse ?	« La REVICA Tanongou, nous faisons la petite locale chasse ici à Tanongou. Avec le temps l'espace dimunie. »
Qui bénéficie de ce service ?	« On utilise pour notre alimentation, et on revend entre nous, pas ailleurs. »

Table 15: Lessons learnt beekeeping

Quels sont les problèmes, menaces et activités nuisibles actuelles et dans le futur ?	« notre problème c'est la ruche […] des gens sont venus pour nous former et donner d'autres ruches […] (mais) les abeilles ne restent pas dedans […] il y a certains abeilles qui ne quittent pas la ruche mais ne produisent pas du miel. On va manquer d'abeilles, puisque les abeilles ne restent pas dans les ruches. » « Les fourmis et les souris mangent le miel et dérangent les abeilles.» « Le niveau où reste les ruches, les feux de brousses sont une menace. » « Le traitement avec les herbicides des champs de coton. Avec le vent les herbicides et pesticides tuent les abeilles. Les abeilles utilisent les fleurs et utilisent une substance jaune pour formier le miel avec, mais avec le traitement des champs, elles ne trouvent plus cette substance jaune pour produire le miel. »
Est-ce que le service a chuté ou augmenté ?	« Notre apiculture a diminué. Avant c'était beaucoup mieux. »
Y a-t-il des mesures de gestion permettant de conserver ou améliorer ce service ?	«Il y a des gens qui sont venus pour nous aider à améliorer notre apiculture. Ils ont apporté de grandes ruches mais les abeilles ne restent pas. Venez nous aider car ça ne va pas."
Où se trouve votre zone de chasse ?	« C'est ici dans Batia, mais les gens nous causent des problèmes. Dans nos champs les gens nous volent. C'est dans nos champs. Notre espace a diminué. »
Qui bénéficie de ce service ?	« C'est ici on vend. Si dieu nous a donné on va déposer à l'entrée du parc et les touristes achètent. Aussi entre nous on vend. »
Ne pensez-vous pas qu'il faut délimiter une zone vers la montagne pour y faire une apiculture plus structurée ?	« Oui, mais on a un problème de terre, et de sécurité, ils nous volent notre miel. Si on laisse ça dans les montagnes il n'y a aucune sécurité. »

Table 16: Lessons learnt fishing

Quels sont les problèmes, menaces et activités nuisibles actuelles et dans le futur ?	Focus group beekeepers in Batia : « Avant on allait dans le parc pour pêcher mais maintenant ils nous ont interdit l'accès. […] C'est cette année ils ont fermé le parc. Ils ont dit qu'ils vont nous aider pour faire la pisciculture. […] mais plus rien depuis. C'est le ProAgri avec GIZ. Focus group beekeepers in Batia : « Les gens amènent les bidons vides d'herbicides pour prendre de l'eau et ça tue les poissons en grands nombres. » Focus group fishermen in Porga : « Avant on faisait la pêche, on ne gagnait pas beaucoup, […] mais désormais ils nous interdisent l'accès à la rivière. On n'a pas appris un autre métier et aucun projet n'est venu pour notre reconversion. […] Le fleuve est transfrontalier et au moment actuel où on nous interdit l'accès, ceux du Burkina-Faso font actuellement la pêche et épuise souvent le stock de poisson avant qu'on ne reçoive notre autorisation de pêcher ici. […] On a 6 mois d'autorisation par an pour pêcher et étant donné qu'on n'a aucune autre activité. […] Les gardes tirent sur nos pirogues même quand on est légalement sur l'eau. Malgré qu'on aide ans le parc. Nous avons des problèmes de matériels. »les gardes en alertant dans le cas où on voit des intrus dans le parc, ils nous rendent la vie impossible. […] Malgré nos permis, on est obligé de rentrer comme des clandestins.
Est-ce que le service a chuté ou augmenté ?	Focus group fishermen in Porga : « Le rendement de notre pêche dépend de la pluviométrie, avec une forte pluviométrie nous avons assez de poissons et moins dans le cas contraire.»
Y a-t-il des mesures de gestion permettant de conserver ou améliorer ce service ?	Focus group fishermen in Porga : « Nous n'avons pas d'accompagnements. Nous mettons des troncs d'arbres morts dans l'eau pour offrir un refuge aux poissons. »
Où se trouve la zone de la pêche ?	Focus group fishermen in Porga : « Nous avons accès à tout le long de la rivière pendjari ici, mais nous allons souvent seulement jusqu'à la mare Yangoualy avec nos moyens. L'espace augmente par rapport à l'accroissement des poissons. »
Qui bénéficie de ce service ?	Focus group fishermen in Porga : « Nos poissons sont vendus un peu partout, du Bénin au Nigéria. » Focus group beekeepers Batia : « Nous vendions nos poissons jusqu'à Tanguiéta. Les gens venaient acheter ici.»

Annex 3. Full Assessment

Annex 3.1. Aboveground biomass densities (Mg. ha^{-1}) and total biomass stocks (Mg) for different land classes (Chabi et al., 2016).

LULC/LUCa	Descriptive statistic				
	Range of biomass density (Mg ha^{-1})		Mean biomass density (SE)	Percentage error (% error)	Total biomass stocks (Mg) and its SE
	Min.	Max.			
Forest land					*340,534.70 ± 36,445.4*
Riparian forest and woodland	76.29	120.22	94.58 (4.98)	(10.33)	32,271.87 ± 334.74
Savanna Woodland	27.22	69.84	45.29 (2.51)	(10.89)	24,8050.22 ± 27,019.98
Shrub Savanna	6.47	25.14	14.05 (0.72)	(10.11)	60,212.61 ± 6090.67
Grassland					*349.66 ± 68.81*
Savanna grassland	0.06	9.20	3.62 (0.36)	(19.68)	349.66 ± 68.81
Cropland					*26,409.82 ± 5024.04*
Cropland and fallow	0.07	9.32	3.28 (0.31)	(19.02)	26,409.82 ± 5024.04
Settlements					*2375.84 ± 988.13*
Settlements	0.86	9.60	4.86 (1.03)	(41.59)	2375.84 ± 988.13
Agroforestry					*1132.73 ± 584.46*
Cashew plantation	10.74	211.19	46.06 (14.40)	(61.28)	1132.73 ± 584.46
Plantation					*3138.20 ± 1777.35*
E. grandis	7.69	695.20	204.92 (57.69)	(55.17)	2819.78 ± 1556.44
T. grandis	32.41	232.75	162.00 (64.88)	(78.50)	145.80 ± 114.46
A. indica	64.45	240.53	179.62 (57.61)	(62.86)	129.33 ± 81.30
G. arborea	10.39	34.39	25.17 (7.46)	(58.09)	43.29 ± 25.14

Words in italic indicate the plantation type

Value within the parenthesis indicate the standard error and percentage error

The age of plantations and agroforestry system varied from 5 to 45 years which explained the large standard and percentage errors obtained from their plots data. The minimum (min.) and maximum (max.), the mean biomass density and its stand error (SE), the percent error and the total biomass at each LULC type/LUCa were illustrated

Annex 3.2. NDVI image Pendjari biosphere reserve

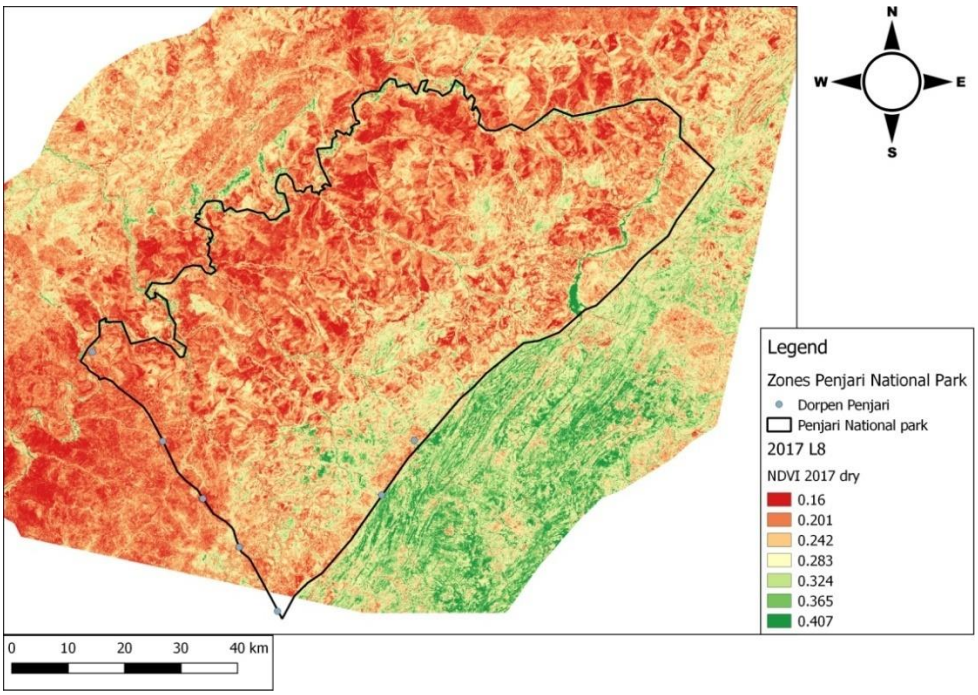

Fig. 22: Normalized Difference Vegetation Index (NDVI) image of the Pendjari Biosphere Reserve

(june 2017). Red colors represent low vegetation densities, while green colors represent high vegetation densities. (Gaillard & Knoops, 2018)

Annex 3.3. Land classes Pendjari biosphere reserve

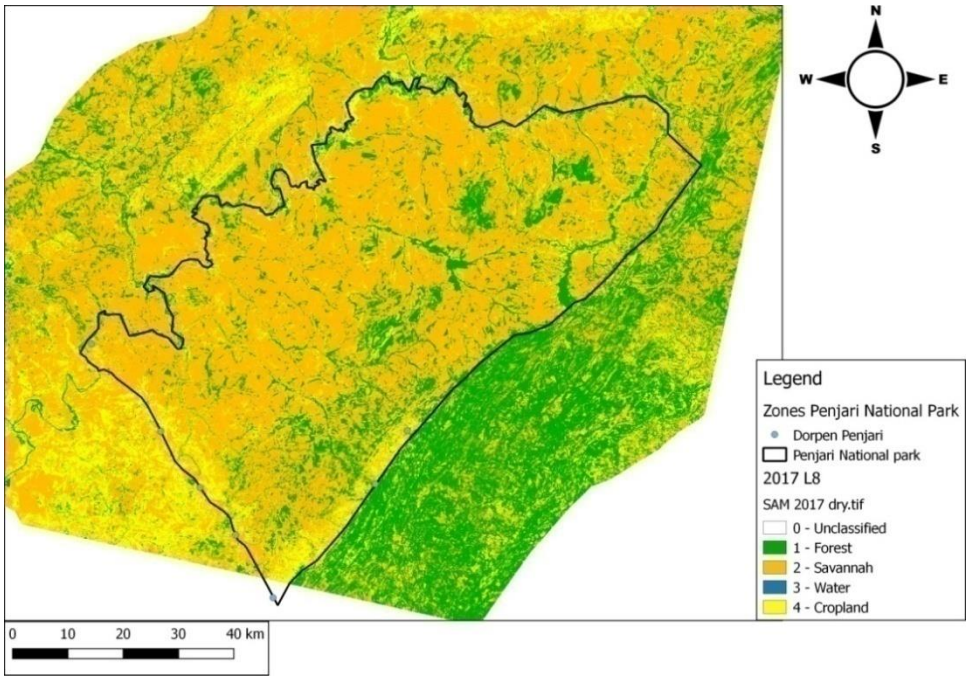

Fig. 23: Distribution of land classes in the Pendjari biosphere reserve

Annex 3.4. Lesson learnt full assessment concerning water

Table 17: Results water use

Village	Where does the water, that you use, come from?
Kani(5)	Water comes from men-powered pumps (4)
	-Before you can use the pumps, you have to pay 5000 f CFA, I take water elsewhere. (1)
Tanongou (2)	-the men powered pumps are broken. Since march 2017 there is un château avec robinet . (1)
	-from the tap, but because it work on solar panels, it does not work in the morning (1)
Sepounga (group)	-pump and tab (château avec robinet)
Bourgninonsou(4)	-pumps, river, rain water (1)
	-pumps are currently broken, so now the river (1)
Sangou (group)	there are two pumps with human motility, when they are broken, you have to go to the water source.

Village	Is there enough water available?
Kani (group)	No, there is not enough water. In the rainy season, we use the water from the rain to cook and shower. Only to drink we use the pumps. In the dry season, there is not enough water.
Tanongou (2)	-for the moment, there is enough (1)
	-insufficient taps for the amount of people in Tanongou. (1)
Sepounga (group)	All year long, there is more water than we need.
Sangou (group)	We cannot always wash ourselves.

Village	Daily amount of water use (drinking, cooking, washing) per household per day
Kani (5)	183 L
Tanongou (2)	210 L
Sepounga(group)	500 L
Bourgninonsou (3)	143 L
Sangou (group)	150 L

Village	Problems associated with water use
Kani	-The quality of the water is good (5)
	-the water has a white color and there are many insects in it (2)
Tanongou (1)	Sometimes there are living things in the water from the tap
Sepounga (group)	Normally, animals drink from the river, but rivers are drying up. So they also drink from the pump. That's a problem. In the pumps, there are living insects and a substance forms in the basin. When it rains, the water becomes white.
Bourgninonsou(1)	-the pumps contain living insects

Annex 3.5. Interview CARDER

Nom:

Fonction: CARDER

Lieu, Date: 02/10/2017, Tanguièta

Part I : Général

1. **Quels sont les produits cultivés les plus importants pour les riveraines dans la région ? (les cinq plus important)**

Le mais	Le riz	Le soja	Le coton	Le sorgho

2. **Quel pourcentage de la superficie cultivée est utilisé pour produire chacun de ces produits ? [Si deux ou plusieurs cultures sont cultivées dans le même endroit en même temps, affectez proportionnellement la zone productive (par exemple : si 20% de la superficie cultivée est utilisée pour cultiver le riz suivi du mais chaque année, les deux cultures évaluent 10%). Si deux cultures sont cultivées successivement (par exemple, si 30% de la superficie est utilisée pour cultiver une culture de riz de saison humide suivie d'une culture de maïs en saison sèche), enregistrez les deux cultures (30% de riz, 30% de mais)]**

(2016-2017)

6774 ha	3300 ha	1212 ha	6750 ha	2106 ha

(2017-2018)

7752 ha	3645 ha	1615 ha	8800,350 ha	2430 ha

3. **Environ combien de ménages dans la région participent à la culture de ces produits principaux ?**
   4503 ménages

Part II : Description des cultivateurs

1. **Environ combien de ménages (et entreprises) cultivent ce produit dans la région ?**
   /
2. **Quel pourcentage de la culture est par : Population rurale locale,Pas de population rurale locale, Personnes urbaine, Personnes d'autres pays :**
   Il n'y a pas des données
3. **Les personnes qui cultivent le produit proviennent d'un groupe socio-économique particulier ? Et si c'est le cas : quel ? (groupes ethniques, femmes, personnes sans terre, etc.)**
   Non , ils ne proviennent pas d'un groupe socio-économique.
4. **Est-ce que ces personnes dépendent en particulier de ce produit pour leur subsistance ?**
   En particulier, les gens dépendent du mais et du riz pour leur subsistance.
5. **Les cultivateurs sont-ils organisé ? organisation ou coopérative ?**
   Il y a des coopérations pour le coton, le soja et le riz.

Part III : Description des produits

1. **Combien de temps dure la culture (de la plantation à la récolte) ?**

3-4 mois	3-4 mois	3-4 mois	4 mois	3-4 mois

2. **Si le cycle de vie des cultures est inférieur à un an, plusieurs produits cultivés sont-ils cultivés sur le même terrain?**
   Oui, ça passe.
3. **Quelle est la durée de toute période de jachère entre les cultures ou le stockage avec le bétail?**
   Les gens faire la culture seulement une fois par an. Le reste d'année, ils ne font rien. Donc, la période de jachère est 8-9 mois par an.

4. **Quelles unités sont utilisées localement pour quantifier le produit ? Quelle est la conversion entre ces unités et l'unité métrique concernée ?**
   le bassin = 20-25 kg

Part IV : Bénéficiaires

1. **Sur 100 unités du produit, combien d'unités sont utilisées pour la subsistance et combien sont vendues ?**
   Il n'existe pas des données.
2. **Si on le vend, quel pourcentage des bénéficiaires sont : Population rurale locale, Pas de population rurale locale, Personnes urbaines, Personnes d'autres pays :**
   Il n'existe pas des données.
3. **Le produit est-il traité par l'agriculteur avant sa vente, ou vendent-ils le produit brut?**

Oui	Non	Non	Oui	Oui

4. **Si on traite le produit, Y a-t-il des coûts associés au traitement ?**
   Il y a des coûts associés avec le traitement. Un sac de traitement coûte 350F CFA et on le peut utiliser pour 4 sacs de produits.
5. **Où le produit est-il habituellement vendu?**
   A Tanguièta.
6. **Est-ce que les agriculteurs prennent le produits au marché eux-mêmes ou existe-t-il une personne qui vient dans les villages pour acheter le produit?**
   Ça dépend vraiment des agriculteur spécifiques et change souvent. Parfois ils vont eux-mêmes à Tanguièta, parfois ils viennent des personnes aux villages pour acheter les produits. Seulement pour le riz ça existe, il y a des personnes qui achètent et vendent le riz : ils viennent aux villages pour acheter.
7. **Quel est le prix actuel du marché pour une unité locale du produit ? Ou vivent les cultivateurs, Au marché le plus proche, À la ville la plus proche ?**
   / nous devions le demander à une autre personne. Il ne le savait pas.
8. **Le prix varie-t-il beaucoup au cours de l'année? Expliquer et décrire**
   / la même chose.
9. **Si le produit n'est pas vendu sur un marché et on ne cultive pas, quel effet cela aurait-il sur leur vie?**
   Ça aurait un très grand impact sur la vie de la population.
10. **Si vous ne pouviez plus cultiver le produit et qu'il devait le remplacer, quel produit devez-vous acheter et quel coût pour un montant équivalent?**

Part V : Durabilité

11. **En ce qui concerne les cinq dernières années, les rendements de ce produit (par unité de surface), les intrants nécessaires pour le produire ou le prix payé pour celui-ci a-t-il changé?**
    Je ne sais pas pour le prix et les intrants nécessaires.
    Les rendements sont augmenté les dernières années. Sauf pour le soja l'année passé, les rendements son diminués. On change à coton.

Part VI : Les coûts de main-d'œuvre

12. **Existe-t-il un salaire minimum légal ?**
    Non, ça ne existe pas.
13. **Quel est le taux de salaire quotidien typique pour la main-d'œuvre agricole dans la région? Les taux varient-ils de façon saisonnière?**
    Ils louent des gens. Le taux de salaire typique est environ 15.000F CFA/ha.
14. **Y a-t-il beaucoup de chômage dans la région? Quelles sont les probabilités d'une personne ayant un jour de travail rémunéré si elles le souhaitaient ?**
    /
15. **Y a-t-il beaucoup de saisonnalité dans la demande de main-d'œuvre et les niveaux de chômage?**
    Oui, la plupart du travail se situe dans les mois juin et juillet.

Annex 3.6. Field sizes different crops in the ZOC.

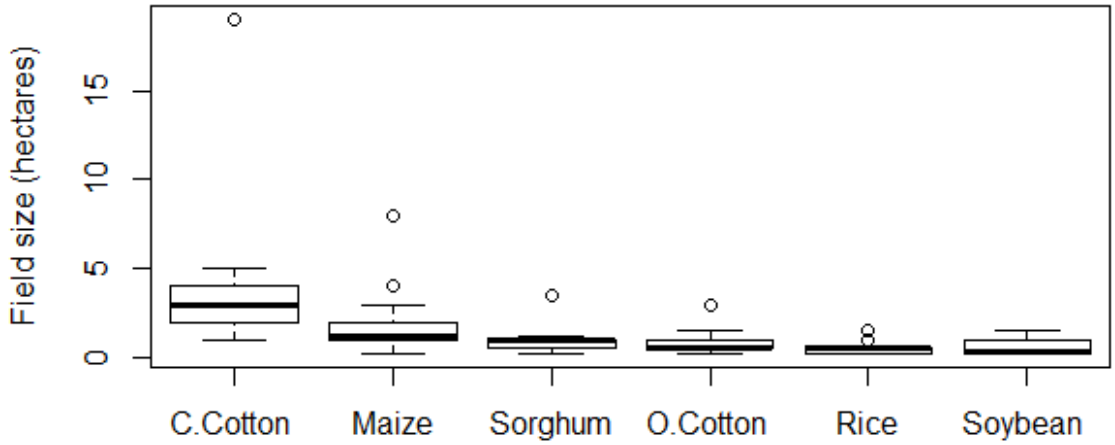

Fig. 24 : Field size of different crops in the ZOC

(C. cotton = conventional cotton; O. Cotton = organic cotton)

Annex 3.7. Subsistence farming around the Pendjari biosphere reserve

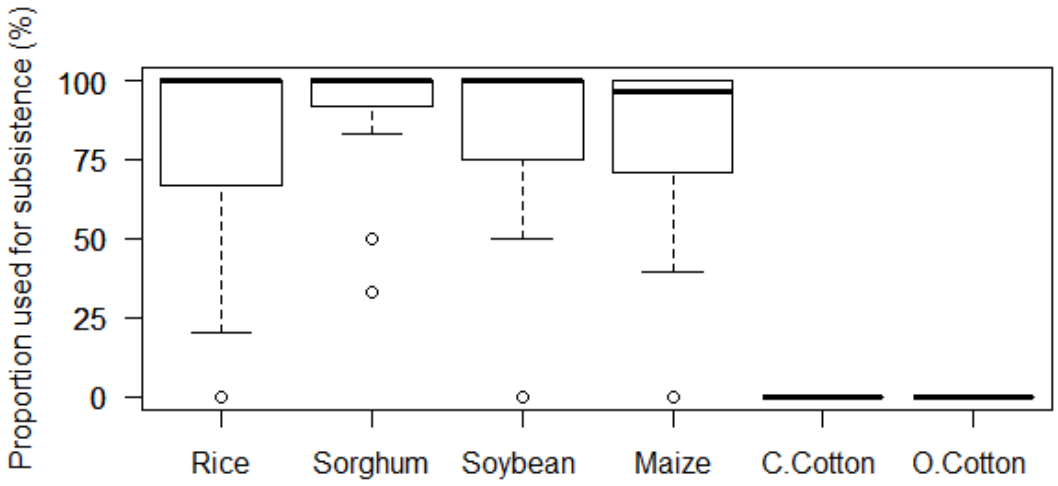

Fig. 25: Subsistence farming around the Pendjari biosphere reserve

Proportions of production used for subsistence purposes are shown for different crops. (C. cotton = conventional cotton; O. Cotton = organic cotton)

Annex 3.8. Lessons learnt concerning organic cotton

Table 18: Lessons learnt organic cotton

(individual interviews farmers)

Biological cotton	
Why do you grow biological cotton?	The agricultural land is quickly tired. Herbicides etc. cause diseases. People do not get sick To make money (it is just for credit). Lack of money for the conventional cotton To avoid chemical products enter the water.
There is follow-up on the production of biological cotton?	All the time by members of AVIGREF, but there are no project or support.
Are you going to continue growing biological cotton?	Farmers will continue to cultivate organic cotton, but there is a lack of land Yes, even if the price is the same as conventional cotton.

Table 19: Lessons learnt conventional cotton

(individual interviews and group discussion).

Conventional cotton	
Why do you grow conventional cotton?	Individual farmers: It is due to conventional cotton farmer make money and can use fertilizer for maize. Until there are improvement for maize (higher yields), they will continue growing conventional cotton. If you do not have cotton fields, you cannot use fertilizer for the maize fields. Group discussion Wanteoun: There are no credits in advance for the biological cotton. Conventional cotton is cultivated, because farmers need it to buy fertilizer for the maize production (on credit).

Annex 4. Improved cooking stoves

Annex 4.1. Results Wanrou figures

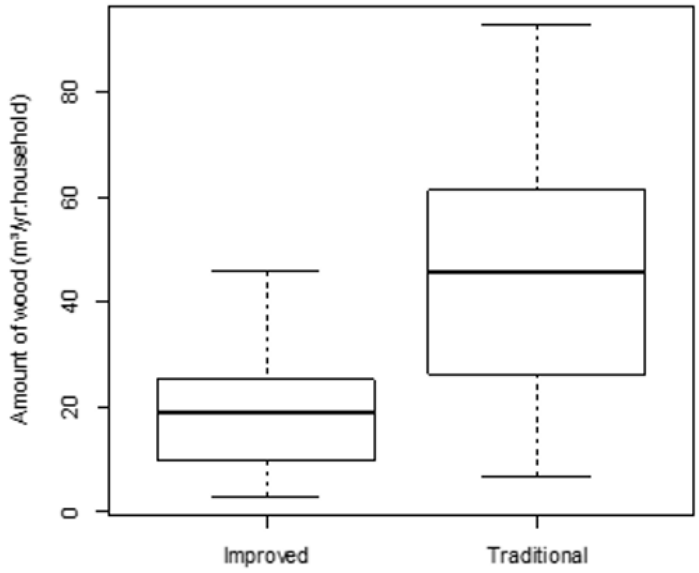

Fig. 26: Comparison amount of wood collected between improved and traditional stove.

Median amount of wood collected improved stove: 19 m³/ yr. household; median amount of wood collected traditional stove: 46 m³/ yr. household. (improved: n=16; traditional: n=15).

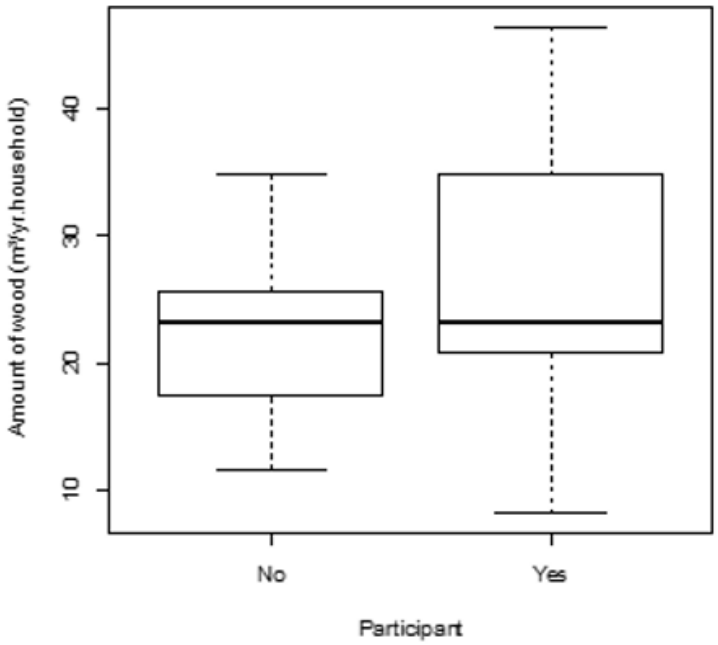

Fig. 27: Comparison values wood consumption between participants of the project and others

(No: n=11, Yes: n=23)

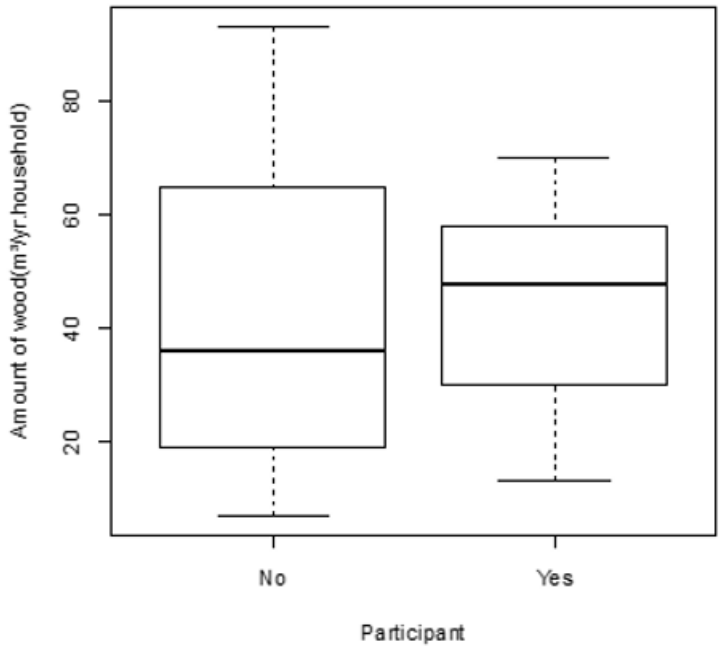

Fig. 28: Comparison of the amount of wood collected between participants and non-participants of the project.

(No-participant: n=9; Yes-participant: n=15).

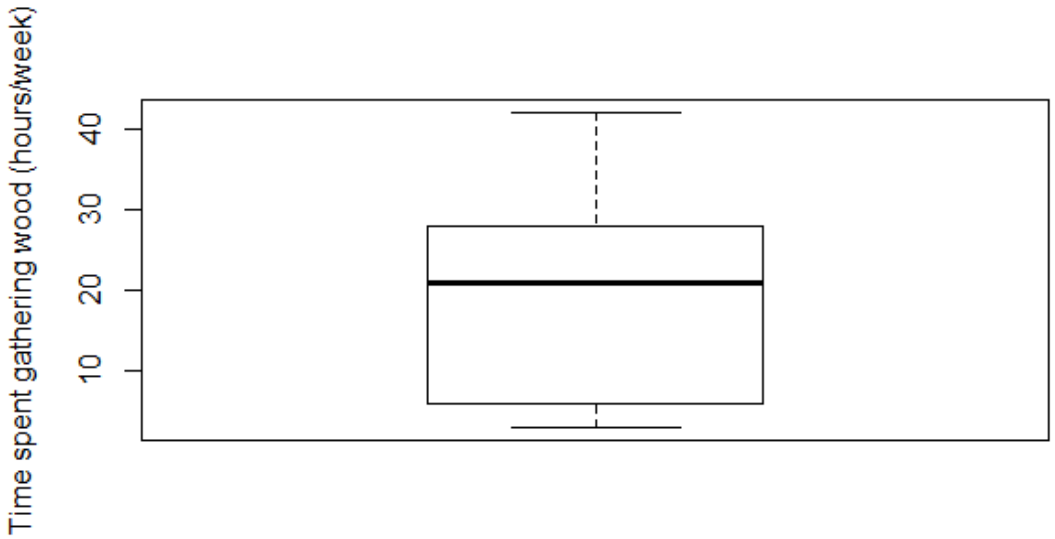

Fig. 29: Time spent on wood collection in the dry season

The mean time spent to gather wood per household per week = 21 hours. (n=14)

Annex 4.2. Results surveys Wanrou tables

Table 20: Advantages improved stoves Eco-Benin according to the users

Advantages improved stoves Eco-Benin	Number of times cited
Increased hygiene in the kitchen	10
The improved stove consumes less wood	9
Cooking time is reduced	8
The improved stove is beneficial for the general health	6
There is less smoke	2

Table 21: Evaluation of the relationship between Eco-Benin and the users

	Proportion (%)
Support Eco-Benin: *Did Eco-Benin or anyone else support you during the project*? (n=14)	
Proportion trained by Eco-Benin itself	21
Proportion receiving active, regular support	7
Proportion receiving support, but not from Eco-Benin	50
Follow-up of the project: *Did Eco-Benin visit you? Which frequency?* (n=25)	
Eco-Benin never visited	40
Eco-Benin visited only once in three years	20
Eco-Benin visited regularly	24
Communication: *Do you want more communication with Eco-Benin?*(n=10)	
I would like more communication	40
Continuation: *Would you continue/start again using the improved stoves even without Eco-Benin*? (n=14)	
I have the intention to start again	93

Table 22: Results conditionality of the project.

	Proportion (%)
Conditions (n=25):	
Are there any kind of conditions associated with the improved stoves?	
No	100
Payment (n=25):	
Did you pay anything for either construction or use of the improved stove?	
No	100
Reward (n=25):	
Did you ever received any kind of reward?	
No	8
yes	92

Extra: *What did you receive and from who?*

-an installer : "I received seven ducks, I had to raise them and return the ducklings. I am not sure it is from Eco-Benin"

-an user: "I received once 2000 F CFA, but I have no idea from who"

Table 23: The reasons people not use an improved stove

Reason not using an improved stove	Number of times quoted
I was not present at the moment when the stoves were built.	4
I have not found enough help.	3
I did not know the stoves existed.	3
There are some conditions to obtain the stoves (e.g. pay 3000F CFA).	1
I am not interested.	1
I want to build a kitchen first, so I can install the stove inside.	1
Group discussion Sangou: We did not know the stoves existed at the moment, afterwards we had to pay.	4
Extra:*Are you interested to join the project? (n=13)*	
Yes (proportion)	0.92

Table 24: Lessons learnt group discussion Tiele

When did the project start ? When did you start with the installation of the fireplaces?	-The project started three years ago.
Does Eco-Benin monitor the project ? Is someone paid?	-We have never met someone of Eco-Benin, there has never been anyone. There is never any help. -Maybe the people who were trained by Eco-Benin get some help, but we are not sure. These do receive money and we are not happy with that. In this way we are not motivated to start again (constructing). We work so hard, but we do not get recognition. -Those who were trained indirectly by Eco-Benin (villagers learn each other how to construct the stoves) have to help the others and they do it well. But they are not recognized for that. They do not receive a compensation. Eco- Benin does not even come to see what is happening in the villages. -we know that villagers in other villages receive compensation, that is not fair.

Will you start again?	-we want to start again at the end of the rainy season, but we want to build them for ourselves and not in the name of Eco-Benin.
What are the benefits?	-hygiene -people are protected from smoke -it is good for health -the pots are always clean
What are you going to change in order to avoid stoves break ?	-now we know that rain is not good for the stoves. We are going to cover the stoves each time to protect them.
How many stoves are still working?	-in total, there are 500 households. We think it works only for 10 households.

Table 25: Some passages from the interviews with 'formatrices' of Eco-Benin

Qu'est-ce que vous faites exactement ?	« Je construis les foyers pour les autres. Elle est dans le comité qui représente le village. Elles font des sorties officielles. Ça passe deux fois par an. Mais elle font aussi régulièrement des visites officieuses. »
Aviez-vous reçu quelque chose pour le travail ? Une compensation ?	« Ni les formateurs ni les bénéficiaires reçoivent quelque chose. Mais elle a reçu des canards, mais elle n'est pas sûr qu'est directement d'Eco-Benin. Elle a reçu 7 canards comme récompense et c'était un contrat. Elle devait redonner les poussins et elle a déjà fait ça. Mais elle ne sait pas si c'était un cadeau d'Amadou personnellement (contact Eco-Benin) ou d'Eco-Benin en général. »
Comment est le contact avec Eco-Benin ?	« Le représentative d'Eco-Benin vient régulièrement. »
Comment voulez-vous améliorer le projet/les foyers ?	- « Il faut trouver quelque chose pour améliorer les foyers. Peut-être une autre type de sable, argile ou il faut changer la composition ou il faut ajouter quelque chose comme ciment. Parce que maintenant les foyers se cassent après un certain temps. » -« Les femmes qui aident les autres doivent recevoir quelque chose. Parce que les autres les insulter et ils doivent travailler dur. Donc, si Eco-Benin veut que nous continuons avec le travail, ils doivent donner une récompense. » -« Les gens utilisent encore les feux trois pieds pour préparer la bière locale. Et presque tout le monde prépare la bière locale et le foyer amélioré est trop petit pour les grandes marmites. »

Annex 4.3. Lesson learnt Operational plan.

(based on The Gold Standard, 2017)

- Eco-Benin implements the micro scale-VPA and the carbon consultancy company CO_2 logic will advise them on technical aspects of the projects.
- Costs for the stoves are minimal, since cheap local materials are used. The improved stove has a lifespan of three years. However, without proper maintenance and regular reparations, the stoves will rapidly deteriorate. Instructors help the end-users to maintain and repair the stoves.
- End-users have to pay a construction cost of 1500 FCFA. This money is used to
- pay the constructor.
- Eco-Benin will visit all end-users at least one a year.
- The improved stoves will be replaced at least once during the crediting period (7 years).
- The intervention area of the project is the department of Atacora in the municipalities of Tanguièta, Matéri, Kérou, Cobly and Boukoumbé.
- The baseline fuel and stove are respectively firewood and a three stone fire.
- The project replaces all the traditional stoves of a participating household with improved stoves (with a thermal efficiency of at least 20%) in order to avoid double counting. A unique serial number is assigned to each end-user and saved in an electronic database**.**
- End-user can choose between different sizes of improved stoves
- Each end-user cede their rights to claim emission reductions by signing a waiver.
- The extent to which the baseline stoves are still in use will be monitored. Only on exceptional event, the baseline stove may be used.
- A CO_2 reduction of less than 10,000 tons of CO2e/yr is expected.
- rural households using woody biomass are targeted by this project.
- A confirmation of no public funding is needed.

Monitoring

- The usage rate of the improved stoves is monitored annually. Cooking stoves which are considered ‘not-usable’ will be excluded from the database for the crediting period until it is repaired.
- The discount factor to account for efficiency loss is monitored annually.
- The discount factor to account for the baseline stove still in use is monitored annually.

The methodology for the monitoring is the same for each factor above. Annually, a sample is taken from each size of cooking stove (referred to as target group). Assigned sample sizes are as follows:

- Target group population < 300: minimum sample size = 30
- 300 < target group population < 1000 : minimum sample size = 10% of population size
- Target group population >1000 : minimum sample size = 100

Annex 5. Images

Annex 5.1. Improved cooking stoves

(Above: Improved cooking stoves still working; below: broken improved stoves)




Annex 5.2. Image Focus groups