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INTERUNIVERSITY MASTER OF SCIENCE IN MARINE AND LACUSTRINE SCIENCE AND MANAGEMENT

Rapid ecosystem service assessment & conceptualization of conservation effectiveness in Pendjari National Park, Benin

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Cover Page Figure Captions

The village of Tanguiéta as seen between two Baobab trees from mid-height of the Atacora mountain chain (left). A woman from Tchanwassage stands in her rice fields, the termite mounds destroying patches of her field in the foreground (right).

ABSTRACT

The Pendjari Biosphere Reserve in Benin is of great ecological, scientific and cultural importance, but is not immune to the global trend of biodiversity loss and ecosystem degradation. This study examines the threats to and trends of ecosystem service provision according to local communities living around the Pendjari Biosphere Reserve through use of a TESSA (Tool-kit for Ecosystem Service Site Assessment) inspired NGT (Nominal Group Technique). The study also assesses the perceptions of local communities regarding the recent management shift which occurred in mid-2017, when *African Parks Network* (APN) assumed management of the previously state-run Pendjari Biosphere Reserve under a 10-year private-public partnership concession. The application of the TESSA-NGT method generated locally relevant data on ecosystem services in the Pendjari, which can serve to improve the sustainable management of natural resources. The method, however, proved difficult with respect to organizing focus groups in advance and accessing participants with higher levels of education.

The results of this study provide a snap-shot of the perceptions of local communities on the threats to ecosystem services and the changes following the recent management shift. The results indicate that *Land Tenure Security* and the *Strict Enforcement of Rules & Loss of Extractive Access* are the most important responses according to the demographic interviewed. The results also indicate that the rapid (8 month) management shift from a state-run agency to APN appears to have eroded what trust was built following the recent two decades of successful participatory management. Examination of trends of ecosystem service provision indicate that local communities perceive that service provision has declined with respect to all services presented, except tourism and ecological education. This is due to increases in logistic, technological and financial capacity since the management shift. A Bray-Curtis dissimilarity matrix was created to represent average heterogeneity of TESSA-NGT rank importance response data. Non-parametric permutational analysis of variance (perMANOVA) models were fit to this matrix to asses whether socio-demographic characteristics had a significant effect in determining focus group responses. The results indicate that participant municipality and gender had a significant effect in determining how local communities perceive threats to ecosystem services and changes in management. Gender and district specific approaches to resource use and management should therefore be a focal point of management schemes as the differential experiences of those of different genders and municipalities yield different understandings and knowledge of the Pendjari ecosystem and its associated threats. The data collection methods and analyses described in this study are recommended to others studying protected areas as similar studies can reduce the paucity of local and traditional ecological knowledge in decision-making and policy.

Key words: Natural resource management, ecosystem services, nominal group technique, Tool-Kit for Rapid Ecosystem Service Site-Based Assessment, Pendjari Biosphere Reserve, Benin.

FRAMEWORK & FUNDING

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"There is a pleasure in the pathless woods,

There is a rapture on the lonely shore,

There is society, where none intrudes,

By the deep Sea, and music in its roar:

I love not Man the less, but Nature more,"

- Lord Byron, Childe Harold's Pilgrimage

LIST OF ABBREVIATIONS

APN: African Parks Network

[U-]AVIGREF: Village Associations for the Management of Wildlife Reserves (l'Union des Associations Villageoises de Gestion des Réserves de Faune)

β_{JAC}: Jaccard dissimilarity

BELSPO: The Belgian Federal Science Policy Office

CBD: Convention on Biological Diversity

CENAGREF: National Centre for the Management of Wildlife Reserve (Centre National de Gestion des Réserves de Faune)

CITES: Convention on International Trade of Endangered Species

d_{BC}: Bray-Curtis dissimilarity

df: Degrees of Freedom

ES: Ecosystem services

GDP: Gross Domestic Product

GIZ: German Agency for International Development (Deutsche Gesellschaft für Internationale Zusammenarbeit)

GPS: Global Positioning System

HDI: Human Development Index

ICTZ: Inter-Tropical Convergence Zone

IUCN: International Union for the Conservation of Nature

IPBES: Intergovernmental Platform on Biodiversity and Ecosystem Services

MA: Millennium Ecosystem Assessment

MAB: Man and the Biosphere

MBI: Market Based Instruments

NGT: Nominal Group Technique

nMDS: Non-Metric Multi-Dimensional Scaling

PBR: Pendjari Biosphere Reserve

perMANOVA: Non-Parametric Permutational Multivariate Analysis of Variance

PES: Payments for Ecosystem Services

PNP: Pendjari National Park

PPP: Public-Private Partnership

RBINS: Royal Belgian Institute of Natural Sciences

SD: Standard Deviation

SDGs: [United Nations] Sustainable Development Goals

TEEB: The Economics of Ecosystems and Biodiversity

TESSA: The Tool-kit for Ecosystem Service Site-Based Assessment

KU Leuven : Katholieke Universiteit Leuven

UAntwerp: Universiteit Antwerpen

ULB : Université Libre de Bruxelles

UNCTAD: United Nation Conference on Trade and Development

UNDP: United Nations Development Program

UNEP: United Nations Environment Program

UNESCO: United Nations Educational, Scientific and Cultural Organization

WAP: W-Arly-Pendjari Transboundary National Reserve Complex

West African FCFA: West African CFA Franc (Franc de la Communauté Financière Africaine de l'Ouest)

WHO: World Health Organization

ZOC: Zones of Controlled Use (Zones d'occupation contrôlées)

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1.0 INTRODUCTION

1.1 Ecosystem Services, Biodiversity & Protected Areas

Despite increasing public awareness and inclusion into both academic and policy spheres, natural ecosystems and the services they provide are under intense and widespread pressure (IPBES, 2019; MEA, 2005). Humans have dramatically altered ecosystems worldwide, hindering the ability of these systems to deliver goods and services (IPBES, 2019; MEA, 2005). This, coupled with expedited loss of biodiversity required for service delivery[1] is further reducing ecosystems' capacity to deliver the goods and services upon which the entire population depends (Dobson et al., 2006; Naeem et al., 1995; Chapin III et al., 2000; Loreau et al., 2001).

Notwithstanding the dichotomous debate regarding the relationship between man and the environment,[2] the urgent need safeguard biodiversity and the services it provides remains. (Braat and de Groot, 2012; Costanza et al., 2017, 1997; Drupp, 2016; Ehrlich and Mooney, 1983; Farley, 2012; Gómez-Baggethun et al., 2009; Piccolo, 2017; Ridder, 2008). The inclusion of biodiversity and the ecosystem services[3] it supports into natural resource management plans has become increasingly common following the mainstreaming of the concepts by highly publicized reports such as the *Millennium Ecosystem Assessment (MEA)*, and *The Economics of Ecosystems and Biodiversity (TEEB)* (Braat and de Groot, 2012; Costanza et al., 2017;MEA, 2005). Many alternatives exist[4] but protected areas[5] remain the crux of many global strategies to conserve biodiversity and ecosystem services (Balvanera et al., 2006; Durán et al., 2013; Egoh et al., 2012; Lele et al., 2013). While humans worldwide depend on ecosystem services for their livelihood and well-being, it is understood that rural people living in developing areas have a greater and more direct reliance on natural resources and are therefore more susceptible to negative impacts associated with transformation, degradation and biodiversity loss (Egoh et al., 2012; Muhamad et al., 2014).

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[1] The relationship between biodiversity and service delivery is defined as a "broad consensus" among the scientific community by (Hooper et al., 2005).

[2] ES is an inherently utilitarian conceptualization of nature (Braat and de Groot, 2012; Costanza et al., 2017, 1997; Gómez-Baggethun et al., 2009). This may be contrasted with the argument that nature should be preserved simply because of its inherent value to human society (Piccolo, 2017; Ridder, 2008).

[3] Defined in the seminal paper by Costanza et al. (1997) as "the benefits human populations derive directly or indirectly, from ecosystem functions."

[4] Many alternatives to the preservation of ecosystem services and biodiversity exist including the monetization and commoditization of nature via institutional structures designed to allow trades and transactions with the leading Market Based Instruments (MBI) being Markets for Ecosystem Services (MES)[4] and Payments for Ecosystem Services (PES)[4] (Gómez-Baggethun et al., 2009).

[5] Protected areas, according to the IUCN are "an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means" (IUCN Commission on National Parks and Protected Areas 1994 pp 3)

The Pendjari Biosphere Reserve (PBR) in Benin is of great ecological, scientific and cultural importance but is not immune to the global trend of ecosystem degradation and transformation. The area faces threats such as pollution, overexploitation, habitat transformation, human encroachment, illegal grazing and poaching which are driven, in part, by high population growth, poverty and food insecurity (Sogbohossou et al. 2014). The area, and in particular its ability to provide sustenance through rain-fed agriculture, is further threatened by climate change as the region has experienced an average recession in rainfall of 3.2mm/year and a linear increase in temperature of 0.03 ° C / year since 1960, exasperating desertification and food insecurity (Kate et al., 2015). A comprehensive understanding of the threats to and trends of ecosystem services in the Pendjari Biosphere Reserve is essential for the sustainable management of natural resources and will help to safeguard the livelihood and well-being of local populations.

1.2 The Republic of Benin

1.2.2 Demographics & Economy

The Pendjari Biosphere Reserve (PBR) lies in the extreme north-west of Benin (10°30′ to 11°30 N, 0°50′ to 2°00′E) and forms the largest part of the W-Arly-Pendjari (WAP) complex, a transnational complex of three national parks that spans Benin, Niger and Burkina Faso (Figure 1). Benin is a small (114,763 km^2) West African country that

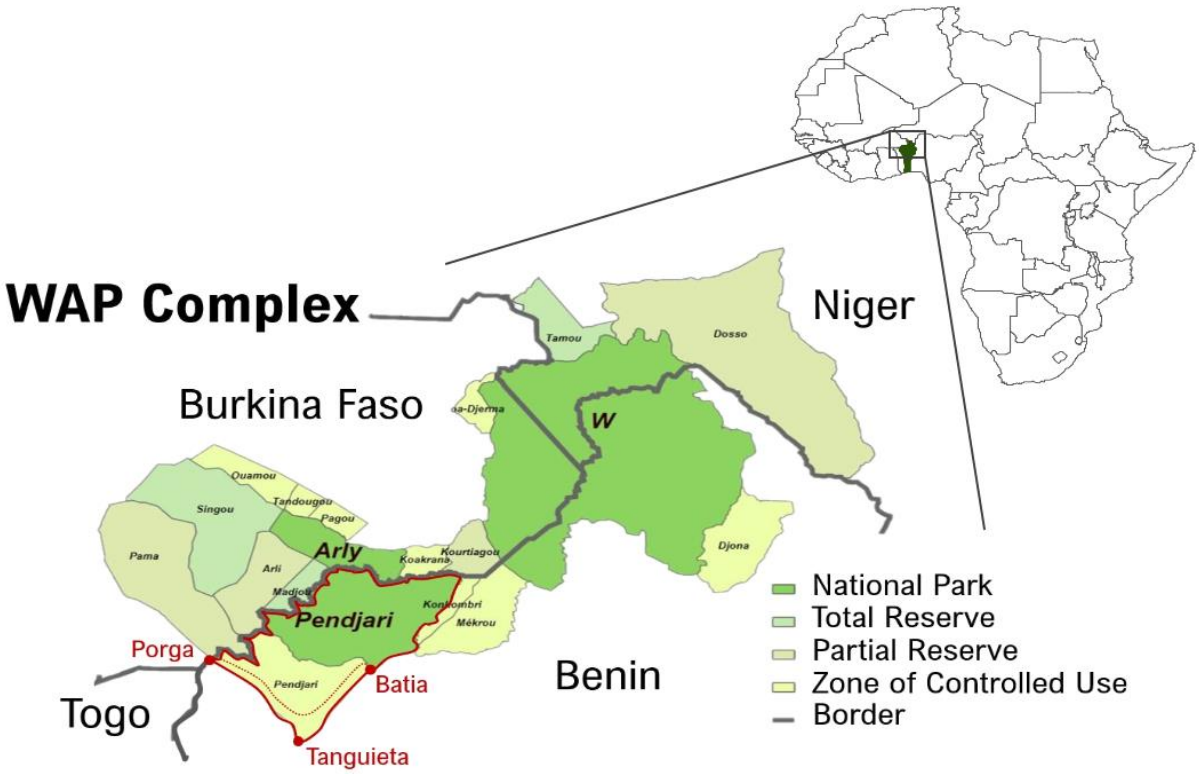

Figure 1. Map of the WAP Complex which spans Benin, Burkina Faso and Niger. The Pendjari Biosphere Reserve is outlined in red. Source: © Iliana Jansens

has a current population of 11.2 million and a population growth rate of 2.8% (World Bank Group, 2018). The overall population density is 99 inhabitants/km^2 but the country exhibits decreasing population density from the southern capital region (185 inhabitants/km^2) to the northern Atacora department (20-40 inhabitants/km^2) where the national park is located (Floquet, 2011; World Bank Group, 2018). The country has an average literacy rate of 32.9% and a Gross Annual National Income Per Capita (GNI) of 1,611 US$ (World Bank Group, 2018). Benin ranked 163rd globally in 2017, with a Human Development Index of 0.515 (HDI, 2017). 37.4% of the population lives below the poverty line but those living near the national park are among the poorest in the country and their population is growing at the fastest rate (3.0% population growth rate) (CENAGREF, 2015; World Bank Group, 2018).

The Beninese economy is agrarian-based; 43.2% of the population is employed in agriculture which corresponds to 26% of GDP (Dognon et al., 2018). In the north-west region, the growing population drives the transformation of savannah and grassland into agricultural fields for sustenance with sorghum (*Sorghum bicolor*), peanut (*Arachis hypogaea*), yam (*Dioscorea sp.*), corn (*Zea mays*), cassava (*Manihot esculenta*) and rice (*Oryza sativa*) as primary crops. In 2013, satellite imagery showed that humans had encroached into and converted 15% of the buffer zone[6] surrounding the WAP complex (CILSS, 2016).

Livestock rearing is the second most important economic activity of rural people in the country. It accounts for 6.2% of GDP and averages 15% of agricultural GDP (Djohy, 2017). Cattle exhibits highest densities in the northern regions of the country where they are raised for sustenance and consumed during periods of climatic or economic instability (Lesse et al., 2015). Cattle in northern Benin are essentially nomadic. While three transhumance corridors were established in the WAP 2014, several threats are still associated with the movement of cattle including disease transmission, ecosystem disturbance, and competition between wild and domestic animals (Lesse et al., 2015).

Cotton (*Gossypium hirsutum*) is the main cash-crop in Benin, accounting for 40% of GDP and 80% of agricultural exports. However, apiculture has been found to be an equally competitive economic activity in northern Benin despite not receiving due attention from neither villagers nor development cooperation projects (Ambaliou et al., 2012; Paraïso et al., 2012). On February 15, 2018 under article 29[7], the European Commission placed Benin as one West African country of eight capable of importing honey into European markets, giving momentum for the expansion of Beninese production, which currently sits around 600 000kg/year (Commodafrica, 2018).

Benin was under French colonial rule from 1904, forming one state of eight in West French Africa. The country gained full independence in 1961. Benin has since ratified many international conventions on the protection

[6] Refer to section 1.3.3 for additional information regarding the zonation of the Pendjari Biosphere Reserve.
[7] Article 29 of Directive 96/23/CE, as applicable to signatories of the Economic Partnership Agreement (EPA).

of the environment including the Convention on Biological Diversity (CBD), the Convention on International Trade of Endangered Species (CITES) and the Ramsar Convention on Wetlands of International Importance. With the support of the United Nations Development Program (UNDP), the Beninese government has undertaken several capacity building and advocacy programs to advance their specific UN Sustainable Development Goals (SDGs): Goal 2 on Zero Hunger, Goal 3 on Good Health and Well-Being, Goal 4 on Quality Education, Goal 6 on Clean Water and Sanitation and Goal 16 on Peace, Justice and Strong Institutions (UNDP, 2016). The national legislation[9] in Benin recognizes four types of protected areas: classified forest reserves (46), reforestation zones (7), hunting zones (3) and national parks (2) – the W National Park and the Pendjari National Park.

1.3 The Pendjari Biosphere Reserve

1.3.1 Climate, Geology & Biodiversity

The climate of the Pendjari Biosphere Reserve is governed by the Inter-Tropical Convergence Zone (ITCZ) and falls within the West Savannah Sudanese climatic zone – tropical temperatures, unimodal rainfall and a seasonal semi-arid climate (Callo-Concha et al., 2012). The area knows two seasons per year: one wet season that generally runs from April/May to October and one dry season that runs from November to March (Djagoun et al., 2013). The area receives under 1300mm of annual rainfall (Floquet, 2011). The reserve and surrounding area are of impervious crystalline clay of volcanic origin and therefore of naturally lower fertility.

The region is dominated by savannah but a range of habitats including shrub lands, wooded savannah and gallery forests are also found. The reserve offers protection to a rich diversity of flora and fauna including elephants (*Loxodonta africana*), lions (*Panthera leo*), cheetah (*Acinonyx jubatus),* leopards (*Panthera pardus*), buffalos (*Syncerus caffer*), hippopotamus (*Hippotragus equinus koba*), and over 400 species of birds (Bouché et al., 2016; CENAGREF, 2015; Floquet, 2011). The Atacora region of the PBR is recognized as one of the five Important Bird Areas (IBA) in Benin. This is because 20 of the 34 species that have a breeding ground restricted to the Sudanese biome are found in that area of the Pendjari (Cheke, 2001). Many of the organisms that find refuge in the park are IUCN Red Listed as critically endangered (*P. leo*), endangered (*L. africana*) and vulnerable (*A. jubatus)* (IUCN, 2019). Extirpation would have serious consequences as biodiversity is the infrastructural support system that maintains ecosystem services, and serves to increase ecosystem resilience against perturbations such as climate change and invasive species (Balvanera et al., 2006; IPBES, 2019).

[9] The first legislation regarding protected areas in Benin was developed by the French colonial rule in 1935. Additional legislations and decrees regarding protected areas include the following: Decree no. 1704 AP of 1935, decree no. 1107/EFC of 1943, law no. 87-012-014 of 1987, decree no. 89-385 of 1989, and decree no. 0020/MDR/DC/CC/CP of 1992.

1.3.2 History & Management

For the 20 years prior to its inscription as a partial wildlife reserve in 1954, human populations were actively expulsed from their lands by colonial authorities to create a game reserve (Idrissou et al., 2013). One year later, in 1955, the area was designated as a complete reserve and in 1961, the area was renamed the Pendjari National Park (PNP). In 1986, the central areas, surrounding buffer zones and hunting zones were collectively designated as a Man and the Biosphere Reserve[10]. In 1996, the PBR, as part of the WAP complex, was officially inscribed as a UNESCO world heritage site. Today the terms Pendjari National Park and Pendjari Biosphere Reserve are used interchangeably.

From inscription until 1992, the park was managed by the national forest department. The prolonged coercive expulsion from park land and exclusion from management created an environment of distrust characterised by clashes and conflicts between national authorities and local communities regarding access to park resources (Idrissou et al. 2013; Vodouhê et al. 2010). A participatory management scheme was introduced in 1993[11], however an environment of distrust had already been established which hindered initial engagement and success. In response to the new management scheme, most of the peripheral villages formed a union called the *Village Associations for the Management of Wildlife Reserves* (AVIGREF, *l'Union des Associations Villageoises de Gestion des Réserves de Faune*).

Three years later in 1996, the Beninese government created the autonomous authority known as the *National Centre for the Management of Wildlife Reserve* (*CENAGREF, Centre National de Gestion des Réserves de Faune*)[12]. CENAGREF managed the protected area with AVIGREF members directly until August 2017 when *African Parks Network* (APN) assumed management. APN is an international non-profit NGO[13] that presents itself as a solution to the institutional and financial constraints to conservation that many African governments face (Busher, 2011; Saporiti, 2006). APN currently manages 15 national parks in nine African countries under the Public-Private Partnership (PPP) model of management. PPPs are long term concession contracts between states and private companies where the company is granted commercial rights to the park and is responsible for conservation and management activities. While management may have shifted hands and approaches multiple times over the last 65 years, the general zonation of the park has remained relatively consistent.

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[10] UNESCO Man and the Biosphere (MAB) Reserves are an approach to natural resource management that aims to reconcile the sustainable use of resources by the local communities and the conservation of biodiversity. Zonation of the PNP according to this approach is discussed in section 1.3.3

[11] The participatory management scheme is governed under law no. 93-009 of 2 July 1993.

[12] CENAGREF was legislated by decree no. 96-73 of 2 April 1996 of law no. 93-009 of 1993.

[13] Non-Governmental Organization

1.3.3 Zonation

The Pendjari National Park has been uninhabited and unfenced since it was initially created in 1954. It is composed of three main zones – a core, a buffer and a transition zone – that conform to MAB UNESCO requirements for the sustainable co-management of socio-ecological systems (Figure 2). It is these three areas that are collectively referred to as the Pendjari Biosphere Reserve following UNESCO MAB designation in 1986 despite common colloquial use of the term National Park to also refer to the entire area.

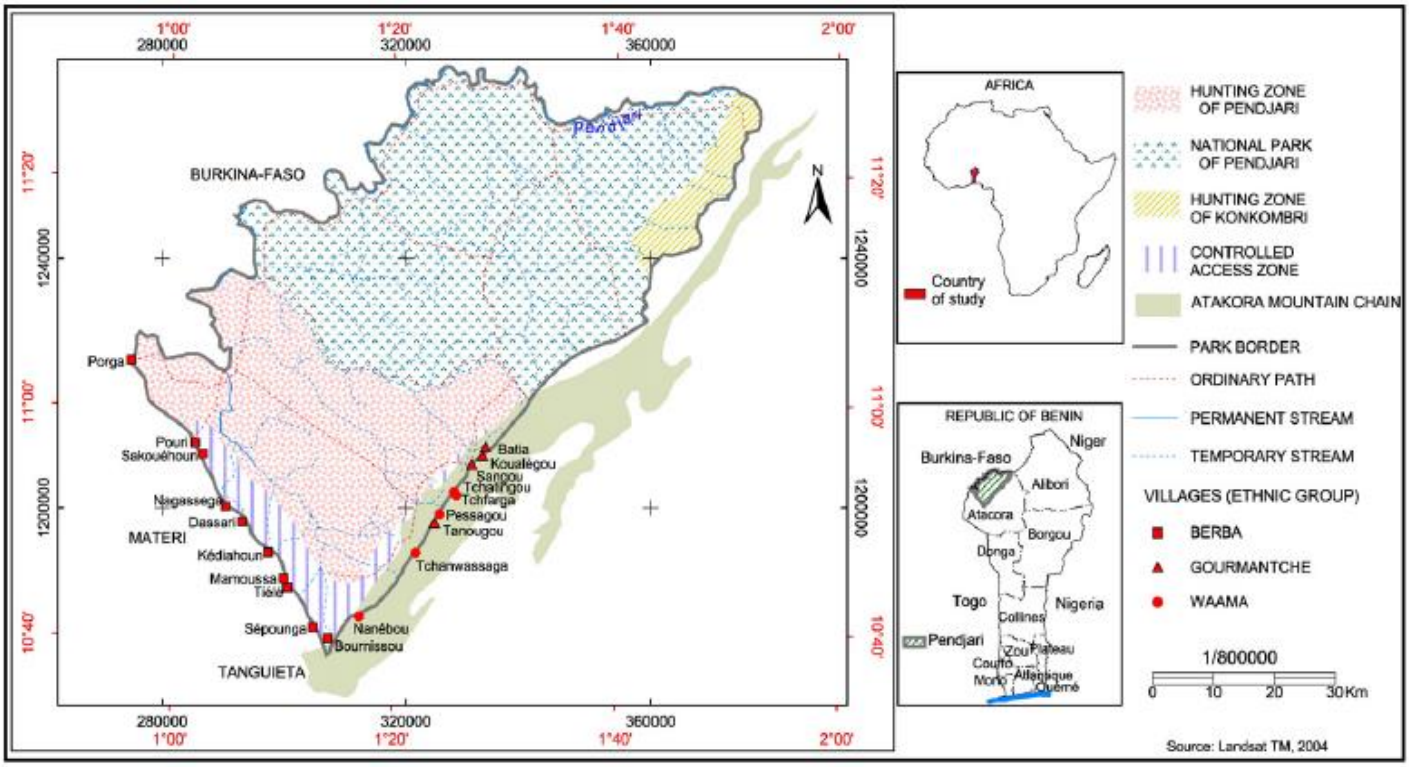

Figure 2. Map of the zonation of the Pendjari Biosphere Reserve in north-western Benin in Western Africa. Source: Vodouhê et al., 2010.

The core area is the area that was initially designated as a hunting reserve in 1954 and a full reserve (national park) in 1961. Extraction and exploitation of resources has been banned since 1961. There, human activity is restricted but research, eco-tourism and monitoring are permitted. The central areas are surrounded by a buffer zone that is designated to mitigate impact from outside areas (Figure 2). The buffer zone consists of five distinct areas within three protection categories: an ecological buffer zone to further ensure conservation of the core areas, an ecotourism zone and a controlled concession-based trophy hunting zone (CENAGREF, 2015).

The transition zone, known by local communities as the zones of controlled use (ZOC), forms the southern limit of the reserve and borders the two main road axes around the reserve (Figure 2). The Tanguiéta-Porga runs

from north-west towards Togo and Burkina Faso. The Tanguiéta-Batia axis runs north-east towards Nigeria and is bordered to the south-east by the Atacora mountain chain.

The ZOC provides a third degree of protection in the park by regulating activities like agriculture, extraction and grazing, and prevents human encroachment into protected areas (Floquet, 2011). The boundaries of the ZOC were formally defined in 2002 but limits remain in conflict with those delineated by traditional methods of land allocation (Tiomoko, 2014). The population depends on the access to land for sustenance but due to high population growth rates, threats such as illegal grazing, agricultural encroachment and illegal exploitation of resources still occur (IUCN, 2017).

1.3.4 The Human Environment

The local populations of the PNP live in 23 villages along two main road axes. Three main ethnic groups live along the axes: Berba (65%), Gourmantché (23%), and Waama (7%). Those of Berba ethnicity live along the Tanguiéta-Porga axe, and those of Gourmantché and Waama live along Tanguiéta-Batia axe (Vodouhê et al., 2010, see Figure 2). Ethic groups have strong traditions in hunting and communities are often ruled by highly influential kings or cult leaders. Indigenous religion accounts for around 50% of local belief systems while Christianity (40%) and Islam (10%) make up the remainder. In 2002, 96.7% of the 27 783 inhabitants were involved in agriculture as compared to the national average of 43.2% (CENAGREF, 2015; Dognon et al., 2018). As mentioned in section 1.3.1, the soils of the reserve are of naturally lower fertility, however it is the poor agricultural technique and intensive use of pesticides and fertilizers that expedite soil degradation, reduce infiltration and increase run-off in the ZOC (Adaawen et al., 2015; Hanson et al., 2012; Westerburg, 2017). This land degradation coupled with a 13-15% anticipated reduction in rainfall between now and 2100 can be excepted to have detrimental impacts on food security and agricultural productivity (Yegbemey et al., 2013). Strong adaptation and mitigation strategies including (but not limited to) crop diversification, income diversification and improved water conservation techniques are required to sustain local livelihoods.

Many socio-professional organisations have emerged from the villages surrounding the national park to aid in co-management of natural resources and to represent the local population. Some of these groups include women's groups, fishermen's groups and local village unions. The most prominent of is the which is the union of *Village Associations for the Management of Wildlife Reserves* (AVIGREF). AVIGREF provides members with 30% of the revenue from activities such as partial park-entry fees, hunting revenues, and fines from illegal activities, thus generating support for conservation (Vodouhê et al. 2010). However, this 30% is shared among only 10% of the population; of those that received additional revenue, 37% said that the value was insufficient to compensate for the

lack of access to park resources that they depended on, thus necessitating illegal entry into the park and exploitation of resources (Vodouhê et al. 2010).

In 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) released the first global assessment of the status of biodiversity and ecosystems since the Millennium Ecosystem Assessment[14] (IPBES, 2019; MEA, 2005). The report was the first global assessment to include local and indigenous knowledge, and highlighted that while three-quarters of terrestrial ecosystems are degraded, those managed by local or indigenous communities are, on average, less severely affected by degradation (IPBES, 2019). Protected areas are the crux of many conservation strategies worldwide and the IPBES report highlights that there is a paucity of local and indigenous knowledge in regional scenarios of negative change with respect to biodiversity loss, climate change, and loss of ecosystem function. The report states that there is a need for "explicit consideration of the views, perspectives and rights of indigenous peoples and local communities, their knowledge and understanding of large regions and ecosystems and their desired future development pathways" (IPBES, 2019 pp 6). The management schemes of these reserves should therefore be based on both conventional scientific knowledge and local and traditional ecological knowledge (Berkström et al., 2019; Muhumuza and Balkwill, 2013).

1.3.5 Tourism & the Reserve

Despite having the natural and ecological capacity to allure hoards of tourists, Benin as a whole, and thus the Pendjari Biosphere as well, operates far below its potential according to the global travel competitiveness index (Peter Keller, 2004). Currently, the tourism sector only accounts for 2.6% of GDP, and presents large potential to increase and provide sustainable livelihood opportunities for local villages (UNCTAD, 2017; World Economic Forum, 2016). Specifically, the park attracted 6000 tourists in the 2017 season, a slight increase from the 5295 ± 314 average tourists per season from 1999 to 2015 (Olaniyi et al., 2018).

The 2017 report from the United Nation Conference on Trade and Development (UNCTAD) on focusing economic growth through tourism found that most African countries face significant challenges to developing their tourism sector (UNCTAD, 2017). Within the continent, the percentage of international tourists visiting Africa grew by an average 6% per year from 1995-2014. However, Benin specific data (summarized from the report and presented in Table 1) present a different pattern. As seen in Table 1, tourism in Benin (as well as tourism in Western

[14] The Millennium Ecosystem Assessment (MA) is a report released in 2005 under the United Nations Environmental Program (UNEP). The report was the first global assessment of the state and trends of ecosystems and associated services. It is credited with mainstreamed the concept of ES into policy and decision making by elucidating ecosystem service classification, identifying drivers of ecosystem change, publicizing the current trend of ecosystem degradation and transformation, and highlighting the diverse benefits of protected areas as a tool for both ecosystem service and biodiversity conservation (Lele et al. 2013; MEA 2005).

Africa as a whole) declined in the 2011-2014 period with respect to *Average Annual Growth Rate*, *Tourism Export as Share of Total Export*, and *Tourism Export as Share of Service Total*.

Table 1. Beninese tourism statistics from 1995-2015. Data derived from United Nations Conference on Trade and Development (UNCTAD), 2017. Economic Development in Africa: Tourism for Transformative and Inclusive Growth.

Year	International Tourist Arrivals (thousands of people)	Annual Average Growth Rate	Average international tourism receipts (millions of dollars)	Annual average growth rate of international tourism receipts	Tourism export revenue as share of total export	Tourism export revenue as share of total service export
1995-1998	145	4	71	6	11	46
2005-2008	183	3	165	-11	14	63
2011-2014	226	2	173	36	8	39
2015	255	5	154	-4		

This decline is in part due to the 2014 Ebola crisis; the outbreak epicenter occurred in Guinea and neighbouring Sierra Leone and Liberia had the highest number of cases (WHO, 2016). While Benin had no confirmed cases, the negative public health perception remained. Tourism in Benin is further hindered by regional insecurity. To the north of the park in the Sahel, large swathes of land have extreme poverty, high degrees of conflicts and low government presence (UNODC, 2017). This situation has fostered the expansion of Jihadist extremist groups affiliated with ISIS and Al Qaeda. As a result, large parts of Burkina Faso, Mali, Niger and Nigeria are widely considered as "no-go" zones by many government advisory boards. The area in northern Benin is widely considered a "red zone" with low regional tourist safety and security according. Other factors hindering tourist reception include limited flight accessibility, inadequate capacity in the service and production sectors in terms of quality, hygiene and safety and reputational challenges (UNCTAD, 2017; World Economic Forum, 2015).

In May 2017, *African Parks Network* (APN) and the Beninese government signed a 10 year contract to manage, secure, and revitalize the park (APN, 2017). The agreement secured a total of the US$23M to safeguard the last remaining intact ecosystem in Western Africa - US$6M committed by the Beninese government over five years, US$10M committed by the Wyss foundation, and US$7M committed by the National Geographic Society. APN has since input tremendous amounts of money into upgrading and the park:

- GPS collars placed on 10 elephants and 10 lions

- 35km of new roads and an airstrip constructed
- A new aerial surveillance program implemented and a lightweight aircraft purchased
- Three 40m masts installed to increase communication systems
- Law enforcement and ranger training strategies created and executed
- Guide training and awareness programmes implemented

Since their arrival, APN has expedited the goals of the Beninese government to rehabilitate and revitalize the Pendjari (APN, 2017).

PPPs present one solution among many to the current biodiversity crises, especially when local governments lack the financial or logistical capacity to adequately safeguard their natural resources (Awortwi, 2010, 2004; Dunn-Cavelty and Suter, 2009; Saporiti, 2006). However, their success depends on a number of prerequisite conditions including a high degree of trust and willingness among local communities and partners, strong participation of all stakeholders, and a strong conduit of communication and sharing of responsibilities (Awortwi, 2010, 2004). Given that the research took place exactly one year following the management shift, one of the objectives of this report is to examine the impact that this management shift had on the local villages. Additional objectives include a comprehensive understanding of threats to and trends of ecosystem service provision. Such locally generated knowledge can inform management regarding the sustainable management of natural resources, thus ideally safeguarding the livelihood and well-being of local populations.

2.0 RESEARCH OBJECTIVES

1. To assess the threats to priority ecosystem service provision in the Pendjari Biosphere reserve
2. To identify the temporal trends of service provision in the area
3. To understand the impact of the management shift on local communities

3.0 MATERIALS AND METHODS

3.1 Tool-kit for Ecosystem Service Site-Based Assessment (TESSA)

It is globally understood that ecosystem services are not adequately evaluated, resulting in exclusion from policy and decision making (Peh et al., 2013). The lack of ES mainstreaming is hindering global governmental

success at achieving CBD[18] Aichi Target 14 (the maintenance and protection of ecosystem services) and hindering the achievement of over half of the United Nations Sustainable Development Goals (SDGs) which are underpinned by ecosystem service delivery. Undervaluation of ES and subsequent exclusion from decision-making is a common phenomenon due to logistic, financial, spatial and temporal constraints and a fragmentation of expertise (Bagstad et al., 2014; Peh et al., 2013). However, there is a range of qualitative and quantitative decision support tools which aim to expand the existing knowledge base, aid in decision making and increase stakeholder participation and confidence (Bagstad et al., 2014; Hanson et al., 2012; Kettunen et al., 2009; Peh et al., 2013).

Given the aforementioned regional context of the Pendajari Biosphere Reserve (Section 1.3), the Tool-kit for Ecosystem Services Site-Based Assessment (TESSA) was selected as a decision support tool based on its low requirements for specialist knowledge, time frame, man-power, cost and successful previous application in generating locally-relevant data on ecosystem services (Peh et al., 2013). TESSA provides non-experts with a methodological framework to identify and evaluate the services that an area provides. This yields a more comprehensive understanding of services, which facilitates ES inclusion in policy and decision making . Stakeholder engagement is stressed throughout the framework's recurrent six steps: preliminary work, rapid appraisal, the identification of plausible (alternative, future) states, method selection, data acquisition, and analysis & communication (Figure 3). The six steps are then to be repeated to assess the differences in utilitarian and intrinsic

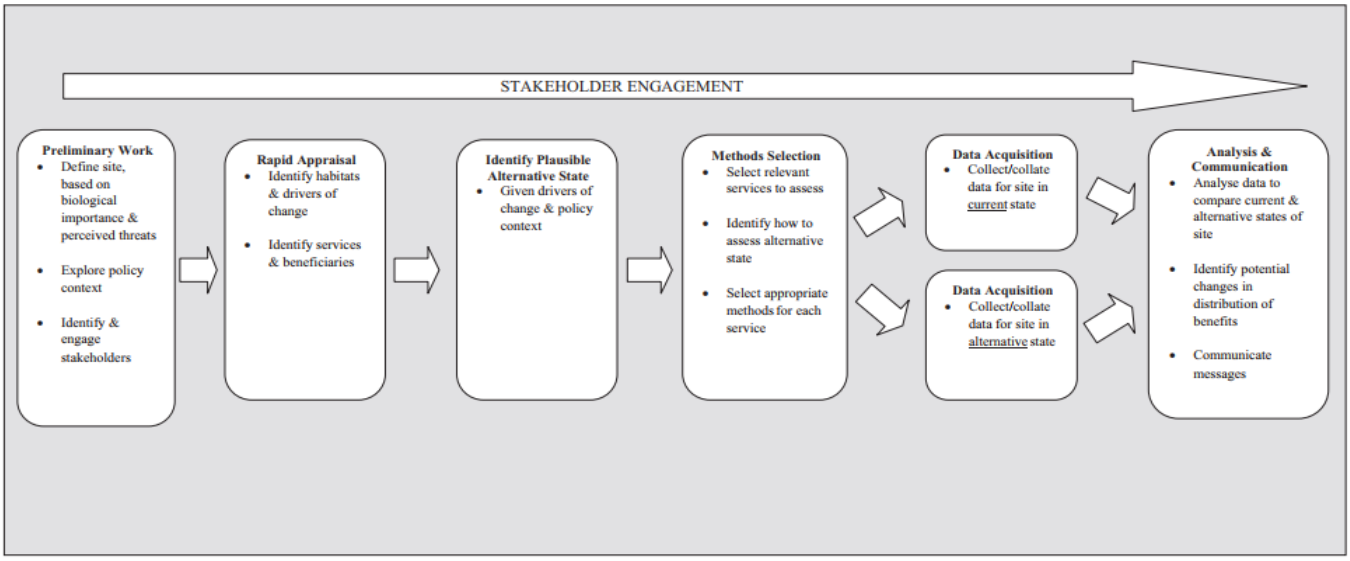

Figure 3. The Tool-kit for Ecosystem Service Site-Based Assessment (TESSA) methodological framework used to identify priority ecosystem services in an area.

[18] The Convention on Biological Diversity (CBD) is an international treaty that came into force in 1993 and has three main objectives to (1) conserve biological diversity (2) ensure the sustainable use of all aspects of biodiversity (3) to ensure the equitable sharing of genetic resources. The CDB Strategic Plan for Biodiversity (2011-2020) contains the Aichi Biodiversity Targets which consist of five strategic goals and 20 targets.

benefits provided by the alternative state, whether or not the transition to the alternative state has yet to occur. Decision support tools aimed to assess ecosystem service provision typically employ coarse resolution data obtained through modelling approaches (Peh et al., 2013). In contrast, TESSA enables the collection of fine resolution data through a myriad of templates which users adapt to site-specific conditions, making the toolkit globally applicable (Peh et al., 2013). This is an important element of TESSA because coarse resolution data is incompatible with the fine-scale at which natural resource management decisions take place.

The first phase of TESSA is the preliminary scoping appraisal, which aims to identify important habitat types and the activities that impact the site over a range of spatial and temporal scales. Table F (found in Annex A) of the appraisal provides a template through which facilitators can ask stakeholders how service provision in the area has changed in the past five years and how it might change in the future. It is the preliminary scoping appraisal of the TESSA that inspired the modifications for the Nominal Group Technique (NGT), thereby harnessing the power and comparability aspects of TESSA and NGT's reduction of group-decision-making biases. Moreover, TESSA has proven successful as a tool to generate locally-relevant data on ecosystem services, re-enforcing the important role that local and traditional knowledge bases can play in guiding natural resource management decisions (Peh et al., 2013).

3.2 The Nominal Group Technique

The Nominal Group Technique (NGT) is a participatory, group-based technique that was developed in 1968 by André P. Delbecq and Andrew H. Van de Ven (Sink, 1983). Initially developed as a tool in psychology, the NGT has over time become one of the most commonly used structured research tools used to generate group consensus (Harvey and Holmes, 2012). There are many examples and applications of the NGT in the literature but the technique is relatively unknown in the fields of conservation and ecology, with only 15 examples worldwide and only one in Africa (Hugé and Mukherjee, 2018; Queiros and Mearns, 2018).

Comprehensive analysis of the merits of the NGT as a tool in decision making and its juxtaposition against other decision making tools are found in Hugé and Mukherjee (2018) and Mukherjee et al., (2018), respectively. Of the 14 instances in ecology and conservation, Hugé and Mukherjee (2018 pp 36) found that the NGT was typically used as a tool to accomplish one of four main goals:

"(1) to support biodiversity management,

(2) to identify stakeholder preferences and attitudes,

(3) to prioritize in capacity-building exercises and

(4) to explore novel concepts."

The juxtaposition of the NGT against other decision-making techniques found in Mukherjee et al., (2018) showed that the NGT is most commonly used in the decision making process at sub-national levels (Figure 4). There, decision making was defined as the "actual process of engaging stakeholders to reach a consensus" and was slated to include aspects such as problem definition, the identification &/or prioritization of options and consensus generation (Mukherjee et al., 2018 pp 57). The technique is less commonly used in problem identification (pre-decision) and least commonly in post-decision (implementation and evaluation). This dearth in the literature presents an interesting opportunity to assess the suitability of the NGT in post-decision contexts.

A conventional NGT exercise consists of a group of 4-20 participants of homogenous hierarchical positions but with an emphasis on increasing the potential diversity of opinions (Hugé and Mukherjee, 2018). It is time efficient in that it requires but one session to elicit judgement and yields both qualitative and quantitative data (Harvey and Holmes, 2012). Preparatory work involves identifying the objectives of the exercise, preparing a list of objective-specific (often open-ended) questions targeted towards the desired demographic and organizing the logistics of the exercise.

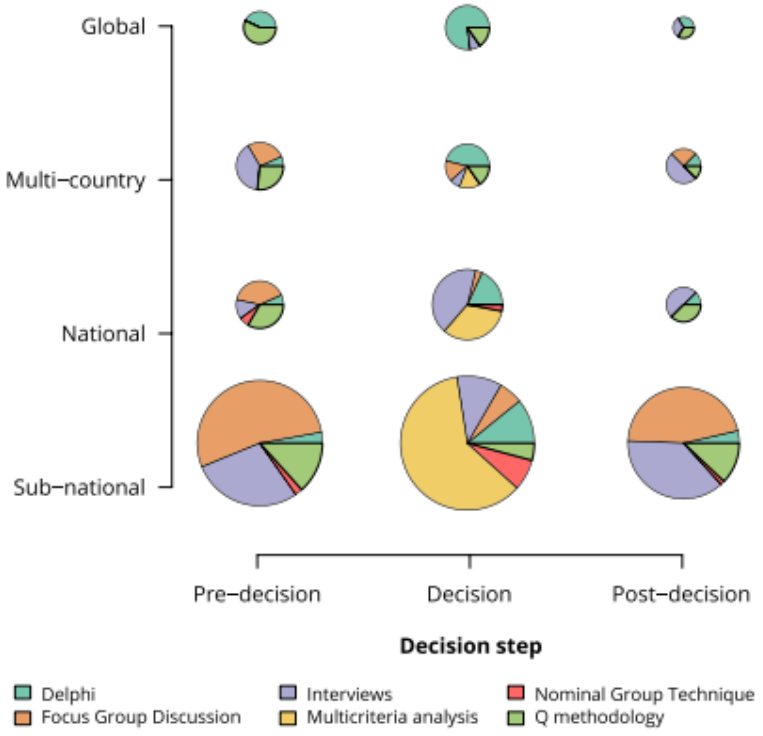

Figure 4. Scale and frequency at which socio-ecological research techniques were found to occur within the literature (n = 423). Where, "the radii of the circles are proportional to the square root of the number of studies." Source © (Mukherjee et al., 2018).

The general procedure (derived from Hugé and Mukherjee, 2018) occurs in four steps as described below:

> *1) Individual Brainstorming:* The facilitator introduces a pre-determined, open-ended question. Participants are given 5-15 minutes to create a customized list of answers to the question. Each additional question requires its own exercise (ie. repeat steps 1-4). The lack of interaction between participants at this step reduces "production blocking"[19] (Hugé and Mukherjee, 2018).
>
> *2) Round Robin:* Here, participants are asked to singularly and nominally announce one item on their list (thus reducing the dominance effect)[20]. The facilitator writes each addition on the large flip-board or projected computer screen, and the listing process continues until all ideas have been announced. Unwritten ideas are encouraged.
>
> *3) Group Discussion:* During this phase, the facilitator will ensure full comprehension through idea elaboration and clarification to ensure the voting is an informed process.
>
> *4) Voting & Ranking:* Here, participants are asked to individually approach the collective list and personally rank the ideas from 5 (most important) to 1 (least important). Scores are then summed by the facilitator yielding a prioritized list.

The NGT could permit the identification of the opinions of those living around the Pendjari Biosphere Reserve regarding the threats to ecosystem service provision in the area. As very few examples of NGTs with non-experts exist, and given the literacy rate of ZOC inhabitants (section 1.2.2), adaptations to the traditional method described above were required. Maynard and Jacobson (2017) proposed adaptations to involve low-literacy stakeholders in focus group exercises such as smaller group sizes, the use of visual cues (*i.e.* a range of shapes and sizes with associated meaning) and increased assistant presence to ensure comprehension of all participants could shift the focus of the NGT from experts to lower literacy levels. Similar adaptations as those found in Maynard and Jacobson (2017) were adopted in the current study and will be more extensively detailed in section 4.3.

The bulk of adaptations to traditional NGT were inspired the Scoping Appraisal of the Tool-Kit for Ecosystem Service Site-Based Assessment (TESSA, Section 3.1 & Annex A). For this reason, the NGT examining threats to ecosystem services will henceforth be referred to as TESSA-NGT.

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[19] Production blocking occurs when the ideas of a participant are "blocked" during collective, verbal brainstorming by the voices of others, thus reducing the diversity of ideas.

[20] The dominance effect is a phenomenon in focus groups wherein the voice of a dominant personality has a strong influence on less dominant voices, thus skewing the results towards the opinions of the dominant.

3.3 Data Collection

Data was collected in the villages around the Pendjari Biosphere Reserve for seven weeks from mid-August to early October 2018. Collection occurred with the help of two local translators who translated local language exercises into French and assisted exercise execution. A third intern was present to record the results of the exercises in a separate notebooks and ensure participants remained within the vicinity throughout the duration of the exercises. At least two and often three people were present to facilitate the exercises during the research period. Prior to arrival, a complete list of stakeholders was adapted from De Ryck (2018) who identified the priority ecosystem services around the PBR in 2017.

Every day over the course of seven weeks, the research team took motorcycles to the various villages located along the two main axes bordering the reserve. If a group had not previously been arranged by Mr. Kassa, then between the hours of 0730 and 1630, the research team would travel to local villages and the local translators would gather willing participants. Participants of a homogenous demographic were selected to ensure confidence of expression and to minimize some group biases, which could be suppressed in heterogenous groups due to the hierarchical nature of rural Beninese society. The maintenance of group homogeneity is also congruent with standard NGT protocol.

Once focus groups were formed, the facilitator and assistants were introduced by the translators in the local language. The date, group size and village were recorded, and the following categorical demographic statistics were collected: sex (M/F), age (<30 years; 30 > age < 60; > 60 years), level of education (alphabetisation, primary, secondary, university), occupation, time lived in that village (<10 years; 10 > years < 20; >20 years) and ethnicity. Participants were also asked whether they were a member of the AVIGREF[23] union, whether they previously worked for CENAGREF[24] and whether they currently work for APN[25].

Next, the list of five priority ecosystem services specific to that village as identified in 2017 were introduced to the group. Henceforth, village-specific ES will refer to the top five ecosystem services identified in one village. Participants were then asked to individually reflect on the threats associated with the their village-specific services. The first priority ES was then re-introduced and participants nominally listed the threats associated with that one service until exhaustion (Figure 5). The process was repeated for the remaining four village-specific ES. At the end of the first exercise, participants were asked whether there were any additional threats to non-listed ecosystem

[23] Village Associations for the Management of Wildlife Reserves (l'Union des Associations Villageoises de Gestion des Réserves de Faune)
[24] National Centre for the Management of Wildlife Reserve (Centre National de Gestion des Réserves de Faune)
[25] African Parks Network

Figure 5. A photo of the TESSA-NGT process with a group of 4 participants in the village of Dassari, in the department of Matéri, Benin. Two translators are present third and fourth from left to assist in the translation from the local language into French.

services, as the list itself was dependant on the participant profiles from the previous year. Question formulation in this section was inspired by the Preliminary Scoping Appraisal of TESSA (See Section 3.1).

At this point in the exercise participants would typically approach the physical list of threats to ES and would individually rank the threats from 5 (most important) to 1 (fifth most important). Instead, the list was first read aloud to all participants, and each participant was then approached individually, re-read the list a second time and then asked to individually rank threats from 5 to 1. Finally, each participant was then individually asked the trend in provision of each ES over the last five years – whether service provision has increased, decreased or remained stable. Questions regarding trends in provision were also inspired by the Preliminary Scoping Appraisal of TESSA (See Section 3.1).

Next, the same group of participants were asked the question: "What has changed since *African Parks Network* assumed management of the park in 2017?." It was repeatedly emphasized that answers could be positive or negative as all changes were of interest. Participants nominally listed changes until the list was exhaustive. Again, the list was recorded in a note book and re-read to the group. Then each participant was approached and the list of

changes was read aloud to each participant individually. Participants then individually ranked changes from most important (5) to fifth most important (1).

3.4 Data Analysis

Response data and socio-demographic characteristics were first input *verbatim* into Microsoft Excel and then then organized and coded into categories. Data was then formatted using the same program. Subsequent descriptive statistics and analyses were conducted using R ver. 3.5.1 (R Core Team, 2018). Descriptive statistics allowed the presentation of focus group profiles (4.4.1), a comparison of importance versus agreement on both threats to ES provision (4.4.2), trends of ES provision (4.4.3) and changes following the recent shift in management of the park (4.4.4). Inferential multivariable analyses (4.4.5) were then used to determine whether socio-demographic variables had a significant effect in determining TESSA-NGT responses to threats to ecosystem service provision and changes in management.

3.4.1 Focus Group Profiles

Over the course of seven weeks, 27 TESSA-NGT exercises were conducted with 101 participants. Due to difficulties in participant retention and involvement in some instances, three focus groups were omitted from analyses, yielding 24 focus groups with 90 participants[26]. There was a concerted attempt to maintain group homogeneity due to both requirements of the traditional NGT process and to the hierarchical nature of Beninese rural society. However, groups were rarely 100% homogenous[27]. In the case of a clear majority, the majority participant statistic was taken to be the group characteristic. In the case of no clear majority, the social hierarchy of age was chosen over numerically equal categories. For example, a focus group with three men over the age of 60 and three men between the ages of 30 and 60 would be reduced to a group of six 60-year-old men. Similarly, if there was disparity in occupational characteristics, the most common local occupation (usually, a farmer) was chosen. Focus groups with even one single participant who had an affiliation to AVIGREF, CENAFREF or APN were recorded. The majority of socio-demographic characteristics of participants taken were categorical, with the exception of occupation, and the binary yes/no answers to membership/employment with either AVIGREF, CENAGREF or APN.

3.4.2 Threats to Ecosystem Services

Focus group responses were compiled in excel and reduced into 17 categories. Responses were ranked by importance and agreement. Importance refers to the sum of rank values (5 to 1) given to a specific response

[26] See Section 4.1 for a comparison to international practice.
[27] See Section 5.1 for group homogeneity statistics.

summed across all focus groups (most akin to abundance data). Agreement refers to the frequency of occurrence of a specific response across all groups, regardless of rank (most similar to presence/absence data). Inspiration for coding, structuring and analyzing data as such was found in Mountjoy et al. (2014). Threats were removed if only voted for once.

3.4.3 Trends of Ecosystem Service Provision

Individual responses to trends in service provision of the village-specific priority ES were compiled in Microsoft Excel. Positive (*i.e.* an increase in ES provision in the last five years) and negative (*i.e.* a decrease in ES provision in the last five years) trends were summarized and plotted in R ver. 3.5.1 (R Core Team, 2018).

3.4.4 Changes to Management

Focus group responses to the NGT exercise assessing how local communities were impacted by the change in management were compiled in Microsoft Excel and reduced to 14 categories. Importance and agreement were tabulated and plotted in R ver. 3.5.1 (R Core Team, 2018).

3.4.5. Inferential multivariable analyses

The effect that different socio-demographic characteristics had in determining focus group responses was tested using non-parametric permutational multivariate analysis of variance (perMANOVA). The method is a multivariate ANOVA with permutation that compares the centroid distances of an underlying dissimilarity matrix derived from a data set. It applies a linear, iterative model to the dissimilarity space and therefore provides a robust alternative with no assumption of multivariate normality (Anderson, 2001; Hagan, 2018).

Response data was standardized by focus group size and then dissimilarity matrices were created using Jaccard dissimilarity (β_{JAC}, an incidence-based index chosen to represent rank agreement of responses) and Bray-Curtis dissimilarity (d_{BC}, an abundance-based index chosen to represent rank importance). Non-Metric Multi-Dimensional Scaling (nMDS) ordinations were used to visualize variations in NGT responses, according to socio-demographic characteristics in the multivariate space based on the chosen dissimilarity indices. Multivariate dispersion provides a measure beta of diversity (Anderson et al., 2006). Neither species-incidence nor abundance were recorded but the response data is similar in nature to that of a multivariate species data set and thus beta diversity analyses were chosen to examine response heterogeneity. Henceforth, beta diversity will refer specifically to the variation in focus group responses among socio-demographic predictor variables relative to the overall response diversity, rather than species among sampling units relative to a given geographic area. For that reason, the term response heterogeneity will be used instead of beta diversity.

PerMANOVA models were fit to Jaccard and Bray-Curtis dissimilarity matrices using the following socio-demographic characteristics individually: gender, municipality, ethnicity, age, time spent in village, occupation, and affiliations with AVIGREF, CENAGREF and APN. A single perMANOVA model was then executed using all variables to ascertain that significance was not due to collinearity. 10 000 permutations were computed in all models. All p-values returned from perMANOVA models were corrected for multiple comparisons using the Bonferroni correction. Mantel tests were conducted to test correlation between Bray-Curtis (importance) and Jaccard (agreement) matrices to determine if dissimilarities are sensitive to weighting in importance.

The null hypothesis of the perMANOVA models states that there are no differences between group centroids. For example, within the gender category the null hypothesis states that the locations of the centroid of male and female (group) clusters in multivariate space do not differ. The model however does assume that between-group multivariate dispersion is homogenous (*i.e.* that the distance to group centroid for males is the same as that of females) (Anderson, 2001; Hagan, 2018). This assumption was therefore tested in pairwise beta dissimilarity matrices to ensure that Type I errors were avoided. Spread around group centroid was examined using permutation tests for homogeneity of multivariate dispersions. Permutation tests are a more robust alterative to parametric ANOVA that return a p-value which indicates whether groups differ (Follmann and Proschan, 1999). The spatial means of the groups of significant socio-demographic characteristics were plotted to visualize differences in spatial means.

PerMANOVA is sensitive to unbalanced design and can yield overestimations of average heterogeneity (Anderson, 2014). To qualify results, the average response heterogeneity of the smaller sample size within each socio-demographic category was calculated as the average multivariate distance to the spatial median. The average response heterogeneity of the larger sample size within each socio-demographic category was calculated using a re-sampling approach, also known as randomization (Baselga, 2010). This method is executed by taking the average (± SD) of 100 random samples of the same number as smaller samples to equalize the unbalanced design (Baselga, 2010). For example, if there were more focus groups executed with males than females, then the male statistics would be calculated using the re-sampling approach to account for the unbalanced design. Significant results returned from permutation tests for homogeneity of multivariate dispersions were examined as described by above. Randomization is important because it further accounts for the potential paucity left by pairwise dissimilarities, as pairwise dissimilarities are not suitable to measure response heterogeneity across multiple variables since calculations could ignore patterns of co-occurrence (Baselga, 2013).

All analyses were computed using R ver. 3.5.1 (R Core Team, 2018). PerMANOVA and nDMS ordinations were conducted using the vegan package. Result qualifications were done using the betapart package.

4.0 RESULTS

Due to the low literacy rate among participants, many changes were required of the traditional NGT process. As many participants were unable to write, the brief (10-15 minute) period of individual reflection was shortened by five minutes. This was based on suggestions from Mr. Kassa, who has conducted socio-logical inquiries around the national park for both CENAGREF and APN, and after participating in trial runs of the exercises. Instead of a longer period of individual reflection, village-specific priority ES were individually re-introduced one at a time after the introduction in order of village-specific priority as determined in 2017.

Furthermore, focus group responses were recorded in a small book rather than on a flip-board for convenience. Three of 27 focus groups were conducted with the prescribed flip-board method of collecting answers since only two groups were fully literate and university educated. The frequency at which each service was presented is found in Figure 6. While tourism was regularly presented during focus groups, many participants immediately stated that they knew nothing of the service and its threats. The priority ES tourism were therefore adapted on the spot according to this problem; tourism was regularly replaced with either medicinal plants or livestock as they were often ranked in 5th and 6th place (De Ryck, 2018). Further dynamic adaptations were necessary on the field, as

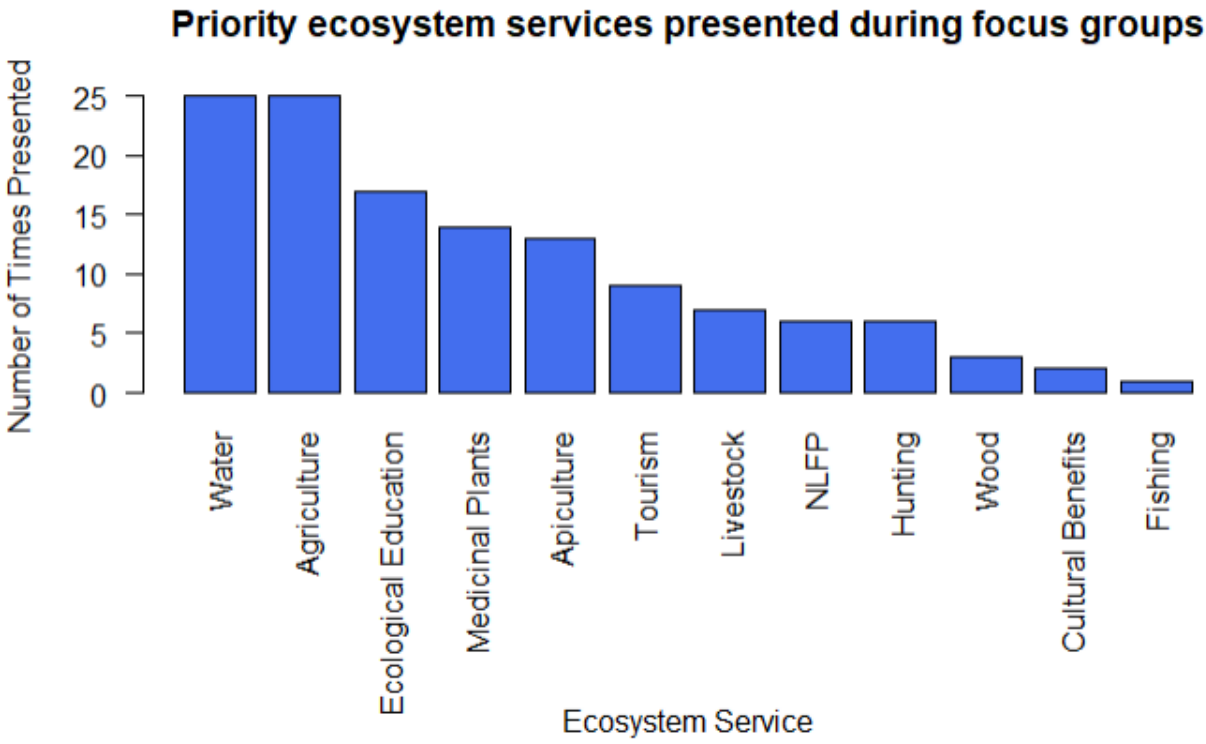

Figure 6. The frequency with which priority ecosystem services were presented for inquiry during the 24 TESSA- NGT exercises.

priority ES identification was subjective, and could depend the occupation, rank, education of the participants and involvement in the local union AVIGREF.

4.1 Focus Group Profiles

Over the course of seven weeks, 27 TESSA-NGT exercises were conducted with 101 participants. Due to difficulties in participant retention and involvement in some instances, three focus groups were omitted from analyses, yielding 24 groups with 90 participants. The number of participants per group ranged from 2 to 8, with an average group size of 4. The number of participants per exercise was low relative to meta-analyses of focus group discussion and traditional NGT. With regards to focus group discussions, the average number of participants ranged from 2 to 21, with a median of 10 (O.Nyumba et al., 2018). In comparison, the average number of participants in an NGT exercise ranged from 4 to 20 (Hugé and Mukherjee, 2018).

NGT group profiles had homogenous profiles in terms of sex (96.7%), occupation (92.2%), education (90%), time lived in village (85.6%) and age (76.7%). There was a greater percentage of male (75%) than female (25%) involvement (Table 2). The only mixed-gender exercise occurred with recent secondary school graduates. This group had twice the number of female than male students, skewing the group statistic to be represented as female. Equal portions of participants had either no formal education (38%) or some degree of secondary education (38%). Smaller portions of participants were either alphabetized or attended primary school (18%) or received a university education (4%)[33]. The age range of participants was closely distributed between age categories – 25% of participants under the age of 30, 50% between the ages of 30 and 60, and 30% over 60 years. Participants having lived in their current village for more than 20 years dominated the focus groups (71%) while those having lived in the village between 10 and 20 years (13%) and less than 10 years (17%) were interviewed less frequently. AVIGREF members were present for 42% of NGT exercises but whose members constituted 64% of the group participants. CENAGREF and APN were present for one exercise each and constituted 100% of participants of those specific groups. NGT group profiles are found in Table 2. Particiapnt occupation profiles are found in Annex B.

[33] As stated in Section 4.4.1, participant profiles were reduced to create group statistics. Thus, a group with a majority presence of secondary educated participants would likely contain at least one participant with no formal education. This disparity in education was one of the reasons why notebooks were preferred over large flip boards in the field protocol. Another reason is that groups were formed haphazardly in the field meaning that exercises were rarely executed in a formal setting with walls upon which flip-boards could be affixed.

Table 2. NGT group profiles (n=24) of exercises conducted in Benin. Participant profiles were reduced to create focus group profiles with the following degree of homogeneity: sex (96.7%) and education (90%), age (76.7%) and time lived in village (85.6%).

Characteristic		% of Focus Groups
Gender	Male	75
	Female	25
Age (years)	< 30	25
	30 < age < 60	50
	>60	25
Education	None	38
	Alphabetisation/Primary	17
	Secondary	38
	University	8
Time Lived in Village (years)	< 10	17
	10 < time < 20	13
	> 20	71
Affiliations	AVIGREF	42
	CENAGREF	4
	APN	4

4.2 Threats to Ecosystem Services

Responses to the TESSA-NGT exercise examining threats to ecosystem services were compiled, coded and plotted (Figure 7). Abbreviations for responses are found in Table 2 and correspond to those found in the bar plots juxtaposing rank importance and agreement of responses (Figure 7).

High congruency was found among all TESSA-NGT exercises with regards to rank importance and agreement of responses in the following five threats: *Land Tenure Security* (LTS), *Water Scarcity* (WS), *Agricultural Expansion & Other Land-Use Changes* (AEO) *Poor Use & Management of Natural Resources* (PUM), and *Poor or Distant Infrastructure* (PDI) (Table 3 & Figure 7). *Land Tenure Security*, comprising primarily either physical or perceived scarcity of arable land (88.5%) yielded the highest rank (241) value and was voted for in 15 of 24 TESSA-NGT exercises. This was the highest ranked threat by 75 points. *Water Scarcity* [35] ranked 2nd with an importance value of 168 and came 4th in terms of agreement. *Water Scarcity* was voted for in 12 of 24 exercises. *Agricultural Expansion & Other Land-Use Changes* was voted as the third most important threat according to the demographic interviewed. This category was voted for in 16 of 24 TESSA-NGT groups, and comprised primarily deforestation

[35] Water scarcity as cited as a threat to agriculture. This category was comprised exclusively of water scarcity.

(72.7%) with the intent to create new agricultural lands. *Poor Use & Management of Natural Resources* (PUM) was ranked 4th in terms of importance but was voted for in 14 of 24 exercises, receiving a cumulative score of 117. The two dominant subcategories within PUM were the excessive use of pesticides and fertilizers (resulting in soil infertility) (67.5%) and controlled crop fires following harvest[36] (12.0%). Poor or distant infrastructure was rated as the 5th most important threat (116 votes) and was voted for in 13 of 24 groups. This category comprised water related infrastructure (59.4%) and tourism-related infrastructure (40.6%).

Table 3. Compiled responses to the TESSA-NGT exercises (n=24) examining the threats to village-specific priority ecosystem services in the Pendjari Biosphere Reserve. Responses are ranked by importance and agreement. Categories and codes below correspond to those found in Figure 7.

Category	Code	Importance	Agreement
Land tenure security	LTS	243	15
Water scarcity	WS	168	12
Agricultural expansion & other land use changes	AEO	158	16
Poor use & management of natural resrources	PUM	117	14
Poor or distant infrastructure	PDI	116	13
Water Pollution	WP	59	8
Reduced agricultural yield	RAY	43	6
Soil pollution & degradation	SP	33	6
Human-wildlife conflicts	HWC	31	5
Lack of watering holes for livestock	WH	30	3
Social conflict	SC	25	4
Climate change	CC	21	4
Illegal exploitation	IE	21	2
Population growth	POP	16	3
Poaching	POA	8	2

[36] Controlled crop fires following harvest instead of creating grazing grounds livestock. This action was said to stem from a social conflict between transhumance tribes and sedentary farmers, necessitating illegal grazing of both transhumance and sedentary herders to graze illegally inside of park boundaries.

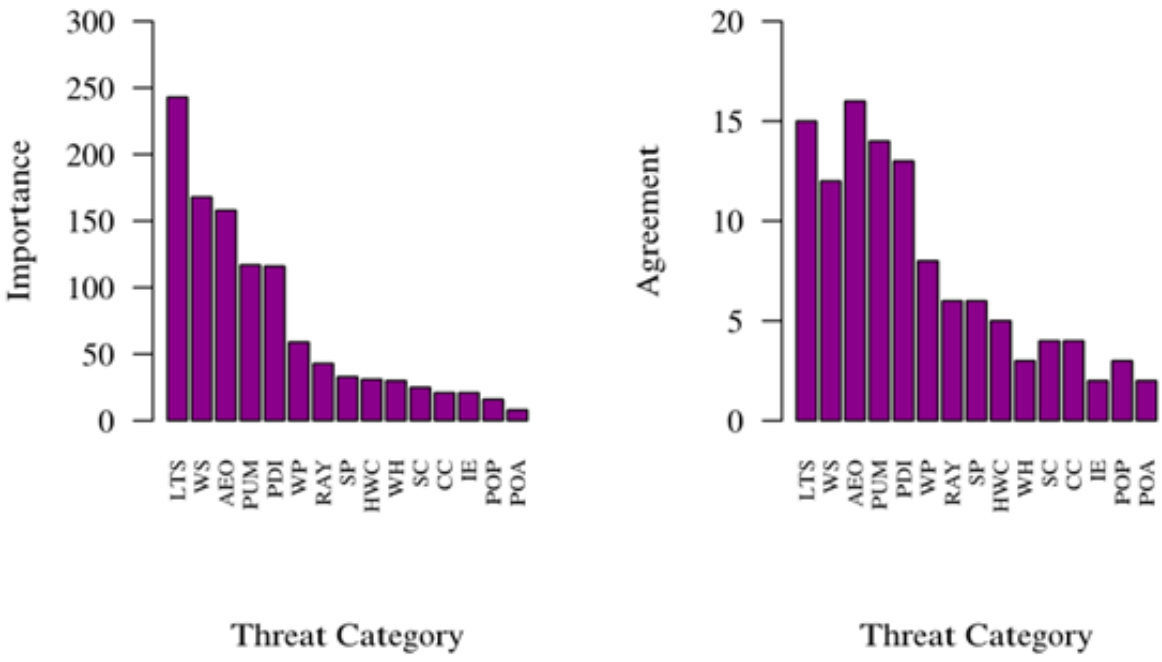

Figure 7. Bar plot comparison of importance (left) vs. agreement (right) of compiled responses to TESSA-NGT exercises (n=24) investigating the threats to village-specific priority ecosystem services in the Pendjari Biosphere Reserve. specific priority ecosystem services. Abbreviations of threat categories and associated codes are found in Table 3.

4.3 Trends in Ecosystem Service Provision

Two-thirds of all participants interviewed (69.3%) stated that service provision of priority ES has decreased in the past five years (Figure 8). Participants perceived a net decline with respect to provision of the following ES: *Agriculture, Apiculture, Medicinal Plants, Non-Ligneous Forest Products (NLFP), Wood, Livestock and Cultural Benefit.* Approximately one third of all participants questioned (27.2%) stated that service provision has increased in the past five years. *Ecological Education, Tourism* and *Fishing* were the only services for which participants perceived a net increase. Specifically, two-thirds of participants noted an increase in both *Ecological Education* (67.3% increase, 32.7% decrease and 0.0% stable) and *Tourism* (64.7% increase, 23.5% decrease and 11.8% stable). Only 3.5% of all participants stated that service provision has remained stable in the last five years. Participants that perceived service provision as stable noted *Livestock* (1.75% of total votes[37]; 36.4% of specific votes[38]), *Tourism* (0.88% of total votes; 11.8% of specific votes), *Hunting* (0.66% of total votes; 21.4% of specific votes) and *Wood*

[37] Total votes referring to the percentage vote relative to the total of all responses
[38] Specific votes referring to the relative percentage of one trend of one service relative to the sum of votes for that specific ecosystem service.

(0.22% of total votes; 6.2% of specific votes) as remaining stable. Stable service trends received relatively less votes and were therefore excluded from Figure 8.

Trends to the environment's ability to provision agriculture and water were queried with the same frequency, but 77.5% of participants stated that the environment's agricultural capacity has declined and 65.8% stated that the water declined. Of the 90 participants asked regarding the trend in provision of water and agriculture, zero participants stated that the trend has remained stable in the past five years.

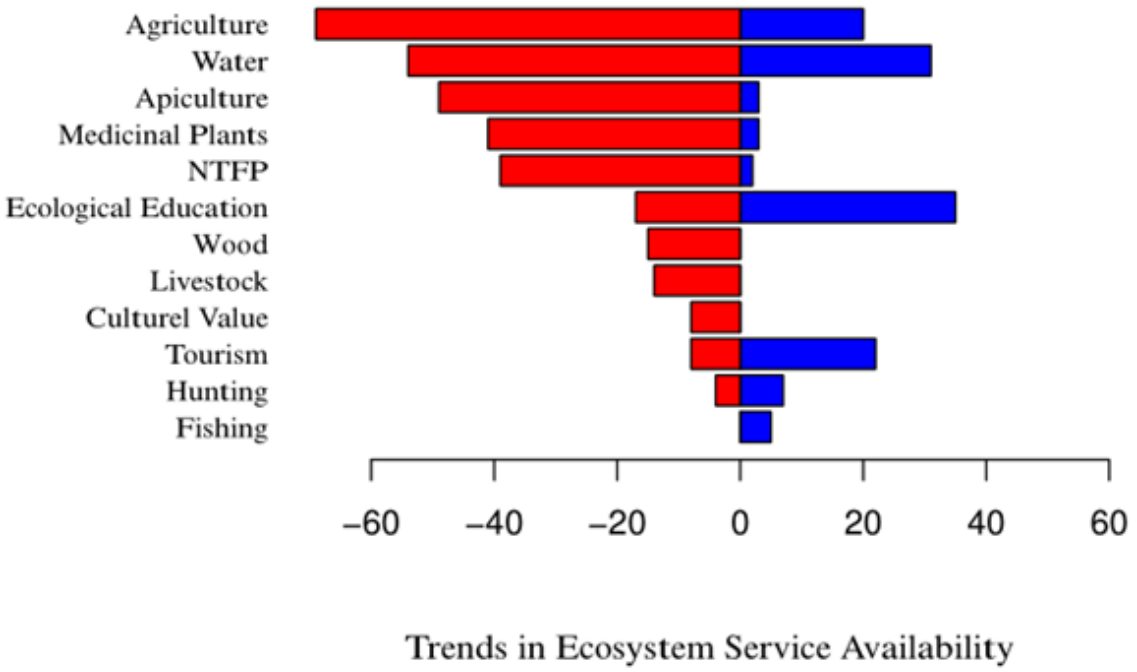

Figure 8. Participant responses (n=90) to trends in the five village-specific priority ecosystem service provision in the Pendjari Biosphere Reserve over the past five years. Negative scores (red) denote a decrease in service provision and positive scores (blue) denote an increase in service provision. The 3.51% of participants that stated that ecosystem service provision remained stable are omitted from Figure 8.

4.4 Changes in Management

Participant responses to the NGT exercise examining how local villages were impacted by the change in management were compiled, coded and plotted (Figure 9). Abbreviations for group responses are found in Table 4 and correspond to those found in the bar plots juxtaposing rank importance and agreement of responses (Figure 9).

High congruency was found among all groups between the rank importance and agreement of responses to the NGT exercise that investigated the change in management. The *Strict Enforcement of Rules & Loss of*

Extractive Access was the most important impact, with a cumulative score of 309 and voted for in 75% of exercises (18 of 24). The *Eviction of Farmers (Encroaching Illegally)* was ranked second most important impact, with a score of 210, and was voted for in 50% of exercises. *The Exclusion From Management & Lack of Communication*[40] between APN and local villages was voted for more frequently (58%, 14 of 24 groups vs 12 of 24 groups) but yielded a lower rank importance than *Eviction of Farmers* (127 votes vs 210). *Job creation* was voted for in 12 of 24 groups (50%) and received a cumulative rank importance 120 points (4th most important). *Increased Floral and Faunal Security* was also voted for in 12 of 24 exercises (50% of the time) and received a rank important of 104 points. The dissemination of *False Radio Transmission*, which stated that populations of charismatic mega-fauna like elephants have doubled since APN has assumed management of the park (2017)[41]. While only voted for in 8 of 24 groups (33.3%), the perceived doubling of elephant populations received a cumulative rank importance of 82; the 6th most important impact.

Table 4. Compiled responses to NGT exercises (n=24) examining the changes since the management shift in the Pendjari Biosphere Reserve, ranked by importance and agreement. Categories and codes below correspond to those found in Figure 9.

Category	Code	Importance	Agreement
Strict enforcement of rules & an loss of extractive access	SE & AB	309	18
Eviction of farmers encroaching illegally	EF	210	12
Exclusion from management and lack of communication	EM & C	127	14
Increased employment opportunities	JC	120	12
Increased floral & faunal security	F & FS	104	12
False radio transmissions	FRT	82	6
Creation of and funding for social support programs	EE	72	9
Loss of cultural & religious access	C & RA	68	7
Inceased tourism	IT	42	6
Changes to environmental education	EE	33	5
Infrastrucutural & logistic support in the park	I & Ls	27	3
Lack of support from the state	SS	25	4
Lack of sustainable alternatives to access ban	SA	19	2
Termination of the CPL program	CPL	16	2

[40] The shift in management was rapid and occurred in a three-month time-frame. APN has stated that information is readily available at the office but villagers without the means or leisure to travel up to 50km to the Tanquiéta office would not have access to such resources. As a result, local populations often stated that the strict enforcement of either pre-existing or new access rules, para-militarization and eviction of farmers occurred without warning.

[41] This report states that such transmissions were false as elephants have a commonly known gestation period of 22 months, making the doubled of populations of such large, late developing species in only 12 months impossible. Perhaps *False Radio Transmissions* would have been better titled *APN Propaganda*, as similar, erroneous facts heard in such transmissions were commonly cited in the NGT exercises. Source of radio transmissions: Personal recording of transmissions provided by T. Kassa (2018).

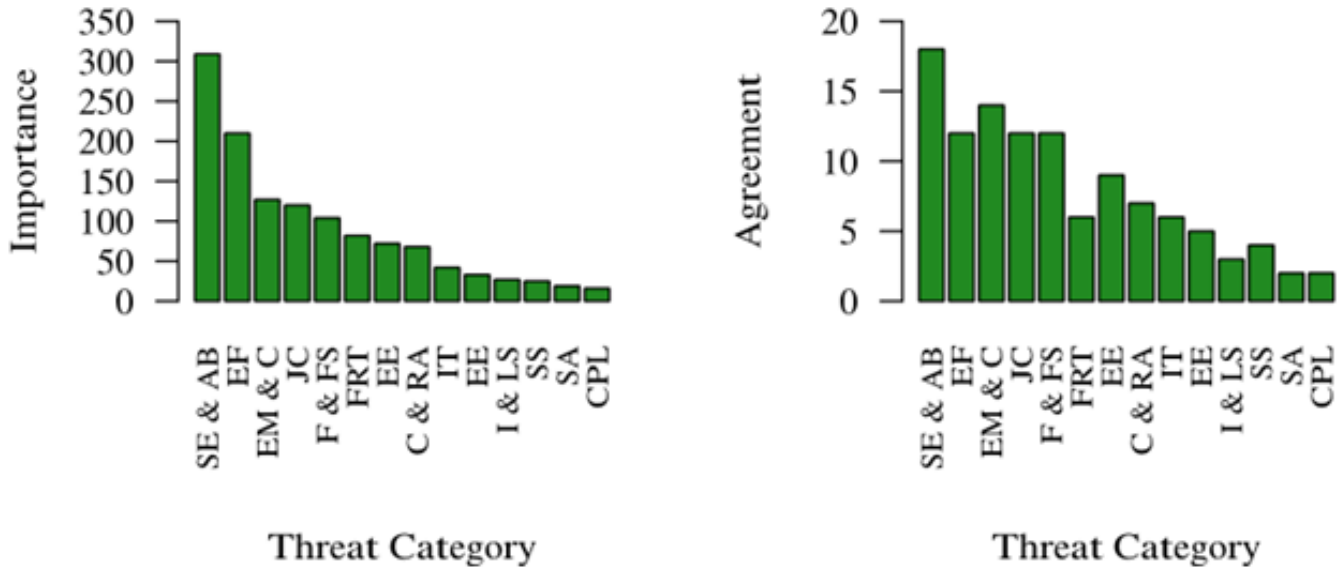

Figure 9. Bar plot comparison of importance vs. agreement of compiled responses to NGT exercises (n=24) examining the change in management in the Pendjari Biosphere Reserve from CENAGREF to APN. Abbreviations of changes are found in Table 4.

5.4 Inferential multivariable analyses

The NMDS stress[42] associated with two-dimensional ordination was calculated to be weak using Jaccard dissimilarity (β_{JAC}, Stress = 0.19) and Bray-Curtis dissimilarity (d_{BC}, stress = 0.2) but still within limits of maintaining two-ordination axes. Mantel tests run with 10 000 permutations revealed strong correlation between Bray-Curtis and Jaccard dissimilarity matrices, indicating that the dissimilarities are not sensitive to weighting by importance (Spearman's $r_s = 0.87$, $P < 0.001$). PerMANOVA model results using Jaccard dissimilarity matrix are omitted from the proceeding section but can be found in the Annex C.

Permutational multivariate analysis of variance results, when corrected for multiple comparisons using Bonferroni correction, show that there was no significant difference in groups centroids in multivariate space for the following socio-demographic categories: education, age, occupation, number of participants and affiliation with CENAGREF, AVIGREF or APN (Table 5). Group centroids within municipality and ethnicity categories were determined

[42] Stress is the standard statistic used to test goodness of fit of data dissimilarity matrix within two axes (Kruskal & Wish 1978)

to be statistically different. However, the response was found to be weak (Municipality: r^2_{BC} = 0.15, Ethnicity: r^2_{BC} = 0.16).

One perMANOVA with all socio-demographic factors was run to examine collinearity among predictor variables. The results indicate that municipality had the highest effect as a predictor variable (r^2_{BC} = 0.15), but with weak significance (P = 0.052). Ethnicity had a weaker effect (r^2_{BC} = 0.065, compare to above) which was not significant (P = 0.33). The relative determinative strength of education and time spent in village increased (r^2_{BC} = 0.12, r^2_{BC} = 0.14, respectively) but results were not significant (P = 0.67, P = 0.58, respectively). The results indicate high likelihood that of the effect of ethnicity is confounded and not unique from municipality. However, many predictor variables and relatively few observations reduce the statistical power of this model, making it less robust, but nonetheless a strong exploratory tool.

Table 5. Permutational multivariate analysis of variance (perMANOVA) results based on the effect that socio-demographic characteristics collected during focus group interviews had on rank agreement of responses for TESSA-NGT exercises. PerMANOVA models were run individually with socio-demographic characteristics and fit to a Bray-Curtis dissimilarity (d_{BC}) matrix. Significance levels are denoted as follows: P< 0.001 *** , P< 0.01

	Bray Curtis Dissimilarity				
Demographic Characteristics	*df*	*R2*	*pseudo F*	*P*	*P**
Gender	1	0.06	1.52	0.12	1
	22	0.94			
Municipality	1	0.15	3.94	0.0003***	0.003**
	22	0.85			
Ethnicity	1	0.16	4.29	0.0002***	0.002**
	22	0.84			
Education	3	0.21	1.80	0.016*	0.16
	20	0.79			
Age	2	0.14	1.67	0.094	0.94
	22	0.86			
Occupation	1	0.08	1.98	0.04	0.4
	22	0.92			
APN	1	0.08	1.90	0.039	0.39
	22	0.92			
AVIGREF	1	0.01	0.18	0.99	1
	22	0.99			
CENAGREF	1	0.05	1.33	0.29	1
	22	0.95			
Number of Particiapants	4	0.24	1.49	0.042	0.42
	19	0.76			

Variation in focus group response based on sociodemographic characteristics was visualized using non-metric multi-dimensional scaling ordination based on d_{BC} (Figure 11). Variation was mapped using a two-dimensional configuration, with each symbol representing a different group within each socio-demographic category. Predicting variables which returned significant results (municipality, ethnicity) or significant prior to Bonferroni correction (education) were plotted. Gender (Figure 11b) is also plotted in Figure 11 as female responses present in a tight cluster in the multivariate space and therefore required additional analyses upon visualization.

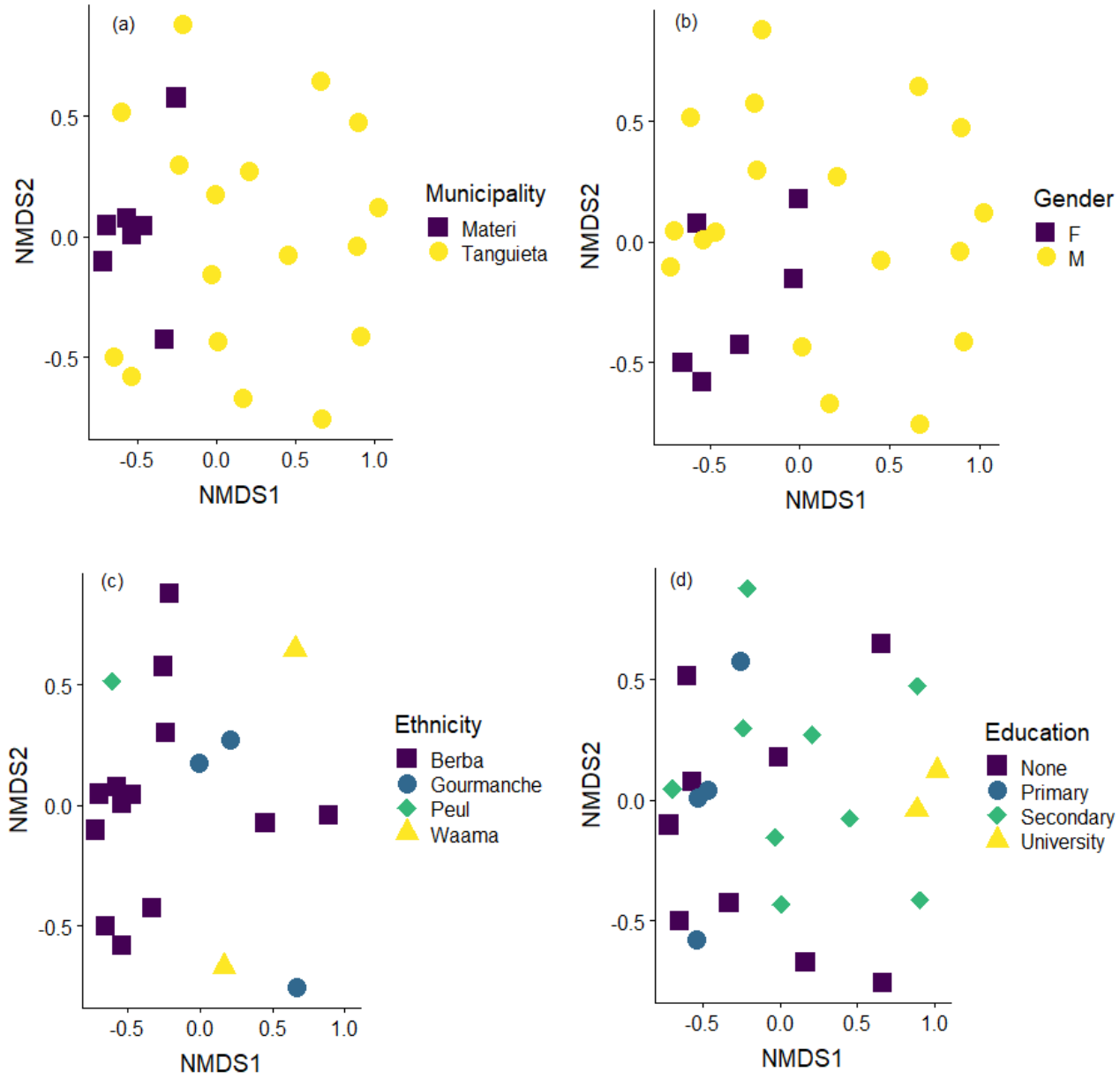

Figure 10. Non-metric multi-dimensional scaling plots (nMDS) to visually discriminate patterns among responses to NGT exercises (n=24) based on rank importance using Bray-Curtis dissimilarity (d_{BC}). The following socio-demographic predictor variables are visualized: (a) municipality, (b) gender, (c) ethnicity and (d) education. For all plots, stress = 0.20 and linear R^2 = 0.80.

Permutation tests for homogeneity of variances were conducted using the following four socio-demographic characteristics: municipality, ethnicity, education and gender (Table 6). The distance to spatial means of multivariate dispersion is visualized in Annex D. The results confirm that the group means within the municipality category were significantly different (P = 0.002). The permutation tests based on ethnicity and education were not significant (P = 0.78; P=0.14, respectively), indicating that neither had an effect in determining response patterns. With regards to gender, the results of the permutation contradict those of the perMANOVA model (See: Gender, Table 5). Specifically, the permutation test returned that the spatial means of the location of the male and female groups within the ordination space were significantly different (P = 0.018). This confirms that the tight cluster of female responses visualized in Figure 11b is significantly different from the male response clusters in multivariate space.

Table 6. Permutation test for homogeneity of variances results based on the effect that socio-demographic characteristics collected during focus group interviews had on rank agreement of responses for TESSA-NGT exercises. Variances are based on a Bray-Curtis dissimilarity (d_{BC}) matrix. Significance levels are denoted as follows: P< 0.001 *** , P< 0.01 **, P < 0.05*.

Demographic Characteristics	*df*	*Sum of Squares*	*F*	*P*
Gender	1	0.04	6.56	0.018*
	22	0.13		
Municipality	1	0.20	11.78	0.002**
	22	0.38		
Ethnicity	2	0.02	0.04	0.78
	15	0.59		
Education	3	0.12	1.99	0.14
	20	0.41		

As perMANOVA is sensitive to unequal design, randomization was therefore required to qualify significant results from perMANOVA (municipality, see Table 4) and permutation tests (gender, see Table 5). Both gender and municipality had unbalanced design. Specifically, there were 18 male groups and 6 female groups, and 17 groups from Tanguiéta and 7 groups from Matéri. Results confirm that both male and female response diversity are significantly different. The three tests, in concert, confirm that the location of multivariate means and the average multivariate distance to spatial mean are significantly different between male and female response patterns, and between response patterns from participants from Tanguiéta and Matéri.

Table 7. Average NGT response heterogeneity calculated as average multivariate distance to spatial median. Male groups (n=16) and groups formed from participants from Tanguiéta (n=17) had larger sample sizes. Male and Tanguiéta averages are reported as mean ± SD of 100 random groups of 6 (male) and 7 (Tanguiéta) samples to equalize the unbalanced design.

Category	Group	Mean (+/- SD*)
Gender	Male	0.81 +/- 0.024
	Female	0.74
Municipality	Tanquieta	0.83 +/- 0.018
	Materi	0.7

5.0 DISCUSSION

5.1 Rank Importance & Agreement of Focus Group Responses

The results indicate that *Land Tenure Security* and the *Strict Enforcement of Rules & a Loss of Extractive Access* are the most important responses according to the demographic interviewed. *Strict Enforcement of Rules & A Loss of Extractive Access* received the most votes in the "changes to management" NGT exercise, 309 in total, and 99 more than the second most voted for response, indicating that local populations were heavily impacted by changes in access to resrouces. This response was voted for in four more NGT groups (18 of 24) than any other response in the "changes to management" discussion. In the "threats to ecosystem services" discussion, *Land Tenure Security* received 243 votes of importance, 75 more than any other response in those discussions. However, only *Agricultural Expansion and other Land-Use Changes* was voted for more frequently than *Land Tenure Security* – receiving votes in 16, rather than 15 groups and a total score of 158, indcating that local populations are aware of the threat that agricultural expansion poses to ES delivery.

5.1.1 Land Tenure Security

Land Tenure Security is an extemely complex and convuluted issue in northern Benin. The villages of the Tanguiéta–Batia axe (see Figure 2 Section 1.3.3) are situated in a narrow band of land between the Atacora mountain chain and the park boundary. As mentioned, agriculture is extensive and due to the presence of the mountain chain, villages of this axe repeatedly mentioned a physical lack of arable land. The opposite Tanguiéta–Porga axe repeatedly referenced same problem despite a lack of a geographic barrier. In 2015, CENAGREF stated that the perception of land scarcity along the Tanguiéta–Porga stems from the displacement and regrouping of people into artificial villages

following independence in the 1960s for administrative purposes[44] (CENAGREF, 2015). This would have exasperbated existing tensions created by the first wave of artifical relocation by colonial authorities that took place between 1926–1954 to establish the park (CENAGREF, 2015; Idrissou et al., 2013; IUCN, 2017).

In contrast, Hougani (2013) argues that disputes regarding ownership may be traced to legal discrepancies caused by the marginalization of customary land tenure. This causes the validity of land purchases and transfers to be extremely difficult to prove given the often oral nature of the north-western region of the country. The situtation is further complicated by wealthy politicans puchasing large plots of arable but uncultiavted land around the Pendjari, while those with larger families but little access to land lack sustenance. CENAGREF and the German Agency for International Development (GIZ) attempted to remedy this problem by creating a more equal distribution of land but the project was never completed, and therefore the solution achieved. All of these factors contribtue to this complex issue and serve to increase human encroachment into the protected area. The need of arable land for sustenance – regardless of whether land insecurity is physical, legislative or a combination of all three – has been and will continute to be a major source of conflict between ethnic groups and villages, resulting in the destruction of crops and livestock and exasperbating long-standing ethnic tensions and food insecurity[46]. A development project similar to that of the GIZ should be re-implemented and completed to adress the problem of ownership discrepencies and unequal distribution of arable land.

5.1.2 Strict Enforcement of Rules & A Loss of Extractive Access

The *Strict Enforcement of Rules & A Loss of Extractive Access* was the response that was most strongly and frequently voted for among NGT exercises during the "changes to management" discussion. In many villages, APN established capacity building programmes, built wells, watering holes and increased funding to schools since their arrival and thus began a program creating alternative livlihoods[47]. However, such development projects were only voted for in half (9 of 24) of all NGT exercises as *Strict Enforcement & A Loss of Extractive Access* (18 of 24) and received four times less votes of impotance (72), indicating the inadequacy of such programs at the time at which discussion were executed. The previous participatory management scheme (elaborated below) allowed local villages to have access to the park for cultural and religious reasons, to extract NLFP and medicinal plants, and to water their cattle[48] (Idrissou et al., 2013). The new management of the park has strictly regulated this access,

[44] Despite extensive reviews of the literature, no additional sources confirming the second wave of extirpation and relocation during the 1960s have been found.
[46] The impact of this conflict as described in focus group meetings.
[47] APN has no legal obligation to fund such development projects and provide alternative livelihoods to the strict enforcement of (existing or novel) access rules, only an ethical one.
[48] Loss of cultural access was not included in this category but was voted for separately, receiving a total rank importance of 68 votes, having been voted for in 7 focus groups.

requiring permits and ranger accompiament for cultural access[49] and NLFP, and has completely banned the watering of cattle in the park. The way in which the participants described the loss of access to park resrouces is as follows:

> *"The park took everything. There is nothing left for us." (Group 22)*
>
> *"APN has completely killed us." (Group 8)*
>
> *"The animals are more valued than we are. Once those five species are gone, so is life." (Group 27)*
>
> *"We don't have solutions. We don't know what to do." (Group 11)*

Whether founded or unfounded, many personal accounts of APN's (para-)militarised rangers shooting at both farmers encroaching into park land to farm and entering park boundaries to water their cattle during the dry season were presenting during the NGT exercises. Many farmers claimed to have lost cattle in such shootings. The "landscape of fear" created by APN's militarised conservation was a recurrent sentiment by those farming what they percieved to be rightfully their land due to the complex situation of land ownership as described in Section 6.1.1. *African Parks Networks* recognizes the threat that human encroachment poses on park integrity and states that the threat will be addressed by "overhauling law enforcement" (APN, 2017 pp 86). APN has delivered on this priority, and has confiscated 516kg of fish, 210kg of bushmeat and made 31 arrests – 100% of which have been prosecuted. The local populations percive the changes in law enforcement differently:

> *"We want change, but change doesn't need to be a show of force." (Group 25)*

In addition to overhauling law enforcement, APN has made communication a key priority communication in stating that:

[49]Cultural access – access to the park to visit fetishes, to practice rituals and to sacrifice to traditional gods – is permitted only by application of visit permit to park management and subsequent accompaniment by park rangers. Access to medicinal plants is available upon similar request but watering cattle is now completely banned.

> "Meetings were held in each of the 23 villages to explain African Parks' mandate and vision for the park, as well as the importance of our strategy in helping local communities benefit from effective management and from the park's resources as much as possible" (APN, 2017, pp 87)

The success of PPPs are dependant on a high degree of trust, willingness and communication (Awortwi, 2010, 2004). While it appears that APN made a concerted effort to inform the villages of their mandate, the local populations percieve a different situation: *Lack of communication* accounted for 31 of 127 (24%) votes within the *Exclusion from Management and Lack of Communication* category, highlighting that local communities feel that APN does not communicate with them. However, the more pertinent subcategory was *Exclusion From Management*, voted for 90 of 127 times (71%). The sister study of this thesis, completed during the same period time, interviewed a different, higher ranking and higher educated demographic using the Q methodology. That study found that it was not the lack of communication, but the speed at which the management shift took place that left local communities insufficent time to find sustainable alternatives to the changes associated with the access ban. In contrast participants in the current study explicitly referenced a lack of communication, perhaps revealing a broken line of communication between higher community representatives and the general population. Both studies revealved a perception of exclusion from management decisions since APN assumed management of the Pendjari. The issue was described on September 28, 2018 by the NGO EcoBenin:

> "You do a good job, but you don't communicate. It is not the responsibility of the villages to go to the Park [administration] and educate themselves [on changes to access]" (EcoBenin)

Before the transition towards a participatory management scheme in 1992, the management of the PBR was characterized by a strong degree of conflict and distrust, in particular regarding resource use. This is because the park itself was created without consent and managed for the following decades with "power and repression" (Idrissou et al., 2013, pp 65). The 2013 study by Idrissou et al., (2013) found that after two decades of participatory management the transition could be seen as "relatively successful" because of the reestablishment of trust between government and local villages (Idrissou et al., 2013 pp 66). However, the years immediately following the transition provide caveats and insights into present-day tensions and conflict, indicated through the present research.

Following the introduction of the participatory management scheme in 1992, there was an observed unwillingness of local stakeholders to engage with the management due to the long-standing conflict. This hindered the immediate success of the new participatory management scheme (Tiomoko, 2014, Idrissou et al., 2013). The results of this study indicate a similar situation of conflict and distrust. A true replication of the study by Idrissou et al. (2013) could have provided great insight to the degree of distrust present in the community immediately following the management shift. However, it bodes well to recall that the results of this study provide only a snap-shot in time of the situation immediately following the shift, and that trust is a constantly evolving psychological and behavioral feature (Idrissou et al., 2013). The situation in the Pendjari is dynamic and therefore likely to change in the future. The degree of distrust present in local communities can be perceived through the following quote:

"The population at the base is not with APN." (Group 27).

These results provide a caveat into natural resource management: the prior four decades of conflict trust between local communities and park management created a precarious environment where what trust was built could be quickly eroded despite the two-most recent decades of trust and cooperation.

5.2 Temporal Trends in Ecosystem Service Provision

5.2.1 Net Decline in Service Provision

A net decline in service provision was observed in all services except tourism and ecological education. The net decline reported from participants can be linked to high population growth rate, as more bodies demand more resources. As stated in section 1.2.2, Benin has an overall population growth rate of 2.8% which further increases to 3.1% in the Atacora department where the national park is located (World Bank Group, 2018). United Nations projections from 2015 state that sub-Saharan African births will account 37% of global birth by 2050 and throughout the following decade (2060) "more babies will be born in sub-Saharan Africa than in the whole of Asia" (United Nations Department of Economic and Social Affairs Population Division, 2015). The report further specifies that in Benin in 2015, the average fertility (in children per woman) was 4.9 and estimated to decrease only to 3.8 by 2030 (United Nations Department of Economic and Social Affairs Population Division, 2015). The participants were intimately aware of the relationship between increasing population size and environmental degradation through overexploitation. This is supported in the results, as *Agricultural Expansion* was voted for more frequently than *Land*

Tenure Security (16 vs 15 of 24 groups, respectively). The impact of the increasing population can be best described from quotes taken from group exercises:

"Agricultur[al expansion] increases but the population increases faster." (Focus Group 10)

"Twenty years ago, there was enough water." (Focus Group 2)

As stated in Section 6.1.2, APN is aware of the threat of human encroachment poses. The focus group results did not differentiate between agricultural expansion into reserve boundaries or otherwise, as local villages often perceive the land to be rightfully theirs.

5.2.2 Net Increase in Service Provision

The noted increase in service provision in terms of ecological education and tourism can be best understood through the recent influx of funding to the park since the shift in management. As stated in section 1.3.5, APN has funded mass logistic and security advances to the park. While APN has not yet released numbers or reports for the 2018 season, their 2017 group spending budget was US$44M, 25% of which went to the Pendjari (APN, 2017). APN thus has the experience, reputation[52] and financial capacity to successfully revitalize the park, safeguard its ecological integrity and increase its travel competitiveness. The local population are aware of the influx of funding to the Park, widely noting the corresponding increase in service provision.

African Parks Network stated in their 2017 annual report that environmental education and community awareness are top priorities. Following the shift, the NGO immediately established an environmental education programme which by the end of 2017 had already taken 1124 school children and their teachers into the park (APN, 2017). Personal communications with APN employees provided that the programme has supported over 30 schools, each receiving 50 000 FCFA[53, 54]. It is thus understandable that the local populations observe an increase in

[52] APN is credited with the successful reintroduction of the Black Rhino into Chad – absent from the area for nearly half a century in 2018 and the re-establishment (expansion into new territory) of the African elephant in Malawi (2008), among others. The only park management contract from which the non-profit has pulled out was Nech Sar National Park in Ethiopia, where over 1000 families of the Kore ethnic group were "voluntarily" relocated to the southern borders of the park. Those of the Guji ethnicity faced a much worse fate, with over 500 houses burned and over 9000 families relocated to the most remote areas of the park. None of the families received compensation. APN stated that in an interview with the New Scientist magazine in 2005 that, "we wouldn't take over the park until the resettlement was completed (Pearce, 2005)."

[53] The APN annual report supports the claim of additional support for 30 schools around the Pendjari, but funding numbers are unsupported and only obtained through personal communication.

[54] West African CFA Franc (Franc de la Comunaunté Financiere Africane de l'Ouest)

environmental education and awareness in the last five years, the majority of which was attributed to the actions of APN within the last year.

There was, however, an interesting pattern observed regarding ecological education within older generations. Older generations felt that environmental education had become "radicalized" since APN has arrived. Children, having received classes on environmental protection would come home and adamantly tell their parents not to use certain plants or not to cut down trees. These teachings, while necessary for the sustainable use of natural resources around the park, appear to have created a generational rift, as the older generation see the necessity for extraction and a lack of alternatives. Given the high priority that APN has placed on education, the management regime could remedy this generational disconnect by holding environmental education classes for older generations in local languages and providing alternative livelihood opportunities that would reduce the need to extract natural resources unsustainably.

5.3 Inferential Multivariable Analyses

The results indicated that municipality and gender had the greatest influence in discriminating TESSA-NGT response patterns in multivariate space. In the previously mentioned study assessing trust in the PBR, Idrissou et al., (2013 pp 67) stated that "the propensity to trust depends on one's cultural identity, personality, and previous experiences." This statement may provide insight as to why NGT responses discriminated by municipality and gender yielded strong fit with perMANOVA models.

With respect to gender, the differential experiences of men and women yield a gendered perception of ecosystem services and associated threats (Yang et al., 2018). A comprehensive, gendered understanding of ecosystem services can therefore guide ecologically sustainable and socially just resource management policies. A comprehensive review of gendered analysis frameworks for assessing and promoting gendered issues regarding resource use and management can be found in Yang et al. (2018).

Tanguiéta is the municipality that is bound by park boundaries to the north and the Atacora mountain to the south. While participants from Tanguiéta repeatedly mentioned the lack of physical, arable land, those from the opposite axe, Matéri, perceived the problem of land tenure security differently (Section 6.1.1). The differential experiences of those from different municipalities – perhaps partially linked to the complex problem of land tenure security – result in different understandings and knowledge of the threats to ecosystem services and the changes to management. While the effect that municipality had on discriminating response patterns was significant, co-variance was not assessed. It should be recognized that the central town Tanguiéta is located within the municipality of Tanguiéta. Since it could contain wealthier participants, the effect of municipality could be confounded, which

would drive the effect up. It is suggested that similar studies record the number of hectares of farm land owned and numbers of heads of livestock to provide a proxy for income. This could ascertain that municipality as a response discriminating effect does not co-vary with income.

Nonetheless, the finding that gender and municipality had a significant effect in discriminating NGT responses in multivariate space could be useful to management and aid in advancing the sustainable management of resources around the park.

5.4 Methodological Observations

As stated in Section 3.2 the Nominal Group Technique (NGT) is a focus group variation that is relatively new to the field of conservation and ecology and almost entirely executed with expert groups (Exception: Maynard and Jacobson, 2017). Many adaptations were required to create a fit between method and environment. First, the preliminary scoping appraisal of the Tool-kit for Ecosystem Service Site-Based Assessment (TESSA) provided outstanding guidance and inspiration on how to structure and adapt the open-ended questions to yield socio-ecological data. Forthcoming researchers looking to use this technique in the field of ecology and conservation are urged to examine the TESSA's Preliminary Scoping Appraisal.

The method, however, also presented many difficulties; the greatest of which was organizing focus groups in the field. Despite an extensive network provided by Mr. Kassa, it was nearly impossible to organize focus groups in advance (except for the three groups conducted with expert participants), and even harder to access participants with higher levels of education. For future research, it is recommended that this method is conducted in concert with something like the Q-methodology, which was found to be unsuitable to low literacy level participants. In contrast, the benefit of the NGT over the Q methodology is that the NGT generates new knowledge, perceptions and opinions, while the Q is limited by its pre-established statements (Zabala et al., 2018). However it was easier to organize single participant Q sessions over collective focus group meetings in the field.

Furthermore, each exercise contained two full focus group questions and a third question regarding trends of service provision. Participant fatigue was apparent near the end of the exercise (~2hrs) and assistants (at least two present at all times) were regularly fetching and returning tired participants. The presence of at least two assistants, in addition to the facilitator is highly recommended; group dynamics would have changed dramatically without additional help. Regardless of the difficulties in organizing the focus groups, an adapted NGT as seen here (and referred to as TESSA-NGT), or as in Maynard and Jacobson, (2017) is successful in generating locally-relevant data. Locally-relevant data can contribute to the sustainable management of natural resource as local knowledge,

traditional beliefs, values and practices, "often provide a better foundation for protected area management than plans advised and administered solely by outsiders" (Stevens and De Lacy, 1997 pp9).

Lastly, NGT exercises were conducted by a young, white, western female in a society with strong social and gender hierarchy. This facilitator bias was found to have a significant impact on participant response (Hartter et al., 2016; MacKenzie, 2016). Additional, significant biases were found in the social position and degree of subjectivity of the translator, all of which can act to "filter" the meaning in the local language (MacKenzie, 2016). Age, sex, ethnicity and status impact our "how and what participants choose to reveal to us" – relevant for both facilitator and assistants and thus potentially impacting the validity of the research (MacKenzie, 2016 pp167). It could be advised for those conducting sociological cross-language research that in addition to collecting data on social position (age, sex, occupation) that questions regarding power dynamics between facilitator, participants and assistants be included. This may provide additional insight into how data was impacted by pre-existing perceptions.

6.0 CONCLUSIONS

The results of this study provide but a snap-shot of the perceptions of local communities on the threats to ecosystem services and the changes following the recent management shift. Mass infrastructural, logistic and educational improvements have occurred in the reserve through large financial investments. Given the *African Parks Network's* history of success in Africa, the likelihood of revitalizing the Pendjari is high. However, the results also indicate that local communities have been heavily impacted by the loss of extractive access to the park and exclusion from management decisions. Expulsion of local communities from the national park began nearly a century ago but effective participatory management – only two decades ago. The long history of conflict and distrust between local communities and park management created a precarious environment where what trust was built could be quickly eroded despite the two-most recent decades of trust and cooperation. This, coupled with the eviction of farmers encroaching illegally into park lands, and the most strongly and frequently ranked threat – *Land Tenure Security* – has left a widespread and recurrent perception of marginalization through the exclusion from management decisions and the lack of communication. *African Parks Network* is an internationally recognized NGO with many success stories across Africa. However, the NGO has also received steep international for the common criminalisation of those who traditionally hunt or gather food or medicinal plants. In the case of the Pendjari, the management shift appears to have created conflict.

The perceived exclusion from management is particularly disconcerting given the findings of the recent IPBES[58] Global Assessment on Biodiversity and Ecosystem Services report (IPBES, 2019). The report was the first

[58] Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES).

global assessment since the Millennium Ecosystem Assessment in 2005 and it is the first global assessment to include local and indigenous knowledge. The report highlighted that while three-quarters of terrestrial ecosystems are degraded, those managed by local or indigenous communities are on average, less severely affected by degradation (IPBES, 2019). The Pendjari Biosphere Reserve, its biodiversity and the ecosystem services it supports face serious threats like human encroachment, land transformation, overexploitation and degradation but the inclusion of local communities is paramount to park vitality and community well-being. The results of this study indicate that participant municipality and gender had a significant effect in determining how local communities perceive threats to ecosystem services and changes in management. Gender and district specific approaches to resource use and management should therefore be a focal point of management schemes as the differential experiences of those of different genders and municipalities yield different understandings and knowledge of the Pendjari ecosystem and its associated threats. The data collection methods and analyses described in this study are recommended to others studying protected areas as similar studies can reduce the paucity of local and traditional ecological knowledge in decision-making and policy.

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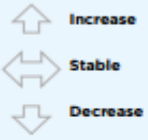
SUPPLEMENTARY MATERIAL

Annex A

Table S1. Figure F of the Preliminary Scoping Appraisal Tool-Kit For Ecosystem Service Site-Based Assessment (TESSA). Questions asked to participants regarding trends in ecosystem service provision were adapted from this table. TESSA (V. 2.0) is available for free download at the following address: http://tessa.tools/.

Most important services identified in table E	**Trends in provision of the service over the past 5 years**  Increase Stable Decrease	**Expected change in service availability in the site's alternative state**  Increase Stable Decrease	**Service beneficiaries** Local/District/ National/Global (identify which of these geographic scales apply - there may be more than one - and circle the one where the greatest impacts of the change will be felt)	**Relevant activities impacting the site** (select all that apply from the list in Part 1 table B)

Annex B

Table S2. Occupational summary of focus group conducted in Benin. Participant profiles were reduced to create group statistics with 92.2% homogeneity.

Occupation	Number of Groups	% of Groups
Farmer (Agriculture)	7	29.0
Hospitality & Tourism	3	12.5
NGO	2	8.3
Hunter	2	8.3
Farmer (Livestock)	2	8.3
Transformers (Shea)	2	8.3
Student	2	8.3
Ranger	1	4.2
Teacher	1	4.2
Tranditional Medicine	1	4.2
Apiculturist	1	4.2

Annex C

Table S3. Permutational multivariate analysis of variance (perMANOVA) results of the effect of different socio-demographic characteristics on TESSA-NGT response patterns based on Jaccard dissimilarity (β_{JAC}), and Bray-Curtis dissimilarity (d_{BC}). Significance levels are denoted as follows: *P*< 0.001 *** , *P*< 0.01 **, P < 0.05*.

	Jaccard Disimilarity				Bray Curtis Dissimilarity			
Demographic Characteristics	*df*	*R2*	*pseudo F*	*P*	*df*	*R2*	*pseudo F*	*P*
Gender	1	0.05	1.30	0.19	1	0.06	1.52	0.12
	22	0.94			22	0.94		
Municipality	1	0.14	3.51	0.0006***	1	0.15	3.94	0.0003***
	22	0.86			22	0.85		
Ethnicity	1	0.15	4.03	0.0005***	1	0.16	4.29	0.0002***
	22	0.84			22	0.84		
Education	3	0.20	1.67	0.019*	3	0.21	1.80	0.016*
	22	0.80			20	0.79		
Age	2	0.06	1.39	0.15	2	0.14	1.67	0.094
	22	0.94			22	0.86		
Occupation	1	0.06	1.51	0.11	1	0.08	1.98	0.04
	22	0.94			22	0.92		
APN	1	0.07	1.56	0.037	1	0.08	1.90	0.039
	22	0.93			22	0.92		
AVIGREF	1	0.01	0.21	0.99	1	0.01	0.18	0.99
	22	0.99			22	0.99		
CENAGREF	1	0.04	1.05	0.53	1	0.05	1.33	0.29
	22	0.96			22	0.95		
Number of Particiapants	4	0.18	1.01	0.45	4	0.24	1.49	0.042
	19	0.82			19	0.76		

Annex D

Figure S1. Average distance to multivariate spatial means of (a) municipality, (b) gender, (c) ethnicity and (d) education. Distances were based on Bray-Curtis dissimilarity (d_{BC}) matrix. Differences in multivariate spatial group means are visualized below but tested using permutation tests of homogeneity of variances.