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The complexity of the conservation-development nexus in Central African national parks and the perceptions of local populations

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ABSTRACT

Conservation programmes of recent decades aimed to adopt an approach that addresses biodiversity conservation goals through socio-economic tools and to better integrate the human dimension into biodiversity conservation. Yet, to analyse this complex conservation-development nexus, studying conservation perceptions of local populations are crucial to understand the dynamics and establish sound conservation-development management policies. Therefore, we aim to identify the key determinants of conservation perceptions in the Central African context in order to implement successful local and regional conservation strategies. Conservation perceptions of two national parks' adjacent populations were examined through household surveys, adapted from the Poverty-Environment Network (PEN), in Rwanda and Republic of Congo. Outcomes were statistically analysed to identify the most important factors affecting perceptions about conservation measures. Using a nonlinear canonical correlation analysis, we found that economic factors (e.g. salary, savings, cattle size) and education positively affect conservation perceptions while ecosystem-dependent factors such as hunting and gathering other non-timber forest products have negative effects. Though, we identified a significant difference between two sites, whereby, conservation perceptions are negatively affected by bushmeat factors in Republic of Congo, and NTFP in Rwanda. In addition, our study showed that resource use and rights play a major role in communities' perceptions and that revenue-sharing projects have a key impact on the perceptions. To ensure sound conservation and development measures, revenue-sharing schemes focusing on material benefits and alternative livelihoods may provide the best approach if participation of communities in the decision-making process is ensured. In this optic, improving education levels will raise awareness and positive perceptions of conservation measures. Development measures should target poor households as they appear to be more conservation-adverse. We conclude that in depth research on local demands for ecosystem products, relationships among stakeholders and community decision power are crucial factors to understand the complexity of the conservation-development nexus.

1. Introduction

Tropical forests are highly important terrestrial ecosystems for the Earth system, in particular for their role in climate mitigation and in water cycle regulation at local, regional and global levels (Millennium Ecosystem Assessment, 2005). They comprise the most important biodiversity hotspots of the planet, holding many endemic vegetal and animal species. They are home for billions of people, who heavily rely on natural resources for food, health and livelihood needs (Lhoest et al., 2019; Wasseige et al., 2012) estimated that over a billion people obtained benefits, directly and indirectly, from forests, underlining the importance of conserving such ecosystems.

The Congo Basin expands over six countries in Central Africa and contains the second-largest tropical forest on the globe with over 2 million km^2 (Mayaux et al., 1998; Wasseige et al., 2012). Over 113 million people are estimated to live in Central Africa, 60 million of which in rural areas (Abernethy et al., 2016). Although showing low deforestation rates compared to other tropical regions (Mayaux et al.,

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2013), forest degradation has detrimental consequences and needs to be apprehended with care, as agriculture and its underlying factor population pressure being the two main drivers (Gillet et al., 2016).

New economic investments are now affecting the integrity of Central African forests. Agribusiness companies are increasingly interested by huge dense forest areas for producing rubber, palm oil and cocoa, cotton and annual crops. Oil and minerals (gold, diamond, iron, copper, coltan) are very abundant in Central Africa and mining for such resources will further degrade forests (Wasseige et al., 2012). The planned opening of roads throughout the sub-region also poses a threat to the integrity of the forest massifs (Kleinschroth et al., 2019). Fuelwood is a vital resource for local populations, largely used for home cooking especially in rural areas (Schure et al., 2010). Illegal logging is the other component of wood exploitation that jeopardizes forest resources. Adequate forest governance is key for combatting this threat (Cerutti & Tacconi, 2009).

Households having low economic and capital factors, and relying on nature products, e.g. bushmeat, tend to see the effect of conservation negatively, as it hinders their livelihood (Blomley, 2010). Without any form of compensation or alternative livelihoods, conservation measures may even increase poverty instead of alleviating it, and result in negative views on conservation. In this optic, conservation management should develop strategies that tackle poor households' livelihood to increase conservation performance by better revenue-sharing (Brashares et al., 2011). The duality of bushmeat needs to be acknowledged and a differentiation between subsistence and commercial use is necessary to address the bushmeat issue more deeply.

It is estimated that the bushmeat extraction rate in Central Africa is six times higher than the sustainable rate, with over 4.5 million tonnes extracted each year (Bennett, 2002; Nasi et al., 2011). While most urban households consume bushmeat on a regular basis (for instance 88% of households in Brazzaville in 2006; Mbete et al., 2011), rural populations daily use bushmeat for both basic protein needs (15% to 27% of meals in a village in Cameroon; Lhoest et al., 2020a) and as a source of income (Fa et al., 2015; Mbete et al., 2010). In Tanzania, three-quarters of hunters aim to generate income while a quarter only hunts for their protein intake (Loibooki et al., 2002). In south-eastern Cameroon, 57% of the volume of rural bushmeat consumption is purchased from local hunters and villagers eat on average 56 kg of bushmeat per person and per year (Lhoest et al., 2020a). Illegal hunting also affects protected species, with some revenue generated for the local populations, but more importantly causing links with criminal networks and armed groups leading to instability of rural areas (Wittig, 2016). Moreover, some local hunters may sell a large part of their hunting bag in order to get an income from hunting in the time of food insecurity (van Vlient et al., 2017).

To reduce the impacts of these factors on Central African ecosystems and species, several strategies were implemented in the 20th century. Biodiversity conservation started with the assumption that, to protect nature, humans had to be excluded from certain areas of high interest. The creation of protected areas followed this assumption by evicting millions of locals from ancestral lands without any form of compensation (Cernea & Schmidt-Soltau, 2006; Wilkie et al., 2006). With the recognition of the failure of 'fortress conservation' in the 80′s, numerous conservation programmes started to integrate the human dimension. These conservation approaches assumed that alternative livelihood strategies and poverty reduction will help reducing the human pressure on the environment. Such approaches allow joint management between local populations and state authorities (Colchester, 2004; Hughes & Flintan, 2001). Yet, several reviews showed the difficulties to reconcile conservation and development (Agrawal & Gibson, 1999; Hughes & Flintan, 2001). Salafsky and Wollenberg (2000) argue that the lack of success takes root in the difficulties to correctly recognize and assess existing trade-offs. Other studies claim that the problem comes from unreliable governance (Sandker et al., 2009). Information on conservation perceptions of local populations is thus crucial to understand the dynamics and establish sound conservation-development management policies (Bennett et al., 2019).

Bragagnolo et al. (2016) state that positive local attitudes to a protected area constitute a potentially important component of any conservation initiative, especially in the developing world where human pressure on natural resources is often high in contexts of poverty. Similarly, Allendorf and Yang (2013) conclude that protected area conservation, if conducted with awareness of people's already-existing perceptions of benefits, can begin with a discussion of win–win scenarios. Therefore, attitudinal and perception-based studies are increasingly being adopted as tools for evaluating public understanding, acceptance and the impact of conservation interventions (Karanth & Nepal, 2021; Kideghesho et al., 2007).

Recently, Nielsen et al. (2021) highlighted that key gaps in our understanding of how to achieve behaviour change for biodiversity conservation and suggest how to identify key behaviour changes and actors capable of improving biodiversity outcomes. However, local perceptions of protected areas and conservation vary and show a complex picture of the conservation-development nexus. For example, human-wildlife conflicts are particularly common in the periphery of protected areas where communities reside, besides large herbivore and carnivore populations (Gandiwa et al., 2016). There, a higher perceived effectiveness of integrated conservation and development projects would be associated with a decline in human-wildlife conflicts. For example, revenue-sharing may offset wildlife costs and improve local attitudes toward conservation (Archabald & Naughton-Treves, 2001).

Community-based conservation emerged in the 80′s to actively involve local communities in conservation and incorporate their livelihood in national parks or wildlife refuges (Gezon, 1997). Parry and Campbell (1992) found that local populations in Botswana did not acknowledge some conservation benefits such as the reduction of wildlife conflicts. Moreover, Infield and Namara (2001) found that 40% of the neighbouring communities had a positive attitude towards Lake Mburo National Park while 15% of them thought the park should be abolished. They also showed that where community projects have been carried out, only half of the people saw benefits from living close to the park. Local populations living near 17 national parks in Thailand also show conflicting views and various perceived impacts of conservation on their livelihoods, with general negative perceptions of protected area governance and management (Bennett & Dearden, 2014). This underlines the challenge of involving communities due to their higher interest in development than conservation issues.

In order to improve performance of community-based conservation, incentive-based projects may be developed such as payments for environmental services (PES) in order to incentivize land users to supply an environmental (ecological) service that benefits society and the environment (Engel et al., 2008). The recent developments to deal with the conservation-development nexus have concentrated on integrating both biodiversity conservation and rural development in projects (Hughes & Flintan, 2001). However, it may be noted that the basic concept of bottom-up approaches does not fail but rather the lack of willingness of conservationists to improve the delegation of power to communities and recognize the importance of trade-offs between conservation and development (Kiwango et al., 2015). Moreover, each local context implies different and complex situations, emphasizing the need to deeply understand local interests and perceptions of conservation to inform any sustainable management strategy (Holmes, 2003). Considering the ideas, opinions and observations of local people is crucial to provide policy-makers with concrete recommendations integrating stakeholders' perceptions, concerns and struggles (De Keyzer, 2020).

Because of the lack of information concerning these local trade-offs between conservation and development, we aim to improve our understanding of conservation perceptions in the Central African context for implementing more sustainable conservation strategies in this biodiverse and poorly studied region. Local conservation outcomes can only be achieved by better understanding human and social dimensions of environmental issues (Bennett et al., 2017). Therefore, the objective of

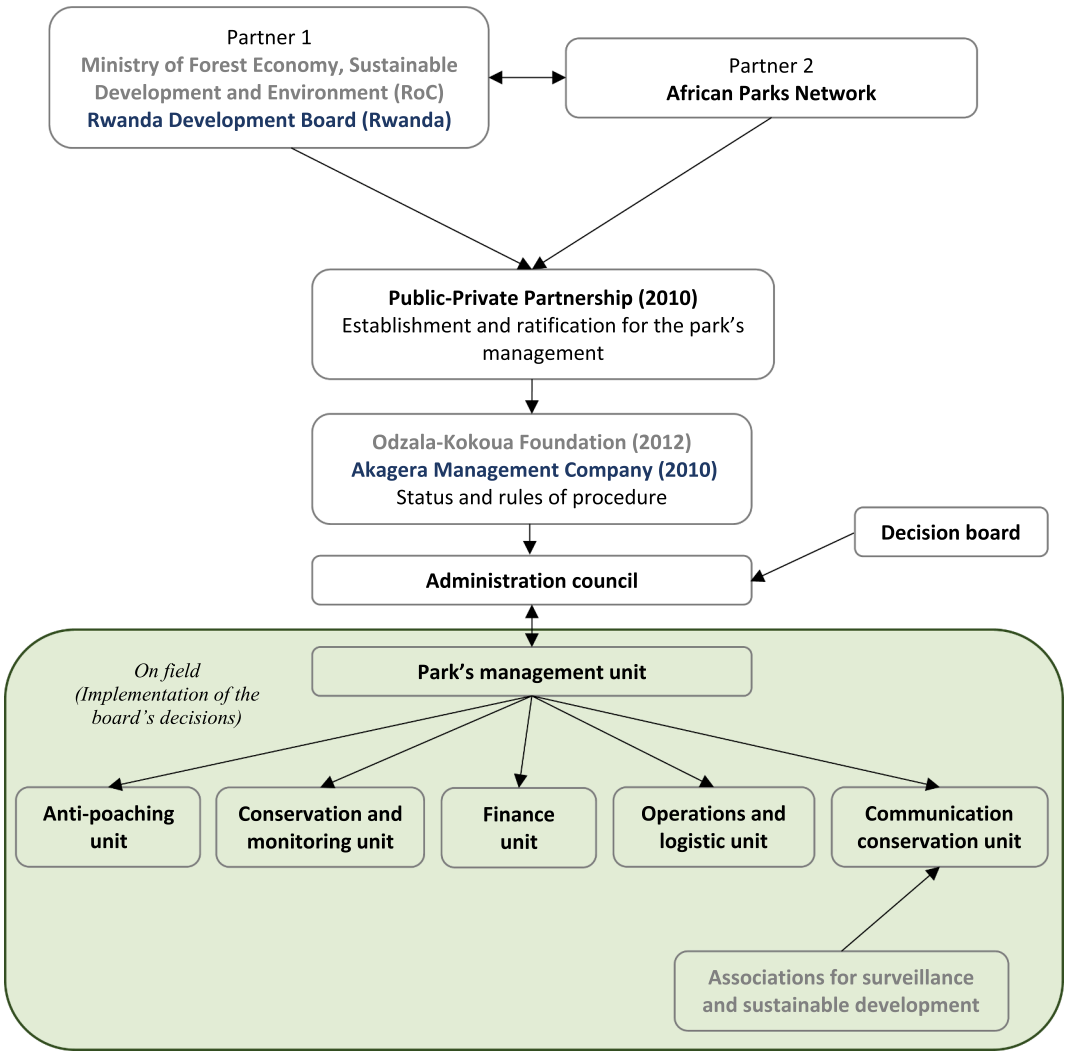

Fig. 1. The main actors under the PPP between national government and African Parks Network. The grey colour represents Republic of Congo while blue accounts for Rwanda. Local communities are involved in the decision-process through two representatives of local associations for surveillance and sustainable development. The decision board is composed of both African Parks Network and national government representatives. While in PNOK communities are represented by association's representatives, with two of them being statutory members of the administration council, no such community representation is present in Akagera National Park's decision board. (adapted from Buttoud et al., 2016).

this study is to identify key determinants among local people for realizing efficient and sustainable conservation strategies. We surveyed local populations neighbouring two national parks in Central Africa to examine their communities' livelihood strategies, local conservation perceptions, and the factors influencing them. We applied statistical approaches to find the most significant factors affecting conservation outcomes and disentangle the interrelationships among these variables. Finally, we analysed the complexity and develop a knowledge base for managing the conservation-development nexus and draw recommendations for improving the conservation perceptions of local populations.

2. Material and methods

2.1. Study area

The study area comprised two national parks and their neighbouring communities in two countries of Central Africa: Rwanda and Republic of Congo. The national parks were selected to facilitate comparison as they are under the same management body, African Park Network (APN), however, achieving the conservation-development goals to different levels affected by their specific socio-economic conditions

In 2010, African Parks Network (APN) established public–private partnerships (PPP) with national government for both Akagera National Park (ANP) and Odzala-Kokoua National Park (PNOK) (Fig. 1). APN has the responsibilities to contribute to the Government's socio-economic development effort for local residents by participating in the implementation of income-generating activities, and in general, contributing to the conservation and sustainable management of natural resources within the national parks.

In our study areas, for example, local populations have been practising bushmeat hunting for centuries, making it a strong habit difficult to change. However, this habit may affect the conservation perceptions and, consequently, the implementation and sustainability of conservation projects in African national parks. In Rwanda, local populations are excluded physically from the park since the 2011 fencing. Resources that were previously gathered within the park are now difficult to find (fuelwood, NTFP) and few alternatives are present.

2.1.1. Akagera national park

Akagera National Park (ANP) in Category 2 of IUCN protected areas (Dudley, 2008) is situated in eastern Rwanda, along the Tanzanian border. Created in 1934, the park originally covered over 2500 km^2 but

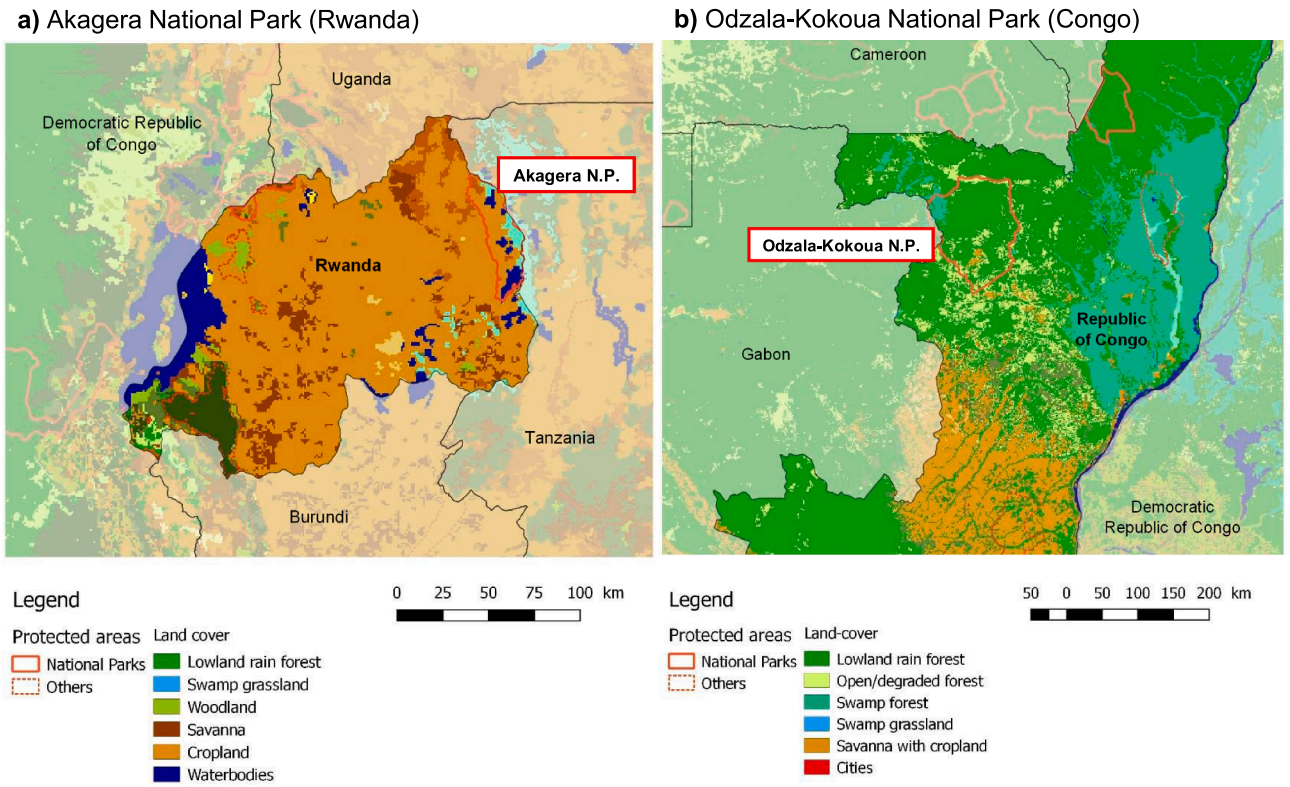

Fig. 2. Location and land cover of study areas Akagera National Park, Rwanda (2a) and Odzala-Kokoua National Park, Congo (2b).

was reduced to 1122 km^2 to give farmland and pasture to genocide refugees. This rapid changed Akagera's wildlife and ecosystem, pushing flag species to extinction and reducing wildlife by 50–80% in Akagera NP (Dubois et al., 2015; Kanyamibwa, 1998). It is now under the management of ANP with a joint managemnet board composed with members from RDB (Rwanda Development Board) and ANP until 2029 (Ngoga, 2016). Despite a relatively small area of 1122 km^2, Akagera National Park park hosts a large diversity of wildlife, including several rare species such as the shoebill (Balaeniceps rex) and sitatunga (*Tragelaphus spekii*). The lion (*Panthera leo*) has been reintroduced after 20 years of absence, as well as the black rhino (*Diceros bicornis*). From 2013 to 2015, the populations of large herbivores have increased, including savanna elephant (*Loxodonta africana*), buffalo (*Syncerus caffer*), giraffe (*Giraffa camelopardalis*), eland (*Taurotragus oryx*), roan (*Hippotragus equinus*), waterbuck (*Kobus ellipsiprymnus*), zebra (*Equus quagga*), topi (*Damaliscus korrigum*), impala (*Aepyceros melampus*), warthog (*Phacochoerus africanus*), and hippo (*Hippopotamus amphibius*).

The park is composed by a mosaic of wetlands, acacia forests and grasslands (Dubois et al., 2015). Since the re-introduction of lions (2015) and black rhinos (2017), ANP has become a 'Big Five' park hosting over 8000 wildlife animals including; lions, the leopard, black eastern rhinoceros, the Cape buffalo, over 100 savannah elephants, antelope, impala, hippos, crocodiles and over 500 bird species with about 100 species endemic. Akagera national park is the biggest national park in Rwanda, covering 1122 km^2.

As in Fig. 2, ANP is in the Eastern Province of Rwanda and overlaps 3 districts (Nyagatare, Gatsibo and Kayonza), and more specifically 8 sectors. The combined population of these sectors is 289,391 inhabitants, not all of them directly in the neighbourhood of the park (National Institute of Statistics of Rwanda, 2014). Populations neighbouring the park has limited economic activities, relying on subsistence farming and livestock (e.g. Cattle, Chicken) to provide food resources.

Yet, as seen in Rwanda, revenue-sharing projects often focus on community associations and fail to integrate poorer households, which continue depriving forests of resources.

High dependence of local populations on ecosystem resources are due to the high demand for cropland, fuelwood and water, and this dependence is linked to poverty. Hunting for bushmeat appears almost inexistent as most of the wildlife is found within the park. In Kayonza, poverty is relatively low (35.9% of the population under the World Bank poverty line) while in Nyagatare and Gatsibo the situation is more dramatic (respectively 62.3% and 63.6%) (National Institute of Statistics of Rwanda for 2013/2014, 2015).

The park's revenues linked to tourism have increased by 300% in the last six years. In 2015, tourism revenues represented 1.225.469 $US (22% more than in 2014) with 32,239 tourists visiting the park in 2015. As part of the RDB's revenue-sharing schemes, 5% of tourism revenues of Rwandan parks are combined into a national pool. The share is then redistributed to populations living on the surrounding of the parks according to population density (ANP receives 30% of those 5%). This helps Akagera Management Company improve communities' livelihood through the construction of infrastructures and the funding local associations (African Parks, 2017). Over $ 985,436 were redirected to Akagera community's project between 2005 and 2016 (Ngoga, 2016). The allocation of another 5% of tourism revenues to the special guarantee fund enables locals to be compensated for human-wildlife conflicts (African Parks, 2017).

The number of locals employed in tourism sector also increased between 2010 and 2014, from 59 to 220, according to park's report.

2.1.2. Odzala-Kokoua national park

Odzala-Kokoua National Park (PNOK) in Category 2 of IUCN (Dudley, 2008), is situated 850 km north from Brazzaville, near the equator at the border with Gabon, in the centre of a complex of mining and logging concessions (see Fig. 2). It was created in 1935, making it the oldest protected area of Congo. PNOK was then merged with the *Réserve de Faune de la Lékoli-Pandaka* and the *Domaine de Chasse de Mboko* in 1955. In 2001, the park was again extended to reach its actual area of 13.762 km^2, becoming the largest park of Congo (Dubois et al., 2015; Hecketsweiler et al., 1991). Since 2010, the park is managed by African Parks

Table 1
Household general characteristics.

Construct	Topic	Question
General information	Household	Who are the members of this household (number, sex, year)? What is your marital status? When was this household formed? Where are you originally from? Do you own your house? How many m^2 is your house?
	Education	Until which class did you go to school?
	Age	How old are you?
Land	Land area	Indicate the amount and type of land that you own and rented in/out
	Land-use change	Did the household change the way the land was used in the last 5 years? If yes, how much/for which purpose/what type of land-use was it/what was the ownership status/ how far from the house? How much land used by the household has over the last 5 years been abandoned (left to convert to natural re-vegetation)? Do you think you will still be able to use your current land for all the next 5 years? If no, what are the reasons? Do you plan on changing the land-use in the future? If yes, for which purpose?
Livestock	Cattle numbers	How many cattle's does you own? For which purpose?
	Chicken numbers	How many hen's does you own? For which purpose?
	Goat numbers	How many goat's does you own? For which purpose?
Assets and savings	Salary	Do you own a salary? If yes, how much approximatively?
	Income source	What is your main livelihood source?
	Savings	How much does the household have in savings?
	Debts	How much does the household have in debt?
	Wages	What is the wage in the village?
Ecosystem's resources	Fuelwood/Water/ Bushmeat/NTFP	How far is the *resource* to collect? Does your household collect *resource*? If yes how much time per day do you spend for collection? Does your household now spend more or less time than you did 5 years ago? How has availability of *resource* changed over the past 5 years? If declined, how has the household responded to the decline in the availability of *resource?* Did your household undertook any measures concerning the *resource* over the past 5 years? If yes: what are the main purpose(s)?
Crisis	Economic shocks	Has the household faced any major income shortfalls or unexpectedly large expenditures during the last 5 years? If yes, how severe and how did you cope with costs/losses
Welfare and perceptions *(over the last 5 years)*	Satisfaction	How are you satisfied with your life over the past 5 years? Has the household's food production and income over the last year been sufficient to cover what you consider to be the needs of the household?
		Compared with other households in the village (or community), how well-off is your household? How well-off is your household today compared with the situation 5 years ago? If worse or better-off: what is the main reason for the change?
	Conservation perception	How well-off is your household today compared with to the situation before conservation actions were taken? If worse or better-off: what is the main reason for the change? Are you satisfied with the conservation actions that were undertaken in the last 5 years? What would be the main thing to improve conservation-livelihood relation?

(AP). The decision board is composed of AP, government representatives and two local community representatives.

With more than 440 bird species, PNOK is an Important Bird Area and home to over 100 mammal species and in excess of 10,000 plant species. However, the species are under threat as a result of poaching pressure. Many elephants were killed before African Parks took over the management of Odzala. The park is one of the last strongholds for some of central Africa's iconic and endangered species, such as African forest elephant (*Loxodonta cyclotis*), western lowland gorilla (*Gorilla gorilla gorilla*) and chimpanzee (*Pan troglodytes*). The populations of elephants and gorillas are in decline due to disease such as Ebola as well as the illegal wildlife trade for pets and bushmeat, while the number of chimpanzees is considered to be stable. The park is also characterized by the presence of a population of forest buffalo (*Syncerus caffer nanus*), spotted hyenas (*Crocuta crocuta*), hippos (*Hippopotamus amphibius*) and serval (*Leptailurus serval*) in the 6% of the Park's savannah. A total of 106 mammal species have been identified in the park.

Nowadays, villages are grouped along the roads at the edge of the park due to past evictions (Hecketsweiler et al., 1991). It is estimated, however, that only 10,000 people distributed into 39 villages live at the periphery of the park (African Parks, 2015). Human population density is around 0.8 inhabitants km–2 in these areas, a sustainable rate for the environmental and fauna conservation (Mavah et al., 2018).

Yet, with the absence of development and planning in recent years, villagers kept a traditional subsistence lifestyle in the 5 km buffer zone. Bushmeat is a necessary resource for communities as it accounts for 80% of their protein diet (Mbete et al., 2010). Rural communities combine agricultural products and bushmeat to feed. However, increasing bushmeat demand in urban areas (Mbete et al., 2010) is pushing those communities to hunt for extra income. Most of the villages have sanitation problems as no drinking water is provided. Moreover, health centres and schools, if present, are in bad condition.

Revenue-sharing schemes are present (Pyhälä et al., 2016) but with only 100 tourists visiting in 2016, it is not generating enough revenues to develop communities' projects. Since 2012, only 81,600 $US were generated for community projects (20,400 $US/year in average (African Parks, 2015)).

In Congo, communities have access to a 5 km eco-development zone to harvest resources. Due to low agricultural productivity and remoteness from markets, households' dependency on forest is high. Unlike in Rwanda, community representatives are part of the decision board in Congo.

Table 2
Predictive variables, their units and evaluation ranks (in brackets) used in the factor analysis.

Quantitative	Qualitative	Supplementary
Bank savings *$*	Conservation perception *[−,0,+]*	Distance to protected area *meter*
Debt *$*	Satisfaction *[−2,−1,0,1,2]*	Village *name*
Salary *$/month*	Situation over 5 years *[−2–1,0,1,2]*	Household formation *years since formation*
Wage *$/day*	Roof material [thatch, metal]	Number of household members *Nr.*
Cropland area *hectares*	Sufficient food *[−1,0,+1]*	Education *Years*
Livestock number *nr.*	Main livelihood *[agriculture, shop, livestock, mining (gold), job, hunting]*	District *nr.*
Resource collection time *hours/week*		

2.2. Data collection

We accounted for absolute values with specific units (disaggregated) instead of their relative values (aggregated) and in smaller units to increase the quality of responses and details of analysis. As discussed by Jagger et al. (2012), disaggregated data, numerical and non-numerical information that have been broken down in component parts or smaller units of data, are useful to directly measure the behaviour of the populations through detailed questions (i.e. on ecosystem's use). Therefore, a questionnaire was adapted from the Poverty-Environment Network (PEN) developed by CIFOR that aims to have a global comparative database on forest-livelihood relations (Angelsen & Wunder, 2003; Angelsen et al., 2014). PEN uses a standardized set of village and household-level questionnaires to study the importance and role of environmental income in rural livelihoods and its contribution to rural households' income portfolios. Both quantitative and qualitative data were collected. Quantitative variables were composed of continuous and discrete variables. Qualitative data included ordinal (i.e. five-point Likert-scale questions) and categorical variables as proposed by Angelsen et al. (2014).

We collected data on socio-economic factors (demography, education, food consumption, NTFP and bushmeat collection, income-generating activities) to encompass livelihood strategies. Here, we define a household as being people (usually related) living in the same house and sharing resources. The questionnaire was divided into different parts (Table 1).

The sampling design was elaborated on the field after several discussions with the community liaison unit of the park management teams. To be included, villages had to respond to certain characteristics to be representative of the studied contexts. Regarded characteristics to select communities were the distance to the park, presence of community projects, administrative location, source of risks, tourism impact and degrees of access to represent the full range of modalities. Within each village, diverse households were randomly selected to have a representative sample. Because reliable village lists were unavailable, households (in order to have at least 30% of the total households) were selected along several road axis resulting in at least 90 households (statistically representative) per site. Attention was paid not to exclude most remote households. Households from every part neighbouring the park were surveyed in Rwanda, while due to limited time only households on the southern part of the park were surveyed in Congo. Their economic factors are also represented by asking about their "Savings" and "Livelihood".

The aim of the survey was explained to households in order to have their prior and informed consent before the beginning of each survey and full anonymity was guaranteed to reduce biased answers and no payment of any kind was given. The questionnaire was pre-tested to get an idea of the answering time and any potential improvement. A Garmin Dakota 20 GPS was used to collect every household's coordinates and calculate distance to the protected area. A translator per site (English-Kinyarwanda and French-Lingala) was hired to ensure good communication and understanding of the questionnaire. A one-day training session, explaining the objectives and the protocol, was done with them previous to conducting the questionnaire. Finally, we successfully conducted the survey in 2018 and reached 180 households responding to the questionnaire in an average time of 1.5 h.

2.3. Statistical analysis

Data management consisted of coding ordinal variables (i.e. "very unsatisfied", "unsatisfied", "neither unsatisfied nor satisfied", "satisfied", "very satisfied" as an ordinal variable taking on values −2, −1, 0, +1, +2), converting monetary values (RwF and FCFA to $) and calculate households' distances to the park boundaries with QGIS. All data was analysed with SPSS 25.0 (IBM Corp., 2019a).

First, we looked at the possibility to analyse both datasets (Akagera and Odzala) as a single population. A *t*-test was used to check whether the Congo and Rwanda data were different from one another considering all the variables and needed a separate analysis.

Responses for each variable were analysed to understand general socio-economic patterns (Engen et al., 2019). We have included many variables in the analysis to explore the full picture explaining conservation perception and development nexus. Therefore, a factor analysis was then used to detect the most significant predictor variables among a set of socio-economic (demographics, livelihood, income sources) and resource-related variables in relation to conservation perception. Moreover, this allows identifying the distinct groups of inter-related socio-economic and resource-related variables with emphasize on the most significant variables with the highest common variance among all variables. Table 2 summarize the list of variables and, for categorical variables, their assigned ranges. In our case, correlation coefficients above |0.3|for Rwanda and |0.4| for Republic of Congo were selected to reduce the number of independent variables to 12 variables for each site and facilitate the interpretation of interrelationships (see the list of 12 variables for each study area and their variance in Appendix Tables A.2 and A.3). We have conducted a Nonlinear Canonical Correlation analysis to determine and illustrate the interrelationships between the two data sets i.e. responses (as in Table 2) and the 12 influential variables identified by factor analysis. In our case, we separated our single criterion variable "conservation perceptions" and its three responses levels (−,0,+) from conservation project's effects (less well-off, the same, better-off) and related variables and their response levels. Finally, the plot of centroids labelled by variables were used to visualize the relations among the response categories (quantitative, qualitative, and supplementary in Table 2) and find out the clustered categories specifically affecting the categories of conservation perception in the centroid plots. Those plots are used to provide an interpretation base for homogeneity analysis (Corp, 2019b) and distinguish between contradictory groups and identify their positive and negative correlations.

3. Results

3.1. Household's characteristics

The original dataset was composed of 195 households and 175 response variables to the questions. Some variables were correlated with other variables (i.e. reasons for better-off situation in comparison to 5 years ago).

Household head's age varied between 20 and 81 years old with an average of 45. In average, household formation was 13 years ago with 7 persons per household. Average education was equal to 4 years of

Table 3
Household general characteristics.

Variables		All data	Rwanda	Congo
Livelihood (%)	Agriculture	65.6	**85**	**45.3**
	Livestock	4.6	8	1.1
	Job	8.2	5	11.6
	Shop	1	2	0
	Hunting/Agri.	20	0	**41.1**
	Small-scale gold mining	0.5	0	1.1
Resource collection time (*hours/week*)	Fuelwood	6.6	7.8	5.3
	Water	10.1	13.3	6.8
	NTFP	2.5	0.4	4.8
	Bushmeat	–	–	17.5
Cropland area (*ha*)		0.9	0.95	0.86
Resource availability (1 = *decreased; 2 = same; 3 = increased)*	Fuelwood	1.61	1.28	2.01
	Water	1.51	1.83	1.17
	NTFP	1.86	2	1.85
	Bushmeat	–	–	1.58
Education (*years*)		4.3	2.6	6.2
Age		45	42	48
Number of persons		7	5	9
Salary (*$/month*)		43	0	89.1
Savings (*$*)		143.6	92.5	197.4
Debts (*$*)		201.4	**60.2**	**350.3**
Wages (*$/day*)		5.85	9.3	2.3
Conservation perceptions (%)	Negative	34.4	8.1	**62.1**
	Same	25.1	35.4	13.7
	Positive	40.5	**56.6**	24.2

schooling. Households were situated between 0.1 and 14.6 km from the two national park's borders (mean = 5.4 km).

Over 65% of individuals relied on agriculture as their principal source of livelihood, 20% on hunting, 8.2% on a salaried job and 4.6% on raising livestock. The rest of the individuals (2.2%) depended on small shops and small-scale gold mining. The average cropland area per household was 0.9 ha with some households holding up to 8 ha.

Households satisfied with conservation measures (40.5%) invoked reduced human-wildlife conflicts, revenue-sharing schemes, boosted local economy, employment and environmental education. Reasons for less well-off situation (34.4%) were access to resources, human-wildlife conflicts and missing revenue-sharing schemes. The rest of the households (25.1%) had a neutral opinion, being neither satisfied nor unsatisfied with conservation measures.

The *t*-test result showed that there was a statistically significant difference between the two sites (p-value = 7.071 10^{-5}, see Tables A.1–A.3 in Appendix). Therefore, we reject the null hypothesis that there is no difference between Rwanda and Congo.

As Rwandan and Congolese households are statistically different (t-tests), the two datasets were then analysed separately (Table 3) to get country-specific information.

3.2. Conservation perceptions and related factors

3.2.1. Rwanda

To retain enough information and variables in our nonlinear canonical correlation analysis, variables with correlation coefficients above |0.3|were selected. The first two dimensions of factor analysis were analysed and explain jointly 23% of the variable total variance. This choice helped us to better understand relationships among selected variables (12 out of 32 variables in dimension 1 and 2). . KMO and Bartlett's test were found statistically significant (KMO = 0.512, $p < 0.05$) proving that the PCS test could act efficiently regarding the correlations among variables.

The bi-dimensional component loadings plot (Fig. 3a) separates the retained variables into 3 groups and an empty group divided by horizontal (dimension 1) and vertical (dimension 2) lines. We classify and name the bundle of variables allocated to each quadrant. Group 1 is located at the upper-left quadrant and may be called *wealth/capital* group as it includes variables picturing household wealth ("chicken numbers" and "house area") and households' level of satisfaction. Group 2 is located at the up-right quadrant and represents just two variables "NTFP collection" and "NTFP availability". Group 3 include the highest number of variables and is composed of 7 variables including "conservation perceptions" in the bottom left quadrant (negative figures for both dimensions 1 and 2). None of the variables have been plotted in the bottom-right quadrant (group 4) meaning that no variable had a negative and positive load on dimension 1 and 2, respectively.

Looking at the centroids (arithmetic averages) plot (Fig. 3b) of significant variables, the interrelationships between three response levels of single criterion variable "conservation perception" (better-off, the same, less well-off) and the response levels of other 12 variables are illustrated in a bi-dimensional space. In the lower left quadrant, respondents have a positive perception of conservation (better-off), have savings, have big cropland area, own cattle, high education and have

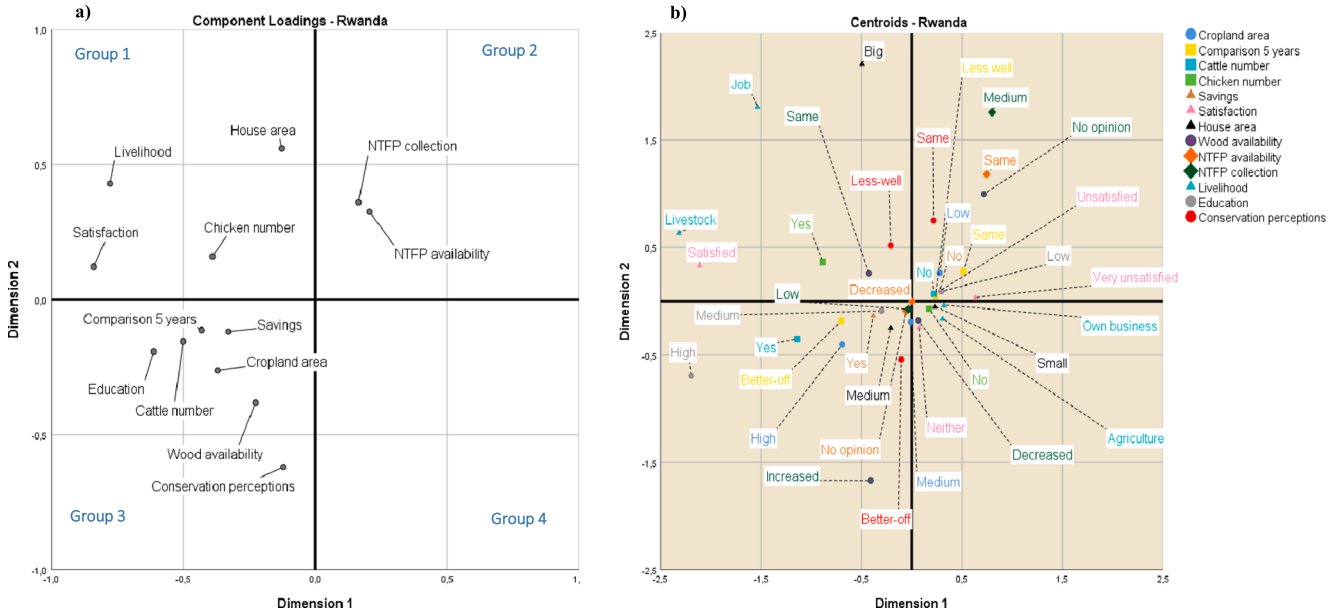

Fig. 3. Bi-dimensional visualization of component loadings (3a) and centroids of variables response levels (3b) for Akagera National Park (Rwanda).

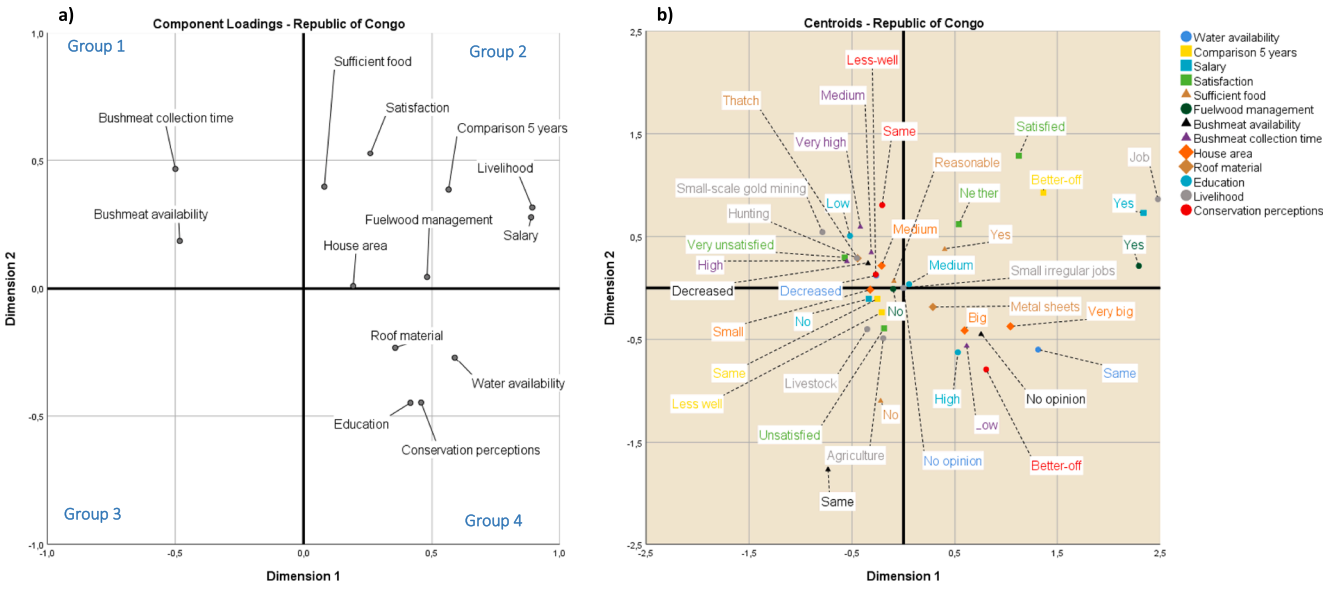

Fig. 4. Bi-dimensional visualization of component loadings (4a) and centroids of variables response levels (4b) for Odzala-Kokoua National Park (Congo).

seen their fuelwood availability increased in the past years. In the upper left quadrant, households are less well-off with conservation measures, have small cropland area, have chickens and rely on employment and livestock as their main livelihood, however, are also satisfied with their life situation. Conservation perception is indifferent (the same) for respondents that have low education and own law properties and no cattle and have realized an even lesser life satisfaction in the last 5 years.

3.2.2. *Congo*

Variables with correlation coefficients above |0.4|were selected as predictor variables. The first dimension accounts for an important amount of the variance (15%). Although the second dimension's eigenvalue is below 3, it brings further information concerning the interactions between variables. Dimension 1 and 2 consist of 12 significant variables and explain 25% of variance among variables. Both KMO and Bartlett's test were found statistically significant (KMO = 0.575, $p < 0.05$) proving that the PCS test could act efficiently regarding the correlations among variables.

The component loadings bi-dimensional plot (Fig. 4a) reveals 3 different groups of variables. Group 1, up-left quadrant, represents the *survival group* with "bushmeat collection time" and "bushmeat availability". Group 2, at the top right quadrant, can be regarded as the *socio-economic* group with variables such as "Livelihood", "Salary", "House area". There is no variable in the group 3 area because none of the variables had a negative load for both dimensions simultaneously. Group 4 occupies the bottom right quadrant and is composed of 4 variables including "conservation perceptions", "Roof material", "Education". Similar to Rwanda, education conservation perceptions are in the same group.

The in-depth relationship between the response levels of *conservation perceptions* and the retained variables can be analysed by looking at the plot centroids (Fig. 4b). In the upper left, the respondents perceive a decrease in water and bushmeat availability in the last 5 years, they have a high bushmeat collection time, have small to medium houses with thatch roof, low education, rely on small-scale gold mining and hunting. This results in a neutral (the same) or even negative (less well-off) perceptions of conservation. In the lower right quadrant, people have a positive perception (better-off after conservation) of conservation, are more educated, have bigger houses with metal sheets, and a low bushmeat collection time.

4. Discussion

Our results showed that positive economic factors and capital may provide positive attitudes and activate personal and social norms towards conservation. However, the results are just valid for the two case study areas (ANP and PNOK protected areas) in Rwanda and Congo. Moreover, the contextual complexity of conservation and socio-economy ask for more applied studies to improve our understanding of the conservation-development nexus. Among economic factors studied here, "Agriculture", "Livestock" and "Own business" are the only types of livelihoods showing a positive influence on conservation perceptions (Fig. 3b and Fig. 4b). Off-farm employed households and wealthier ones are less dependent on natural ecosystems (Masozera & Alavalapati, 2004). As the dependency decreases, households are less affected by conservation regulations and start to understand and accept it (Epanda et al., 2019). In addition, off-farm employment from conservation bodies or from revenue-sharing projects provides direct livelihood benefits through a salary (Masozera & Alavalapati, 2004). This is fully in line with the comprehensive action determination model (CADM) proposed by Klöckner and Blöbaum (2010), assuming that behaviours are determined directly by three sources (intentional, behavioural and habitual) and indirectly by normative processes (social and personal norms, awareness of need and awareness of consequences). On the other hand, they state that the survival factors are anchored in communities' behaviours (see more details about CADM in Appendix).

4.1. *Conservation perceptions*

Several means exist for designing effective conservation strategies by considering the perceptions and attitudes of local populations toward wildlife, by disseminating environmental education programmes (Hariohay et al., 2018) and implementing participative conservation planning by involving local people (Groulx et al., 2021; Niemiec et al., 2021). Our results suggest that environmental education has a positive influence on conservation perceptions. This is in accordance with Marchini and Macdonald (2020), who found that educated people had more off-farm employment opportunities and improving education levels might be part of the solution to raise positive perceptions about conservation. This is also in accordance with the systematic review of Ardoin et al. (2020), indicating the concrete effects of environmental education on addressing conservation issues. Conservation programmes based on environmental education can improve the perceptions of wildlife

conservation and lower poaching activities when combined with the improvement of local people's livelihoods through the creation of alternative income (Epanda et al., 2019).

In our study, communities report low access to resources as one of the main reasons for their weak involvement in conservation, as also observed by Lhoest et al. (2019) in Cameroon. Having been evicted from their ancestral land without any form of compensation and benefiting now from limited or no access to the park, local populations often perceive conservation negatively in the Congo basin (Cernea & Schmidt-Soltau, 2006) and Uganda (McKenzie et al., 2017).

In the two study sites, water access has been improved in the last years through the construction of wells thanks to revenue-sharing schemes, but their number remains too small for the population. Fuelwood is now gathered from deadwood in agricultural fields and is becoming less available (65.7% of respondents). Although some afforestation programmes are being implemented by the government and Akagera Management Company, fuelwood alternatives are needed to reduce dependency. As Jagger and Das (2018) suggest, an improved stove or dry manure fuel could alleviate anthropogenic pressures on the last forest patches present in Rwanda. Overall, water access does not appear to be a problem linked with conservation perceptions even though the issue was tackled through revenue-sharing programmes in Rwanda and in Congo.

In Congo, bushmeat and NTFP stocks have decreased over the last five years according to the community members interviewed, as already stated by Mavah et al. (2018) for the same area. It has a negative influence on conservation perceptions, easily explained since communities rely on bushmeat for both subsidence and commercial use. Moreover, the strong habit of traditional bushmeat use must be taken into consideration to understand population's behaviours (Klöckner & Blöbaum, 2010).

On one hand, bushmeat is the only accessible protein source for remote and poor communities (Brashares et al., 2011). Bushmeat also plays a role of safety net in the economies of poor people (Bennett et al., 2007) and households relying on bushmeat hunting are usually the poorest and most marginalized people, lacking education and skills to switch to alternative livelihood or food sources. Hunting regulations hinder communities to hunt legally and alternative hunting regulations or/and alternative protein sources must be found to sustainably manage bushmeat as well as development projects to reduce rural bushmeat dependency (Mbete et al., 2010).

On the other hand, the commercial use of bushmeat plays a major role in rural livelihoods of studied areas in Rwanda and Congo. Impoverished people seem to be more dependent on sales of bushmeat than the rich because of its high value and tradable commodity (Lhoest et al., 2020a; Merode et al., 2004) but wealthier households are the ones receiving most income from bushmeat hunting (Coad et al., 2010). In addition, this commercial dimension opens opportunities for illegal hunting of protected species, which provides important short-term income for local hunters, sometimes going towards food insecurity to ensure revenues for their family (van Vliet et al., 2010).

Most households report a decrease in bushmeat availability, underpinning the necessity of addressing the bushmeat issue on local, regional and global scales. If conservation and development projects fail to sustainably manage bushmeat, rural populations will be affected by the loss of wild protein supply and in the long run loss of ecological functions (Lhoest et al., 2020a) such as diaspora dispersion of NTFP (Evrard et al., 2017). Yet, few models are available and proposed approaches by Vermeulen et al. (2009) and van Vliet et al. (2010) remain theoretical for practical and logistic reasons. van Vliet et al. (2010) recommend that inclusion of hunters in the decision-making process would empower local communities and may result in sound hunting controls and awareness rising.

To reduce anthropogenic pressure on wildlife consumed, education and awareness programmes will increase off-farm employment opportunities for poor households (Nasi & Brown, 2008). Revenue-sharing schemes will create income-generating projects and diminish local bushmeat dependence (Lhoest et al., 2019). Such projects could even target food sufficiency and alternative protein sources (i.e. poultry, fish farming).

Bushmeat was found to have an adverse effect on conservation perception. Accurate context-specific information on household's bushmeat consumption and sales are needed to better understand their social and psychological determinants (Hariohay et al., 2018; Mikołajczak, 2019). Most determinants may be site-specific, requiring local scale data for an integrative, participative and adaptive conservation planning. Bushmeat demand and markets in urban centres and around protected areas must be examined as well as wildlife population dynamics to refine conservation-development policies (Lhoest et al., 2020b). The cultural dimension of bushmeat was not the centre of interest of this study but it must be taken into consideration to get a full understanding of the importance of bushmeat for local communities (van Vliet & Mbazza, 2011).

4.2. Conservation and development

Revenue-sharing and compensation schemes have started to be implemented in the last decades with mixed success (Ogra & Badola, 2008). Communities seem to have positive views (40.5%) on such projects and this could help to raise positive perceptions of conservation measures (McKenzie et al., 2017). We found that human-wildlife conflicts and revenue-sharing schemes have mixed outcomes as they are mentioned as reasons for both better and less well-off situations due to conservation measures. This ambiguous trend can be interpreted by the unequal distribution of revenue-sharing schemes and guarantee funds.

Revenue-sharing has been used in Rwanda to improve infrastructure (schools, health centres, roads), resource access (water wells) and to implement income-generating projects for communities (bee-keeping, craft-shop souvenir). Such projects aim to create alternative livelihoods and empower local populations and are generally well perceived as communities' may finance their health and schooling using the project's income (Hartter et al., 2014; Sassen & Jum, 2007). Yet, communities are excluded from the decision process and are unaware of project's selection processes, hindering them from realizing the potential benefits of such projects (Nsabimana & Spencer, 2013). Increasing communities' decision power and communication between the various actors will improve the implementation and success of revenue-sharing projects with appropriate governance (Nsabimana & Spencer, 2015). A meaningful community engagement process needs to be fully open and participatory, showing mutual respect among participants and clarity of roles and responsibilities (Dyer et al., 2014).

Tourism in PNOK has always been limited due to the remoteness of the park and the lack of infrastructures (100 tourists/year) (Hecketsweiler et al., 1991). Consequently, revenue-sharing funds are small and external inputs are needed to implement community projects. While cocoa plantations have been developed in some northern villages, such initiatives are just beginning in the southern part. As recently implemented, the participation of community representatives in decision board in Congo could facilitate the implementation of projects useful for communities if sufficient funds were available, as experimented in similar projects in Cameroon (Epanda et al., 2019).

In Rwanda, human-wildlife conflicts have been addressed through guarantee funds by allocating 5% of total tourism revenues to compensate community members. While being properly defined, we found that the process is complicated as park authorities, police and RDB agents need to be present to evaluate the damages, and the monetary compensation often arrives late. Recently, the Rwanda Development Board decided to increase the revenue-sharing rate from 5 to 10% for the whole country. The percentage of profit used for revenue-sharing seems to be arbitrary and it might be more adequate to calculate it based on an opportunity cost analysis or socio-economic assessment of local communities.

A special attention to factors affecting revenue-sharing schemes and economic development is necessary (Archabald & Naughton-Treves, 2001). Long-term institutional support is crucial to guarantee the viability of the conservation project. Appropriate identification of the target community and project type will improve attitudes and offset individual and community-level costs of conservation (Archabald & Naughton-Treves, 2001). Communities should therefore take part in the decision process to improve their awareness about revenue-sharing allocation and positive perception of such schemes. Transparency, accountability and adequate funding will improve, (under condition, see Crosman et al., 2021) relations between communities and protected areas' managers. Assessment and monitoring of existing projects will bring essential information about factors affecting the social and economic viability. Several initiatives allowed responsive behaviours from local people when they can increase their income by changing their livelihood system (e.g., in Indonesia; Feintrenie et al., 2010).

4.3. Future research

The context differences between the two cases studied here require further investigation to obtain a clearer and broader view of conservation-development dynamics. This could be achieved by surveying more communities in similar context or by focusing more in-depth on one protected area.

As local communities are at the centre of conservation-development issues, investigation of their internal dynamics will provide information on factors affecting conservation perceptions and success of development projects. We should examine communities in their particular context of conservation and development by focusing such an approach on the numerous interests of all members of a community (Agrawal & Gibson, 1999). Understanding how local actors influence collective and individual decision-making is crucial.

Moreover, relationships among the various stakeholders need to be fully understood to target specific actors depending on the issue. Interactions between the park and local authorities, communities and national authorities are complicated in the Republic of Congo due to the political context. Factors and actors affecting communication and sound policy implementation need to be assessed to increase positive perceptions and success of conservation measures. In particular, the logic of action (guiding policy) and the logic of inquiry (guiding research) do not always align (Barton et al., 2021). Through the synchronization of these two logics, researchers and organizations can produce actionable science for conservation and development, following a guide of best practices provided by Gerber et al. (2020).

In this study, we focused on general perceptions of conservation. Detailed information on perceptions of revenue-sharing schemes, tourism and specific conservation measures would help to better understand local populations. As communities' activities neighbouring protected areas affect conservation's perception and success, future research should also focus on examining habit strengths of community's behaviour. This aspect is crucial as it influences the intention-behaviour relations (Klöckner & Blöbaum, 2010). The decisions of community stakeholders can only be understood under the lens of economic and psycho-social factors. The scientific field of conservation psychology provides new tools to consider pro-conservation attitudes and behaviours (Mikołajczak, 2019).

5. Conclusions

Influences of social and economic factors on the perception of protected areas were analysed in this paper through nonlinear canonical correlation analysis. The nature of conservation perceptions by local communities is mixed and depends on local factors such as resource access and locally integrated decision-making processes. On one hand, we found that socio-economic factors such as "Savings" and certain types of "Livelihoods" (agriculture and livestock) have a positive effect on conservation perception. This is explained by the fact that employed and rich households become less resource-dependent, suffering less from resource access restrictions and regulations. On the other hand, "survival factors" have a negative effect on conservation perceptions. Those households are dependent on natural resources such as bushmeat and NTFP for both food and cash. Yet, regulations concerning the use of natural resources hinder these households to maintain their traditional practices. Important to note is the increase in commercial hunting to supply nearby towns. Access to and use of natural resources play a central role in community's livelihoods. Providing information and improving education by explaining resource's access measures and the reasons for sustainable use of forest resources could help communities to collaborate with conservation bodies.

To increase positive perceptions and guarantee a sustainable development of populations neighbouring protected areas, the implementation of revenue-sharing projects could provide the most wanted outcome. Such projects should focus on material benefits such as health centres, schools and infrastructures. In particular, income-generating projects would decrease community's dependence on ecosystems and increase their awareness of conservation benefits (Hartter et al., 2014). Yet, such schemes should involve concerned communities in the decision process to identify desired projects. In addition, as found in this study, projects should focus not only on "communities" but also on poorer households as they are the more conservation-adverse. Approaches geared towards individual professional training, aimed at conservation and urban service professions, should be considered.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Comprehensive action determination model

The comprehensive action determination model (CADM) was proposed by Klöckner and Blöbaum in 2010. This model is based on previous theories and incorporates the individual habit strength. Here, habit strengths are thought to depend on individual's characteristics rather than on behaviour's characteristics. The CADM assumes, like

the theory of planned behaviour (TPB), that behaviours are determined directly by intentions and perceived behavioural control and adds the habit strength as an independent predictor. Further assumption is that habit influences the intention-behaviour link depending on the habit strength. Intentions are linked with attitudes, social norms (subjective norms), Perceived Behavioural Control (PBC, as stated in the TPB) as well as personal norms. Combining the Norm Activation Theory (NAT) and Value Belief Norm (VBN) Theory's assumptions, personal norm can be activated by awareness of consequences and ascription of responsibility, PBC, social norm and New Environmental Paradigm (NEP). Personal norms are considered stable over time but can be activated or deactivated at any time, changing their impact on the intention. The NEP is itself determined by self-transcendence and self-enhancement values. Self-transcendence values represent the orientation of an individual towards universalism (being part of whole). On the other hand, self-enhancement accounts for the egoistic part of the individual. People with self-transcendence values are believed to hold a moral obligation towards pro-environmental behaviours. According to Klöckner and Blöbaum (2010), intentions is the strongest predictor for environmental behaviour, followed by habit strengths while PBC shows only a little impact on behaviour (36% of variability explained). Intentions are influenced, in order of impact, by attitudes, PBC, personal norms and social norms (55% of intention's variability explained). Personal norms' variability explained by the seven variables is 47%, all variables showing similar impact. Habits are predicted by intentions, personal norms and PBC.

Factor analysis

Tables A.1–A.3 summarize the results of factor analysis for both national parks located in Rwanda and Congo.

Table A.2
Correlation coefficients of retained variables for Rwanda.

Rotated Factor Matrix[a]		
	Factor	
	1	2
Wood availability	,300	
NTFP availability		,886
Water availability		
Wood_col		
Water_col		
NTFP_col		,988
Cropland	,527	
Comparison 5 years	,421	
CattleNumbers	,413	
GoatNumbers		
ChlckNumbers	,709	
Dist_PA		
Area	,407	
Bank. savings	,648	
Debts		
Wages		
Livel hood	,387	
Satisfaction	,647	
sumclent_food		
Education	,353	
Number_persons		
Household_for		
Wood_mana		
NTFP_mana		
Water_mana		
Conservation perceptions		

Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Table A.1
T-tests results.

	Unit	mean in Rwanda	mean in Congo	ci.lower	ci.upper	p-value
Distance to PA	Km	5.83	4.885	−0.574	2.465	**0.221**
Respondent	M/F	1.56	1.2	0.217	0.503	1.61E-6
Marital status	Nominal	2.62	4.653	−2.475	−1.59	7.52E-16
Household formation	Years	7.701	18.842	−14.065	−8.218	9.82E-12
Persons/household	Number	5.48	8.863	−4.381	−2.386	4.75E-10
Mean wage	$	9.22	2.273	6.383	7.512	2.87E-46
Education	Years	2.61	6.189	−4.556	−2.603	1.23E-11
Own house	Yes/No	1.25	1.021	0.087	0.371	0.00185
Wall material	Mud/Concrete	2.62	1.442	0.811	1.545	1.90E-9
Roof material	Thatch/Metal	3	2.221	0.579	0.979	1.10E-11
House Area	m^2	37.87	34.937	−2.337	8.203	**0.274**
Main livelihood	Nominal	1.24	2.937	−2.102	−1.291	2.48E-13
Salary	$	0	89.145	−140.325	−37.964	8.18E-4
Bank savings	$	92.47	197.368	−295.986	86.189	**0.279**
Debts	$	60.05	350.295	−434.888	−145.601	1.24E-4
Satisfaction	Likert-scale	2.32	2.221	−0.164	0.362	**0.459**
Sufficient food	Likert-scale	1.52	2.105	−0.781	−0.39	1.73E-8
Comparison 5 years	Likert-scale	1.61	1.789	−0.402	0.043	**0.114**
Comparison conservation	Likert-scale	2.48	1.621	0.645	1.073	2.83E-13
Collection_wood	Hours/week	7.792	5.308	1.01	3.959	0.00109
Collection_ntfp	Hours/week	0.428	4.758	−5.685	−2.976	5.74E-9
Collection_water	Hours/week	13.266	6.833	4.089	8.777	2.44E-7
Collection bushmeat	Hours/week	0	17.484	−20.641	−14.327	1.43E-18
Wood availability	Likert-scale	1.18	1.905	−0.869	−0.582	1.09E-18
NTFP availability	Likert-scale	0.14	1.537	−1.583	−1.211	4.75E-32
Water availability	Likert-scale	1.46	2.168	−0.913	−0.504	2.52E-10
Bushmeat availability	Likert-scale	0	1.084	−1.259	−0.909	2.68E-21
Conservation management	Yes/No	2.69	3.853	−2.342	0.017	**0.0533**
Cropland area	m^2	0.951	0.86	−0.21	0.392	**0.552**
Crop production	Nominal	186.61	218.537	−45.506	−18.348	9.49E-6
Land-use change	Yes/No	0.12	0.011	0.042	0.177	0.0018
Current land-use	Nominal	0.85	0.011	0.765	0.914	5.31E-44
Cattle	Number	1.36	0	0.312	2.408	0.0115
Goat	Number	1.23	1.021	−0.643	1.061	**0.629**
Chicken	Number	1.17	7.968	−9.018	−4.579	1.57E-8

Table A.3
Correlation coefficients of retained variables for Republic of Congo.

Rotated Factor Matrix[a]		
	Factor	
	1	2
Fuelwood availability		
NTFP availability		
Water availability		,450
Bushmeat availability	−,672	
Fueldwood collection time		
Water collection time		
NTFP collection time		
Bushmeat collection time	−,799	
Cropland area		
Comparison 5 years		,461
Goat		
Chicken		
House area	,529	
Olstance to PA		
Roof material	,497	
Savings		
Debts		
Salary		,820
Wages		
Livelihood	−,562	
Satisfaction		,533
Sufficient food		,439
Education	,412	
Number_persons		
Household formation		
Fuelwood management		,570
NTFP management		
Water management		
Bushmeat management		
Conservation perceptions		

Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.
3. Rotation converged in 3 iterations

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