

Complexity of zoning management in biosphere reserves: the case of the Yangambi Biosphere Reserve in DRC

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HIGHLIGHTS

- The Yangambi Biosphere Reserve (YBR) in DRC is highly threatened through unsustainable activities undertaken by riparian communities in the reserve.
- Restrictions imposed on access to resources by the zoning of the YBR have forced riparian populations into over-exploitation of village lands.
- Zoning applied to the reserve did not take into account the social dynamics nor the participation of riparian communities in the Yangambi region.
- Variations in the reserve boundaries have led to substantial uncertainty and were found to be at the root of clashes and latent conflicts between the local population and the YBR managers.
- To reduce the pressure on the resources of the YBR, we suggest an improvement in agricultural techniques coupled with the participatory delimitation of village exploitation zones, as well as a revitalization of participatory structures.

SUMMARY

Riparian communities activities threaten conservation in biosphere reserves in the Democratic Republic of Congo (DRC). The Yangambi Biosphere Reserve (YBR) is no exception to this degradation. Thus, the objective of the presents study was to elucidate the local factors underlying the high pressure on natural resources and analyze the complexity of biosphere reserve zoning management using an interdisciplinary approach combining document review, field surveys and semi-structured interviews.

Our results revealed that the zoning applied to the YBR did not take into account social dynamics. With population growth, the riparian community is doomed to remain in restricted areas, leading to over-exploitation of the space and land degradation, forcing the population to travel long distances to reach fertile plots into the protected area. Also, the lack of employment and the absence of participatory zoning also exacerbate tensions between the manager and the riparian community. For an effective management of the YBR, political authorities should become more involved in the participatory zoning of conservation areas and village exploitations. In addition, they should improve farming techniques to mitigate soil degradation.

Keywords: agriculture, biodiversity conservation, Yangambi, participatory zoning

Complexité de la gestion par zonage des réserves de biosphère. Cas de la réserve de biosphère de Yangambi en RDC.

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Les activités des communautés riveraines menacent la conservation dans les réserves de biosphère en République démocratique du Congo (RDC). La réserve de biosphère de Yangambi (RBY) n'échappe pas à cette dégradation. De ce fait, les objectifs de la présente étude étaient d'élucider les facteurs locaux qui sous-tendent la forte pression sur les ressources naturelles et d'analyser la complexité de la gestion par zonage

des réserves de biosphère en utilisant une approche interdisciplinaire combinant la revue documentaire, les enquêtes et les entretiens semi-structurés.

Nos résultats ont révélé que le zonage appliqué à la RBY ne tenait pas compte de la dynamique sociale. Avec la croissance démographique, la population est condamnée à demeurer sur des zones restreintes, ce qui entraîne une surexploitation de l'espace et une dégradation des terres, obligeant la population à parcourir des longues distances pour atteindre des nouvelles terres fertiles dans la zone protégée. En outre, le manque d'emploi et l'absence d'un zonage participatif n'ont fait qu'exacerber la tension entre le gestionnaire et la communauté locale. C'est ainsi, pour une gestion efficace de la RBY, les autorités politiques devraient s'impliquer dans le zonage participatif des zones de conservation et d'exploitations villageoises. En plus, elles devraient améliorer les techniques agricoles afin d'atténuer la dégradation des sols.

Complejidad de la gestión de la zonificación en las reservas de la biosfera: el caso de la Reserva de la Biosfera de Yangambi en la RDC

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Las actividades de las comunidades ribereñas amenazan la conservación en las reservas de la biosfera de la República Democrática del Congo (RDC). La Reserva de la Biosfera de Yangambi (RBY) no es una excepción a esta degradación. Así pues, el objetivo del presente estudio fue dilucidar los factores locales que subyacen a la elevada presión sobre los recursos naturales y analizar la complejidad de la gestión de la zonificación de esta reserva de la biosfera mediante un enfoque interdisciplinar que combinó la revisión de documentos, las encuestas de campo y las entrevistas semiestructuradas. Los resultados revelaron que la zonificación aplicada a la RBY no había tenido en cuenta las dinámicas sociales. Con el crecimiento de la población, la comunidad ribereña está condenada a permanecer en las zonas restringidas, lo que conduce a la sobreexplotación del territorio y a la degradación del suelo y obliga a la población a recorrer largas distancias para llegar hasta parcelas fértiles dentro la zona protegida. Además, la falta de empleo y la ausencia de una zonificación participativa también exacerbaban las tensiones entre el gestor de la reserva y la comunidad ribereña. Para una gestión eficaz de la RBY, las autoridades políticas deberían involucrarse más en la zonificación participativa de las zonas de conservación y en las explotaciones de los pueblos. Además, las técnicas agrícolas deben mejorar con el fin de mitigar la degradación del suelo.

INTRODUCTION

The forest is a common universal good that contributes to the equilibrium of nature and climate, and serves as a habitat for a great variety of animal and plant species. Globally, forest-lands cover approximately 4 billion hectares and serve as a major source of revenue for populations (FAO and UNEP 2020). With 155.5 million hectares of forestlands, the Democratic Republic of Congo (DRC) harbours the largest forest-land of any country in Africa and ranks second among the world's tropical region (Eba'a and Bayol 2009). However, anthropogenic activities such as land conversion to agriculture, artisanal mining, industrial logging and population growth have significantly altered the forest landscape causing deforestation, loss of biodiversity as a result of fewer ecological niches, and contributed to significant effects of climate change (Mayaux *et al.* 2013, Pelissier *et al.* 2015).

According to the Convention on Biological Diversity, the creation of protected areas (PAs) worldwide has been advocated as a strategy to conserve natural resources (Stone 1996). The first protected areas created in Africa during the colonial period, were characterized by the expulsion of the local population from their lands and denial of access to the lands' natural resources (Asriyani and Verheijen 2020, Igoe and Brockington 2007). This approach could not ensure sustainable conservation of natural resource as the local people continued applying unsustainable methods to these protected areas, which they felt were their customary lands that had been stolen from them and assigned to conservation purposes.

Thus in 1974, UNESCO adopted its Man and the Biosphere (MAB) programme and developed a "biosphere reserve" concept which incorporated the human factor in the creation and management of protected areas based on zoning (UNESCO 1996).

Although zoning-based management has produced satisfactory results in terms of natural resource conservation (Portman 2007, Bruggeman *et al.* 2018), it has been described by some as a tool designed to benefit conservation, relegating socio-economic development to the background, yet it is a pillar of sustainable management (Hull *et al.* 2011, Kilensele 2015, West and Brockington 2006). In addition, most of the management models designed at the regional level such as decentralized governance of natural resources and community-based management, have difficulty being implemented at the local level because of their inadequacy with regard to local practices and realities and, consequently, deforestation continues to increase under the effect of man, with the corollary of increased CO₂ emissions into the atmosphere (Clement 2010, Ishwaran and Persic 2008, Joiris *et al.* 2014). This scheme can be considered to be an example of the "colonial ecology" referred to by Ferdinand (2019), in which it has been demonstrated that Northern Ecology has been imposed on Southern countries.

The creation of PAs in the DRC was motivated by a concern to protect nature against threats of industrialization on the one hand and to allow populations to remain close to nature to reconcile with their past and have their origins respected on the other. This second aspect of this motivation

was a political objective that was in keeping with the spirit of Zaïrianization and the recourse to authenticity that was advocated by the president of Zaïre (now the DRC) in 1970 (IUCN 1976).

Although created to preserve natural resources, PAs in the DRC continue to face threats including armed conflict, illegal mining and logging, poaching and illegal agricultural exploitation (IUCN/PACO 2010, Butsic *et al.* 2015), leading to a considerable loss of forest cover estimated at a rate of 0.27% between 2000 and 2012 (Hansen *et al.* 2013), and forest degradation of 0.12% between 2000 and 2005 (Ernst *et al.* 2012). The primary concern of this research was how to reduce the pressure on natural resources in the country's protected areas.

Within this framework, much research revealed that the participation of the local population in the management of community projects is relatively low, hence the persistence of losses of the country's natural resources and conflicts between managers and the local community (Nyange 2014, Kilensele 2015, Stiem and Krause 2016, Kyale *et al.* 2019a). Other studies have analyzed the problem from a technical perspective using remote sensing tools to assist managers in decision-making (Kabulu *et al.* 2015, Semeki *et al.* 2016). However, studies elucidating the intrinsic factors, otherwise referred to Joiris (2004) as "local social logics" capable of compromising the governance of natural resources in a protected area not addressed, as the knowledge that does exist is either lacking or incomplete, which can lead to misguided decisions on the governance of natural resources by managers and exacerbate conflicts in the environment.

This study aims firstly to elucidate the local factors underlying the intense pressure on natural resources in the DRC's protected areas and secondly, to analyse the complexity of biosphere reserve zoning management in a landscape that seeks to combine human needs and biodiversity conservation in order to propose a management approach designed to improve the governance of PAs. A case study was conducted in the Yangambi Biosphere Reserve (YBR), a protected area, subject to natural resource preservation and rational use by the local community due to its status, but which is currently subject to anthropogenic threats leading to a loss of 0.38 per cent of the forest cover between 2003 and 2016, as well as a proliferation of unsustainable activities, such as poaching, artisanal logging and pirogue manufacture in the supposedly protected area (Van Vliet *et al.* 2017, Schure and Lwanga 2018, Kyale *et al.* 2019b). This research was carried out in order to help to shed light on the social logics created by the interaction between the manager and the local communities within the YBR and to inspire a management approach appropriate to the YBR.

MATERIALS & METHODS

Location and background

The necessity to carry out botanical and silvicultural studies in a region rich in floristic and faunal diversity led to the

creation of the Yangambi Floristic Reserve by Ordinance Law No. 121 Agri. of 25 November 1939 by the Governor General of the Belgian Congo (INEAC 1941). It was only in 1977 that it was inscribed on the UNESCO world heritage list and recognized as the Yangambi Biosphere Reserve (UNESCO 2010). Many reasons have led to the selection of the YBR as a study area: Firstly, the YBR is part of the biosphere network reserve, which is a field laboratory for many national and internal research entities. Secondly, the YBR is overrun by riparian and subjected to high deforestation rate (Kyale *et al.* 2019b).

The YBR is subject to the status of classified forest according to Law n° 011/2002 on the Forest Code (Articles 10 and 12) and is part of the public domain of the State, integrating not only conservation but also traditional human activities (Loi N°011/2002 du 29 aout 2002, Loi n° 14/003 du 11 Février 2014). The Ministry of the Environment and Sustainable Development (MEDD) manages the YBR in collaboration with the MAB program of UNESCO and the National Institute of Agronomic Studies and Research (INERA) which is in charge of the research component. Administratively, the YBR is located in Isangi and Banalia, west of the city of Kisangani, in the Province of Tshopo, DRC. It is located between 24°18' to 25°08' East longitudes and 00°43' to 01°08' North latitudes with altitudes varying between 400 and 500 m (Figure 1) (Kombele 2004). Dominated by equatorial rainforest, the YBR is in the vast central basin of Congo, with an annual rainfall of 1 600 to 2 200 mm, characteristic of Af-type climatic zones according to the Köppen classification (Bultot 1950).

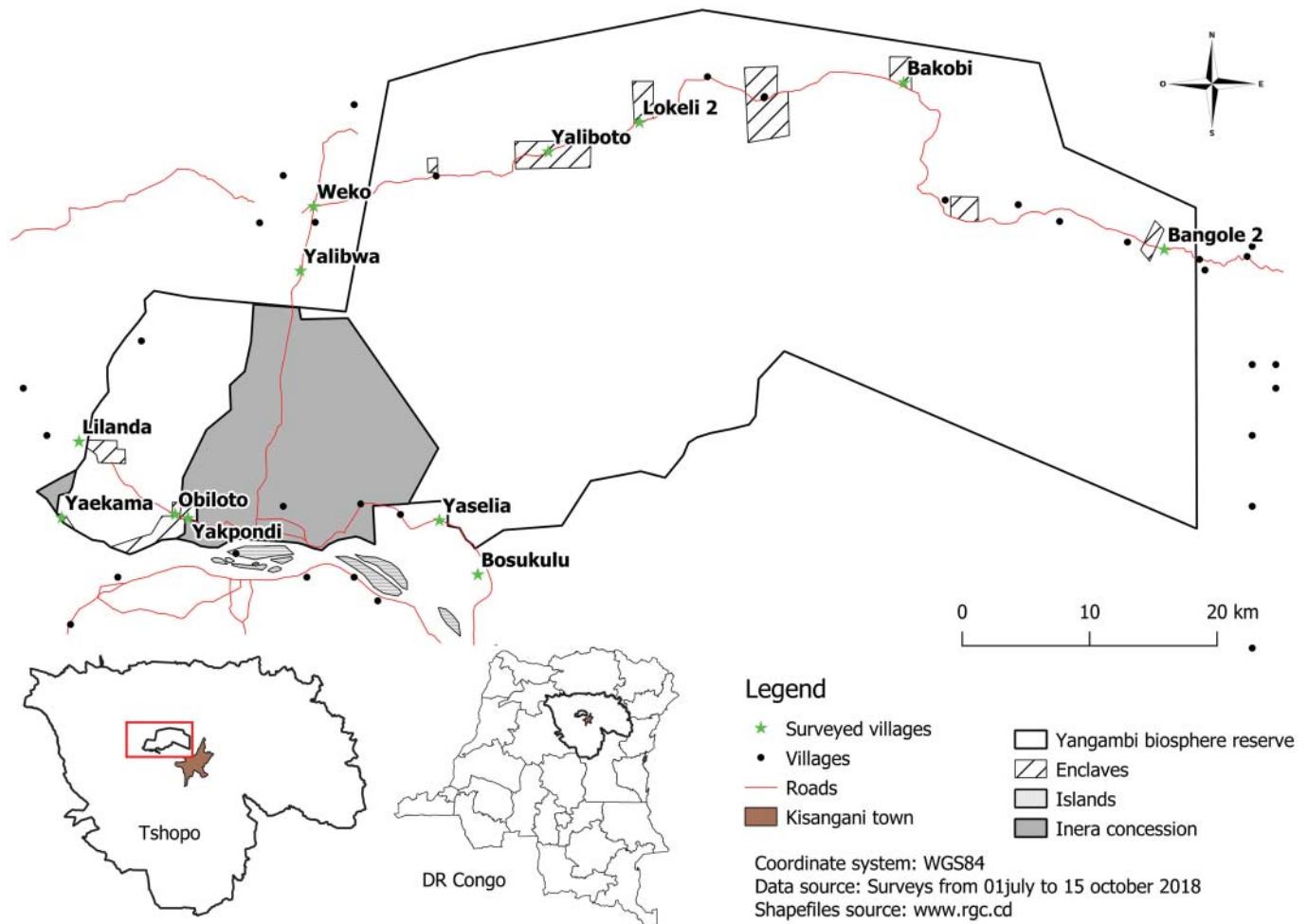
The YBR has a very rich flora with over 2 100 species and a very abundant and varied fauna that includes CITES emblematic species, in particular *Manis gigantea* (ground giant pangolin), *Hippopotamus amphibius* (hippopotamus), *Potamochoerus porcus* (Red River Hog or bush pig), and *Cercopithecus spp* (old world monkey) (UNESCO 2010). The population living in and around the YBR is composed mainly of two ethnic groups, the Turumbu and the Bamanga (Henry 1979). According to the *Institut National de Statistique* (INS) the population in the Yangambi region rose from 90 643 in 1984 to 226 931 in 2015 (INS 1992, Kyale *et al.* 2019b).

Conceptual and theoretical framework

As recommended by UNESCO, biosphere reserves have three functions divided into different zones, that is, (i) a core area allocated to the conservation and preservation of biodiversity, (ii) a buffer zone where only actions compatible with the conservation of biodiversity take place, and (iii) a transition zone allowing collaboration by all stakeholders in activities favouring the sustainable management of the reserve (Batisse 1997). The implementation of this management method requires the effective participation of all the actors whose actions could impact conservation and local development.

Therefore, to understand the circuits of interaction between the manager and the local communities in the YBR and elucidate the factors that can affect its governance, our study used a strategic stakeholder analysis (Crozier and Friedberg 1977). This approach identifies and analyzes the strategies deployed

FIGURE 1 Location in the Province of Tshopo, the Yangambi Biosphere Reserve, and the investigated villages (DRC)



by the various actors involved (e.g., Eco-guards, local communities, MEDD) and to clarify the ambiguity of their relationship in order to propose potential solutions to the management problems encountered in the YBR. Content analysis was used to process data from archives objectively, reports, focus groups and questionnaires (Aktouf 1987). The survey data, were encoded in Excel and used in the R studio software (version 3.6) to produce descriptive statistics and graphics.

Data collection

Data were collected through the literature review, questionnaire and focus group surveys conducted between July 1 and October 15, 2018. The literature review allowed the identification and analysis of the management methods applied to the YBR since its creation. The surveys were conducted in 12 villages consisting of 8 land enclaves (Obiloto, Yakpondi, Lilanda (Yafake), Yaekama, Yalibutu, Lokeli 1, Bakobi and Bangole 2) allocated to villages by the territorial administrators for the exercise of indigenous rights (INEAC 1941) and 4 villages established before the creation of the YBR (Busukulu, Yaselia, Yalibwa, and Weko). The existence before the creation of the reserve and the large population were the criteria used for the selection of the villages. This choice was

determined by the desire to learn about the evolution of management and local development policies implemented by the various managers of the YBR.

The village surveys were conducted among households, as they constitute the basic unit of the village farm. Since the villages presented the same socio-economic and cultural characteristics, households were selected based on occasional sampling, the principles of which are based on the availability accessibility of subjects during the survey (Berg 2001). A total of 158 households were surveyed (Table 1). The objective of the survey was to investigate local land use practices in the villages of the YBR.

While semi-structured interviews were conducted with key informants (village chiefs, MAB and INERA workers, civil society members, political-administrative authorities and the various actors working in the YBR) in order to understand management policies and issues that hinder effective governance in the YBR. Finally, a focus group of 8 to 12 people was held in each village in order to enable triangulation of respondents' opinions on land use patterns, their perception of the YBR, and the nature of their relationship with the manager.

To better analyze the surveys, the various respondents were classified by gender of the head of household, age range, level of education, seniority in the village, and the number of

TABLE 1 Number of households surveyed in enclaves and former villages in the Yangambi Biosphere Reserve

Village name	Number of households in 2018	Households surveyed	Sampling intensity per village (%)
Enclaved villages			
Bakobi	43	10	23.26
Bangole 2	56	11	19.64
Lilanda (Fafake)	64	13	20.31
Lokeli 1	46	11	23.91
Obiloto	47	10	21.28
Yaekama	59	12	20.34
Yakpondi	62	11	17.74
Yaliboto	39	9	23.08
Old villages			
Yaselia	180	26	14.44
Yalibwa (Yalofa)	41	10	24.39
Busukulu	101	14	13.86
Weko	118	21	17.80
Mean sampling effort			20.00

Sources of demographic data: Isangi and Bamanga sector office in 2019 and the health zones of Lilanda, Bakobi, and Yangambi.

dependents (Table 2). It was found that, 71.52% of the respondents are men and 40.51% of the households were composed of 7 to 10 people. The level of education in this region is low, 34% of our respondents had stopped studying at the primary level and 30% at the higher secondary level while 22% had not attended school.

In order to identify shortcomings in the management plans implemented in the YBR and the specific characteristics of the environment, mapping tools were used (QGIS 3.4). Old topographical maps on the YBR boundaries since its creation were digitized (1939, 1950 and 1976) and the shapefile was downloaded for the most recent boundaries (2007) from the site of the *Congolese Institute for the Conservation of Nature* (ICCN) provided by the World Resources Institute (WRI). The vector layers of roads and waterways, downloaded free of charge on the *Référentiel Géographique Commun* (RGC) website, were used as the base map for the digitalization process. These data made it possible to analyse the consequences of the reserve boundary variations on access to and utilization of resources and the impact on the YBR governance efficiency.

RESULTS

Use of farmland in the Yangambi Biosphere Reserve

In the Yangambi region, agriculture is highly valued as a source of revenue, accounting for 78.5% ($N = 158$) of the household activities in the survey. Hunting and fishing were practiced by 9.5% and 7.6% of the respondents, respectively, while the employees represent only 1.9% of the sample.

However, agriculture is not their only source of income; it is combined with hunting, fishing, collection of non-wood forest products (PFNL), and some also practice charcoal burning and artisanal logging.

One individual opens 2 fields per crop year, with an average area of 0.88 ha. At the end of the crop year, the field is left fallow for an average of 5 years. Since cassava products are the staple food in the Yangambi region, this crop is the most widely grown. For economic reasons, they combine rice, plantain, beans and yam with this main crop. Several reasons were cited to explain the distance away from home of fields (Figure 2), and in order to carry out major agricultural operations such as ploughing, sowing and harvesting, 64% of the households surveyed set up seasonal camps next to their fields because of this distance.

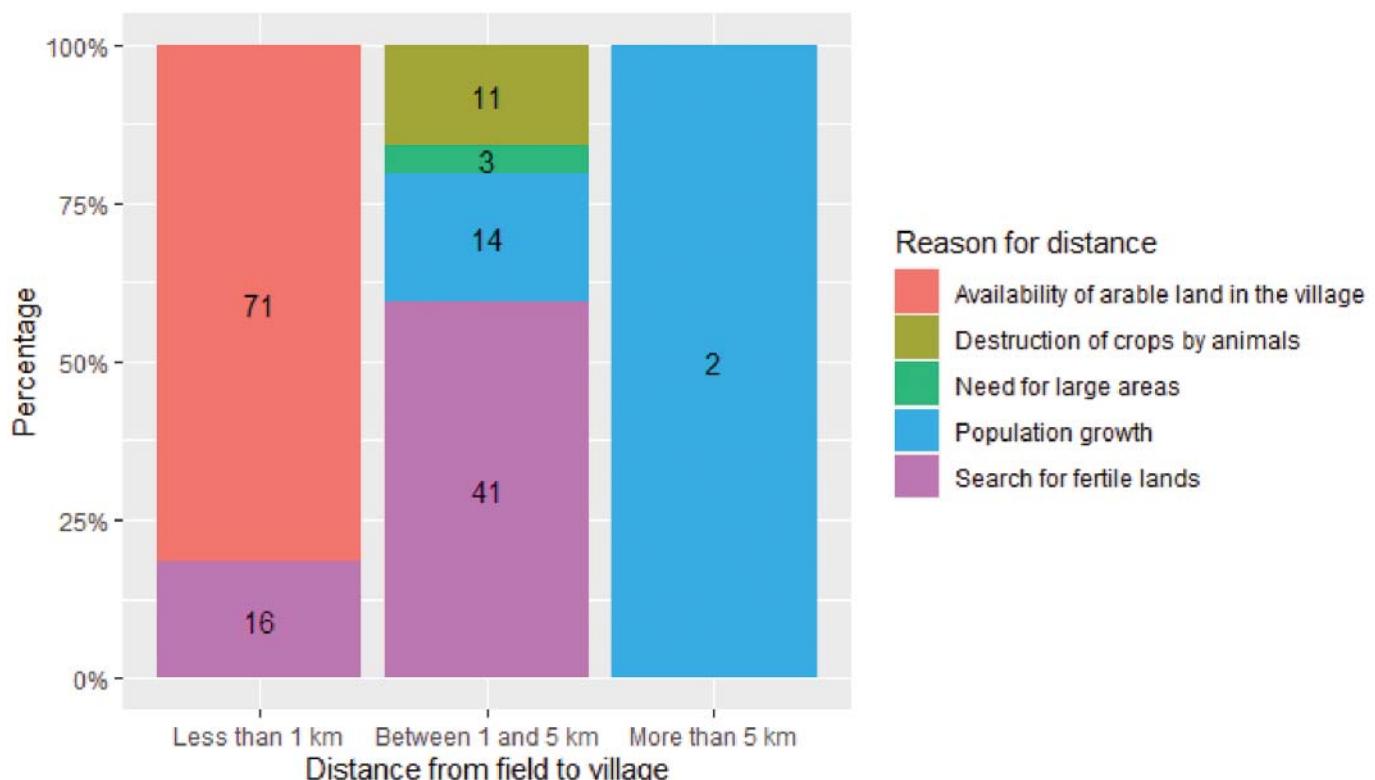
Some 45% of the survey respondents have a field located between 1 and 5 kilometers from their village due to the unavailability of fertile land near the villages. The search for arable lands around the villages led to the occupation of land on the reserve by the local community, with the MAB programme recording 37 settlements within the reserve in 2017.

Since the YBR is in a conservation zone, logging is not permitted. The few people who engage in logging do so in a clandestine and artisanal way. With regard to mining, no active quarries were found in the Yangambi landscape, but rather traces of old gold panning areas that were more than 15 years old. When asked about the reasons for their intrusion into the reserve, our interviewees revealed that the lack of clearly defined boundaries of the YBR and the lack of employment in the Yangambi area were the main reasons for them to continue their activities in the reserve.

TABLE 2 Characterization of the head of household surveyed in the villages of the Yangambi

Characteristic	Category	Number of Respondents	Proportion of Respondents
Ethnic group	Turumbu	109	68.99
	Bamanga	35	22.15
	Others	14	8.86
Head of household type	Male	113	71.52
	Female	45	28.48
Age range	Under 25 years old	7	4.43
	25 to 40 years old	93	58.86
	41 to 60 years old	42	26.58
	More than 60 years old	16	10.13
Level of education	Without instruction	22	13.92
	Primary level	57	36.08
	Secondary level	31	19.62
	higher secondary level	48	30.38
Seniority	Less than 5 years old	27	17.09
	5 to 15 years	21	13.29
	16 to 30 years old	6	3.80
	Since birth	104	65.82
Size of household	Less than 4 people	19	12.02
	4 to 6 people	61	38.61
	7 to 10 people	64	40.51
	More than 10 people	14	8.86

FIGURE 2 Distance between fields and living areas in the Yangambi Landscape. For each of the « distance option », number of respondents mentioning the « main reason » are quoted in the figure



Variations in the Yangambi Biosphere Reserve boundaries

Created in 1939 and delineated in 1950, the YBR has seen its limits change over time according to the manager's objectives at the time. Each of these managers used a management plan with a map of the reserve to enable the eco-guards to monitor it. This variation in boundaries is shown in Figure 3.

The variation in the shape of the reserve caused confusion about the total area of the reserve. At its creation in 1939, the YBR covered 225 000 ha (Figure 3.A). By 1950, with the allocation of indigenous land to the local communities living in the reserve, 239 524 ha were delineated as a reserve, of which 235 224 ha were in the conservation area and 4 300 ha in the enclaves (Figure 3.B). This area was revised downwards when the Congolese government (formerly Zaire) requested that the Yangambi Floristic Reserve be included in the UNESCO Biosphere Reserve Network by adopting a zoning based exclusively on the floristic inventory carried out in the Yangambi region during the colonial period, with a total area of 178 800 ha, of which 141 250 ha were occupied by the transition zone and 37 550 ha by the core zone (Figure 3.C). Finally, in 2007, ICCN retained a zoning of the YBR with no subdivision of zones which are typically recommended for

any biosphere reserve by UNESCO, with a surface area of 223 284 ha and for which no description of its implementation was revealed (Figure 3.D).

Impact of changing the boundaries of the YBR on conservation and local development

The boundaries of the YBR used by MEDD and MAB, although existing on paper, were not clarified on the ground and local people communities were no longer able to segregate between the area devoted to their livelihood activities and the one allotted to conservation. As such, some of villages once located outside the reserve were by then included within its boundaries (Figure 4).

Our results revealed that the MAB national committee, considered to be the police of the YBR, uses the model of the boundaries that were delineated in 1950 (figure 3.B) while the MEDD and its partners (IUCN, WCF, and CTB) uses the ICCN boundaries (figure 3.D). This lack of consistency regarding the definition of the boundaries used by officials is a cause of conflict between the managers and local communities. On the one hand, the communities are exploiting the space without identifying the forbidden zone, while on the

FIGURE 3 Variation in the boundaries of the YBR over time. (Figure 3.A. shows the boundaries of the YBR at its creation in 1939 while figure 3.B. shows the boundaries as delineated in 1950 by INEAC. Figure 3.C. shows the zoning carried out in 1976 while figure 3.D shows the boundaries selected for the YBR by ICCN in 2007)

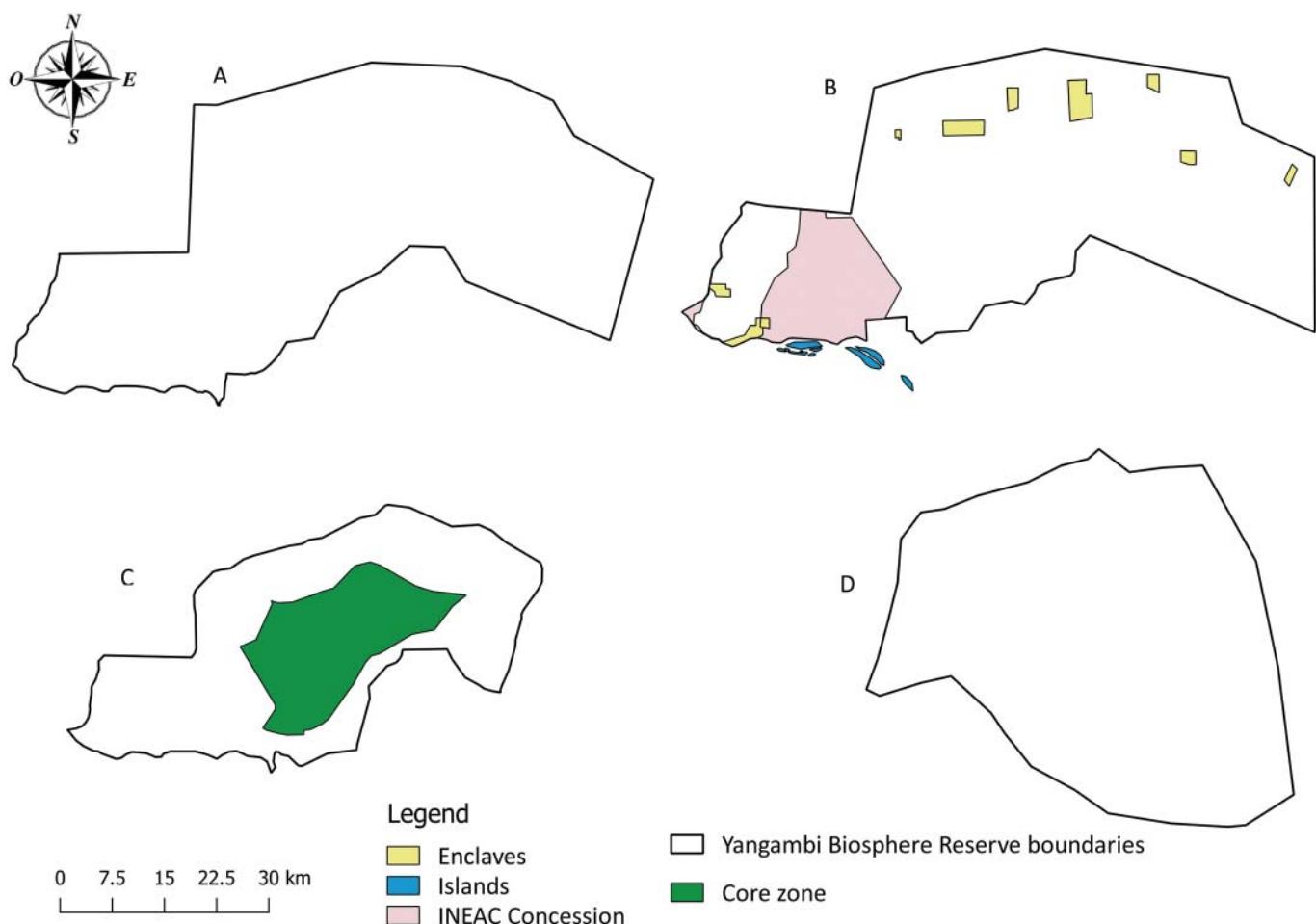
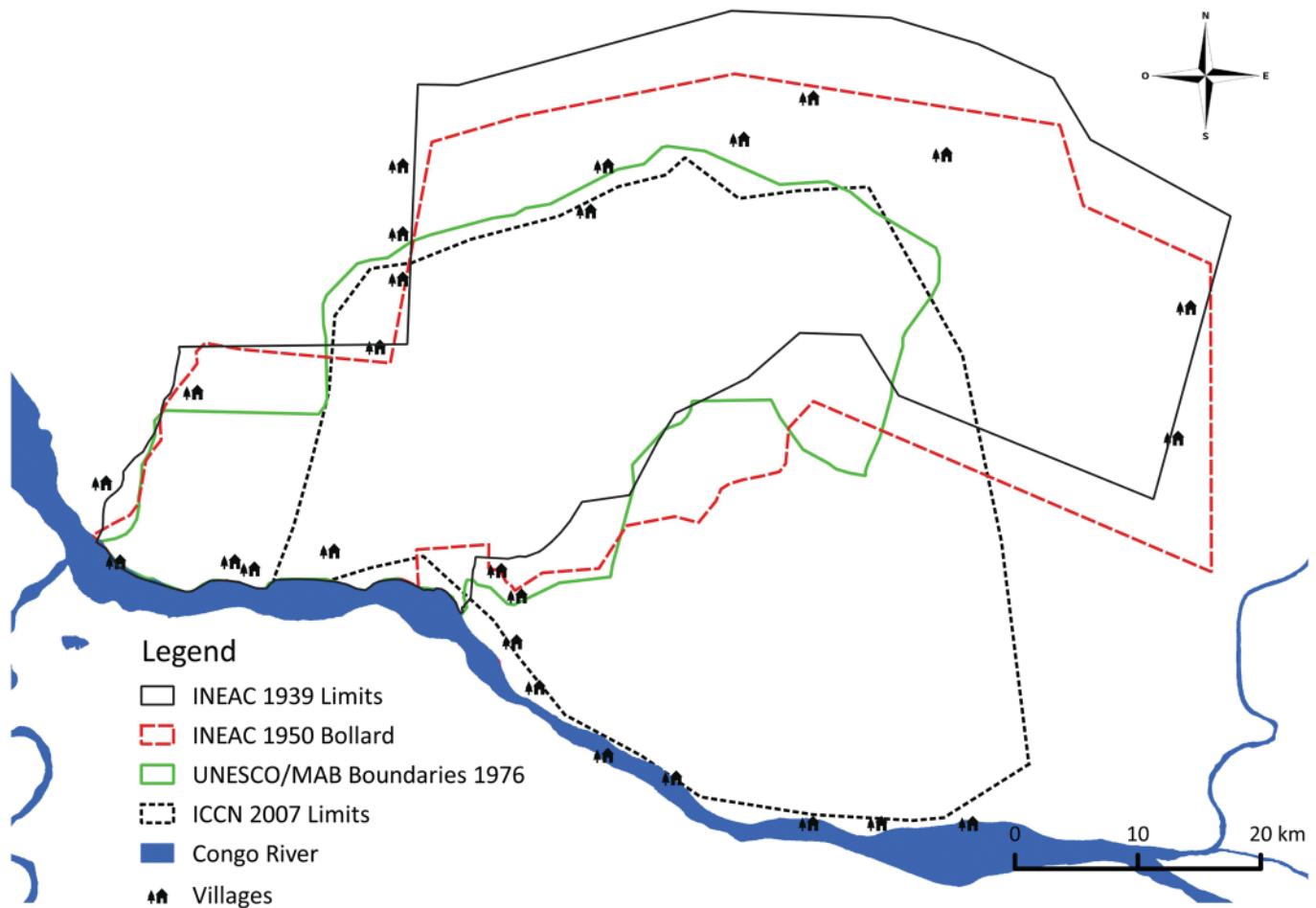


FIGURE 4 An overview of the different official boundaries used for the Yangambi Biosphere Reserve from 1939 to present



other hand, the eco-guards are patrolling the area without being clear where the boundaries are for the zone allocated to the communities for village exploitation.

Community involvement in changing the boundaries of the YBR

At the creation of the reserve, the boundaries were determined based on the floristic, ecological, and phytosociological importance of the Yangambi region, but also with a view to integrating the forest areas that were still intact. Hence the administration's refusal to establish the boundaries to the north of the YBR on the grounds that "*it is desirable that the northern boundary be pushed back to the left bank of the Aruwimi, so as to increase our reserve of beautiful forests which are absolutely intact and of great scientific and biogeographical interest*" (INEAC 1941). These comments on the delimitation and extension of the boundaries of the YBR reveal the authoritarian character of the management regime that characterized the colonial era by excluding local communities at the creation of protected areas.

This exclusionary approach continued into the post-colonial period. While the floristic reserve had to be included in the network of biosphere reserves, the zoning produced in 1976 was the sole prerogative of the MEDD and the University of Zaire. The same is true for the boundaries

adopted by ICCN in 2007 (Figure 3.D); the local communities were not involved in any discussions. This exclusion led to the non-appropriation of the conservation objectives by the local population in the Yangambi region.

DISCUSSION

Use of farmland in Yangambi Biosphere Reserve

Agriculture is the main activity undertaken by the local communities in the Yangambi region (UNESCO 2010, Kyale *et al.* 2019b) but, unfortunately, it remains rudimentary, practiced without inputs such as improved seeds and bio-fertilizers that increase crop yields. The average duration of fallow, estimated at five years, is much lower than the 15–20 years once observed in the same area during the colonial period (Staner 1955). This type of agriculture is described as slash-burn agriculture by Barrau (1971), as it consists of clearing agricultural land in a forested area by fire without observing a long fallow period. The disadvantage of this practice is that it stops soil restoration and recolonization of the space by the forest (Dounias 2000, Bahuchet and Betsch 2012). The reduction of soil fertilization around the YBR is at the main reason for the current agricultural practices and the opening of new plots located between 1 and 5 km from their villages.

This remoteness of the fields has led to an increase in work effort and, conversely, a decrease in overall agricultural productivity, thus amplifying poverty in the area. Also, it encourages the intrusion of local populations into the conservation areas, thus increasing the pressure on the reserve's resources. The situation was different in the colonial period, when fields were set up near villages, which enabled the administrative authorities to control the pressure on the Yangambi floristic reserve (Staner 1955).

In addition, population growth in the Yangambi region is among the factors that have led to land degradation around the villages and reduced fallow periods. According to the census conducted by the National Institute of Statistics in 1984, the Yangambi region had 90 643 people (INS 1992). In 2015, census data collected at the Turumbu and Bamanga sectors by Kyale *et al.* (2019b) gave a total population of 226 931 people. Unfortunately, the various zoning schemes used to manage the YBR do not take this population growth into account when defining village farming areas in spite of the increased need for arable land. This constrains the population to remain in small areas resulting in over-exploitation of agricultural land and, as such is a major cause of arable land degradation in agroforestry areas (Colchester 1996, Dounias 2000), and the fragmentation of forest landscapes in the Congo Basin as observed by Bamba (2010) in the Kisangani region; Alongo *et al.* (2013), and Kyale *et al.* (2019b) in the YBR and by Nackoney *et al.* (2013) in the Maringa-Lopori-Wamba Landscape (MLW). Because it is recognized that the education level of inhabitant significantly influences their perception of environmental disturbances (Giliba *et al.* 2011), this overexploitation could be exacerbated in the Yangambi region where levels of education amongst local communities are relatively low. Only 30.4% of respondents have an upper secondary level of education, while 13.9% of respondents have not attended school at all.

Variation in the Yangambi Biosphere Reserve boundaries

By instituting a zone-based approach to natural resource management, UNESCO hoped to develop a harmonious coexistence between local communities and the ecosystems on which they depend (Batisse 1997). This approach implied that scientists, conservation and development actors, managers and local communities would work together to reconcile conservation and sustainable use of natural resources (UNESCO 1996). However, although in some cases this approach has contributed to reducing the loss of forest cover, such as in the Bhutan region (Bruggeman *et al.* 2018), its effectiveness in promoting conservation and local development has not been proven in other cases (Portman 2007, Hull *et al.* 2011, Xu *et al.* 2016). Behind these mixed results, is a poor zoning design, marked by low participation of local communities, as well implementation that did not take socio-cultural preferences into account (West and Brockington 2006, Kilensele 2015). It can be argued that this weak involvement of local communities in the design and implementation of zoning is at the root of contestation for most protected areas around the world. This situation can be manifested by the recurrence of

practices that are not compatible with conservation objectives, such as the use of bombs for fishing in Wakatobi National Park in Indonesia (Pimbert and Pretty 1995), and the mass capture of African Lions (*Panthera leo*) by the Maasaï people in southern Kenya (Hazzah *et al.* 2009). In the YBR, the population engages in vandalism by attacking project activities and deforesting large areas to sabotage conservation efforts, situations which could have been avoided through consultation with local populations in the planning process.

The case of the YBR is a striking example of the need to consider social dynamics in the development of a protected area zoning system. The first zoning of the YBR was carried out in 1939, in the context of a low population density and based solely on forest prospecting (INEAC 1937, 1941). However, now, with the high population growth in the region, the YBR should be subjected to an evaluation of its governance as recommended by UNESCO through the Seville Strategy, which would lead to a redefinition of the objectives in the conservation policy in order to enable the reserve to play its role in the conservation of natural and cultural biodiversity (UNESCO 1996). Unfortunately for the YBR, without an evaluation of its governance, nor involvement of the local communities in the definition of the priority axes of conservation and local development, the boundaries of the reserve have changed over time, leading to a blurring of the conservation zone and the zone reserved for communities for village exploitation as recognised by the Congolese State (Loi N°011/2002 du 29 aout 2002).

Impact of changing the boundaries of the YBR on conservation and local development

The variation in the boundaries of the YBR places the local population, and the eco-guards, in a situation of confusion and thus encourages activities that are incompatible with conservation within the reserve. The local population, not knowing where they are permitted to go, find themselves carrying out their activities in the central part of the YBR despite the non-adaptation of their practices to conservation objectives. The eco-guards, without being clear on the location of the boundaries of the different zones of the reserve, start to repress the communities, sometimes even on land that is not part of the reserve. Management by trial and error on the boundaries of the conservation and village exploitation zones is at the root of the strong tensions, and even confrontations between local communities and managers, including the eco-guards, INERA workers and those from the Ministry of the Environment.

Faced with this lack of clarity of reserve boundaries and the absence of alternative activities proposed by the manager, the local communities have ended up implementing strategies such as setting up permanent camps in areas of the reserve that are not easily accessible in order to escape the surveillance of eco-guards and carrying out the night-time evacuation of field or hunting products across the rivers, as well as collaboration with political and administrative authorities to influence access and use the resources of the reserve.

For his part, the Manager reported that he deplores the lack of financial means and adequate equipment to carry out surveillance patrols. He admitted that the insufficient number of eco-guards to ensure complete surveillance of the reserve would favour incursions of the population into the integral protection zone. According to Ahrends *et al.* (2011) and Waldron *et al.* (2013), funding conservation projects can reduce the loss of natural resources and avoid a new wave of biodiversity extinctions. In the case of the YBR, it is a possibility that the precarious living conditions of the eco-guards could predispose them to corruption by operators and consequently lead to the loss of the YBR's natural resources. Therefore, the empowerment of MAB agents and the implementation of an integrated development program could reduce negative effects on conservation. It is within this framework that the *dina* (social norms) has enabled concerted governance, and hence sustainable management of natural resources in Madagascar (Andriamalala *et al.* 2013).

Community involvement in changing the boundaries of the YBR

It appears that since the creation of the YBR, and even when its boundaries changed, the involvement of the population was purely symbolic (Kyale *et al.* 2019a). To address this shortcoming and to consider participatory management, several international conservation agencies, including WWF and IUCN, have been conducting talks with various stakeholders working in the reserve.

These meetings led to the creation in 2011 by the IUCN of a local development committee, the elaboration of local development plans and the construction of schools and health facilities. These structures contributed to an improvement in the fragile relations between the managers and the local populations, following previous cases of conflict, which led to the death of a member of the Turumbu community (Kyale *et al.* 2019a). However, with the end of the WWF project in 2016, these structures ceased to function due to a lack of operating costs, thus rekindling tensions between managers and local communities. Because of this conflictual relationship, the local communities were said to have nicknamed the agents of the MAB service “*agent mabé*”, a word that means “bad agent” in Lingala language.

The symbolic participation of local communities in environmental management, characteristic of neo-colonialist management (Joiris *et al.* 2014, Ferdinand 2019), contributes to the failure of conservation projects in protected areas. Populations are simply consulted and informed about project actions without being involved in the decision-making process (Pimbert and Pretty 1995, Brockington and Schmidt-Soltau 2004, Eneji *et al.* 2009, Joiris *et al.* 2014, Kilensele 2015, Samndong 2018, Kyale *et al.* 2019a). Moreover, even when they participate, populations are frequently disappointed by the managers' failure to respect the agreements (Colchester 1996, Birner and Mappatoba 2003, Reed 2008), which very often leads to the local population not taking ownership of the conservation objectives. This is the case for most of the projects undertaken in the YBR.

In short, a succession of poor management systems, that are characteristic of both pre- and post-colonial conservation management regimes around the world, and which are common in the Yangambi landscape, has created a situation on the ground that is creating tension because it is confusing, and does not appear to take account of local people's wishes.

CONCLUSION

Management policies adopted to manage the YBR have not led to the sustainable conservation of natural resources and have maintained conflictual situations between the manager and the local communities. The lack of clarity about the boundaries of the YBR and on the space reserved for village exploitation, and the absence of measures to compensate for land losses by local populations, are at the root of clashes between the local community and the managers of the reserve. In addition, the population growth observed in the region and unsound farming practices as well as the restrictions on access to resources imposed by non-participatory zoning have significantly contributed to the over-exploitation of natural resources in the villages, leading communities to enter the conservation zone in order to meet their subsistence needs.

For effective management of the YBR, it is necessary to conduct a participatory diagnosis in order to identify the different areas of village exploitation, social norms, and local practices related to conservation, such as the prohibition of killing specific fauna and flora species in the Bamanga and Turumbu, which should be integrated into the management plan. In addition, the government of the DRC should become more involved, as well as international conservation organizations, to propose a zoning system that will consider not only the representativeness of ecosystems and resources, but above all, integrate existing socio-cultural practices. This should involve traditional dignitaries in the planning, which will enable the local communities concerned to take ownership of the conservation objectives.

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REFERENCES

- AHRENDS, A., BURGESS, N.D., GEREAU, R.E., MARCHANT, R., BULLING, M.T., LOVETT, J.C., PLATTS, P.J., KINDEMBA, W.V., OWEN, N., FANNING, E., and RAHBEK, C. 2011. Funding begets biodiversity. *Diversity and Distribution* **17**: 191–200.
- ANDRIAMALALA, G., PEABODY, S., GARDNER, C., and WESTERMAN, K. 2013. Using social marketing to foster sustainable behaviour in traditional fishing communities of southwest Madagascar. *Conservation Evidence* 37–41.
- AKTOUF, O. 1987. *Méthodologie des sciences sociales et approche qualitative des organisations. Une introduction à la démarche classique et une critique*. Les Presses De l'Université Du Québec. 213 pp.
- ALONGO, S., VISSER, M., DROUET, T., KOMBELE, F., COLINET, G., and BOGAERT, J. 2013. Effets de la fragmentation des forêts par l'agriculture itinérante sur la dégradation de quelques propriétés physiques d'un ferralsol échantillonné à Yangambi, R.D. Congo. *Tropiccatura* **31**: 36–43.
- ASRIYANI, H., and VERHEIJEN, B. 2020. Protecting the mba komodo in riung, flores: local adat, national conservation and ecotourism developments. *Forest And Society* **4**: 20–34.
- BAHUCHET, S., and BETSCH, J. 2012. L'agriculture itinérante sur brûlis, une menace sur la forêt tropicale humide? Savoirs et savoir-faire des amerindiens en Guyane Française. *Revue d'Ethnoécologie* 1–30.
- BAMBA, I. 2010. Anthropisation Et Dynamique Spatio-Temporelle De Paysages Forestiers En République Démocratique Du Congo. Thèse, Université Libre De Bruxelles (ULB). 205 pp.
- BARRAU, J. 1971. La culture itinérante, longtemps mal comprise et encore mal nommée! *Journal D'agriculture Tropicale Et De Botanique Appliquée* **18**: 100–103.
- BATISSE, M. 1997. Biosphere Reserves: A challenge for biodiversity conservation & regional development. *Environment: Science And Policy For Sustainable Development* **39**: 6–33.
- BERG, B.L. 2001. *Qualitative research methods for the social sciences*, 4th Ed. Allyn & Bacon 162 p.
- BIRNER, R., and MAPPATOBA, M. 2003. Community agreements for conservation-balancing community and conservation interests in the Lore Lindu National Park in Central Sulawesi, Indonesia. *Policy Matters* **12**: 254–263.
- BRUGGEMAN, D., MEYFROIDT, P., and LAMBIN, E.F. 2018. Impact of land-use zoning for forest protection and production on forest cover changes in Bhutan. *Applied Geography* **96**: 153–165.
- BULTOT, F. 1950. Carte des régions climatiques du Congo Belge établie d'après les critères de Köppen. INEAC, hors-série., 344 cartes, 11 figures et 35 tableaux.
- BUTSIC, V., BAUMANN, M., SHORTLAND, A., WALKER, S., and KUEMMERLE, T. 2015. conservation and conflict in the democratic republic of congo: the impacts of warfare, mining, and protected areas on deforestation. *Biological Conservation* **191**: 266–273.
- CLEMENT, F. 2010. Analysing decentralised natural resource governance: proposition for a « politicised » institutional analysis and development framework. *Policy Science* **43**: 129–156.
- COLCHESTER, M. 1996. Beyond “participation”: indigenous peoples, biological diversity conservation and protected area management. *Unasylva* 33–39.
- CROZIER, M., and FRIEDBERG, E. 1977. *L'acteurs et le système: les contraintes de l'action collective*. Du Seuil. Paris. 500 pp.
- DOUNIAS, E. 2000. La diversité des agricultures itinérantes sur brûlis. In: BAHUCHET, S., GRENAUD, F., GRENAUD, P., De MARET, P. (Eds) *Les peuples des forêts tropicales aujourd'hui*, Volume II. APFT – ULB, Bruxelles. 65–106 pp.
- EBA'A, R.A., and BAYOL, N. 2009. Les forêts de la République Démocratique Du Congo en 2008. In: De Wasseige C, Devers D, De Marken P, Et Al. (Eds) *Les forêts du bassin du Congo. Etat Des Forêts 2008*. Office De Publication De l'Union Européenne, Luxembourg. 115–128 pp.
- ENEJI, V.C.O., GUBO, Q., OKPILIYA, F.I., ANIAH, E.J., ENI, D.D., and AFANGIDE, D. 2009. Problems of public participation in biodiversity conservation: The nigerian scenario. *Impact Assessment and Project Appraisal* **27**: 301–307.
- ERNST, C., VERHEGGHEN, A., MAYAUX, P., HANSEN, M., and DEFOURNY, P. 2012. Cartographie du couvert forestier et des changements du couvert forestier en Afrique Centrale. In: *Les Forêts Du Bassin Du Congo Etat Des Forêts 2010*, 2nd Edn. COMIFAC, Yaoundé, Cameroun. 23–42 pp.
- FAO And UNEP. 2020. *The state of the world's forests 2020. forests, biodiversity and people*. FAO And UNEP, Rome. 197 pp.
- FERDINAND, M. 2019. *Une écologie décoloniale – penser l'écologie depuis le monde Caraïbe*. Seuil. Ed. Paris XIX. 464 pp.
- GILIBA, R.A., BOON, E.K., KAYOMBO, C.J., CHIRENJE, L.I., and MUSAMBA, E.B. 2011. The influence of socio-economic factors on deforestation: a case study of the bereku forest reserve in Tanzania. *Journal Of Biodiversity* **2**(1): 31–39.
- HANSEN, M.C., POTAPOV, P.V., MOORE, R., HANCHER, M., TURUBANOVA, S.A., TYUKAVINA, A., THAU, D., STEHMAN, S.V., GOETZ, S.J., LOVELAND, T.R., KPMMAREDDY, A., EGOROV, A., CHINI, L., JUSTICE, C.O., and TOWNSHEND, J.R.G. 2013. High-Resolution Global Maps Of 21st-Century Forest Cover Change. *Science* (80-.). 342, 850.
- HAZZAH, L., BORGERHOFF, M., and FRANK, L. 2009. Lions and warriors: social factors underlying declining african lion populations and the effect of incentive-based management in Kenya. *Biological Conservation* **14**: 2428–2437.
- HENRY, J. 1979. Les obstacles écologiques rencontrés lors des tentatives de rationalisation de l'agriculture traditionnelle des Turumbus. *African Economic History* 155–170.

- HULL, V., XU, W., LIU, W., ZHOU, S., VIÑA, A., ZHANG, J., TUANMU, M.N., HUANG, J., LINDERMANN, M., CHEN, X., HUANG, Y., OUYANG, Z., ZHANG, H., and LIU, J. 2011. Evaluating the efficacy of zoning designations for protected area management. *Biological Conservation* **144**: 3028–3037.
- IGOE, J., and BROCKINGTON, D. 2007. Neoliberal conservation: A brief introduction. *Conservation And Society* **5**: 432–449.
- INEAC. 1941. Rapport annuel pour l'exercice 1939. Gembloux (Belgique). 11–29 pp.
- INEAC. 1937. Rapport annuel pour l'exercice 1936. Gembloux (Belgique). 12–36 pp.
- INS. 1984. Zaïre. Recensement scientifique de la population - Juillet 1984-. Ministère Du Plan, Kinshasa, RDC 88 pp.
- ISHWARAN, N., and PERSIC, A. 2008. Concept and practice: The case of unesco biosphere reserves. *International Journal Environment And Sustainable Development* **7**: 118–131
- JOIRIS, D.V. 2004. Développement et conservation de la nature: L'apport des sciences humaines. *Tropicultura SPE*: 44–46.
- JOIRIS, D.V., BIGOMBE, L.P., and ABEGA, S.C.(†). 2014. La gestion participative des forêts en Afrique Centrale. Logique développementiste, gouvernance antiparticipative et stratégies d'acteurs. *Revue D'ethnoécologie* **6**: 23.
- KABULU, D.J., BAMABA, I., MUNYEMBA, K.F., DEFOURNY, P., VANCUTSEM, C., NYEMBWE, N.S., NGONGO, L.M., and BOGAERT, J. 2015. Analyse de la structure spatiale des forêts au Katanga. *Annales De La Faculté Des Sciences Agronomiques*, Université De Lubumbashi **1**: 1–12.
- KILENSELE, T.M. 2015. Limites des stratégies de conservation forestière en République Démocratique Du Congo – Cas de la Réserve De Luki. Thèse, Université Libre De Bruxelles. 300 pp.
- KOMBELE, F. 2004. Diagnostic de la fertilité des sols dans la cuvette centrale Congolaise. Cas des séries Yangambi et Yakonde. Thèse, Université de Liège. 464 pp.
- KYALE, J.K., MAINDO, A.M.N., and WARDELL, D.A. 2019a. Moving beyond the illusion of participation in the governance of yangambi biosphere reserve (Tshopo Province, Democratic Republic Of Congo). *Nature Conservation* **33**: 33–54.
- KYALE, J.K., WARDELL, D.A., MIKWA, J-F.N., KABUANGA, J.M., MAINDO, A.M.N., OSZWALD, J., and DOUMENGE, C. 2019b. Dynamique de la déforestation dans la réserve de biosphère de Yangambi (République Démocratique Du Congo): Variabilité spatiale et temporelle au cours des 30 dernières années. *Bois Et Forêts Des Tropiques* **341**: 15–28.
- Loi N°011/2002 du 29 aout 2002. Code forestier. République Démocratique du Congo, Journal officiel, 102 pp.
- Loi N° 14/003 Du 11 Février 2014. Relative A La Conservation De La Nature. République Démocratique du Congo, Journal Officiel, 38 p.
- MAYAUX, P., DESCLE, B., CLERICI, M., BODART, C., LUPI, A., BRINK, A., NASI, R., and BELWARD, A. 2013. State and evolution of the african rainforests between 1990 and 2010. *Philosophical Transactions Of The Royal Society B: Biological Sciences* **368**: 10.
- NACKONEY, J., RYBOCK, D., DUPAIN, J., and FACHEUX, C. 2013. Coupling participatory mapping and gis to inform village-level agricultural zoning in the Democratic Republic Of The Congo. *Landscape And Urban Planning* **110**: 164–174.
- NYANGE, N.M. 2014. Participation des communautés locales et gestion durable des forêts: Cas de la réserve de la biosphère de Luki en République Démocratique Du Congo. Thèse, Université Laval Québec, Canada et Université De Kinshasa, RDC. 227 pp.
- PELISSIER, C., De MARCKEN, P., MAPILANGA, J.-J.T., and WILUNGULA, C.B. 2015. République Démocratique Du Congo, In: *Aires Protégées d'Afrique Centrale. Etat 2015*. OFAC-COMIFAC & RAPAC, Kinshasa, République Démocratique Du Congo Et Yaoundé, Cameroun, P. 112–148.
- PIMBERT, M.P., and PRETTY, J.N. 1995. Parks, People And Professionals: Putting 'Participation' Into Protected-Area Management. *Geneva* **16**(57): 297–330.
- PORTMAN, M.E. 2007. Zoning Design for cross-border marine protected areas: the Red sea marine peace park case study. *Ocean And Coastal Management* **50**: 499–522.
- REED, M.S. 2008. Stakeholder Participation for environmental management: a literature review. *Biological Conservation* **141**(10): 2417–2431.
- SAMNDONG, R.A. 2018. The Participation illusion: questioning community participation in a REDD+ pilot project in the Democratic Republic Of Congo. *International Forestry Review* **20**: 390–404.
- SCHURE, J., and LWANGA, K.M. 2018. Rapport diagnostic de la filière bois Energie de La réserve biosphère de Yangambi. 62 pp.
- SEMEKI, N.J., LINCHANT, J., QUEVAUVILLERS, S., KAHINDO, J-M.M., LEJEUNE, P., and VERMEULEN, C. 2016. Cartographie de la dynamique de terroirs villageois à l'aide d'un Drone dans les Aires protégées de la République Démocratique Du Congo. *Bois Et Forêts Des Tropiques* **330**: 69–83.
- STANER, P. 1955. Les paysannats indigènes du Congo Belge et du Ruanda-Urundi. *Bulletin Agricole Du Congo Belge* **XLVI**: 468–550.
- STIEM, L., and KRAUSE, T. 2016. Exploring the impact of social norms and, perceptions on women's participation in customary forest and land governance in the Democratic Republic Of Congo – Implications for REDD+. *The International Forestry Review* **18**: 110–122.
- STONE, C.D. 1996. La Convention De Rio De 1992 Sur La Diversité Biologique 118–134 pp.
- IUCN/PACO. 2010. Parcs et réserves de la République Démocratique Du Congo: Evaluation de l'efficacité de gestion des aires protégées, BF. Ed. IUCN, Gland, Suisse, 149 pp.
- IUCN. 1976. Compte rendu de la 12^{ème} assemblée générale Kinshasa, Zaïre 8–18 Septembre 1975. Morges, Suisse, 293 pp.

- UNESCO. 2010. Réserves de biosphère: des lieux pour le développement durable, 2010. UNESCO. 597 pp.
- UNESCO. 1996. Réserves de biosphère. La stratégie de Séville & le cadre statutaire du réseau mondial. Paris. 20 pp.
- VAN VLIET, N., MUHINDO, J. and NYUMU, J.K. 2017. Diagnostic Des Filières Viande De Brousse/Poisson/Chénilles A Yangambi. Rapport, 86 pp.
- WALDRON, A., MOOERS, A.O., MILLER, D.C., NIBBELINK, N., REDDING, D., KUHN, T.S., ROBERTS, J.T., and GITTELMAN, J.L. 2013. Targeting global conservation funding to limit immediate biodiversity declines. *Proceedings of the National Academy of Sciences of the United States of America* **110**: 12144–12148.
- WEST, P., and BROCKINGTON D. 2006. An anthropological perspective on some unexpected consequences of protected areas. *Conservation Biology* **20**: 609–616.
- XU, W., LI, X., PIMM, S.L., HULL, V., ZHANG, J., ZHANG, L., XIAO, Y., ZHENG, H., and OUYANG, Z. 2016. the effectiveness of the zoning of china's protected areas. *Biological Conservation* **204**: 231–236.