Human–Wildlife Conflict: The Case of Crop Raiding and Its Socio-economic Implications Around Pendjari Biosphere Reserve, Northern Benin

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Abstract Human–wildlife conflict is becoming a serious threat for both wildlife conservation and human well-being. Its main representations are livestock predation and crop raiding. This chapter examines the problem of crop raiding by wildlife and its socio-economic implications around Pendjari Biosphere Reserve in northern Benin. Data were collected in 2017 through field observations, semi-structured interviews, and a questionnaire survey of 209 farmers of the surrounding villages of the reserve, and 98% of them reported losses of crop every year due to wildlife. Crops with the highest degree of destruction are cotton, maize, millet, and sorghum, and the wild animals responsible for this are mainly baboon, warthog, and elephant. Crop raiding causes, for an average farmer, an annual financial loss ranging from $94.64 in farms of sorghum to $311.8 in farms of cotton. Compared to the annual minimum salary in Benin, these numbers are considerable. Farmers try to manage the impacts of crop raiding with various mitigation measures such as guarding, but the heavy toll of crop raiding and the low level of effectiveness of such measures clearly reveal the vulnerability of agricultural households bordering protected areas.

Keywords Crop raiding · Benin · Economic losses · Pendjari biosphere reserve · Survey

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1 Introduction

Social–ecological systems are composed of interdependent and interacting ecosystems and human communities (Berkes et al. 1998; Folke et al. 2010). Humans' interactions with the ecological environment can be positive or negative (Redpath et al. 2015; Fisher 2016). Positive interactions or ecosystem services refer to the benefits that human societies derive from nature. These benefits are divided by the Millennium Ecosystem Assessment (2005) into four groups: regulatory services, support services, supply services, and cultural services. Supply services are goods produced or obtained from ecosystems such as food, water, wood, fibers, and materials. As for cultural services, they include recreational (i.e., hiking and ecotourism) and cultural pleasures, aesthetic values, as well as the educational interest offered by nature, or even spiritual enrichment. Air and water purification are classified in regulatory services, and support services are services that underpin all of the above services, for example nutrient cycling. The negative interactions of humans with their environment take into account, among other things, the problematic relations of locals with wildlife. These negative human–wildlife interactions have been a reality faced by mankind since the beginning of its existence (Lamarque et al. 2009). Human–wildlife conflicts are any interactions with a negative impact for both parties. Human–wildlife conflict has traditionally been viewed to occur "when the needs and behavior of wildlife impact negatively on the goals of humans or when the goals of humans negatively impact the needs of wildlife" (Madden 2004).

Conflicts are more frequent in the peripheries of protected areas and include, among others, attacks by humans (Packer et al. 2005), the depredation of crops and granaries (Pimentel et al. 2005; Perez and Pacheco 2006), the predation of cattle, transmission of disease to livestock and humans, and the opportunity costs where local residents abandon certain economic or life choices because of the presence of wild animals or protected areas (Thirgood et al. 2005). But the most important forms of manifestation of human–wildlife conflicts in the world are crop depredation and livestock predation (Mhuriro-Mashapa et al. 2018), with crop depredation being the most pressing issue in Africa (Lamarque et al. 2009; Fairet 2012).

Many authors are increasingly interested in crop raiding in Africa: Biset et al. (2019) in Ethiopia; Nsonsi (2018) in Gabon; Kouao et al. (2018) in Ivory Coast; and Fairet (2012) in Gabon. The latter studied crop raiding around Longo National Park and assessed the vulnerability of households there. In Benin, Sogbohossou et al. (2017) and Dossou et al. (2019) studied the crop raiding around the Mono Delta Transboundary Biosphere Reserve in Southwest Benin and Ouémé River area in central Benin, respectively.

Within the same perspective, this chapter examines the extent and patterns of crop raiding and the financial impacts and determinants of crop raiding by wildlife in the Pendjari Biosphere Reserve, northern Benin. The remainder of the text is organized as follows: Sect. 2 details the study zone and data collection; the results of the analysis are presented in Sect. 3; and the discussion is presented in Sect. 4 followed by concluding remarks.

2 Methodology

2.1 Study Area

The study was carried out around Pendjari Biosphere Reserve in Atacora department, north-west Benin (Fig. 1). It represents one of the better managed protected areas in West Africa semi-arid regions. The south of the reserve is bordered by the Atacora Mountain chain (elevation of 400–500 m altitude), which is directly connected to the mountain of northern Togo. Apart from these mountains and a few isolated hills, the topography of the reserve is flat, ranging between 150–200 m above sea level (Delvingt et al. 1989). The reserve is part of a complex of four adjoining protected areas W, Arly, Pendjari, and Oti-Mandouri (WAPO) in four adjacent countries (Benin, Burkina Faso, Niger, and Togo). The Pendjari Biosphere Reserve was established in 1954, upgraded to National Park status in 1961, and to a UNESCO Man and Biosphere Reserve in 1986. It comprises Pendjari National Park (2.660 km^2), Pendjari and Konkombri Hunting Zones (1.600 km^2 and 251 km^2, respectively), and a buffer zone with controlled land-use access for local people (340 km^2). The Reserve is bordered to the north and west by the Pendjari River and to the east by the Atacora Mountain range (CENAGREF 2016).

In this Sudanian ecosystem, the climate is characterized by a dry season from October to May and a wet season with a total annual rainfall of 800–1000 mm. The vegetation is a mixture of open grass and tree savannahs interspersed with dry and

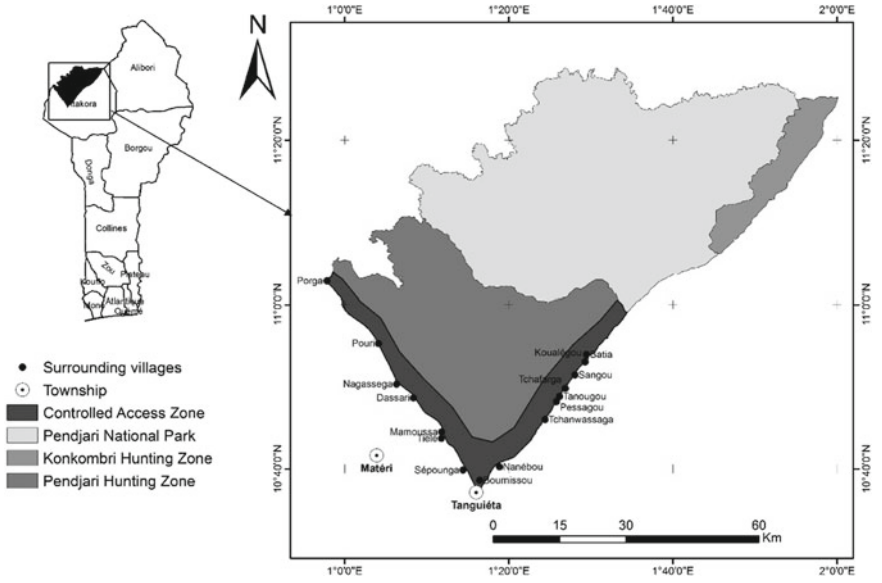

Fig. 1 Pendjari Biosphere Reserve and the surrounding villages

gallery forests. The fauna of the Pendjari Biosphere Reserve is typical for this region of West Africa (Kouton et al. 2019). There are eleven different species of antelopes; some emblematic species—such as the cheetah, the elephant, the lion, and the African wild dog—are in Pendjari Biosphere Reserve. The leopard is also present. In addition, Ahouansou Montcho et al. (2009) have identified 378 bird species and 62 fish species from 21 families, Nago et al. (2006) 17 amphibian species, and Djossa et al. (2008) 28 species of flying foxes.

Agriculture and breeding are the main activities of the local communities in the villages surrounding the Reserve (Houinato and Sinsin 2000). But agriculture is subject to a number of constraints, including the insufficiency of cultivable land, in particular on the Tanguiéta-Batia axis, where populations are trapped between the Atacora chain and the Reserve, which reduces the duration of the fallow; soil poverty; erosion; irregular and insufficient rain; and the depredation of crops by fauna (Lokossou et al. 2018).

2.2 Data Collection and Analysis

Data on crop raiding and management measures were collected through field observations, semi-structured interviews, and questionnaire survey between January and February 2017. The questionnaires are not placed in Appendix because of lack of space, but they are of course available upon request. Three main criteria prevailed in the choice of villages to be surveyed: the proximity of the village to the Pendjari Biosphere Reserve; the socio-cultural group; and the extent of animal damage. On the basis of these criteria, 15 villages were chosen in the municipalities of Tanguiéta and Materi (Fig. 1). The managers of the protected area and the farmers from the local communities were questioned. Questions were related to crop raiding manifestations, mitigation measures, and socio-economics implications. A total of 209 farmers participated in the study. One person per household was interviewed. Data were analyzed using SPSS v.16. Descriptive statistics were used to depict crop raiding. We used for each crop mean yield the prices obtained from the Beninese Office of Food Security (Office National de Sécurité Alimentaire, ONASA) in December 2016 to evaluate the economic impact of human–wildlife conflicts. Those prices were converted from XOF to US dollar using the USD value of September 1, 2017 (1 USD = 550 XOF).[1] More precisely, data collection and computations enabled us to determine costs per farmer. For proceeding as such, we first determined the average area cultivated by a farmer for each of the four main crops (cotton, maize, sorghum, and millet).

[1] www.mataf.net/fr/conversion/monnaie-USD-XOF.

Table 1 Socio-demographic characteristics of respondents

Variables	Characteristics			
Ethnicities (%)	Berba (50.7)	Gourmantché (26)	Wama (17.7)	Boulba (4.3)
Marital status (%)	Single (3.3)	Married (93.3)	Widow (3.3)	–
Instruction (%)	Uneducated (55.5)	Elementary school (29.2)	High school (15.3)	–
Sex	Male (94.3%, $n = 197$)		Female (5.7%, $n = 12$)	
Age (years)	Min (19)	Max (70)	Mean (41.15)	SD (10.38)

3 Results

3.1 Respondents' Demographic and Socio-economic Characteristics

All respondents were farmers from the three main ethnic group surrounding the Reserve: Berba (50.7%), Gourmantché (26%), and Waama (17.7%). The age group of the respondents ranged from 19 to 70 years old, with an overall mean age of 41.15 $\pm$ 10.38 (SD) years. Overall, more males (94.3%, $n = 197$) than females (5.7%, $n = 12$) participated in this survey, probably because the Beninese rural women do not speak in the presence of men or because women deferred to men in seniority. Those interviewed here were either widows or because of the absence of their husbands (Table 1).

3.2 Farming Activities Around Pendjari Biosphere Reserve

Agriculture is the main activity and source of income for local communities around the Pendjari Biosphere Reserve. All respondents were farmers with 18.64 (SD = 9.7; $n = 163$) years of experience in farming activities. Farms were at an average distance of 2.9 km (SD = 1.7 and $n = 208$) from the villages. The mean farm size per household was 5.03 ha (SE = 0.22; $n = 205$), and there was an average of 5.12 agricultural workers by household (SD = 2.5; $n = 170$). The main crops produced were cotton 2.56 ha (SD = $\pm$ 1.5; $n = 100$), maize 2.02 ha (SD = $\pm$ 1.16; $n = 205$), sorghum 1.27 ha (SD $\pm$ 0.67; $n = 89$), and millet 1.5 ha (SD = $\pm$ 0.98; $n = 46$). Farming activities are displayed in Table 2.

Table 2 Farming activities characteristics

Variables	Number (*n*)	Mini	Maxi	Mean	SD
Experience in agriculture (years)	163	3	50	18.64	9.7
Agricultural workers/household	170	1	14	5.12	2.5
Cultivated area (ha)	205	0.5	21	5.03	3.1
Distance of farm from home (km)	208	0.2	10	2.9	1.7

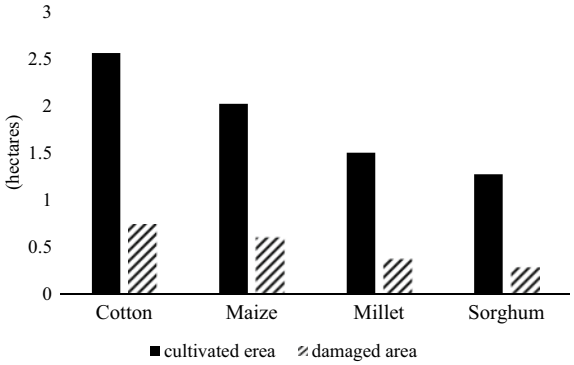

Fig. 2 Main crops damaged by wildlife around Pendjari Biosphere Reserve. *Source* Developed by the authors

3.3 Crop Raiding

Crop raiding is a real problem facing farmers in the peripheries of the Pendjari Biosphere Reserve. Figure 2 shows damages to the main crops considered.

In absolute value (hectares damaged), cotton is much more problematic than sorghum; but it is not the case since all considered crops are very much hit given that the percentages of damaged cultures range from 22 to 30%.

3.4 Crop Raiders

Several wildlife species are involved in crop raiding. Around the Pendjari Biosphere Reserve, Baboon, warthog, and elephant are the main crop raiders (Fig. 3). While damages by warthogs and elephants are recorded at the time of crop maturity and harvest time, damages of baboons are recorded all along the agricultural season, which may explain the high percentage of their citation by local populations.

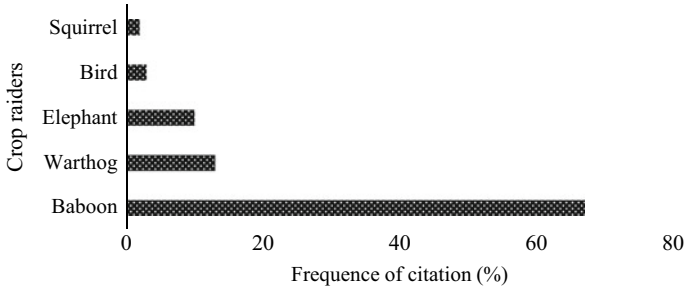

Fig. 3 Main crop raiders around Pendjari Biosphere Reserve. *Source* Developed by the authors

3.5 Economic Impact of Crop Raiding

The economic impact of human–wildlife conflicts was evaluated considering annual crops destroyed per farmer. Farmers can lose from $94,64 in sorghum farm to $311,8 in cotton farm (Table 3).

Considering the average yield per crop and the production loss (Fig. 2) due to animal interactions (Fig. 3), and considering the average crop price, we were able to determine, in local currency, the annual loss per crop type. Converting these numbers in USD revealed that an average farmer loses around $312 for cotton production, $255 for maize, $104 for millet, and $95 for sorghum. These numbers are not trivial. As a matter of fact, for illustration purposes, suppose that the average farm size is 5.03 ha as mentioned above in Sect. 3.2 and that such a standard farm includes production of all four crop types in proportion of its average area mentioned in Table 3 (i.e., 1.75 ha, 1.38 ha, 1.03 ha, and 0.87 ha for cotton, maize, millet, and sorghum, respectively). Computing lost quantity, annual loss in XOF converted in USD gives us a loss of $213 for cotton, $174 for maize, $71 for millet, and $65 for sorghum. The overall

Table 3 Economic cost of crop raiding

Crops	Cotton	Maize	Millet	Sorghum
Average cultivated area (ha)	2.56	2.02	1.5	1.27
Average yield (kg/ha)	1100	1680	940	1150
Average production (kg)	2816	3393.6	1410	1460.5
Proportion of loss (%)	29	30	25	22
Quantity lost (kg)	816.64	1018.08	352.5	321.31
Average price/kg (XOF)	210	138	162	162
Agricultural income (XOF)	591,360	468,317	228,420	236,601
Annual loss (XOF)	171,494.4	140,495	57,105	52,052
Annual loss (US$)	311.8	255.45	103.82	94.64

Note $1 = 550 FCFA
Source Developed by the authors

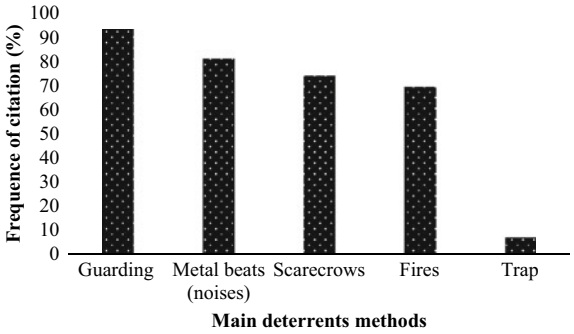

Fig. 4 Farmers' crop raiding coping strategies around Pendjari Biosphere. *Source* Developed by the authors

annual loss of that average hypothetical farmer is therefore $523. When compared with the minimum wage of some $873 a year (40,000 XOF a month since 2018), it is easy to see that human–wildlife conflict may indeed have very important economic consequences.

3.6 Mitigation Measures

Farmers develop some strategies to cope with crop raiding. These strategies are mainly guarding, noises, and scarecrows (Fig. 4).

Guarding is the most used (93%) coping strategy by farmers surrounding the Pendjari Biosphere Reserve. Farmers generally seat on strategic watchtowers (tall trees) to guard their farms against raiders. Children also go around the field by shouting. Making noise with metallic objects (81%) is often associated to guarding. At sunset, some farmers make fires with green branches (69%) to deter animals with the smoke. Others spend the night in fields under huts with flashlights to deter nocturnal raiders like elephants and warthogs and animals frequently appearing around sunrise like baboons. Guarding is time-consuming for farmers, especially when the farm is relatively large. They often (74%) use scarecrows made from salvage items. Traps, which are banned, are rarely used as they harm the survival of wildlife species.

4 Discussion

We focused our study on crop raiding, the most important form of human–wildlife conflict in Africa (Lamarque et al. 2009) and around the Pendjari Biosphere Reserve (Efio et al. 2018). It was observed that cotton, maize, millet, and sorghum were the main crops destroyed by wild animals, the most important of which were baboon,

warthog, and elephant. These crops were also those identified by Sogbohossou et al. (2017) and Dossou et al. (2019) as the main crops destroyed by hippopotamus in the Mono Delta Transboundary Biosphere Reserve in Southwest Benin and along the Ouémé River in central Benin, respectively. Like in Cameroon (Weladji and Tchamba 2003), baboon, warthog, and elephant were the most important crop depredators. Elephant, which is usually the most important threat to crops (Parker et al. 2007), was not the first raider around Pendjari. This can be explained by the fact that villages are separated from the protected area by a buffer zone and the density of most wildlife is very low close to villages. One exception is baboon, which can also be found on the mountain bordering villages in the eastern part of the Reserve and hills found in the western side villages. This is because the baboons are not afraid of humans and they are present in villages. Half of the villages is bordered by the Atacora Mountain, which is home to baboons too.

Whether in the North of Benin around the Pendjari Biosphere Reserve, in the Southwest around the Mono Delta Transboundary Biosphere Reserve or in central Benin along the Ouémé River, the main crops destroyed were cereals and cotton. If damages during sowing could be repaired by another sowing, damages during the harvest period are unrecoverable. This indicates that the crop raiding threatens households' food (Barua et al. 2013) and economic security, since cotton is the main cash crop of Beninese farmers and Benin is the leading producer of cotton in Africa (WTO 2020). Human–wildlife conflicts caused an average loss of 25% of the cultivated area around the Pendjari Biosphere Reserve, which results in an annual loss ranging from $94.64 to $311.8, depending on the type of crop. This value is similar to the cost of damage to hippopotamus around the Mono Delta Transboundary Biosphere Reserve estimated at $254.54 by Sogbohossou et al. (2017). This cost could seem insignificant, but it constitutes a heavy tribute for these poor local communities which live on less than a dollar a day. To limit the impact of wildlife's damage on their livelihoods, local communities develop measures that very often boil down to deterrence mechanisms and are rarely effective (Nyhus 2016; Efio et al. 2018).

Mitigation measures used by populations around the Pendjari Biosphere Reserve were non-lethal. This is quite positive as local communities did not seem to think about retaliatory killing as a way to reduce predation, which is contrary to other parts of Africa where wildlife pays a heavy tribute due to conflicts (Nowell and Jackson 1996; Balme 2009). As already highlighted by Sogbohossou (2011) and Sogbohossou et al. (2011), local communities around Pendjari have a rather positive attitude toward the protected area that they considered as their heritage and a source of revenue through tourism.

The oldest and most widely used deterrence method in the Pendjari Biosphere Reserve is guarding, and it seems to be the most effective human–wildlife conflicts management measure (Nyhus 2016). However, the costs of labor and the need for constant vigilance are the key drawbacks of this approach (Tehou et al. 2018). This method can be effective both against crop raiders and livestock depredators; however, its efficiency is limited against nocturnal depredators as it is difficult to guard farms during the night. Fire, used to dissuade nocturnal predators, is also not a prominent

measure because fire made with dry wood does not last long enough to prevent animals to visit cultivated areas (Conover 2002; Linnell et al. 2012).

The heavy toll of human–wildlife conflicts and the low level of effectiveness of measures to manage the crop raiding clearly reveal the vulnerability of agricultural households bordering protected areas. This concept of vulnerability has been introduced into the literature on human–wildlife conflicts since the 1990s by Naughton-Treves (1997). The author defined it as the degree to which farm households are exposed to the risk of damage from wild animals, combined with their individual abilities to deal with damage. Two years later, Naughton et al. (1999) refined this definition by including the individual and collective dimensions of man–wildlife conflict management measures.

Focusing on the vulnerability of agricultural households to crop raiding around Longo National Park in Gabon, Fairet (2012) identified three dimensions of vulnerability: institutional, biophysical, and social. The same three dimensions of households' vulnerability to crop raiding can be found in the Pendjari Biosphere Reserve. The institutional vulnerability comes from the classical top-down conservation strategies, excluding local populations from the decision-making process (Adams 2004; Adams and Hutton 2007). These conservation regulations may indeed hinder farmers' ability to protect themselves against raiding animals (Thirgood et al. 2005), thereby creating a form of institutional vulnerability (Fairet 2012). The biophysical vulnerability results from the proximity of wild animals, and, in our case study, it is greatly aggravated by the geomorphological conditions of the region (Kiansi 2011). Finally, the social vulnerability is due to the damage caused to agricultural production by animals, especially that this activity is the main source of subsistence and income for neighboring households. The social vulnerability process goes as such: First, crop raiding increases labor and brings about threats to health or education through increased time spent in guarding fields (Naughton-Treves 1997; Hill 2000, 2004; Gadd 2005; Osborn and Hill 2005; Ogra 2008); then, it affects farmers' livelihoods inducing economic and food insecurity (Kaswamila et al. 2007; Barirega et al. 2010; Hartter et al. 2011), sometimes leading households, in extreme cases, to abandon fields or villages (Naughton et al. 1999; Sitati et al. 2005; Treves et al. 2006).

Although the phenomenon of human–wildlife conflicts is the expression of the interaction between humans and wildlife, most studies to date have focused on either humans or wildlife, and very little studies approach the phenomenon from a holistic point of view (Fairet 2012). In Africa, several researches have been carried out on human–wildlife conflicts. Those who approach the problem from a biophysical perspective often deal with the damage aspects, the animals involved, and the environmental factors of human–wildlife conflicts (Kolowoski and Holekamp 2006; Kouao et al. 2018; Biset et al. 2019). As for research focusing on local communities, they often address the socio-economic impacts of the damage and attitudes toward wildlife. Some authors, such as Aust et al. (2009) and Rust and Marker (2013), are interested in this aspect of the question.

In Benin, a West African country that hosts the Pendjari Biosphere Reserve around which agricultural activities are practiced (Houinato and Sinsin 2000; Sogbohossou 2000), human–wildlife conflicts are a reality that has interested many researchers,

such as the works of Sogbohossou et al. (2011, 2013, 2017) and Djagoun et al. (2017). Most of these works studied the biophysical aspects of the question, and only Tehou et al. (2018) and Efio et al. (2018) focused their work on local communities. The latter, respectively, assessed the economic impact of human–elephant conflicts on households and human–wildlife conflict management measures to curb crop raiding, and they concluded that such measures are not efficient.

Indeed, finding durable techniques to (partially) solve the human–wildlife crisis around the Pendjari Biosphere Reserve requires to take a closer look at the relationships between humans to their natural environment and at the personal representations of their environment (fauna). More specifically, the representations of local residents are underpinned by their level of sensitivity and vulnerability to human–wildlife conflicts. The less vulnerable they are, the more they will be tolerant to wildlife and the more successful conservation efforts will be.

5 Conclusion

This study of crop raiding around the Pendjari Biosphere Reserve reveals that cotton, maize, millet, and sorghum were the most damaged crops by wildlife. The main animals responsible for this destruction are the baboons, the warthogs, and the elephants. The impacts on local communities surrounding this protected area are economic and social, thus making these communities vulnerable.

We have seen that the economic damage is not trivial: Depending on the crop type, 22 to 30% of the annual production may be lost. This entails important losses valued at $95 to $312 for an average farmer. Brought back to an average-sized farm cultivating the four crops, the annual loss would reach $523, which is a very high amount in absolute value, considering the minimum wage in effect in Benin. To minimize those losses and reduce vulnerability, farmers set up various mitigation measures but research showed that their effectiveness is generally limited.

Despite a very abundant literature on human–wildlife conflicts, few studies have addressed the vulnerability of households. Assessing the vulnerabilities of local residents to human–wildlife interactions makes it possible to approach the question from a holistic perspective so as to develop solutions with the potential to ensure the sustainability of the social–ecological system as a whole.

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