Effectiveness and Perceptions towards Human-Wildlife Conflict
Physical Deterrents around Volcanoes National Park, Rwanda

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Executive summary
Management of human-wildlife conflicts (HWC) is a central and crosscutting issue in any poverty reduction and socioeconomic development initiatives targeting local communities neighbouring protected areas. A decrease in HWC may have the desirable effect of encouraging the local people to support the conservation goals of the protected area.

In this study, I analyzed data on Geographic coordinates of wildlife raiding events that occurred adjacent VNP attributed with corresponding information on crop type eaten/damaged and the wildlife species that caused the problem. The data were provided by VNP management. The data were collected from February 2013 to February 2014, by a team of 25 assistants recruited from the local community living adjacent the park. The assistants responded to damage claims made by farmers, in addition to walking amongst designated farmland on a minimum of two days per week. The assistants independently corroborated damage claims made by farmers when responded to, by personally assessing damaged crops and used spoor such as tracks, teeth marks, claw marks, hair and dung to identify and record the most likely raiding species. The assistants classified a crop raiding event as damage to a defined plot of cultivated land (usually a standard 40 x 50m plot).

The effectiveness of physical deterrents – a stone wall and reinforcing trench – constructed along the boundary of the park, was also assessed by comparing the quality of the physical deterrents with density of buffalo raid events per square km. In addition, the effectiveness of these physical barriers was evaluated from the perspective of 90 farmers impacted by wildlife in six sectors: Kabatwa, Shingiro, Kinigi, Nyange, Rugarama and Cyanika. The sectors were selected based on levels of past raids.

From the spatial crop-raiding information, a total of 1,638 mammal raid incidents were recorded during the 13-month period. Six large mammal species were identified as raiders. Overall, eleven crop types were damaged. Irish potato was the most raided crop type (77%) and was raided by all examined mammal species. Duikers were the most frequent crop raider in Rugarama sector while the golden monkey was the most frequent raider in Bugeshi, Bigogwe and Jenda. Generally, raids peaked in February, August and September whereas raiding was least frequent in July and
November. The fewest number of raids occurred in months when the potatoes were being planted and harvested because of heightened guarding by the local communities.

Locations where the wall was in good condition and/or where a reinforcement trench was present tended to have fewer incidences of buffalo raids, suggesting that the presence of better quality deterrents reduced buffalo raid frequencies. In addition, the condition of the wall was likely to be significant in terms of its effectiveness in deterring buffaloes.

Ninety community members from six sectors were interviewed. All the respondents had had problems with wildlife damaging their crops. The farmers regarded buffaloes as the most frequent crop raider, caused most crop damage, and the most feared of all the animal raiders considered in this study. Over 90% of respondents considered the physical deterrents to be ineffective or not effective at all. Poor quality of the stone wall and eroding soil that rapidly filled the trench were the primary reasons respondents gave for the ineffectiveness of the defenses, whereas the explanation for the construction of substandard wall included: lack of technical guidance, lack of proper equipment or materials, and contractual obligations that emphasize length of the stone rather than quality. It is noteworthy that the physical defenses lack clear ownership; there are no agreements on the roles and responsibilities of key stakeholders and no mechanisms that ensure sustainability for their maintenance. The majority of the respondents perceived the frequency of animal raids to be increasing, despite the presence of physical defenses, whereas the lack of long term data makes proof of this claim difficult.

Because the physical barriers are limited in their effectiveness against crop-raiding mammals, 76% of respondents used other means to defend their crops.

I made recommendations geared toward better management of human-wildlife conflict around VNP based on field data and community perceptions. The recommendations revolved around having a management strategy/plan in place for the physical deterrents specifying the roles and responsibilities of the key stakeholders and scheduling of construction and/or maintenance activities

In conclusion, crop raiding by mammals continues to be a challenge to the management of VNP. Data collected over a 13-month period suggest that the physical deterrents reduce buffalo raids. However, the quality of the physical barrier is variable with sections that are in poor condition,
and potentially porous providing access for buffalo to raid crops. Local community members concur that the buffalo is the most frequent and widespread mammalian crop raider. However, the perceptions of the people differ from the actual field records regarding the effectiveness of the deterrents. The farmers believe that the barriers are ineffective whereas the crop-raiding data suggest that the barriers are effective where they are in good condition. The mismatch between the crop-raiding data and the perceptions of the farmers may arise from the sense of extreme loss experienced by very poor farmers with small land holdings. When individuals were severely affected by even a few raids, they still remember and focus on those past severe raiding events.

This study shows the importance of spatial temporal data on mammalian crop raiding incidences in evaluating the effectiveness of the physical barriers on reducing crop raids and how the barriers can be sustainably managed.

**Lessons learnt**

1. Actual data on crop raiding incidences, especially if recorded for a long time, are critical in assessing the spatial and temporal patterns and trends of HWC and the effectiveness of the interventions
2. The participation of the local communities in wildlife crop raid data collection and reporting has the potential of making the results acceptable and improving communication between the local communities and park authorities
3. The asymmetrical distribution of incentives from park determines the attitudes of the local communities towards conservation

**Recommendations**

1. An effort should be made to construct a continuous high quality stone wall and reinforcing trench along the margin of the park instead of having short and fragmented high quality sections
2. The incentives given to cooperative societies at sector level will be redirected to those at cell level
3. There is need to have agreements with all the key stakeholders involved in problem animal management
4. Technical guidance should be sought so that dimensions of a standard stone wall are established and followed when constructing and maintaining the wall
5. There is a need for all the key players to design a time-bound management /strategic plan for the deterrents with activities well specified and prioritized

6. The physical deterrents should be mapped using Global Positioning System (GPS) and Geographic Information System (GIS) technology

7. Data collected for SGF compensation claims should be analysed and evaluated on its viability for assessing wildlife raids as its collection seems to be more sustainable compared to how the data for this study was collected
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1. Introduction
Crop damage caused by raiding wildlife is a prevalent form of human-wildlife conflict along most protected area boundaries (Naughton-Trevis 1998). The individual economic losses suffered from crop raiding and other damages caused by wildlife can be relatively high in developing countries because the farmers are poor and rarely compensated for their losses (Sekhar 1998; Rao et al. 2002). Such losses can make communities antagonistic and intolerant towards wildlife, which can result in retribution killing of problem species as well as undermining and impeding conservation strategies (Nyhus, Tilson and Sumianto 2000).

Considering all these issues associated with human-wildlife conflict, reducing the frequency of crop raids by wildlife may substantially reduce human-wildlife conflict to the benefit of conservation efforts.

Volcanoes National Park (VNP), Rwanda, is recognized as a high-priority area for biodiversity conservation. It is part of the Virunga Volcanoes Range, a home to one of the two remaining populations of the endangered mountain gorillas (Gorilla beringei beringei). The growing human population adjacent to VNP and increasing demand for natural resources that are now restricted to the park, has resulted in unsustainable extraction of forest products and intensification of agriculture, leading to conflict between wildlife and people. Human-wildlife conflict is a complex and pervasive problem in Africa and is a major threat to the long-term persistence of wildlife populations. One of the major components of human-wildlife conflict is crop raiding. The damage large mammals like elephants and buffaloes cause is devastating for the individual farmer. Such species can also cause human injuries and fatalities, as well as property damage. As a result, large mammals often elicit fear and anger among the rural communities adjacent to protected areas. Such circumstances can lead farmers to kill any wild animal found outside the park, and otherwise honest people may fail to report illegal activities like poaching.

Over a decade ago, the Rwanda Development Board (RDB) and International Gorilla Conservation Programme (IGCP) as well as other partners supported human-wildlife conflict interventions around VNP using different mitigation measures, the most prominent being the construction of the buffalo/stone wall and reinforcing trench. The stone wall covers almost the entire stretch of the park boundary while the trench is in short, fragmented sections. However,
the effectiveness of these barriers in mitigating human-wildlife conflict around PNV have never been evaluated since they were installed.

2. A brief history of the physical deterrents
The early history of the physical deterrents is summarized by Kalpers et al. (2011). Construction of the stone wall along the perimeter of VNP started in October 2002 and was completed by 2007. The stone wall, sometimes known as the buffalo wall was initially constructed as a boundary marker in a few portions of the park perimeter, but was later modified and extended to act as a deterrent against crop raiding animals, particularly buffaloes. The extension of the wall was completed in phases depending on the changing intensity and location of buffalo raids. The construction of the wall was initially facilitated by IGCP and CARE, and in the initial years there was no or very little maintenance performed on the wall. The first improvement of the wall was done in 2009 with the digging of the trench on the inside of the wall along sections of the boundary that experienced a relatively high frequency of wildlife raids. After 2009, four associations were put in place, each one being in charge of the wall and trench maintenance in the four critical areas (Gahunga, Nyange, Kinigi and Shingiro) where the wild animals were most problematic. Kalpers et al. (2011) observed that the first version of the stone wall appeared to reduce the level of crop-raiding events observed outside the park. However, a few months later, the level of crop-raiding started to increase again. The wall was not maintained, collapsed portions of the wall were not repaired, and buffaloes subsequently found gaps in the wall. As a remedy, a trench was then dug on the park side of the wall and had the desired effect of reducing the level of crop raiding.

Much as there was no strategy for HWC management, the stone wall has undergone a phased approach – first, it was constructed in the most problematic areas of the park boundary, and then progressively extended to the whole perimeter of the park. From a few years ago, the wall has been and is still being upgraded in the most critical sections.

3. Problem statement
Substantial financial resources and time have been invested in the construction and maintenance of human-wildlife interventions, especially the physical barriers, along the VNP boundary. However, very little has been done in terms of monitoring and auditing the outcome and impact
of the various strategies aimed at preventing or mitigating the human-wildlife conflicts around VNP. Intermittent data on HWC exist for some periods of time, but has not been analysed to determine status or trends in wildlife crop raids. In general, there are no indicators to measure on whether the mitigation measures are working or not. Although some data exist, the lack of quantitative analysis of such datasets represents a substantial gap in information needed by park management to make effective decisions. Decision makers require such analyses to properly understand the general trends in distribution, timing, and intensity of raids, the primary species responsible for raids, and to assess what interventions work best. Anecdotes seem to indicate that human-wildlife incidents are generally increasing and spreading, and that current mitigation measures are insufficiently addressing the problems. However, such observations are not backed by quantitative analysis of georeferenced information.

The purpose of this study was to evaluate the effectiveness and the local perceptions of the efficacy of the physical deterrents to wildlife crop raiding adjacent to the VNP. This study explored (1) spatial and temporal patterns of crop raiding by large mammal species and by crop type, (2) the spatial data regarding the density of buffalo raids in relation to the quality of the stone wall and location of the trench, and (3) farmer’s perceptions regarding the effectiveness of the stone wall and trench as a barrier to buffaloes and crop raiding in general.

4. Methods
4.1 Study area
Volcanoes National Park lies in northwestern Rwanda and borders Virunga National Park – Mikeno sector in the DR Congo and Mgahinga National Park in Uganda (Figure 1). The park is known as a haven for the mountain gorilla (*Gorilla beringei beringei*). It is home to five of the eight volcanoes of the Virunga Volcanoes Range (Karisimbi, Biseke, Muhabura, Gahinga and Sabyinyo) which are covered in rainforest and bamboo. Vegetation varies considerably due to the large altitudinal range within the park. There is some lower montane forest (now mainly lost to agriculture). Between 2,400 and 2,500 m, there is *Neoboutonia* forest. From 2,500 to 3,200 m *Sinarundinaria alpina* (bamboo) forest occurs, covering about 30% of the park area. From 2,600 to 3,600 m, mainly on the more humid slopes in the south and west, is *Hagenia-Hypericum* forest, which covers about 30% of the park. This is one of the largest forests of *Hagenia abyssinica*. The vegetation from 3,500 to 4,200 m is characterised by *Lobelia wollastonii*, *L.*
*lanurensis*, and *Senecio erici-rosenii* and covers about 25% of the park. From 4,300 to 4,500 m grassland occurs. Secondary thicket, meadows, marshes, swamps and small lakes also occur.

![Location of the Volcanoes National Park, Rwanda](image-url)
but their total area is relatively small. In addition to the mountain gorilla, the park hosts other mammals including: the golden monkey (*Cercopithecus mitis kandti*), black-fronted duiker (*Cephalophus niger*), buffalo (*Syncerus caffer*), spotted hyena (*Crocuta crocuta*) and bushbuck (*Tragelaphus scriptus*). There are also some elephants in the park, though these are now very rare. There are 178 recorded bird species, with at least 13 species and 16 subspecies endemic to the Albertine Rift. Most of the large mammals pose a problem to park-adjacent farmers as they frequently raid their crops.

4.2 Wildlife raiding events

I got data on Geographic coordinates of wildlife raiding events that occurred adjacent VNP attributed with corresponding information on crop type eaten/damaged and the wildlife species that caused the problem from VNP-RDB. The data were collected from February 2013 to February 2014, by a team of 25 assistants recruited from the local community living adjacent the park. The assistants responded to damage claims made by farmers, in addition to walking amongst designated farmland on a minimum of two days per week. The assistants independently corroborated damage claims made by farmers when responded to, by personally assessing damaged crops and used spoor such as tracks, teeth marks, claw marks, hair and faeces to identify and record the most likely raiding species. The assistants classified each crop raiding event as damage to a defined plot of cultivated land (usually a standard 40 x 50m plot).

4.3 Local community perceptions towards HWC

Six assistants were identified by IGCP staff to interview farmers affected by wildlife crop raids. The assistants came from the sectors where they conducted the interviews. Farmers from six sectors: Kabatwa, Shingiro, Kinigi, Nyange, Rugarama and Cyanika (Figure 2) were interviewed. The six sectors were selected by IGCP/VNP staff based on perceived information that Shingiro, Kinigi and Nyange sectors experienced the most severe/frequent crop raids and were referred to as critical zones by park management, while Kabatwa, Rugarama and Cyanika sectors were believed to experience moderate to low wildlife crop raids. To identify interviewees within each sector, we randomly selected one cell, the smallest unit of government administration, immediately adjacent to the park boundary and then randomly selected 15 farmers from the cell resident lists held by cell leaders. To be minimally eligible for the survey, an individual had to have a plot of farmland within at least 250 m of the park boundary. This
screening procedure was intended to ensure that the selected interviewees were affected by HWC and had first hand knowledge about the physical deterrents.

In total, I interviewed 90 affected local farmers from the six sectors.

I also held discussions with key players in HWC physical barrier management - IGCP staff, VNP staff, and about 20 members of Kaiki Cooperative.

**4.4 Validation of the results**

Preliminary results of this study were presented to and discussed with about 30 representatives of local communities in sectors from the six sectors where the interviews were conducted and other key stakeholders in physical deterrent management at a one day validation workshop held in Musanze town in November 2015.
4.4 Data analysis

4.4.1 Wildlife raid data
I defined a wildlife raid event following McGuinness (2014) as a raid that occurred in a distinct plot of cultivated land (usually a standard 40 x 50m plot) per night or day. Raid frequencies were computed for all the wildlife species combined per month, each wildlife species per month and raids on each crop type per month. Raid frequency in each sector was adjusted for park-boundary length in each sector while raid frequency for each month was weighted by the number of days in the particular month to get the daily crop raiding frequency. I conducted a multiple ANOVA to compare how the frequency of wildlife raids on each crop type varied among months and how the frequency of wildlife raids in each sector varied among months. A Bonferroni-Holm Adjustment (Zuur et al. 2007) was used to correct for the increased probability of Type I error (rejecting a null hypothesis when it is true) based simply on chance when numerous comparisons made within the same dataset. Spearman’s rank correlation coefficient ($r_s$) was calculated to determine whether there was a relationship between monthly crop-raiding frequency and monthly rainfall patterns including same-month rainfall as well as one- and two-month lag periods for rainfall. Such correlations were calculated for each wildlife species individually and all wildlife species combined and on each crop type.

All statistical tests were performed using R open source statistical software version 3.2.1 (R Core Team 2015). Spatial data on raiding events per animal species were mapped using ArcGIS v.9.3 GIS software (ESRI Inc., Redlands, CA, USA).

4.4.2 Questionnaire data
Percent of the respondents for each potential response to every question were calculated and analysed.

5. Results

5.1 Wildlife crop-raiding events by crop type
A total of 1,638 crop-raiding events were recorded along the boundary of VNP for a period of 13 months from February 2013 to February 2014. Eleven crop types were affected and six large mammal species identified as raiders (Table 1). Buffalo raiding events were the most common
(58.7%), followed by those of golden monkeys (22.7%). Irish potato was the most raided crop (76.9% of all the raiding events), and was raided by all the six large mammals considered. However, buffaloes raided Irish potatoes more than any other wildlife species (58.6% of the potato raiding events). With the exception of mountain gorillas, all the other mammal species raided Irish potatoes more than any other crop. Pyrethrum and eucalyptus were raided mostly by buffaloes and mountain gorillas, respectively. Only an incidental number of crop raid events by wildlife affected millet, maize, peas, beans, bamboo, cabbage, sorghum, and tomatoes (Table 1). There were a few incidences of non-crop destruction like the trampling of empty fields by golden monkeys and were therefore removed from subsequent analyses.

Table 1 Wildlife raiding events observed from February 2013 to February 2014 in areas adjacent Volcanoes National Park, Rwanda

<table>
<thead>
<tr>
<th>Animal raider</th>
<th>Buffalo</th>
<th>Golden monkey</th>
<th>Mountain gorilla</th>
<th>Duiker</th>
<th>Porcupine</th>
<th>Elephant</th>
<th>All mammal species raids combined by crop and non-crop type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td>739</td>
<td>324</td>
<td>35</td>
<td>99</td>
<td>61</td>
<td>2</td>
<td>1,260</td>
</tr>
<tr>
<td>Pyrethrum</td>
<td>118</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>131</td>
</tr>
<tr>
<td>Millet</td>
<td>48</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>53</td>
</tr>
<tr>
<td>Maize</td>
<td>28</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>37</td>
</tr>
<tr>
<td>Peas</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Beans</td>
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<td>0</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Bamboo</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Cabbage</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Sorghum</td>
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<td>0</td>
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<td>Tomato</td>
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<tr>
<td><strong>Non-crops</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trampling</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Injury to people</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>All raids by mammal species combined and individually</strong></td>
<td><strong>961</strong></td>
<td><strong>372</strong></td>
<td><strong>118</strong></td>
<td><strong>114</strong></td>
<td><strong>67</strong></td>
<td><strong>6</strong></td>
<td><strong>1,638</strong></td>
</tr>
</tbody>
</table>
5.2 Spatial variation of animal raiding events

The number of raiding events for all the 13 months per sector adjusted for length of park-adjacent perimeter of the VNP boundary is shown in Figure 3. Sectors found with a relatively high frequency of crop raids included Bigogwe, Kabatwa and Jenda in that order.

Buffalo raids were the most widespread occurring in 11 out of the 12 sectors bordering VNP. However, there were noticeable areas with very few or no raids within Kinigi Sector (Figure 4). Other wide spread raiders were the golden monkey that raided in nine sectors but the raids were mainly concentrated in the western sectors with few in the central sectors and virtually none in the eastern sectors (Figure 5). The golden monkey was the only large mammal that raided fields in the Mukamira sector. Mukamira sector, though a short distance from the park edge, is not directly contiguous with the park boundary. Porcupine raids occurred in six sectors located in the extreme west and east sectors with virtually no raid in the central sectors (Figure 6). Elephant, mountain gorilla and duiker raids were restricted to a few sectors (Figures 7, 8, and 9). Elephant raids were very few and highly localized in the central sectors, gorilla raids were also mostly in the central sectors but occurred in a few more sectors than those of elephants, while raids by the duiker were clustered in the two eastern-most sectors of Rugarama and Cyanika.
Gahunga was the only sector that was raided by all the six large mammal raiders. The reason for this was not clear but could perhaps be related to the distribution of large mammals within the park.

Figure 4 Crop raiding locations of buffaloes in areas adjacent Volcanoes National Park, Rwanda
Figure 5 Crop raiding locations of golden monkeys in areas adjacent Volcanoes National Park, Rwanda

Figure 6 Crop-raiding locations of porcupines in areas adjacent Volcanoes National Park Rwanda
Figure 7 Crop-raiding locations of elephants in areas adjacent Volcanoes National Park, Rwanda

Figure 8 Crop raiding locations by duikers in areas adjacent Volcanoes National Park, Rwanda
Figure 10 depicts the frequency of crop raids per sector (adjusted for park-boundary length) by each of the considered wildlife species. Buffalo raids dominated in most sectors except Bugeshi, Bigogwe and Jenda sectors where the most frequent raider was the golden monkey and Rugarama sector where it was the duiker. It was only Gahunga sector that was raided by all the wildlife species. This indicates spatial variation in wildlife species raids.
When the spatial variation in wildlife crop raids was summarized by crop type, Irish potato was the most widely raided of all the crop types in all the sectors (Figure 11).
5.4 Temporal variation of crop-raiding events by wildlife

Examination of the monthly raiding frequency for the combined six wildlife species showed that raids peaked in February, August and September (Figure 12). The fewest raids occurred in June and July as well as from October to December. However, no month passed without a mammalian crop-raid event.

![Temporal crop raiding patterns for all crop types and all the large mammals combined adjacent Volcanoes National Park, Rwanda](image)

As for individual crop-raider species, only the buffaloes and duikers raided in all 13 months examined and these species were the most frequent raiders every month (Figure 13). Golden monkeys and porcupines crop raided in 12 of 13 months. Elephant crop raids were the least and were recorded as a problem in only 3 of 13 months.
There was no correlation between monthly crop raiding frequency for each individual raider species and when all raiders are combined with average monthly rainfall, even when one- and two-month time lags were considered. However, there was a very strong correlation between crop raids by golden monkeys that incorporated a two-month lag period meaning that there were more golden monkey raids two months after heavy rainfall (p<0.001). When seasonality (short/long dry season and short/long wet season) was taken into consideration, there was no still correlation between the frequency of raids of all species combined and each individual species with rainfall. This implies the frequency of raid events was not determined by rainfall.

The raiding frequency of each animal species among the months was not significantly different except for the elephant (ANOVA Adjusted p-value = 1.656e-15) which raided only in the months of March, June and July.

5.5 Temporal variation of raiding events by crop type
Irish potatoes were the most raided crop in all the 13 months (Figure 14). Eucalyptus and pyrethrum were also frequently raided (10 and 11 out of 13 months, respectively). But the raid frequency on each of these crops every month was not related to monthly rainfall.
Of the different crop types eaten by all wildlife species combined, only the frequency of raiding per month on millet and maize crops (with a two-month lag period) showed a high correlation with rainfall, with more raids occurring after two months of heavy rainfall ($p<0.05$).

The raiding frequency on each crop type did not significantly differ among the months except for the pyrethrum and millet (ANOVA Adjusted $p$-value <0.001) which were raided most in the months of May and August for the former and March for the latter. This could imply that they are eaten by wildlife at or near their mature stage.

5.6 Spatial-temporal variation in crop raiding events
Wildlife raids were generally frequent throughout the 13 months in all the sectors around VNP. However, Rugarama was the only sector that was raided in all 13 months. The least raided sector was Gataraga, where raids occurred in seven months of the 13 months. The raiding frequency per month for the combined wildlife raider species in each sectors did not significantly differ among the months except for Cyanika (ANOVA $p<0.001$) with the highest number of raids in the sector being in October.
6. Physical deterrents

6.1 Location and quality
In a 2012 survey of these physical deterrents, McGuinness (2014) reported that the quality of the wall varied from no discernible wall in localized areas of the western and eastern extremities, to double-thickness wall in more central areas (Figure 15). Moreover, a portion of the boundary bordering the Democratic Republic of Congo (DRC) lacked any form of barrier. Eastern regions had poor quality wall that were either at waist height or below. As shown in Figure 15, in some areas, the wall was combined with a 1x1-m trench on the park side of the wall. There has been some improvements made on the barriers since 2012 but they were not mapped, therefore the park lacks an up-to-date digital map of the quality and location of the physical deterrents.

![Figure 15 Variation in the quality of the stone wall and location of the trenches along the boundary of Volcanoes National Park, Rwanda (McGuiness 2014)](image)

6.2 Effectiveness of the physical deterrents against buffaloes
The density of all buffalo raid incidences between February 2013 and February 2014 inclusive was calculated using the Spatial Analyst tool of ArcGIS 9.3 (Figure 16). A visual comparison of the calculated density of buffalo raiding incidences and quality of the physical deterrents in
Figure 15 was made. Only buffalo raids were used in this analysis as the physical deterrents were constructed mainly to deter buffaloes, from leaving the park. Areas with high quality deterrents appeared to have a lower density of buffalo raids than areas with poor quality barriers. This is especially true in locations where the stone wall is of good quality and is reinforced with a trench. However, lack of an up-to-date digital map of the deterrents precluded the application of more rigorous analyses to determine the efficacy of the physical deterrents.

![Map of Volcanoes National Park, Rwanda](image)

**Figure 16 Density of all buffalo raid events along the boundary of Volcanoes National Park, Rwanda**

### 7. Local perceptions on the effectiveness of the physical deterrents

#### 7.1 Socio-demographic profile of the respondents and focus group discussion

A total of 90 respondents were approached for an interview and all willingly accepted to be interviewed. The majority of the household heads interviewed were male (69%). However, females comprised a substantial proportion of the respondents (31%). The age range of the respondents was from slightly below 30 years to above 60 years with most (36%) of the respondents being between 30 and 39 years old. Approximately 91% of the respondents were married, 7% widowed and 2% single. The average household size of the respondents was 5.4
members (range 1 – 13). Cultivation of land was the most important livelihood/income-generating activity for the majority (83%) of respondents. Only 10% of the respondents were dependent on paid labour. Approximately 60% of the respondents owned one to three plots of land (standard area of a plot is 40 × 50 m), 24% owned 4 to 6 plots of land, and 16% owned more than six plots of land. Fifty-four percent of the respondents had one plot of land near (<250 m) the park boundary, 24% had two plots near the park and the remaining 22% had three or more plots near the park. The plots of land owned by each farmer interviewed were not contiguous but fragmented.

A focus group discussion was held with about 20 members of the Kaiki cooperative, which has been in existence since 2001. This is a group of former poachers that organized themselves into a cooperative. The cooperative has adopted many more members who were never poachers. All the members are subsistence farmers. The cooperative is registered with RDB as a park partner in order to get incentives for their members who benefit from park related projects. The members of the cooperative primarily work in areas within the park that are adjacent to Kinigi sector.

7.2 Views towards wildlife crop raider species
All the respondents reported problems with wild animals originating from the park in the past one year. All the respondents reported their crops as having been eaten or damaged by wildlife. One respondent had a family member injured by wildlife, 14% of respondents reported their livestock injured by wildlife with buffaloes and elephants identified as the primary culprits. Forty one percent of the respondents had their empty agricultural fields trampled, making the soil compact and difficult to cultivate and thus becoming more susceptible to water erosion and 22% had their physical properties damaged. Generally, buffaloes were regarded by respondents as the most destructive animal to crops (88.8%), most frequent raider (43.9%), and most feared (64.6%). However, in Shingiro and Kabatwa sectors, the golden monkey was ranked as the most frequent crop raider whereas in Rugarama, it was the duiker. The views expressed by farmers were similar to those of cooperative members except on the issue of problem mountain gorillas. When the gorillas come out of the park, community members were supposed to report to park management for action. But the cooperative members complained that the gorillas normally come to community land late in the evening when park staff are off duty. Therefore, community members find themselves watching the gorillas as they forage on crops, particularly when
damaging eucalyptus trees. They expressed the need to be trained by RDB on how to handle gorillas when out of the park.

Farmers were asked to rank all causes of crop loss that they had experienced on a scale of 1-6 to determine the degree to which farmers consider crop damage by wildlife as a significant cause of loss. Farmers were given a multiple-choice set of answers: drought, insect pests, plant diseases, wildlife, poor soils and soil erosion. These causes were grouped according to farmers’ perception as: a) cause greatest loss, b) cause moderate loss, and c) cause least loss. Each category of perception was analysed by scoring the cause of crop damage. Farmers scored crop damage by wildlife to be the greatest in comparison to other causes of crop loss (Figure 17).

![Figure 17 Farmer’s responses regarding the main causes of field crop losses adjacent Volcanoes National Park, Rwanda](image)

**7.3 Attitudes towards the physical barriers**

Of the 90 respondents, 92% were aware of the presence of the physical barriers (stone wall and trench) along the margins of VNP. Of those aware of the physical barriers (n=83), approximately 88% knew the stone wall was intended to deter buffaloes. Sixty four percent of the respondents regarded the barriers to be of limited effectiveness while 31% of the respondents considered the barriers not to be effective at all. Farmers reported that the physical deterrents are less effective for several reasons. First, the mountains have some areas being rocky as a result of the lava flows. It is very difficult to dig a trench in these areas and there is need to break the rock in order
to make a foundation for the stone wall. If the stone wall was constructed on top of the rock, it would be easily knocked down by buffaloes. Some locations have gullies or waterways where it is impossible to construct a deterrent like a trench or a stone wall but where wildlife are able to cross into community fields. The cooperative members, in their assessment, thought 75% of the wall length was strong while 25% was weak and not effective.

Because the barriers were limited in their effectiveness against crop-raiding wildlife, some farmers said they used other methods to protect their crops. Seventy seven percent guard their fields during the day or at night depending on which species they anticipate to raid their gardens, whereas 17% made fences out of tree poles and wire around their gardens. Guarding was intended to deter all wildlife species whereas fences were constructed to prevent buffaloes. Of the respondents that guard (n=69), 67% considered guarding to be of limited effectiveness; whereas 30% thought that guarding was not effective. This was because the buffaloes were many, came out of the park mainly at night yet guarding at that time was done by a few people. Of the respondents that make fences around their fields (n=11), 55% percent perceived the fences to have limited effectiveness, whereas the remainder viewed the fences as not effective at all. This was because the fences are not strong enough for some animals like buffaloes and the golden monkeys can climb the fences.

Ninety-two percent of all respondents (n=90) participated in the construction of the physical deterrents while only 78% were engaged in the maintenance of these barriers. The reasons provided for not participating in construction and/or maintenance varied. Some respondents thought maintenance was the responsibility of RDB and members of the cooperative, while others thought is a waste of time since the deterrents were ineffective. Some respondents stated that the cell leaders do not communicate to and mobilize the community sufficiently, and therefore the respondents were not aware of when work on the wall/trench was planned.

Respondents also mentioned misunderstandings among the community members as some were ready to work on the deterrents while others were not.

Seventy-six percent of the respondents were not aware of any agreement between the park and/or local authorities specifying their role and responsibilities on construction and maintenance of the physical deterrents. The few who understood there was an agreement still had only a vague idea of what their role and responsibilities were. Some confused the monthly community work that
they participate in, known as *Umuganda*, with their responsibility to maintain the wall, because in some months, community work is devoted to maintaining the physical deterrents.

The respondents reported various challenges to wall construction and maintenance. Some respondents reported lack of materials and equipment, some expected to be paid for the work done, and others said there was insufficient supervision such that the workmanship was sometimes substandard. A few respondents reported the need for technical assistance so that they could learn how to build better structures and to be insured in case of injury.

Eighty-six percent of the respondents (n=90) felt it was their role to construct/maintain the deterrents and reported a willingness to do so. The minority (14%) who considered it not their role to construct/maintain the physical deterrents stated that such work should be done by RDB/Government or the cooperative because those entities receive revenue from the park. Fifty-nine percent of the respondents said they receive assistance in the form of payments from RDB, conservation NGOs and cooperatives like Sabyinyo Community Livelihoods Association (SACOLA) for work they do on the physical deterrents. Local leaders at cell level do not mobilize their communities for work on the physical deterrents since they think the cooperatives, which are contracted by RDB, are the ones responsible.

There was general lack of consensus of who is in-charge of the stone wall. As regards proper maintenance of the deterrents, 29% of respondents considered RDB to be the responsible party, 23% stated that it was the responsibility of the cooperatives, whereas 19% viewed it as a joint responsibility between cell leaders and RDB. Seventeen percent of respondents considered the farmers themselves as responsible for maintaining the stone wall. However, the cooperative members claimed to have designated roles and responsibilities in relation to park management although they had no agreement with RDB. Their roles include, but were not limited to, assisting park staff with law enforcement patrols, sensitising their fellow community members on conservation issues and participating in stone-wall and trench construction and maintenance.

The cooperative members got incentives from the park like income generating activities and tenders from RDB for specific activities like constructing and maintaining the stone wall and trenches. For stone wall and trench maintenance, they are paid from the 30% of the revenue-sharing funds that were specifically dedicated to human-wildlife conflict management. However,
the cooperative members considered the funds to be inadequate for building and maintaining a standard quality stone wall. In the most recent financial year (2014/15) they received 1.3 million RFW. However, because the society has a performance contract with RDB, the cooperative had fulfilled the contractual obligation of maintaining six km of stone wall even if the funding is inadequate to build a functional deterrent.

The majority of respondents reported no change/improvements in the physical deterrents since the initial construction, and 40% reported the opposite (Figure 18).

![Figure 18: Perceptions of the farmers on changes made on the physical deterrents since they were installed along the boundary of Volcanoes National Park, Rwanda](image)

Surprisingly, 72% of the respondents perceived the level of crop raiding by wildlife from the park to be higher than before the physical deterrents were installed, whereas only 20% and 8% thought there was no change or lower levels of crop raiding, respectively, than before the physical deterrents were installed.

However, the cooperative members felt that buffalo raids had declined, especially in locations where there was a stone wall reinforced by a trench.

The respondents suggested that the stone wall needs to be made stronger by using cement and wire mesh and by increasing its height and width. Also, construction of an electric fence was suggested for those wildlife species not deterred by the stone wall and trench.
7.4 Record keeping of HWC incidences

The park was collecting data on HWC events in a non-systematic, irregular way, with only part of the data being geo-referenced, and data was collected only in “critical” zones, was therefore not representative of HWC around VNP (McGuinness 2014). In 2012, Dr Shane McGuinness, together with park management, initiated a more systematic data collection process that involved the use of GPS and a simplified data sheet (Appendix 1) for recording HWC incidences all around the park by 25 field assistants. This was the HWC data that was analyzed for this study. The assistants were selected by the umbrella cooperative Animateurs de Conservatour (ANICO) in cooperation with park management. The field assistants were trained in the use of a GPS and crop raid data collection by Dr McGuinness. The field assistants were split into two groups with each group having one supervisor recruited by ANICO. The supervisors were remunerated with payments through park revenue sharing to cover HWC responsibilities while the assistants were paid an ‘incentive’ for data collection cost-shared between RDB and Dr McGuinness under agreement (McGuinness 2014). I was told by park staff that the incentive paid to the assistants was stopped but did not give the exact time when it was done. However, the HWC data exist up to December 2014. However, there were serious quality issues for HWC data collected between March 2014 and December 2014. The raid events seemed to be unrealistically few and were therefore not included in analysis for this report. Also, the park management reports I received had data summarized up to March 2014.

7.5 Sustainability of the physical deterrents

There have been attempts by RDB to transfer ownership of the physical deterrents to the local communities that border the park. In a few areas, park staff reported that the cooperatives had done well in the maintenance of the stone wall. But park staff had a challenge of working with the cooperative members as some of the members do not own fields near the park so they are least affected by animal crop raids. In such cases there is lack of consensus in building/maintaining the deterrents especially when there are no financial incentives.

Another complication facing park management is that of the physical deterrents that must constructed across international borders. The Protected Area authorities in the three countries of Rwanda, DR Congo and Uganda need to consult other government agencies before constructing any structure across an international boundary. For example, there is a stone wall on the eastern
side of VNP in Cyanika Sector, but with no adjoining wall on the Ugandan side, so that wildlife can use that gap to raid crops on either side of the border. In contrast, the western region of the VNP has a wall adjoined by a trench on the DR Congo side. However, in times of insecurity, the trench in DRC was not maintained, thereby allowing wildlife to raid crops.

8. Discussion

8.1 Animal raiding incidences and effectiveness of the defences
This study represents an important step in understanding of crop raids by wildlife, based on actual crop raiding data and farmer perceptions. Except for McGuinness (2014), all the previous studies on crop raiding (RRAM 1987; Plumptre et al. 2002; Kalpers et al. 2011) relied only on farmers and/or park managers perceptions. This study quantified the actual spatial and temporal patterns of crop-raiding of the different large mammal species around VNP. Spatial and temporal analysis of crop raiding incidents revealed considerable variability among the wildlife species. Buffalo raiding incidences were relatively evenly spread among the farms on the edge of the park, while those of other species like the elephant and golden monkey appeared clumped and those of porcupines and duikers were highly localised. Majority of the raiding incidences for all the wildlife species combined were confined to a narrow band of farms lying within one km of the park boundary with few incidences of wildlife going deeper into villages. This tight relationship between crop raids and distance from the forest has been reported at other protected forest sites where parks are surrounded by dense agricultural settlement, such as Kibale National Park in Uganda, where majority of the damage occurred within 160 m of forest edge (Naughton-Trevis 1997). This is because of the dense population of people (300-600 persons/km²) living near the edge of VNP. It has been noted elsewhere in Africa that densely settled band of farms forms the best barrier to wildlife incursions deep into agricultural land (Hill 1997; Naughton-Treves 2001) and the animal raiders need for a forest refuge near (Linkie et al. 2007).

The Irish potato was the most raided crop type both spatially and temporally. It was the only crop that was raided heavily raided by all the animal species with the exception of mountain gorillas which preferentially damaged eucalyptus tree bark. Irish potato was the most raided crop type most probably because it is widely, and abundantly grown throughout the year around the park and was therefore readily available than being preferred to other crops by raiding animals. Lack
of cropping data for the study area makes it impossible to prove whether the potatoes are preferred or they are raided because of availability. However, Irish potatoes are very significant as a staple food and cash crop for the people of northern Rwanda so that it generally cultivated all year round though most of the planting takes place in June, July and November while most of the gardens are harvested in April and October. These months coincide with the lowest frequency of all animal raids combined most likely because of intensified and collective guarding during the Irish potato planting and harvesting seasons (Kalpers et al. 2011). Eucalyptus and pyrethrum are also frequently raided because they are perennial crops. Other crops are raided for a few months because they have a short growing period and are seasonally planted. Livestock and human injury/death due to wildlife were uncommon during this study.

Ranking of mammal species raiding frequencies from actual field data corresponded with those of the farmers interviewed. Buffaloes were regarded as the most frequent raiders temporally and spatially except for Bigogwe and Rugarama sectors where the most frequent raiders were the golden monkeys and duikers respectively. Historically, both the buffalo and the duiker have been regarded as the most regular raider animals (RRAM 1987; Plumptre et al. 2002). But in 1984, the elephants were among the most frequent raiders, next to the buffalo (RRAM 1987). However, elephants were never mentioned by local communities in the 1996 survey (Plumptre et al. 2002). Even though there was a reported small increase in elephant raids in 2010 (Kalpers et al. 2011), there were still very few elephant raids in 2012 (McGuiness 2014) and 2013 (this study). This indicates probably a very low population of elephants remaining in the Virunga Volcanoes massif.

There have been changes in composition of animal raider species over time. Non-human primates, especially the golden monkeys and mountain gorillas, started being a problem only recently, about eight years ago, when they begun straying into community fields more often and spending more time on community land debarking eucalyptus trees and destroying crops. The reason for this sudden change in the behavior of mainly habituated non-human primates is still not well known but it is hypothesized to be either the habituated groups escaping confrontation with the growing number of non-human primate groups, as a result of expanded foraging patterns and the readily available food source of community gardens, or due to a loss of fear of
humans (Ndagijimana DFGF pers comm. 2012). The golden monkey is now the second most frequent raider overall after buffaloes but in some sectors like Bugeshi, Kabatwa, Bigogwe, and Jenda it is the most frequent crop raider.

In 2012 there was significant variation in the quality of the stone wall, with the central sectors having high quality wall (McGuinness 2014). From the animal crop raiding data collected a year later for over 13 months, they seem to be a strong relationship, at least visually, between high quality defences and lower buffalo raids. This shows that the physical deterrents could be having a positive impact on reducing buffalo raiding incidences especially in areas where it is reinforced by a trench. It must be stated that this analysis is not conclusive on the effectiveness of the wall and trench as it is highly qualitative and not robust enough.

8.2 Local people perceptions towards animal crop raiding and the physical deterrents

The local people interviewed were mainly subsistence farmers and a considerable number had at least one plot of land near (<250m) the park. As the farmers are reliant on crops for their livelihood, they were very concerned about crop raiding by wildlife from the park. The buffalo was still considered the major raider as was the case before (RRAM 1987; Plumptre 2002; McGuinness 2014).

Although no single deterrent is effective against all animals, a combined option of the stone wall and a trench work reasonably well against buffaloes, an animal that has been and is still the most frequent and widespread crop raider along the margin of VNP. However, the physical deterrents along the VNP margin were largely regarded by the local people as having very limited success or not effective at all. Even with buffaloes, there was limited effectiveness in the minds of the local people. The reasons given by the local people for the limited success were diverse. Technically, there are some areas where the interventions cannot be constructed. These include the rocky places that are hard to break with human labour and locations with gullies and waterways that run longitudinally on the mountains. Such places where the wall and/or trench are difficult to construct provide gaps which buffaloes use to come out of the park. The local people also judged the physical deterrents to be inadequate at some sites. The stone wall was regarded as weak, and not of standard height and width, so that in some sections, it is easily
pushed or can be jumped over by buffaloes. The sides of the trench easily crumble and refill the trench and they are quickly filled with debris and overgrown with vegetation rendering them ineffective. This makes the trenches labour intensive as they require to be maintained regularly. Local people expressed the need for technical guidance and external expertise on how to build a strong wall as they still relied on traditional technology of just heaping stones on top of each other. During the meetings and interviews, farmers repeatedly drew the analogy of how the banks of roads in Rwanda were constructed with stone, cement and wire mesh to prevent erosion in areas with very steep slopes. They also complained of lack of adequate and proper equipment like pick axes and shovels to use in construction of the wall and trench. In some locations, materials like the stones are not readily available. This requires that the materials be manually ferried from a distance which is not feasible. Other traditional deterrent options used by farmers like guarding, lighting fires, making noise and fencing of fields were considered only partially effective and in some cases exacting high social costs. The fact that there are still being used reflects either the farmer’s perception of their effectiveness against animal crop raids or lack of alternative methods.

The physical deterrents need regular maintenance but more importantly require cooperative shared responsibility as they cannot be constructed or maintained by an individual. Communities adjacent the park clearly differed in their ability and willingness to implement and maintain the physical deterrents. For example, the local people in cells in Kinigi and Nyange sectors seem not to be active in maintaining the deterrents inspite having MoUs to do so with SACOLA cooperative. Disagreements and/or distrust among the community members came out strongly during the interviews as the reason why some community members shy away from participating in construction and maintenance of the deterrents. Unequal landholdings contribute to lack of cohesion among the community members. Some people have most of their land holdings near the park boundary and are directly affected by problem wildlife. Those with more land far away from the park boundary are least affected, therefore lack the incentive to participate in the interventions that protect crops grown that are not their own. Also, the use of cooperatives to maintain the interventions is a disincentive to some community members that are not members but are affected by wildlife raids. Some members of the cooperative come from locations that are a distance from the park boundary and are therefore least affected by wildlife animals. Their main aim of participating in the interventions is to get paid or other incentives from the park.
Community members who are from locations near the park and are affected by problem animals are expected to work with the cooperative members but without any direct incentives. The expected benefit to the former was the reduced crop raids. However, this creates disharmony among the local people. Also, the local people around the park still rely heavily on natural resources for their livelihood (Plumptre et al. 2004), so that maintaining access to the park for resources like water could also explain the retention or creation of gaps in the stone wall (McGuiness 2014).

The local people judged the available resources to be inadequate to address the quality issues concerning the stone wall. Currently, RDB emphasize more on quantified targets rather than quality in the contractual agreements for stone wall and trench construction and maintenance. For example, the Kaiki cooperative had a contractual obligation with RDB to maintain six km of the stone fence last financial year (2014/15). Yet, the funds availed to them were not adequate to construct a standard height and width wall for the contracted length. This resulted in the construction of a substandard wall in order to fulfill the contractual obligation.

Farmer’s perception of the effectiveness of the physical deterrents was that they are largely not effective against crop raiding animals. This contrasts with finding of the actual crop raiding data which show that areas with high quality physical deterrents have fewer animal raids. The unexpected finding of this study was that a vast majority of the local people around the park perceive crop raiding to be higher compared to before the physical deterrents were constructed. Lack of time series crop raiding incidence data makes it hard to prove or disapprove this claim. This perceived ineffectiveness of the deterrents and increase in raids by farmers could be due to a concomitant rise in abundance of the animals in the park or the emergence of new species of animal raiders like the golden monkey and mountain gorillas that were not reported in previous HWC surveys (RRAM 1987; Plumptre 2002). However, these responses could also be more as a result of frustration and resentment against the park because of crop losses to wildlife rather than a real fact (Aluma et al. 1989). A 1996 study of crop-raiding around Volcanoes, Rwanda, showed that animals rarely move further than 100 m forest edge, although occasionally they can move up to 1 km but a questionnaire survey carried out showed that people complained about raiding up to 3 km from the park (Plumptre et al. 2004). Traditionally, African people living around forests balanced crop losses to mammals with bush meat gains by trapping or hunting.
animals in and around their fields (Naughton-Treves 2001). Plumptre (2002) found that in 1996 a reasonably large percentage (28.7%) of the local people around VNP admitted to killing animals, especially bushbuck and buffalo, that venture out of the park into their fields, and more people admitted to doing so (37.4%) near the eastern half of the park. This coping strategy is longer practiced as hunting of wildlife is prohibited by current wildlife laws. During the meetings and interviews, there was consensus that the local defensive mechanisms are curtailed by government ownership of wildlife. This leads to widespread belief that the government is responsible for the problem and should either help guard, cull animals, build a fence or compensate the local farmers for the crop losses.

However, farmer’s perceptions on the effectiveness of the physical deterrents differ considerably from those of the cooperative members and other government officials. During the FGD with Kaiki cooperative members, they affirmed that the physical deterrents significantly reduce animal crop raids. It is probable that those who get direct incentives in the construction/maintenance of the physical deterrents were more likely to present a positive view of the physical barriers. The cooperative members, who gained something extra, in addition to reduced raids, were more likely to sustain the viability of the deterrents. During the validation workshop more evidence on effectiveness of the physical deterrents was brought up.

Fewer SGF compensation claims are being received, an indicator that the wildlife raids were decreasing (Kabatwa sector Agronomist). However, fewer reports of wildlife raids could also be attributed to the negative attitude of the farmers towards the compensation scheme because they get less money than claimed and the compensation process is highly bureaucratic, as it takes long to get even the little money that is approved (Representative Shingiro sector).

Before the deterrents were put in place, the farmers had abandoned cultivating in areas adjacent the park. But now people cultivate up to the park boundary, indicating less raids (Kinigi cooperative chairman).

The monetary value of land along the park edge has increased because of less wildlife crop raids (Kaiki cooperative chairman).
Farmers with negative attitudes towards the physical deterrents are probably the poachers who feel presence of the barriers is inconveniencing them from entering the park (Representative from Shingiro sector and Advisor Bigogwe sector).

When farmers are interviewed about wildlife crop raids, they exaggerate the ineffectiveness of the physical deterrents in anticipation of getting more SGF compensation funds (Executive secretary Gahunga sector)

Little attention was been paid to sustainability of the physical deterrents during their design and implementation. For example, there is lack of ownership of the stone wall. RDB/VNP staff was of the view that the stone wall should be owned by the local people as they are the direct beneficiaries of its presence. However, the community members are of a different view. They claim they are victims of wildlife that they do not own and benefit little or nothing from wildlife. They are of the view that RDB and government should have direct ownership of the stone wall and have the primary responsibility of addressing and managing problem animals since they are the ones that collect and keep the money that is generated from the park and ‘own’ the wildlife. Also, human-wildlife conflicts are administratively managed at a large scale sector level. However, the impacts of the crop raiding are spatially clustered at cell and village levels along the margin of VNP. This makes the leadership at sector detached from the wildlife-human conflict experiences of those who live adjacent the park and makes those at park adjacent cell feel side-lined and consequently do not enforce the interventions.

The stone wall, covering approximately 65km (McGuiness 2014), is a huge undertaking which no individual or single institution can satisfactorily maintain. However, there are no agreements specifying the roles and responsibilities among the key players involved in stone wall and trench management. This has led to lack of commitment and ownership among the key players so that what is currently done on the wall and/or is more of a piece-meal and knee-jerk reaction. However, the physical deterrents are likely to gain more attention in HWC management as farmers are paid far less money than what they claim in the wildlife crop damage compensation scheme. Paying less money than claimed is deliberately done by government so that the farmers can be discouraged from claiming compensation but to focus on other HWC interventions.
especially the physical barriers (Janvier Kwizera, Warden Community Conservations VNP pers. comm.)

8.3 Conclusion
Animal crop raids continue to be a challenge to the management of VNP, Rwanda. However, data collected over a 13 month period shows that the physical deterrents are capable of reducing buffalo raids. However, the quality of the physical deterrents is patchy thus providing room for buffalo raids. Buffalo raids are the most numerous and widespread of all the large mammal raids. Local community concur that the buffalo is the most frequent and widespread mammal raider. However, the perceptions of the people differ with the actual field records when it comes to the effectiveness of the deterrents. The farmers feel the deterrents are not ineffective at all while actual data point to some sections of deterrents that are of high quality being fairly effective in deterring animal raids. The perceptions of the farmers may be determined by being very poor with small land holdings, they are greatly affected by even a few raids. This study therefore shows the importance of collecting spatial temporal data on animal crop raiding incidences and farmer perceptions in monitoring and evaluating the impact of the HWC interventions.

9. Lessons learnt
1. Actual data on crop raiding incidences, especially if recorded for a long time, are critical in assessing the spatial and temporal patterns and trends of HWC and the effectiveness of the interventions. The information can be a key input in improving the management of HWC. The actual field data may also be used to validate farmer perceptions on wildlife raids. Information from the local communities on crop raiding by wildlife may not be accurate as the farmers sometimes exaggerate the intensity of wildlife raids and the ineffectiveness of the deterrent methods. The negative attitudes are sometimes driven by the expectation that there will result in more incentives to the farmers or due to the persistent crop losses to wildlife.

2. The participation of the local communities in wildlife crop raid data collection and reporting has the potential of making the results more acceptable and improving communication between the local communities and park authorities as well as increasing the information available to the park managers and strengthening the technical management of the park.
3. The asymmetrical distribution of incentives from park determines the attitudes of the local communities towards conservation. Farmer perceptions to crop raiding by wildlife seem to be influenced by the direct benefits an individual gets from the park or its services. Those who get direct incentives are more positive than those who do not even when the latter benefit indirectly.

10. Management recommendations

1. Though the construction of the stone wall and the trench were costly and labour intensive in the short run, they were effective in the long run. Judging from the quantity of crops saved, the construction costs would be recovered in a few years and may relieve the costs associated with guarding. Therefore, an effort should be made to construct a continuous high quality stone wall and reinforcing trench along the margin of the park instead of having short and fragmented high quality sections. The latter only diverts the problem elsewhere. Continuous construction and maintenance of sub-substandard stone wall is expensive as it does not deter buffaloes effectively.

2. RDB is in the process of forming problem animal intervention cooperatives based at cell level. This is highly encouraged as it will focus on community members directly affected by the problem animals and thus in dire need of the intervention. The incentives given to cooperative societies at sector level will can be redirected to those at cell level. This will increase on the social capital (potential for collaboration) and may help decrease differences in ability and willingness of the local communities in implementing and maintaining HWC interventions. At cell level, the cooperative will consist of individuals who know each other and experience the same problems.

3. There is need to have agreements with all the key stakeholders involved in problem animal management. These agreements should be negotiated, documented and signed. The agreements should be flexible for periodic renegotiation. These formal agreements should clearly spell out the roles and responsibilities of each stakeholder. One of the stakeholders should undertake regular monitoring and evaluation of the roles and responsibilities performed so that each key stakeholder is held accountable to the agreement.

4. Technical guidance should be sought so that dimensions of a standard stone wall are established and followed when constructing and maintaining the wall. Perceptions of farmers on an effective stone wall should also be put into consideration. Contractual agreements for the
construction and maintenance of the stone and trench should include these standard dimensions and should be realistic and commensurate with available resources.

5. A lot of effort and funds have been injected into the construction of the wall for over 10 years but with no or strategic or management plan. There is a need for all the key players to design a time-bound management /strategic plan for the deterrents with activities well specified and prioritized. The strategy or plan will allow in identification of tasks and responsibilities, scheduling of tasks and budgeting for the whole plan.

6. The physical deterrents should be mapped using Global Positioning System (GPS) and Geographic Information System (GIS) technology. The mapping should take into account the location quality of the deterrents. This will be useful in planning where construction/maintenance should take place and will be a major input in the evaluation of the effectiveness of the deterrents.

7. Data collection of animal raid data helps understand what is happening in the field, assists in decision-making, allows park management to follow distribution and trends in animal raids in relation to the interventions and use the information to communicate to other stakeholders on the successes and failures of the interventions. At present, data is currently a one off activity suggesting there is no clear system for analyzing the data collected in the field. Valuable long term data was lost reportedly because the computers where data was stored and the GPS used to collect data in the field got problems. Field data also had quality problems. For example, a considerable percentage (24%) of the buffalo raid geographic location data were far inside the park when plotted on a map of VNP meaning that those collecting the data do not understand use of the equipment or are using it carelessly. It is recommended that quality control of the data collected in the field is improved by analyzing the data immediately it is turned in. Data collected should be backed up and stored on external drives or in space and other media like CDs since computers have a short life span depending on model and use. There is need for RDB to continue with the process of animal raid data by selected people from the community and provided with an incentive from the 30% revenue sharing programme. Given that it is the community organization that manage the funds meant for HWC, the monitoring process will be community managed and can be sustained can be sustained that way.

8. The current data collection on human-wildlife conflict seems to be intermittent and not sustainable. For example, data collection stopped in December 2014. Even then, there was
serious quality issues in the data collected before it ceased. There seems to be reluctance on part of the organizations involved like RDB, sector executives and community organizations like ANICO to fund the data collection. The data collection that was done before was externally engineered and collapsed once the external force was no longer there. The data were not analysed probably because the analyses were regarded as complicated or the importance of the data in the management of HWC was not recognized by park and community members.

However, I was told by the VNP Community Conservation Warden Janvier Kwizera that there is crop raiding information collected for Special Guarantee Fund (SGF) compensation claims by the compensation committees which is geographic in that the location of the raided is reported, crop type and amount of damage are also recorded and the information is validated by compensation committees, police, sector agronomists and the Chief Warden of VNP. It is recommended that park staff should take advantage of this information to perform the same analyses as in this report or even more. Data collected for SGF compensation claims should be analysed and evaluated on its viability for assessing wildlife raids as its collection seems to be more sustainable compared to how the data for this study was collected.

9. Agricultural yield records by IDPs includes factors that lead to crop losses and can be used by park authorities to compare crop losses due to wildlife and other factors like pests, weather and soil nutrients among others.

10. Farmer’s perception towards the physical deterrents and wildlife conservation in general seemed to be influenced by membership to a cooperative. Future surveys of farmer perceptions to crop raiding by wildlife should include questions of conservation related organization/association an individual farmer belongs to.
Acknowledgments

I would like to thank the International Gorilla Conservation Programme (IGCP) for initiating and funding this study. The staff of IGCP assisted me greatly during data collection and report writing. Mr Charles Kayijamahe greatly facilitated the study by collecting the animal raid incidence field data from Volcanoes National Park and coordinating interviews and discussions with other key players in Human-Wildlife Conflict management as well as organizing a validation workshop where the preliminary results were discussed. Mr Benjamin Mugabukomeye briefed me on the background to study and the views of IGCP on the physical deterrents. Ms Anna Behm Masozera provided unpublished literature on Human-Wildlife Conflict around the Volcanoes National Park, Rwanda and comments on the draft report. Dr Jena Hickey made useful comments on the draft report. Staff of Volcanoes National Park kindly made available the animal crop raiding data and gave me information on current status of the physical deterrents and their management, community members of Kaiki cooperative provided insights on how the physical deterrents are maintained. Farmers in six Sectors of Rugarama, Kinigi, Shingiro, Cyanika, Kabatwa and Nyange are thanked for accepting to be interviewed and willingly offering their frank perceptions on Human-Wildlife Conflict issues.
References


# Appendix 1

A data sheet used for collecting data on crop raiding by wildlife around Virunga National Park, Rwanda

## Volcanoes National Park Human-wildlife Conflict Monitoring Sheet - A

<table>
<thead>
<tr>
<th>Date</th>
<th>Village</th>
<th>Elevation</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Plot Owner</th>
<th>Crop damaged</th>
<th>Age of crop</th>
<th>Damage done</th>
<th>Nearest house</th>
<th>Animal + No.</th>
<th>Day/Night</th>
<th>Exit Lat./Long.</th>
<th>Entry Lat./Long.</th>
<th>Comments</th>
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Received by: __________________________
Submitted by: __________________________________
Date: _________________
Appendix 2

Survey questionnaire to farmers in six sectors bordering Volcanoes National Park, Rwanda, on the effectiveness of human-wildlife conflict physical deterrents

Introduction and request for consent to participate in the study

Greetings Sir/Madam

My name is………………………………. We are conducting a study on problems you experience from wildlife in Volcanoes National Park (PNV) and issues focused on addressing these problems. We humbly seek your participation. The responses you give us will help us assess the impact of problems animals and also help us evaluate the interventions in place from your perspective. All that you share with us will be kept confidential and we will not write your name on this form if you wish us not to.

Your participation in this study is voluntary and you may decide not to respond to some or to all the questions. However, we hope that you will participate in this study because your ideas are important to us.

Are you willing to participate in this study? YES/NO

Date: ________________________________

INTERVIEWER’S NAME: ________________________________________

Sector ___________________Cell ________________ Village ________________

Part 1 Demographic and Background assessment

1. Name………………………………………………………………………

2. Gender (circle one) MALE FEMALE

3. What is your age?
   <30
   30-39
4. What is your marital status?
   Married
   Single
   Widowed
   Other

5. How many people normally live and eat together in your household? ……………………………

6. What is the most important livelihood/income generating activity undertaken by your household?
   a. Trading
   b. Formal employment
   c. Paid labour
   d. Cultivating
   e. Cattle keeping
   f. Mixed farming
   g. Others mention

7. How much land does your household own?
   a. 1 to 3 plots
   b. 4 to 6 plots
   c. More than 6 plots

8. How many plots are adjacent/near (<250m) the park boundary?

9. How far is your homestead from the park boundary?

Part 2 Crop/animal raiding assessment

10. Do you have any problems caused by wild animals from the park?  YES   NO
11. If YES, what problems do they cause?
   a. Crop raiding   YES  NO
   b. Human injury/death   YES  NO
   c. Livestock injury/death   YES  NO
   d. Trampling empty fields   YES  NO
   e. Damage to property   YES  NO

12. Which crop-raiding species is:
   a. Most destructive to your crops?
   b. Most frequent visitor to your gardens?
   c. Most feared?

13. During which months of the year do you cultivate and harvest specific crops? (Complete the table below)

14. At what stage of growth (All, mature, young, leaves, seeds, cobs, flowers, fruits, tubers, roots, bark) is each of the above mentioned crops most vulnerable to raiding and the major raiders? (Complete the table below).

<table>
<thead>
<tr>
<th>Name of crop</th>
<th>Month (s) of planting</th>
<th>Month (s) of harvesting</th>
<th>Vulnerable stage of damage</th>
<th>Major animal raiders</th>
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</table>

15. What are the main causes of crop loss in the field? (Rank: 3=cause of most crop damage, 2=cause of moderate damage, 1=cause of least damage)
<table>
<thead>
<tr>
<th>Cause</th>
<th>Rank</th>
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<tbody>
<tr>
<td>Drought</td>
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<tr>
<td>Insect pests</td>
<td></td>
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<tr>
<td>Plant diseases</td>
<td></td>
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<tr>
<td>Wildlife</td>
<td></td>
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<tr>
<td>Poor soils</td>
<td></td>
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<tr>
<td>Soil erosion</td>
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</table>

16. Have any of your livestock been injured/killed by wild animals?  

  YES  NO

17. If Yes, list the livestock types, number of animal lost due to specific wild animals in the last one year (June 2014 to June 2015)

<table>
<thead>
<tr>
<th>Type of livestock</th>
<th>Quantity lost</th>
<th>Wild animal that caused the loss</th>
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**Part 3 Physical intervention assessment**

18. Are you aware of the presence of physical deterrents (stone wall, trench, combination etc) on the park boundary  

  YES  NO

19. For the physical deterrent(s) you are aware of comment on the animal raider it is meant to deter, the degree of effectiveness and give reason to support your answer. Use the following key and table below (Rank 3=Very effective, 2=Limited effective, 1=Not effective at all)

<table>
<thead>
<tr>
<th>Deterrent</th>
<th>Animal raider supposed to deter</th>
<th>Degree of effectiveness</th>
<th>Reason for degree of effectiveness</th>
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</table>
20. Which other methods do you use to scare crop raiding animals to complement the physical deterrents? (Complete the table below)

21. How would you rate the degree of effectiveness of the complementary methods you have mentioned above and give reason to support your answer. Use the following key (3=Very effective, 2=Limited effectiveness, 1=Not effective at all)

<table>
<thead>
<tr>
<th>Method</th>
<th>Animal raider deterred</th>
<th>Degree of effectiveness</th>
<th>Reason for the degree of effectiveness</th>
</tr>
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</table>

22. Do you ever take part in the construction of the physical deterrents?  
   YES  
   NO  

23. Do you ever take part in the maintenance of the physical deterrents?  
   YES  
   NO  

If NO, why are you not taking part in the construction/maintenance of the physical deterrents?
24. Is there an agreement with the park/local authority specifying your roles and responsibilities?  
   YES  NO

25. If YES, what are your roles and responsibilities?

26. What problems do you face while constructing/maintaining the physical deterrents?

27. Do you feel it is your role to construct/maintain the physical deterrents? YES  NO
   If your answer is YES, are you willing to continue maintaining the physical deterrents?
   If your answer is NO, whom you think should be responsible for doing the work? Give a reason for your answer.

28. Did you receive any external assistance during the construction/maintenance the physical deterrents?  
   YES  NO
   If YES, state the form and source of external assistance

29. Who is in charge of seeing that the physical deterrents are properly maintained?

30. Have there been changes in the physical deterrents ever since they were constructed?  
   ABANDONED  NO CHANGE  MODIFIED  EXTENDED

31. What do you think the level of crop raiding would be today if the physical deterrents were not in place?
32. Do you have any suggestions on how the physical deterrents can be made more effective?

33. Do you have any further ideas? Comments?
1. Background

The International Gorilla conservation programme (IGCP) is a coalition of two international conservation organizations, the Fauna and Flora International (FFI) and World Wide Fund for Nature (WWF) and works in partnership the protected area authorities (PAAs) :the InstitutCongolais pour la Conservation de la Nature (ICCN) in DRC, the Rwanda Development Board (RDB) in Rwanda and the Uganda Wildlife Authority (UWA) in Uganda for the conservation of Mt Gorillas and their afromontane habitat. Its mission is “To conserve gorillas and their habitat through partnering with key stakeholders while significantly contributing to sustainable livelihood development.

Successful sustainable development requires the harmonization of both environmental and human development goals and resolving human-wildlife conflicts including injuries, crop and other properties.

More than ten years ago IGCP and other partners supported human wildlife conflict interventions around Volcanoes National Park using different mitigation measures including construction of a buffalo wall, digging trench, etc. These interventions cover almost the whole stretch of the park boundary separating the forest and the community land.

The International Gorilla Conservation Programme (IGCP) and its partner, the Volcanoes National park intends to evaluate the effectiveness of human-wildlife conflict mitigation interventions around Volcanoes National Park.

34. Objective

The purpose of this assignment is to evaluate the effectiveness of human-wildlife conflicts interventions around Volcanoes National Park, identify challenges and lessons learnt and finally propose different recommendations for future interventions based on challenges and lessons learnt.

- A coalition of-
Specific objectives are:

- Evaluate the effectiveness and efficiency of existing mitigation measures/strategies towards human-wildlife conflicts management near VNP,
- Assess the community perception vis-a-vis the undertaken wildlife mitigation measures
- Propose potential mechanisms towards sustainable management of human-wildlife conflicts near VNP with an emphasis of effective community engagement

35. Methodology

Two main approaches are proposed used for this evaluation study:

- Analysis of different human-wildlife conflict data so far collected
- A field visit on established physical barriers (buffalo wall and trenches) against crop raiding and carry out a stakeholder survey using interviews, structured questionnaires and/or focused-group discussion. Target stakeholders include farmers close to the park boundary, Community Based Organizations, park staffs and different park partnering NGOs.

36. Consultant tasks

- Review and make a statistical analyses of existing data related to human-wildlife conflict;
- Design a detailed data collection method and undertake the survey;
- Analyze the data collected during the survey;
- Facilitate of validation workshop;
- Produce an evaluation report.

37. IGCP task

IGCP and RDB/VNP will provide all existing data and any related document that will facilitate the consultant for this assignment.
38. Outputs
A document containing detailed effectiveness of wildlife mitigation measures around VNP using tangible data (Crop production, frequency of wild animal, particularly Buffaloes outside VNV) and clear recommendations.

39. Scope
This study will be conducted in 6 Sectors including Cyanika, Rugarama, Kinigi, Nyange, Shingiro, and Kabatwa.

40. Timeframe
The consultancy shall be carried out over a maximum of 30 days.

41. Submission
Applications should be sent to the following email address: info@igcp.org, bmugabukomeye@igcp.org or cKayijamahe@igcp.org. The application file should include a technical proposal and a financial proposal.
The deadline for submitting applications is February 16th 2015 at 4 PM Central Africa time.