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Ecosystem services from mountain forests: Local communities' views in Kibira National Park, Burundi

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ABSTRACT

In the tropics, mountain forests provide numerous benefits to surrounding communities. Our participatory research investigates how different ethnic groups including Twa hunter gatherers and farmers of Bantu origin use and value mountain forests in Kibira National Park, Burundi. We carried out an ecosystem service (ES) assessment through 25 focus-group discussions, including Twa (n = 10) and farmers (n = 15). The Twa identify a greater number of forest ES than farmers, and rank wild vegetables as most important forest ES. They also show strong place dependence and identity to the forest, which they call 'home'. Farmers rank microclimate regulation as most important forest ES, and also show place dependence to the forest. Both groups identified numerous plants for provisioning services, but the Twa identified more food-provisioning plants and medicinal plants for humans. Our findings help understand why the Twa continue to enter this park daily. Our results also help suggest some livelihood strategies for the Twa which consider their strengths rather than their weaknesses. Protected areas are the most important tool we have for species' and habitats' conservation, but to ensure their effectiveness -and sustainability- surrounding communities' needs and cultures should be considered.

1. Introduction

The concept of ecosystem services (ES), defined as the ecological characteristics, functions, or processes that directly or indirectly contribute to human wellbeing (Costanzaet al., 2017; MEA, 2005), has become widely used to inform policy makers and land managers of the links between ecosystem functions and human wellbeing (Fisher et al., 2009). There is an increasing recognition of the importance of including socio-cultural evaluation criteria on the assessment of ES (Scholte et al., 2015), particularly, for conservation projects to be successful (Kari and Korhonen-Kurki, 2013; Kovács et al., 2015; Bidegain et al., 2019). Socio-cultural ES evaluation uses research methods from the social sciences (e.g., interviews), valorizes ES in non-monetary terms (e.g., perceptions), and explicitly makes stakeholders the focal point of the research (Orenstein and Groner, 2014). Socio-cultural ES evaluation enables the identification of differences in perceptions of ES among stakeholder groups (e.g. Iniesta-Arandia et al. (2014), Bidegain et al. (2019)), which is particularly relevant in areas where local populations have different livelihood strategies (Lakerveld et al., 2015; Cuni-Sanchez et al., 2019ab).

Socio-cultural ES evaluation can complement and increase the value of traditional economic and ecological ES evaluation approaches, as it helps identify cultural ES (Orenstein and Groner, 2014) and understand local communities 'place attachment' (Cundill et al., 2017).

Place attachment can be defined as the bond between people and a specific place (Altman and Low, 1992; Williams et al., 1992) and can be divided into two components: place identity and place dependence (Raymond et al., 2010). Place identity relates to cultural practices such as certain ceremonies, social cohesion and responsibility, the sense of 'home' for a claimed land, and the link of claimed land to family history and individual identity (Cundill et al., 2017). Place dependence is associated with the opportunities that the 'attached' place provides to meet human needs, including food security, physical security and other aspects of material wellbeing. Local populations with different livelihood strategies may show important differences in their place attachment with ecosystems (e.g. forests, Cuni-Sanchez et al., 2019b).

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Contrary to ES assessments, the use of socio-cultural approaches to wild plant utilisation (ethnobotany, ethnomedicine) is widespread (e.g. Assogbadjo et al. (2012), Sop et al. (2012)) and it is increasingly used in the field of wild animal utilisation (e.g. Batumike et al. (2020). Determining patterns of wild plant or animal utilisation can complement ES assessments, as it can help identify potential alternative livelihood strategies for communities living near protected areas (Cuni-Sanchez et al., 2016, 2019b).

The mountains of the Albertine Rift in Africa, part of a biodiversity hotspot, are known for their exceptional biodiversity: about 7,500 plant and animal species have been recorded, over 1,000 of which are endemic (Myers et al., 2000; Plumptre et al., 2007). The forests in these mountains provide a wide range of ES from local to global scales: water, timber and non-timber forest products, erosion control, hazard protection, climate modulation and carbon sequestration (Alweny et al., 2014). Despite the existence of numerous protected areas, their success in conserving mountain forests has been limited, particularly in Burundi (Pfeifer et al., 2012).

The mountain forests of Kibira National Park (NP) in Burundi support important populations of endangered species such as the eastern chimpanzee (*Pan troglodytes schweinfurthii*) and the Rwenzori colobus (*Colobus angolensis ruwenzorii*) (Plumptre et al., 2003; 2007). This park also provides two thirds of the water for Burundi's largest dam, which generates half of the country's hydroelectric energy (Ntahuga, 2014). To date, engagement of local populations in the management of Burundi's protected areas has been limited. To design effective protected area interventions that also prevent harm and promote the wellbeing of local populations, it is important to consider local populations' needs and perspectives (Martin et al., 2016). To our knowledge, no study has used socio-cultural ES evaluation approaches in Burundi.

In order to inform the management plan of Kibira NP, and contribute towards the identification of current and alternative livelihood strategies for forest edge communities of this and other parks in Burundi, our objectives were: (i) to investigate which forest ES are identified and prioritized by local communities, and if these differ according to livelihood strategies; (ii) to assess if different ethnic groups have different place dependence or place identity with the forest, (iii) to determine if different ethnic groups select different forest species for provisioning ES, and (iv) if plant species of conservation concern are being used by local communities. Considering hunter-gatherer perceptions elsewhere in Africa (Carson et al., 2018; Cuni-Sanchez et al., 2019b), we hypothesized that in our study area: (i) hunter-gatherers would identify a greater number of forest ES than farmer groups, (ii) they would place higher value on forest food products, (iii) they would show greater place identity and place dependence with the forest, and (iv) they would recognize more forest species for provisioning services.

2. Materials and methods

2.1. Study area

Kibira NP (40,000 ha) is contiguous with Nyungwe forest in Rwanda, and together they form a mountain forest block of 130,000 ha (Birdlife International, 2020). Altitude ranges from 1600 to 2666 m (Arbonier, 1996) and annual rainfall between 1700 and 2000 mm yr^{-1} (IUCN, 2011). Fog is a common feature at high altitudes. The forest is dominated by *Entandrophragma excelsum*, *Parinari excelsa, Polyscias fulva, Macaranga kilimandscharica, Syzygium parvifolium* and at higher altitudes by *Hagenia abyssinica* and African bamboo (*Sinarundinaria alpina*) (Lewalle, 1972; Nzigidahera, 2006).

Created as a hunting reserve for the kings of Burundi, this park became a forest reserve in 1933, and logging was allowed. In 1980, it became a national park; logging stopped and human inhabitation in the park was prohibited. Communities living inside, mainly Twa hunter-gatherers, were evicted without compensation (Amani, 2009). Deforestation and forest degradation occurred during the civil war (1993–2005) and continued afterwards (Plumptre et al., 2003; Pfeifer et al., 2012). Currently, access to the park is restricted, no hunting or plant collection is allowed, people caught illegally inside the park risk imprisonment. However, in the Rwegura sector of the park people can buy a permit to harvest dead bamboo or trees. Tourism is limited in Kibira NP and Burundi in general, due to past insecurity and ongoing relative instability. There is coltan and gold inside the park, and although not widespread, artisanal mining takes place (Roca and Carillo, 2016). During dry El Niño years, fires have burned important parts of the park (Plumptre et al., 2003).

Local communities living next to this park are of three major ethnic groups: Twa (hunter-gatherers of Pygmy origin), Tutsi and Hutu (both farmers of Bantu origin). Here we will use livelihood strategy to refer to the main activity used to provide food, shelter and income for a given household, which, in our study area, is related to people's identity and culture. Livelihood strategy not only involves making a living, it also means making it meaningful (Bebbington 2000), meaning that there is a moral or cultural dimension to livelihood choice as well as a material dimension. Most famers (Tutsi or Hutu) rely on rain-fed agriculture (maize, beans, wheat, potatoes) in a small parcel of land (usually $<$ 2 ha). Some farmers also have 1–2 cows, which they have to keep in zero-grazing within their land, following a law enacted in 2018. Twa are the poorest members of the Burundian society: they are landless, they rarely own domestic animals, and they have limited access to education, healthcare, microfinance or training opportunities (park staff, personal communication, August 2019). Their main sources of money for food are selling pottery (which involves illegally collecting clay from inside the park), selling bamboo or firewood (also involving illegally entering the park) or labour jobs. Twa have no money to buy a permit to harvest dead bamboo or trees. Clay pots are used to cook traditional dishes in Burundi, and are sold in local markets or/and to farmer neighbours. Twa tend to marry at a young age and have more children than farmers (park staff, personal communication, August 2019).

2.2. Data collection

We held focus-group discussions (FGDs, as described in Morgan et al., 1998) in 25 permanent villages located within 5 km from the park edge. These were located in three sectors of the park: Rwegura, Musigati and Teza (Fig. 1), and were carried out in August-September 2019. We could not visit the fourth sector of the park due to time constraints. We selected Twa villages (n = 10) and farmer villages (n = 15, it encompasses Tutsi and Hutu villages). When Twa were evicted from the forest, they moved to existing farmers' villages, therefore, most villages are close nearby (see Fig. 1). While for the Twa, the number of villages sampled represents the majority of the Twa villages found around these three sectors of the park, for the farmers they only represent about 10% of the villages. We selected farmer villages located close to the Twa villages, due to time constraints.

First, we obtained permission from local authorities in each village to carry out this research. We then asked for some elders to volunteer to participate in this study. Each FGD involved 5–10 elders, including both men and women (i.e. elder women talk freely in front of males). We selected elders as in our study area these are known to have greater botanical knowledge. All FGDs were facilitated by the first author and were done in Kirundi as all people (Twa and farmers) in the country speak the same language.

FGD participants were first informed that the aim of the study was to better understand the importance of the forest inside the park for local communities. Secondly, informal discussions centered on assessing the importance of the forest, including listing all material and non-material benefits (open question, no limit of benefits to be cited). Thirdly, they were asked to identify and rank the three most important benefits for them as a group stating the reasons behind their choices. Fourthly, if respondents had cited identity as a forest ES, it was

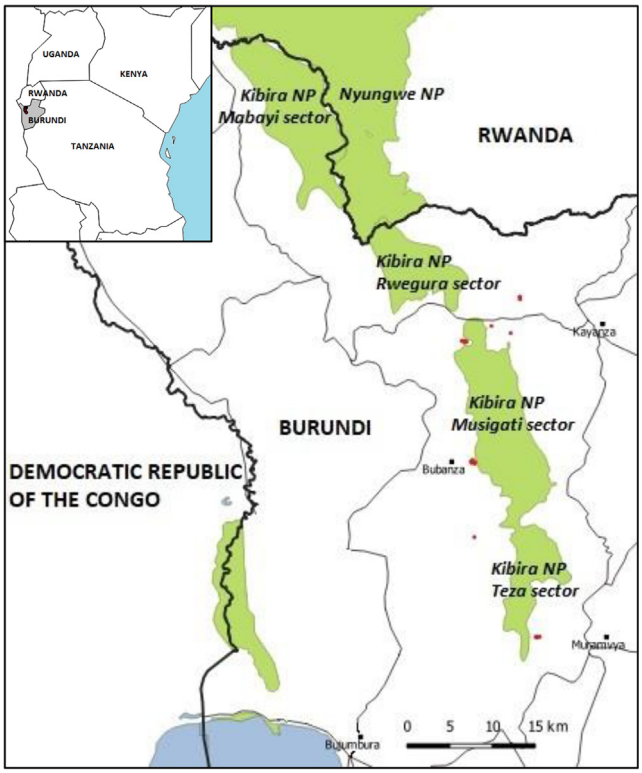

Fig. 1. Kibira National Park (NP) in Burundi, showing villages where focus-group discussions were carried out (red circles). Note that several villages sampled appear as one point in the map as they are located near each other. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

discussed how 'attached' they were to this particular forest, asking them to describe this in their own words. Fifth, participants were asked to identify the forest plant species they considered most important for firewood, construction, medicine, wild fruits and wild vegetables (three species for each category). Transcription was not prepared, only notes were taken during the FGDs. See Appendix B for the guiding questionnaire used.

Plant species' scientific names mentioned in FGDs were determined from plant samples collected from Kibira NP and taken to the Herbarium of University of Burundi and/or Herbarium of Meise (Belgium) for identification. An export permit was obtained to export samples to Belgium. Species presence in the park was checked with the literature (e.g. (Hakizimana et al., 2016). In order to determine if local communities' were using plant species of conservation concern, the conservation status of all the species mentioned in the FGDs was checked at the IUCN Red List (IUCN 2019). Plant nomenclature follows the African Plant Database (version 3.4.0, African Plant Database, 2020).

2.3. Data analysis

During FGDs participants identified forest benefits using their own terminology. These were subsequently translated to English and grouped according to the Millennium Ecosystem Assessment's classification of ES types and sub-categories (MEA, 2005): e.g. 'the forest attracts rains' became micro-climate regulation. Shelter during conflict was considered a provisioning ES as this refers to the physical domain used for hiding (Cuni-Sanchez et al., 2019b). Data from all FGDs from each livelihood-strategy group Twa or farmer was combined and we report responses in terms of percentage of FGDs of each group: e.g. 30% of the Twa reported one ES refer to this ES being cited in 3 of the 10 Twa FGDs carried out. We considered that the three most important ES for each group are those ranked more frequently as first, second and third during the FGDs.

Place attachment has two components: place identity and place dependence. For place identity, we noted mentions of practices such as ceremonies carried out only in the forest; connections between social cohesion and responsibility with the forest; the sense of home in the forest; and the link of the forest to family history, following the categories used by Cundill et al. (2017). We considered that place identity was higher for the ethnic groups which mentioned more key aspects of place identity. For place dependence, we referred to the number of forest provisioning ES cited by both groups, and also if income from forest products was being used to buy food products.

For each provisioning ES considered and group (Twa or farmer), we calculated the total number of species mentioned, and the frequency of citation of each species. The three most frequently cited species for a given ES were considered the three most important. To compare the similarity between plant species mentioned by the different groups, we computed the Jaccard similarity coefficient (J, Jaccard, 1901), defined as the size of the intersection divided by the size of the union of the sample sets:

$$J(A, B) = \frac{A \cap B}{A \cup B}$$

Where A and B are the binary descriptions of species presence/absence in different groups (in our case, as mentioned by different groups). A value of 1 indicates complete similarity, while 0 indicates complete dissimilarity.

3. Results

3.1. Ecosystem service identification and importance ranking

Twa identified 29 ES, farmers 25 ES and 22 ES were cited by both groups (Table 1). Only farmers mentioned that the forest controlled crop pests, it contributed to soil formation and it provided straw for cowsheds, which is related to their livelihood strategy: farming. Only the Twa mentioned that the forest provided clay and plants for pottery-making, and that they used hot springs for medicinal purposes: they said it helped remove lice, cure back pain and other ailments. The Twa highlighted that they sell numerous forest products to farmers, including medicinal plants (used for veterinary medicine by farmers), fodder, ornamental plants (used in wedding ceremonies) and wild vegetables –the later only bought by farmers when crops fail. They also pointed out that contrary to the farmers; they consume wild fruits and vegetables from the forest on a regular basis.

The first most important ES mentioned by farmers (micro-climate regulation, Table 1) also reflects their livelihood strategy as rains are important for their crops. The second most important ES mentioned by Twa (wild vegetables, Table 1) also reflects their livelihood strategy: gathering wild foods. The first most important ES for Twa (firewood) also relates to gathering forest products to make a living.

3.2. Place identity and place dependence

The Twa showed a strong place identity, mentioning cultural identity and social responsibility, the sense of home while being in the forest and the link of the forest to family history and ancestors (Table 2). Farmers did not mention any aspect of place identity. The Twa also showed great place dependence with the forest, highlighting the importance of the forest for food security, health and physical security (Table 2). Although farmers did not make comments such as '*the forest is our source of food*'-which the Twa did, they also show place dependence with the forest, as they buy wild foods from Twa when crops fail, allowing them to meet their basic needs.

Table 1
Forest ecosystem services identified by different ethnic groups. Values refer to percentage of focus group discussions (FGDs) citing an ecosystem service. For Twa n = 10 FGDs, for farmers n = 15 FGDs.

		Twa	Farmers
Number cited		29	25
Most important	*First*	Firewood	micro-climate regulation
	Second	Wild vegetables	Firewood
	Third	Construction materials	wood for carving/ air purification
Provisioning	Construction materials	100%	100%
	Firewood	100%	100%
	Wild fruits	100%	100%
	Wild vegetables	100%	100%
	Medicine resources	100%	100%
	Wood for carving	70%	87%
	Fodder	70%	80%
	Honey	60%	27%
	Minerals (clay)	60%	
	Crafts (baskets)	50%	67%
	Herbs for pottery-making	50%	
	Shelter during conflict	30%	13%
	Mushrooms	30%	7%
	Water	30%	7%
	Bushmeat	10%	7%
	ornamental plants	10%	7%
	Hot springs (medicinal)	10%	
	Perfume (plants)	10%	
	Straw for cowsheds		13%
	Charcoal		7%
Regulating/ supporting	Air purification	100%	100%
	Micro-climate regulation	90%	100%
	Erosion control	50%	60%
	Habitat for wildlife	40%	33%
	Pollination	20%	20%
	Soil formation	10%	33%
	Control of pests		7%
Cultural	Identity	70%	
	Recreation	50%	
	Tourism	30%	27%
	Sense of home	20%	
	Aesthetic	10%	13%

3.3. Preferred forest species for provisioning services

For firewood and construction, over 20 species were mentioned by both groups (Table 3). African bamboo (*Sinarundinaria alpina*) and *Polyscias fulva* were the preferred species for construction for both groups while *Macaranga kilimandscharica* was the preferred species for firewood. For medicine, over 50 species were cited by each group studied (Table 3). While for the Twa the most important medicinal plants were used to treat common ailments among humans (Amoeba, worms, malaria, injuries), those cited by farmers were only used to enhance milk production in cows (*Tabernaemontana stapfiana, Aniso-pappus chinensis*), highlighting the important use of medicinal plants for veterinary medicine for farmers. Remarkably, the Twa used *T. stapfiana* to enhance milk production in humans. For wild fruits and vegetables, fewer species were mentioned, and the preferred ones were the same for both groups: *Myrianthus holstii* (wild fruits) and *Urtica massaica* (wild vegetables) (Table 3). Most plant spices cited had multiple uses. Several species mentioned as important for medicine (*Carapa grandiflora, Parinari excelsa, Prunus africana, T. stapfiana*) or edible fruits (*M. holstii*) were used for firewood (see Table A1 Appendix A). Overall, the Jaccard indexes of similarity (J) were high – except for wild vegetables, indicating similar preferences between groups. J indexes were 0.73 for firewood, 0.65 for construction, 0.71 for medicine, 0.75 for wild fruits and 0.43 for wild vegetables. Overall, only one species of conservation concern was cited in this study: *P. africana* (vulnerable according to the IUCN Red List).

4. Discussion

4.1. Ecosystem service identification and importance ranking

We had hypothesized that the Twa would identify more forest ES than farmers and, that they would place higher value on forest foods. Our findings support both hypothesis but the differences were smaller than we anticipated, as we discuss below.

Kibira forest is very important for the food security of the Twa throughout the year: i) wild vegetables were ranked as the second most important forest ES; ii) they consume them on a regular basis, iii) and they sell other forest products such as firewood to buy food. In south-eastern Cameroon, Baka Pygmies also mentioned that they rely on more food products from the forest than Bantu farmers, and highlighted the importance of the forest for their food security (Carson et al., 2018). Similar findings were reported for the Twa in the Democratic Republic of the Congo (DRC) (Cuni-Sanchez et al., 2019b). However, as farmers buy wild fruits and vegetables from the Twa when crops fail, it can be argued that these act as 'safety nets' for them and are also important for their food security (Shackleton et al., 2011).

Table 2
Key aspects of place attachment identified during discussions with Twa, and examples of comments made.

Themes	
Food security	*'In the forest we lacked nothing, now we suffer because of famine'*
	'The forest is very important to us, it is our source of food and income for buying food'
Health	*'Our kids are very sick because they don't eat well'*[referring to lack of bush meat and wild honey, their staples when they lived in the forest]
	'Here [outside the forest] *there are many diseases, especially malaria, which cannot be found in the forest'*
	'Before we had all the medicinal species of the forest at our disposal'
Physical security	*'The forest is a refuge for us, there is more security in the forest than here* [outside]*'*
Sense of home	*'The forest is a peaceful place where we feel at home more than here* [outside]*'*
Cultural identity	*'The forest is our home, without it we cannot survive'*
	'Even if we were given everything we need, we cannot live without going into the forest'
	'We can't bear to live far from the forest, we must at least see our home, even if we aren't allowed to enter'
	'We prefer to go to prison or be beheaded rather than not entering our home, the forest'
Social responsibility	*'Others have accused us of burning the forest, but we cannot do that because the forest is all we have'*[refers to farmers and park staff accusing the Twa for setting fire to the forest in the past]
	'Others accuse us of destroying the forest, but it was them –not us- who cleared land for farming during civil war'
	'Others accuse us of destroying the forest, but harvesting medicine or bamboo is less harmful than clearing land for farming'
Link with ancestors	*'We used to do offerings to our ancestors, who live in the forest, but now we are not allowed to do so'*

Table 3
The three most frequently cited forest plant species and the total number of species (spp.) reported for different provisioning ecosystem services. Values refer to percentage of FGDs citing each plant species. For Twa n = 10 FGDs, for farmers n = 15 FGDs.

	Twa		Farmers	
Firewood	100%	*Macaranga kilimandscharica*	100%	*Macaranga kilimandscharica*
	100%	*Parinari excelsa*	53%	*Prunus africana*
	70%	*Polyscias fulva*	47%	*Faurea saligna*
		27 spp.		25 spp.
Construction	80%	*Polyscias fulva*	80%	*Sinarundinaria alpina*
	70%	*Sinarundinaria alpina*	60%	*Polyscias fulva*
	40%	*Hagenia abyssinica*	40%	*Macaranga kilimandscharica*
		17 spp.		21 spp.
Medicine	70%	*Tabernaemontana stapfiana*	73%	*Tabernaemontana stapfiana*
	60%	*Lindackeria fragrans*	53%	*Momordica faetida*
	50%	*Parinari excelsa*	47%	*Anisopappus chinensis*
		56 spp.		58 spp.
Wild fruits	100%	*Myrianthus holstii*	100%	*Myrianthus holstii*
	60%	*Rubus pinnatus*	47%	*Rubus pinnatus*
	60%	*Landolphia owariensis*	33%	*Landolphia owariensis*
		5 spp.		4 spp.
Wild vegetables	70%	*Alchornea hirtella glabrata*	53%	*Alchornea hirtella glabrata*
	50%	*Urtica massaica*	13%	*Urtica massaica*
	20%	*Dioscorea abyssinica*	13%	*Dioscorea abyssinica*
		8 spp.		6 spp.

Both the Twa and the farmers highlighted the importance of the forest for medicine, but with an important nuance: for the Twa medicinal plants are used to treat humans (or as source of income), while farmers mostly use them to treat their cattle. The Twa also mentioned the use of hot springs for medicinal purposes, which was not mentioned by farmers. For the Twa access to western medicine is limited because of its prohibitively high cost (participants' comments during FGDs). Even malaria treatment, which is subsidized in some countries (e.g. Kenya, Delbanco et al., 2017), is not subsidized in Burundi.

Apart from relying on the forest for food and medicine, Twa also rely on the forest for income, which they use to buy food. Therefore, they show stronger place dependence with the forest than farmers. Twa depend on farmers buying their products, but farmers also depend on the Twa entering the forest to provide them with these goods. Therefore, farmers also show place dependence with the forest -through buying forest products from the Twa.

Beyond place dependence, the Twa showed strong place identity with the forest. The Twa in Kahuzi-Biega NP (DRC) and Bwindi Impenetrable NP (Uganda) also showed strong place identity with the forest (Berrang-Ford et al., 2012; Cuni-Sanchez et al., 2019b). Because of their strong place identity with their forests, we could relate the Twa to Wilson's 'biophilia hypothesis' which argues that humans have an innate connection to nature (Wilson, 1984). Twa relationship with the forest and their perception of social responsibility towards the forest in particular, can also be related to the 'Mother Earth' perception of indigenous people elsewhere. In the 'Mother Earth' perception Nature does not simply provide services to humans and humans exploit these (a rather stock-and-flow framework), but Nature cares for humans, ES are gifts, and humans have the duty of caring for Nature (see Díaz et al., 2015, and references therein).

Farmers in our study did not perform ceremonies in the forest, or mentioned the importance of the forest for their identity. However, some farmers still show certain place identity to the Kibira forest, as some respondents revealed that in the past, several ceremonies of cultural importance for farmers were performed in this forest. For example i) the kings of Burundi were buried in a site found within the park, ii) a hunting ritual associated with the celebration of sowing *Umuganuro* was performed every year in the valley of Kanindi (found within the park), iii) rituals were regularly performed in the Inangorore cave (found within the park) to worship *Kubandwa* and request fertility (Ntahuga, 2014). Nowadays the royal family does not have the power it used to have and most farmers are now Christians and do not practice animist rituals.

Most forest ES mentioned in this study have been mentioned by Twa or farmers in eastern DRC (Cuni-Sanchez et al., 2019b). In both studies, participants mentioned the ES shelter during conflict. Although shelter during conflict is not considered in mainstream ES assessments (e.g. Costanza et al. (2017), Díaz et al. (2018)), other studies focused on local communities have highlighted this overlooked forest ES (Cuni-Sanchez et al., 2016; 2019b). In Kibira NP, which is contiguous to Nyungwe NP in Rwanda, the forest played a key role as escape route during the Rwandan genocide (1994). It also helped local communities to survive during civil war in Burundi (1993–2005), when people entered the park to farm, hunt or collect firewood and charcoal (Plumptre et al., 2003).

Another forest ES often overlooked in ES assessments is identity, mentioned by the Twa in our study, the Twa in DRC, and some farmer groups in Cameroon and Madagascar (Kari and Korhonen-Kurki, 2013; Cuni-Sanchez et al., 2019a). The identification of this cultural ES was only possible because of the methodology used (open questions with regard to forest benefits), which allowed space to bring in these important non-material forest functions. Many ES assessments identify the services easiest to valorise with the established methods rather than identifying services truly valorised by a given community (Milcu et al., 2013). Overall, most forest ES mentioned in this study have been mentioned in other studies focused on local peoples' perceptions of forest ES in Africa, which also highlighted that local communities report not only provisioning but also regulating and supporting services (e.g. Hartter and Goldman (2011), Kari and Korhonen-Kurki (2013), Mutoko et al. (2015), Byg et al. (2017), Dave et al. (2017), Ward et al. (2018)).

4.2. Preferred forest species for provisioning services

We hypothesized that the Twa would recognize more plant species for provisioning services than farmers. However, the Twa only mentioned more species for wild vegetables and human medicine. We found high J index between groups for most categories. This is different from results in DRC, where J indices between Twa and farmers were much lower (Cuni-Sanchez et al., 2019b). High J indices between groups in Kibira could be explained by two reasons. First, lower number of alternatives due to lower plant diversity in Kibira NP compared to eastern DRC, related to past disturbance, or smaller surface and range of habitats (see Plumptre et al. (2003), Hakizimana et al. (2016)). Secondly, Twa and farmers in Burundi having interacted traded plants and shared

ethnobotanical knowledge more than in eastern DRC in the recent past, due to high population density, shared language (Kirundi) and different socio-political history in both countries.

In our study farmers mentioned more species with veterinary uses. With regard to veterinary uses, cattle is considered a valuable asset (not just economically but also culturally) among farmers, which explains the importance of using medicinal plants for cattle, especially, for enhancing milk production. In Burundi, fresh milk is consumed on a daily basis, even in urban areas. For peoples who place high value on their cattle, veterinary medicine is often mentioned when interviewed about medicinal plants (e.g. Fulani in Cameroon, Samburu in Kenya, Cuni-Sanchez et al., 2016, 2019a).

Most species mentioned for construction, firewood and some mentioned for wild fruits are abundant trees in Kibira forest: *Macaranga kilimandscharica* comprises 20 % of the stems over 10 cm diameter, while *Carapa grandiflora, Faurea saligna, Myrianthus holstii, Polyscias fulva, Syzygium guineense, Tabernaemontana stapfiana* and *Xymalos monospora* comprise over 5 % of the stems over 10 cm diameter (Hakizimana et al., 2016). Unexpectedly, several species mentioned as important for medicine (*C. grandiflora, Parinari excelsa, Prunus africana, T. stapfiana*) or edible fruits (*M. holstii*) are used for firewood. This suggests that firewood demand is so high that people prioritise the unsustainable collection of these species for firewood (and income) rather than other uses –which is often not the case in other forests (e.g. Cuni-Sanchez et al. (2019a,b)). The fact that access to the forest is illegal might also affect species choice for firewood: people choose whatever is available near the park boundary, limiting the time needed to carry out such an illegal activity (participants' comments' during FGDs). Clearly, firewood and income alternatives need to be urgently identified (further discussed below).

In total only one species of conservation concern cited in the FGDs was *Prunus africana*. The bark of this species is traded for export as it used by pharmaceutical companies against benign prostatic hyperplasia (Cunningham et al., 2016). Currently there is a CITES restriction on its export from Burundi (Cunningham et al., 2016), and park managers are monitoring this species in the park. *Fleroya rubrostipulata* (used for medicine) has not been assessed by the IUCN Red List, but studies carried out in Uganda highlighted its overexploitation due to unsustainable harvesting of its bark for medicine (Galabuzi et al., 2015). More research is needed to determine if this is also the case in Kibira NP.

One major limitation of our approach is that we only investigated the views of elders. Although several authors have reported that elders identify more forest ES than younger people (e.g. Sodhi et al. (2010), Scholte et al. (2015)), future work should consider the views' of younger generations. Another methodological caveat is that we only used FGDs. Even if FGDs are recommended for the assessment of ES priorities and values (Poppy et al., 2014), FGDs may not be statistically representative samples of the whole population in a region, and results should not be generalized (Cruz-Garcia et al., 2019). Other complementary methods, such as individual interviews and individual ranking exercises, could be used in the future to complement this study.

5. Conclusions

Our results show that local communities recognise multiple forest ES and that some important differences can be observed between farmers and the Twa. The later show strong place identity with the forest, which we think could be capitalised in future conservation interventions. Our results also help understand why Twa continue to enter the park illegally and which alternative livelihood strategies -designed considering their strengths rather than their weaknesses- could be encouraged.

The Twa around Kibira NP show strong place identity with the forest. The Twa in Rwanda (Gishwati Forest: Dawson and Martin, 2015), Uganda (Bwindi Impenetrable NP: Martin et al., 2015) and DRC (Kahuzi-Biega NP: Cuni-Sanchez et al., 2019b) also maintain tight cultural links with 'their forest', despite not having legal access to it. The creation of protected areas has contributed to numerous injustices for the Twa, including the loss of essential freedoms for self-determination and current difficulties with meeting basic requirements for good physical health –including food and clean water security, health security, physical security (see Martin et al. (2016), Cuni-Sanchez et al. (2019b))- which we show is also the case in Kibira NP. Given that Twa are mostly landless, and most have no formal education or training, the forest is their only source of money (firewood, bamboo, poles, clay) for buying food.

Improved protected area management will require recognizing past injustices and creating equitable benefits to reduce further harm to the hunter-gatherer indigenous culture, livelihoods, and traditional ecological knowledge (Carson et al., 2018). Park managers of Kibira NP and development NGOs have focused on diverting Twa interests from the forest (e.g. encouraging agriculture, involving them in a tree nursery), but they have not considered the possibility of determining an agreed level of usage of park products with the Twa; nor have they considered the existential identity connection of the Twa to the forest, demonstrated here. We suggest that alternative livelihood strategies should focus on activities already performed by the Twa, and which consider their skills and strengths rather than their weaknesses. Bamboo could be planted along the park boundary/buffer zone, and could be sustainably harvested, as it has been shown in Uganda (Sheil et al., 2012). Twa are already involved in bamboo harvesting, transport and trade. Hives made with bamboo could be set up along the park boundary or buffer zone and could be cared and harvested by the Twa. In the contiguous Nyungwe NP (Rwanda) honey from the park buffer zone is traded as high-value through an appellation of origin. For the production of honey, training on making and caring for hives would be needed, but the Twa already harvest and trade wild honey.

Park managers and NGOs could also regulate the collection of clay inside Kibira NP, and even consider improving the pottery market chain through an appellation of origin. For this, no training is needed, many Twa already perform this activity and are proud of doing so -something unique as other activities like bamboo or firewood trade does not give them such pride. Twa place identity with the forest could be further capitalised: they could participate in forest patrolling, to ensure ensure sustainable use, if the park managers allow them to make a living from the forest -as they used to in the past. The Twa already have strong notions of social responsibility towards the forest, as we have shown.

Protected areas are the most important tool we have for species' and habitats' conservation - but their design should minimize adverse social impacts (Martin et al., 2015). Trying to keep the Twa out of protected areas by turning them into farmers has been criticised as cultural assimilation (Barume, 2000; Beswick, 2011). In Kibira NP, like in other protected areas in the region (e.g. Cuni-Sanchez et al. (2019b)), it has not been successful: they own little (if any) land, they have no skills for farming, they have no access to inputs, and crucially, they have no interest in farming. Recent work from eastern DRC has shown that they are the most vulnerable group to climatic changes, and that they have not used any strategy to cope with or adapt to climatic changes, as their most pressing issue is daily survival following forest eviction (Batumike et al., in review). As highlighted by the IPBES (Díaz et al., 2015), indigenous peoples (such as the Twa) and local communities possess detailed knowledge on their ecosystems and their functioning; and they can be important contributors to the governance of biodiversity from local to global levels. They have to be given, though, the chance to be involved in the forest conservation process. We show how socio-cultural approaches to ES valuation can help identify current and future environmental and socio-economic challenges in mountain regions and, in particular, in protected areas. They can also help start the discussion towards sustainable solutions, making the process more participatory and fair.

Table A1
Preferred plant species for different provisioning ecosystem services with regard to groups studied.

	Firewood[a]	Construction[b]	Wild fruits	Wild vegetables[c]	Medicine[d]
Bridelia brideliifolia (Pax) Fedde	T, F				F
Carapa grandiflora Sprague	T, F	T, F			T,F
Croton macrostachyus Hochst. ex Delile		F			T,F
Dracaena afromontana Mildbr.		F			
Ensete ventricosum (Welw.) Cheesman		T	T, F		T,F
Entandrophragma excelsum (Dawe & Sprague) Sprague	T, F	T, F			
Erythrococca bongensis Pax				T	T
Faurea saligna Harv.	T, F	T, F			T,F
Ficalhoa laurifolia Hiern	T, F	T, F			
Ficus ingens (Miq.) Miq.	T, F	T, F			T,F
Hagenia abyssinica (Bruce) J.F. Gmel.	T, F	T, F			
Ilex mitis (L.) Radlk.		T, F		T	T,F
Impatiens burtonii Hook. F.				T,F	
Landolphia owariensis P. Beauv.			T, F		
Macaranga kilimandscharica Pax	T, F	T, F			
Markhamia lutea (Benth.) K. Schum.		T, F			
Maesa lanceolata Forssk.	T, F				T,F
Microglossa pyrifolia (Lam.) Kuntze		F			
Mikaniopsis usambarensis (Muschl.) Milne-Redh.		T			
Myrianthus holstii Engl.	T, F		T, F		T,F
Myrica sp.	T, F				
Neoboutonia macrocalyx Pax	T, F				
Newtonia buchananii (Baker) G.C.C. Gilbert & Boutique	T, F				T,F
Nuxia floribunda Benth.	T, F				
Ozoroa insignis subsp. Reticulate (Baker f.) J.B. Gillett		F			
Parinari excelsa Sabine	T, F	T, F			T,F
Erica benguelensis (Welw. ex Engl.) E.G.H. Oliv.	T, F				
Pittosporum viridiflorum Sims	F				
Polyscias fulva (Hiern) Harms	T, F	T, F			T,F
Prunus africana (Hook.f.) Kalkm.	T, F				T,F
Rubus pinnatus Willd.			T, F		
Schrebera alata (Hochst.) Welw.	T, F				
Shirakiopsis elliptica (Hochst.) Esser	T				
Sinarundinaria alpina K.Schum.		T, F			
Solanecio mannii (Hook.f.) C.Jeffrey	T				F
Strombosia scheffleri Engl.		F			
Symphonia globulifera L.f.		T, F			
Syzygium guineense (Willd.) DC.	T, F	T, F			T,F
Tabernaemontana stapfiana Britten	T, F				T,F
Teclea sp.		F			
Urtica massaica Mildbr.				T,F	T,F
Xymalos monospora (Harv.) Baill.	T, F	T, F			T,F

[a] Respondents highlighted that several species used for firewood are small trees which provide firewood of poor quality (*Solanecio mannii, Erica kingaensis, Tabernaemontana stapfiana*), but these are used due to lack of alternatives –better species are found further from the park boundary.

[b] *Dracaena afromontana* is used to construct fences not houses, *Ensete ventricosum* is used for frames in cowsheds.

[c] *Ilex mitis* leaves are mostly used for medicine but Twa reported eating them as vegetable in times of famine. The Twa also mentioned collecting and trading *Conyza sumatrensis* (Retz.) E.K. Walker, *Solanum nigrum* L., *Basella alba* L. and *Galinsoga parviflora* Cav., species not native to Africa but which can now be found in forest clearings inside the park, possibly due to past disturbance.

[d] Twa know veterinary uses of medicinal plants despite owning no domestic animals, because they sell these plants to farmers. Three species for firewood and three for wild vegetables were not identified and are not included in this table. Numerous species were reported for medicine, we only report here those which also had another use, as we are preparing another publication focused on medicinal plants.

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 A

Appendix B. Focus-group discussions guiding questionnaire

Part 1. The forest in the park

1. Is the forest in the park important for your community?
2. Why is it important? (List the benefits)
3. What other non-material benefits does the forest provide to you?
4. Which of all these benefits that have been mentioned are the three most important for your community and why? (Identify and rank them)
5. Do you feel 'attached' to this forest? For example, is your culture and identity linked with this forest? (Give other examples).

Part 2. Preferred plant species from the forest in the park

6. Which three plant species from the forest are the most important for your community for firewood?
7. Which three plant species from the forest are the most important for your community for construction?
8. Which three plant species from the forest are the most important for medicine?
9. Which three plant species from the forest are the most important for wild fruits?
10. Which three plant species from the forest are the most important for wild vegetables?
11. Is there anything else you would like to add with regard to the importance of the forest in the park and the plant species found inside?

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