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Farmers' Perceptions and Actions to Decrease Crop Raiding by Forest-Dwelling Primates Around a Rwandan Forest Fragment

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Human–wildlife conflict (HWC) presents an increasing challenge to conservation, particularly in densely populated parts of low-income countries. This article assessed one form of conflict, crop raiding by forest-dwelling primates, along the boundary of a tropical montane forest fragment (Gishwati Forest) in western Rwanda. Variation in species involved, crops affected, differences in magnitude with season and distance to the forest boundary, and the nature of mitigation efforts were assessed through semi-structured interviews with farmers and field-based observations during June and July 2009. Substantial losses of crops were reported, with replacement costs possibly reaching 10–20% of total household income. Chimpanzees (Pan troglodytes) and Cercopithecus monkeys were the sole reported raiders, mainly affecting maize and legumes. Mitigation was restricted to guarding of crops and modification of farming practices, the latter potentially having significant dietary consequences for subsistence farmers. These findings highlight the potentially high economic costs, and food security effects of HWC.

Keywords human–wildlife conflict, agriculture and natural resources, crop damage, Rwanda, Gishwati, chimpanzee

Introduction

Human–wildlife conflicts (HWC), in the form of crop damage, livestock loss, disease transmission, and human mortality, around protected areas can comprise a significant biodiversity risk by reducing support for conservation efforts (Adams, 2004; Dickman, 2010; Metcalfe & Kepe, 2008; Naughton-Treves, Holland, & Brandon, 2005; Ogra, 2008; Smith & Bangs, 2008). In addition to losses of livestock (Kolowski & Holekamp, 2006) and human life (Packer, Ikanda, Kissui, & Kushnir, 2005; Prashant, 2004), HWC has less visible effects, such as increased incidences of some diseases (Thirgood, Woodroffe, & Rabinowitz, 2005) and opportunity costs (Hill, 1997, 2000; Hoare, 2000; Naughton-Treves, 1998; Norton-Griffiths & Southey, 1995), including children forgoing school-time in order to guard planted fields (Linkie, Dinata, Nofrianto, & Leader-Williams, 2007).

Crop raiding has been identified as a key form of HWC and the most important perceived disadvantage of farming close to protected areas in western Uganda (Archabald &

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Naughton-Treves, 2001). A combination of inadequacies in a revenue-sharing program and high level of HWC has resulted in active antagonism toward Tsavo National Park, Kenya (Sindaga, 1999). A wide suite of species have been previously implicated, ranging from large mammals destroying crops and agricultural infrastructure (Chiyo & Cochrane, 2005) and birds and rodents raiding stored food (Naughton-Treves, 1998), to invertebrates feeding on standing stock (Naughton-Treves, 1997; Parker & Osborn, 2006; Pérez & Pacheco, 2006). Reduced food security resulting from this can be an important consequence of crop raiding (Barua, Bhagwat, & Jadhav, 2013).

Measures aimed at mitigating HWC include physical barriers, guarding, noise, lethal removal, and relocation (Woodroffe, Thirgood, & Rabinowitz, 2005) and may be directed at the individual household or the entire community. These measures are often palliative and frequently difficult to sustain (Thouless & Sakwa, 1995). None provide complete protection, because of the varied and varying nature of HWC and the taxa involved (Kolowski & Holekamp, 2006). For example, crop-raiding strategies displayed by elephant (*Loxodonta africana* Blumenbach, 1797) can vary according to the behavioral ecologies of individual animals (Hoare, 1999), meaning mitigation strategies aimed at one animal or in one location may be ineffective in other circumstances.

Although physical barriers such as fences, walls, and ditches can protect property from wildlife damage (Hockings & Humle, 2009), their widespread use is limited by the costs of construction and maintenance (Hayward & Kerley, 2009; Pérez & Pacheco, 2006; Thapa, 2010). As a result, alternative mitigation measures have emerged, such as the burning of chilli powder, release of specific deterrent pheromones, solar-powered lights, and the tagging and monitoring of problem animals (Hill, Osborn, & Plumptre, 2002; Parker & Osborn, 2006; Schlageter & Haag-Wackernagel, 2011). Active guarding is also widely adopted (Naughton-Treves, 1998), and has included the use of domesticated animals (Gehring, VerCauteren, & Landrey, 2010; Hill et al., 2002; Muruthi, 2005). Aside from children frequently being given the task of guarding, women are also expected to be custodians of crops (Ogra, 2008). Compensation and insurance schemes can be used to reduce the monetary risks of crop raiding, although their geographic extent and level of capitalization are often limited and their effectiveness is undermined by difficulties in verifying claims (Boitani, Ciucci, & Raganella-Pellicioni, 2010; Bowen-Jones, 2012; Karanth, Gopalaswamy, DeFries, & Ballal, 2012; Ogra & Badola, 2008). Given the complexity in the nature and consequences of HWC, case-specific interventions aimed at reducing the vulnerability and appeal of farmland over protected areas are often considered over global solutions. Additionally, the value of non-empirical studies into HWC and interdisciplinary research designs are being increasingly recognized (Austin, Smart, Justine Irvine, & White, 2010; White & Ward, 2010). This includes investigation of the socioecological drivers of conflict and the perceived impacts of these on livelihoods and quality of life (Metcalf & Kepe, 2008; Naughton-Treves & Treves, 2005).

Modification of farming practices such as planting crops less palatable or appealing to raiders, or planting heavily raided crops beyond a buffer of unappealing crops or unsuitable habitat, may present a more effective and sustainable solution to crop raiding than the construction and maintenance of fences or reliance on guards (Hockings & Humle, 2009). Such mitigation strategies, however, have the potential to cause significant reductions in diversity of food crops produced, especially if local factors already restrict the diversity of potential crops (Akankwasah, 2008; Vedeld, Jumane, Wapalila, & Songorwa, 2012), thereby potentially replacing one source of increased food insecurity with another. Communities dependent on their farmsteads for the food they eat, living close to the margins of protected areas and in economically marginalized parts of the world, are particularly vulnerable to the effects of crop damage (Chiyo & Cochrane, 2005; Naughton-Treves, 1998). This reduced

dietary diversity is often in combination with additional development challenges commonly associated with living close to the boundary of a protected area, such as competition for resources, including water (Adams & Hutton, 2007; McElwee, 2010).

The challenge of meeting development goals and resolving HWCs is often greatest in regions of high population density and associated natural resource pressures. Rwanda, central Africa, is one of the most densely populated countries globally. Natural forest in Rwanda is an outlier of the Albertine Rift biodiversity hotspot, and is therefore part of one of Earth's richest—yet endangered—ecoregions (Mittermeier, Myers, Mittermeier, & Robles, 1999). Much of the forest in western Rwanda was, however, cleared over the last century for commercial plantations, extraction of timber and non-timber forest resources and to accommodate shortages of farmland due to increasing human population levels (Plumptre, Masozera, & Vedder, 2001). What little remains of the original forest cover in Rwanda is characterised by high biological diversity and endemism (CIA, 2012; Olson & Dinerstein, 2002; Olson et al., 2001) and has substantial conservation value (Plumptre et al., 2007).

Clearances over the last century accounted for about 80% of the original designated extent of Gishwati Forest (Figure 1), resulting in a remnant fragment of forest that currently covers an estimated 900 ha of rolling topography from 2,100–2,600 m above sea level in the northwestern part of the country (Ruzigandekwe, 2009). Gishwati Forest originally formed part of a large swathe of moist afro-montane forest, extending from the Virunga volcanoes that lie along the northern international boundary with the Democratic Republic of the Congo and Uganda southwards to Nyungwe Forest on the border with Burundi (Kayijamahe, 2008; Roche, 1996). Despite its size, Gishwati Forest is the largest area of natural forest in Rwanda outside a national park, supporting over 80 bird species, an unknown number of the Endangered golden monkey (*Cercopithecus mitis ssp. Kandi* Matschie, 1905) (Barakabuye et al., 2007) and a stable population of L'Hoest's monkeys (*Cercopithecus l'hoesti* Sclater, 1899). In addition, the forest supports a small population of chimpanzees (*Pan troglodytes* Blumenbach, 1799), currently estimated at 19 individuals (Chancellor, Langergraber, Ramirez, Rundus, & Vigilant, 2012), but likely increasing as a result of conservation efforts (R. Chancellor, personal communication, March 11, 2013).

Gishwati Forest is bordered by smallholder subsistence farming on its southern, eastern, and western edges, while grazing land adjoins the northern and northwestern perimeter. Communities farming this land comprise predominantly resettled refugees following the 1994 genocide, in addition to a small number of former forest-dwelling Batwa people. Heightened population pressure in the region, however, continues to exacerbate both human encroachment and crop raiding (M. Nyiratuza, personal communication, July 1, 2009). As a result of this increased pressure on finite resources, reflecting shortages of water and arable land elsewhere in Rwanda (Barakabuye et al., 2007; IRIN, 2009; Plumptre, 2003), there is no formal buffer zone and crops are now grown up to the forest boundary. Recently introduced restrictions on access to forest resources and food security pose severe challenges generally among farmers and their families around Gishwati Forest, as elsewhere in northern Rwanda. Conflict between forest animals and subsistence farmers cultivating adjacent areas of farmland is documented in the literature (e.g., Hill & Wallace, 2012; Riley & Priston, 2010; Strum, 2010). Crop raiding by forest primates around Gishwati Forest adds to the challenges already faced by local farmers. A compensation scheme for damages caused by wildlife has been approved for communities bordering national parks in Rwanda (P. Uwingeli, personal communication, February 18, 2013). However, Gishwati Forest has yet to be gazetted as a national park, and the details of any compensation scheme that might be available to local farmers remain unknown.

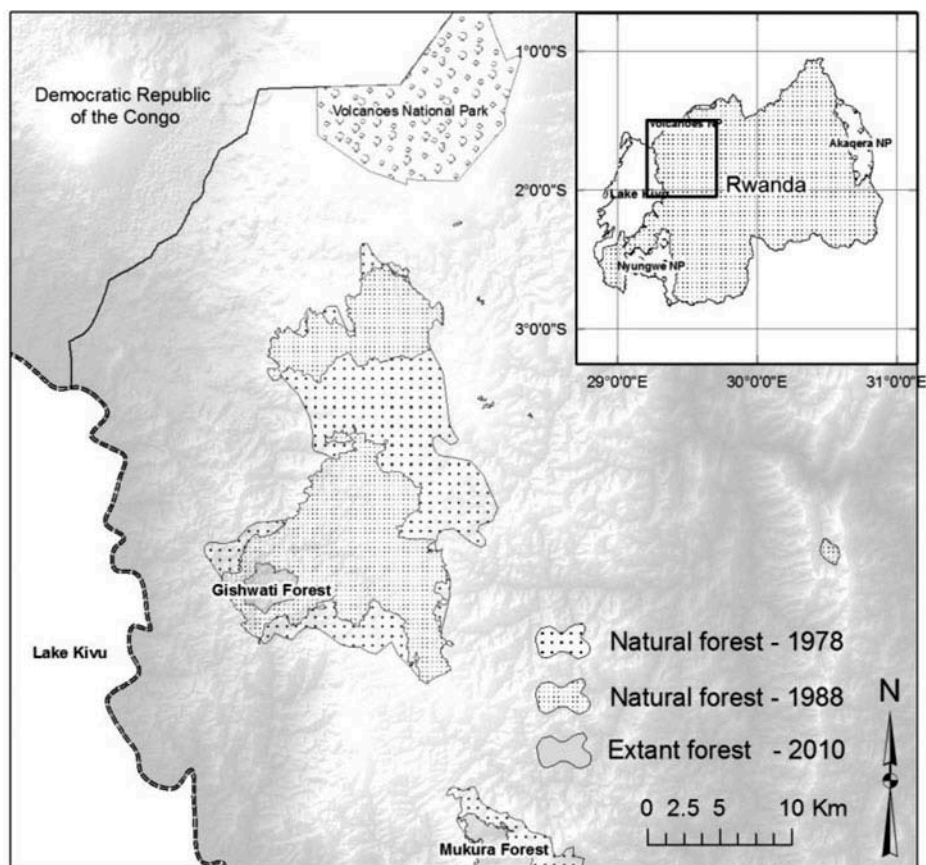


Figure 1. Location map showing decline of moist montane forest in western Rwanda. Note the decline of Gishwati Forest to the current 900 ha fragment. Connectivity between Volcanoes National Park, Gishwati Forest, Mukura Forest and Nyungwe National Park may have been contiguous.

This article assessed the extent and magnitude of the effects of crop raiding by forest-based primates and the success of measures aimed at mitigation, as perceived by subsistence farmers cultivating plots around the margin of Gishwati Forest. The findings highlight the relatively high perceived economic costs and potential food security effects of HWC. Because empirical studies often fail to grasp the social implications of HWC, and perceptions of this conflict often deviate from actual incidence, the objectives of this article were to (a) gain insights into current subsistence farming and the perceived effects of crop raiding by wildlife and (b) to assess current coping strategies adopted, including those advised by conservation organizations. We hoped to advise more socially and ecologically appropriate mitigation efforts in light of food security concerns.

Methods

Semi-structured interviews, conducted around those parts of the southern, eastern, and western perimeter of Gishwati Forest that immediately adjoin cultivated land and concurrent *in situ* observations were designed to elicit information on general farming practices, together with experiences of losses due to foraging by forest-dwelling animals and efforts

to resolve these. Specific questions addressed the remembered incidence of crop raiding on a monthly and seasonal basis and mitigation measures adopted by farmers and their families. Attempts were made to reduce misunderstandings during the interviews, for example due to cultural and language differences, through back-translation of the interview script (Larkin, Dierckx de Casterle, & Schotsmans, 2007; Müller, 2007) and by conducting interviews in Kinyarwanda, the local language. Previously identified sensitivities relating to perceived excessive government control and illegal use of forest resources were also considered in the design and running of interviews, which were carried out by a locally recruited, university-educated research assistant.

According to studies previously carried out elsewhere in the region, primate raiding is unlikely to occur beyond 500 m of the tree-line of conservation areas (Naughton-Treves, 1998; Plumptre, 2002). Gishwati Forest does not host populations of large mammals such as buffalo (*Syncerus caffer* Sparrman, 1779) and elephant, which are often cited as longer-range raiders around protected areas of sub-Saharan Africa (Chiyo & Cochrane, 2005; Hill, 1997; Rose, 2002). Consequently, a decision was made to sample farmers tending plots within 200 m of the forest boundary, as these were assumed to most likely experience losses through crop raiding, as prior consultation revealed that owners of the land, although easier to locate through local administrative lists, may not farm the land or have experience of raiding (M. Nyiratuza, personal communication, July 1, 2009). Those interviewed were encountered in the act of cultivating their land, while the researchers walked along regularly spaced transects of 200 m running perpendicular to the forest edge. As the order in which fields are tended seasonally was not related to location (although it was assumed that plots lying closer to the forest were at greater risk of being raided) selection of respondents was randomly stratified based on distance to the Gishwati boundary.

Field work commenced with a period of familiarization in which the researchers briefed members of the local community on the intentions of the study to allay suspicions and moderate expectations and problems of positionality. Ethical considerations of anonymity, right of refusal, and clarity of outcomes were adhered to, by not recording names or guaranteeing solutions. Data collection was compressed into a four week period due to resource constraints. Although the short duration of data collection in the field is an obvious limitation of the study, the period of fieldwork coincided with high levels of agricultural activity in the study area. As a result, finding farmers in their fields who were willing to be interviewed was not a problem.

Thirty-three interviews were obtained between July and August 2009. Each interview lasted for an average of 25 minutes (range: 14–28 minutes). Respondents were relatively evenly dispersed spatially along the forest boundary. Estimating the proportion of farmsteads sampled, however, was not possible owing to the small, fragmented nature of individual land holdings and complexities over land ownership locally (M. Nyiratuza, personal communication, July 1, 2009). Data were transcribed from recordings and coded, while open-ended responses were cross-referenced where appropriate. These were then triangulated with field notes and follow-up discussions in order to minimize inaccuracies. Responses were coded and aggregated thematically and percentage (%) data were generated from the coded information.

Results

Crops grown within 200 m of the forest margin included maize (*Zea mays* Linnaeus 1753) (37% of plots tilled by interviewed farmers, $n = 33$), potato (*Solanum tuberosum* Linnaeus, 1753) (24%), beans (*Phaseolus vulgaris* Linnaeus, 1753) (16%), peas (*Pisum sativum*

Linnaeus, 1753) (11%), cabbage (*Brassica oleracea* Linnaeus, 1753) (6%), sweet potato (*Ipomoea batatas* (Linnaeus) Lamarck, 1793) (5%), and tree tomato (*Solanum betaceum* Cavanilles, 1800) (1%). Of the cultivated plots sampled within 200 m of the forest, 45.5 % were within 50 m of the boundary. Forty percent of plots immediately adjacent to the forest boundary were planted with maize.

The majority (76%) of interviewees considered themselves subsistence farmers (i.e., not involved in selling their produce at market). Crop raiding was identified as a significant problem around the forest margin, with all 33 respondents interviewed claiming to have lost crops to wildlife raids in the previous year. Neither the claims of raiding incidents nor the magnitude of losses as a result could be verified, though 42% ($n = 14$) of respondents claimed more than half of a given crop could be lost to raiders in a single season. Thirty percent of respondents were willing and able to provide an estimate of annual monetary loss to crop raiding. These estimates varied between farmers, with a mean loss of 51,500 (SD 17,127, i.e., range 34,373–68,627) Rwandan Francs—or ca. 53–105 US\$ (2013 exchange rate). Maize, an important staple locally, was the most frequently (60%) cited crop lost through predation by forest primates. This crop was, however, grown in the same proportions within 50 m of the forest edge as it was farther away, presumably because its importance as a staple food outweighed the risk of losing part of the crop to raiding. Beans were the next most commonly raided crop according to respondents, while the raiding of peas, sweet potato, cabbage and tree tomato, though reported, was much less frequent (9%, 4%, 4% and 2%, respectively). No raiding of potatoes was reported. Of the tuberous crops grown in the study area, sweet potato raiding was limited to scavenging of post-harvest remains.

Chimpanzee and cercopithecine monkeys were perceived as the only species responsible for crop raiding. During interviews, respondents were unable to distinguish between crop raiding events involving the two species of the genus *Cercopithecus* found locally. Thus, in responses “monkey” may refer to either the golden monkey or L’Hoest’s monkey (one of the researchers did however observe L’Hoest’s monkeys raiding legumes during daylight hours). Although all respondents claimed to have experienced crop raiding in the past year, 85% experienced raiding by both chimpanzees and monkeys, while raids by chimpanzee or monkeys separately were experienced by 9% and 6%, respectively. Crop raiding was perceived as occurring exclusively during daylight hours, either in the morning (15%), afternoon (17%), or at any time (68%). According to 67% of respondents, raiding predominantly occurred when crops were at or near maturation. No reference was made during the interviews to losses due to other animals, such as rodents, birds, or insects.

Current mitigation strategies were limited to active guarding, with 96% of respondents claiming to guard crops, usually through the use of children (54%). Of alternative feasible mitigation strategies, such as increased fencing, relocation or removal of problem animals, changing crops to those less palatable or accessible to raiders seemed popular. Fifty-four percent of respondents expressed a willingness to change crops if this would lead to decreased raiding. The remainder were unwilling to modify their farming strategy due to shortcomings in resources and interest. Although community education initiatives run by international conservation nongovernmental organizations (NGOs) encouraged the switch to less susceptible crops, 77% of those willing to change crops had adopted this approach without being advised to do so. Of respondents interviewed, 42% were aware of this education program. A lack of fertilizer (29%), the actions of thieves (35%), and soil erosion (5%) were identified by respondents as additional challenges to farming around Gishwati Forest.

Criticism of local government and of those imposing restrictions on forest access was commonplace and was often manifested as expressed concerns over resource security and involvement in agricultural planning. These concerns were expressed in the context of a clear understanding of the ecosystem services provided by a reasonably intact Gishwati Forest, notably stabilising local climate conditions and moderating the risk of flooding, landslides.

Discussion

Estimated annual replacement costs of food lost to crop raiding by forest-dwelling primates around Gishwati Forest represents a substantial proportion of income, according to a recent baseline study of subsistence farming communities in northern Rwanda that calculated average annual household income to be around US\$540 (Bush, Ikirezi, Daconto, Gray, & Fawcett, 2010). There are problems with the accuracy of the estimate, not least because of the real difficulties that farmers have in quantifying loss (a proportion of which may have been lost in any case, in the absence of crop raiding, through anomalous weather conditions, etc.) but also because an increased awareness of the possibility of compensation for crop raiding losses may have led to inflated estimates (Karanth et al., 2012; Ogra & Badola, 2008). As some types of plants can withstand the attention of crop raiding animals by continuing to yield produce to a farmer (e.g., fruits, seeds, tubers, and timber) (Hockings & Sousa, 2012; Sullivan & Sullivan, 2008; Thapa, 2010), losses due to predation and damage may in part be recovered later in the season. However, even if actual losses to crop raiding are only 50–80% of the estimate, this presents a considerable challenge to families living on the economic and nutritional margins, as it could still account for as much as 10–15% of household income when compared to regional figures (Bush et al., 2010). Losses of maize, an important staple in the study area, are likely to have a disproportionate effect on nutrition, particularly among the most vulnerable.

The claimed preference of forest primates for raiding maize may be related to its higher level of protein, making it a more worthwhile risk (Pérez & Pacheco, 2006; Sukumar, 1989), or because it is the predominant crop grown along the forest boundary. Crop raiding may also be influenced by push factors, such as shortages in the availability of food within the forest or by the behavioral ecologies of individual taxa and individuals therein (e.g., Hoare, 1999). Ongoing research in Gishwati Forest hopes to characterize fruiting tree availability (S. Nyandwi, personal communication, March 10, 2013), which may help explain any seasonal variations in crop raiding (not considered in this research) and provide a basis for anticipatory action in future. Observations around other protected areas harboring populations of chimpanzees found crop damage only in years of reduced forest fruit availability (Tweheyo, Hill, & Obua, 2005). Chimpanzees have even been known to revert to foraging the pith of maize stalks in times of shortages of forest-based food (Wrangham, Conklin-Brittain, & Hunt, 1998), which was also reported in interviews around Gishwati Forest. Conversely, foraging of maize around Kibale National Park, Uganda (Naughton-Treves, Chapman, & Wrangham, 1998) was not found to be related to forest fruit abundance or availability, and was instead opportunistic.

In Gishwati Forest, and in agreement with the results of studies around Volcanoes National Park (A. Plumptre, personal communication, January 12, 2011), agricultural forage could simply be more palatable and therefore a more attractive proposition to crop-raiding animals. The availability of relatively palatable and nutritious food close to the boundary of a forest may be driving behavioral changes in wildlife. This one view of crop raiding in Gishwati Forest is that, as in Bwindi Impenetrable Forest, Uganda (Butynski,

1984), primates that are primarily forest specialists may be becoming less concerned with encountering humans if there is the prospect of being able to access cultivated crops. This may help explain why reports of damage to crops by non-human primates are on the increase, although populations of African primates are static or falling (Tweheyo et al., 2005). An increased awareness of and reduced tolerance toward crop raiding cannot be discounted either. A lack of reports among respondents consulted in the current research of damage due to smaller taxa, including birds, rodents, and insects, is unusual in comparison with other case studies in Africa (e.g., Naughton-Treves, 1998; Nchanji, 2002; Parker & Osborn, 2006). It is unlikely that crops are not being damaged by rodents and other small animals in the study area. This may reflect increased awareness of forest-dwelling primates, in part due to the activities locally of international and national conservation organizations, and the likely selective nature of any scheme to compensate for losses.

Whereas in neighboring Uganda, 15% of farmers within 300 m of the forest edge of Kibale National Park respond to raiders with snares, traps, poison bait, and leaving land fallow, in addition to guarding (Naughton-Treves, 1998), farmers surrounding Gishwati Forest opt for the latter as the sole means of protection, with a proportion adopting crop modification strategies. Insecurities of tenure that are currently evident among the recently settled farmers around Gishwati Forest may preclude investment in more permanent forms of crop protection. Additionally, actively guarding fields also protects against thieves, another commonly cited problem facing farmers in the study area. Although a potentially viable alternative to expensive fencing, switching to less susceptible subsistence crops, such as potatoes, may lead to reduced dietary diversity and hence deepened food insecurity in the future, especially with a steeply increasing population (CIA, 2012; Tweheyo et al., 2005; Vedeld et al., 2012).

The nutritional costs of a reduced diversity of crops grown by subsistence farmers has already emerged among communities surrounding Queen Elizabeth National Park, Uganda, impacted by crop-raiding (Akankwasah, 2008). Additionally, as one respondent in the current research observed, changes in the range and type of food crops grown around Gishwati Forest have the potential to reduce fertility in land surrounding the forest if crops are not rotated. A buffer of unsuitable habitat may reduce raiding due to a lack of ground cover for potential raiders to traverse, although buffers of trees have been known to provide suitable secondary habitat for certain raiders (Hill, 1997). Given the financial constraints preventing subsistence farmers around Gishwati Forest from constructing and maintaining physical barriers and the environmental, technological and market factors restricting the crops they grow, the only viable mitigation strategy would appear to be a modification of farming practices that may involve selection of alternative crops from a relatively narrow range of possibilities. One consequence of this could be that crop choice becomes increasingly dictated in future by the nature of HWC, with potentially detrimental livelihood and health impacts. Further impoverishment of, and food insecurities among, already marginalised people living around the boundaries of forested protected areas in Africa are likely to make conservation of forests on the continent, already highly challenging (Pfeifer et al., 2012), even more difficult. From statements given, animosity between the park and adjacent farming communities is already acute.

Conclusion

Human-wildlife conflict is present around Gishwati Forest in the form of crop raiding and is perceived by locals to be a threat to livelihoods. Crop raiding was found to be predominantly directed at maize and perceived at least to be carried out solely by primates. Reported

losses, although difficult to verify, were relatively high, particularly when compared with overall household incomes. Active guarding by farmers and members of their families was found to be the sole mode of protection from crop raiding around Gishwati Forest. This study highlights the influence HWC can have on farming practices in land bordering fragments of protected forest harboring primates. The results draw attention to the livelihood impacts of HWC, and how these impacts may be deepened as a result of insecure tenure and high population pressures (both human and forest-dwelling primates). Although the current study was limited in extent and seasonal coverage, the results should raise concerns about the future welfare of farming communities and forest-dwelling primates living either side of a protected forest boundary.

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