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# COMPARATIVE STUDY ON WILDLIFE IMPACT IN ELECTRIC FENCED AND UNFENCED COMMUNITIES IN DUNGMIN GEOG, PEMAGATSHEL, BHUTAN

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**Abstract**

Human wildlife conflicts are one of the major challenges for wildlife conservation throughout the globe, and electric fencing (EF) has been used as one of the means to address those challenges. However, the comprehensive study to assess its effectiveness is lacking in many parts. Thus, this study attempted to understand the impact on crops and crop guarding time before and after fencing in communities having both fenced and unfenced households in three Chiwogs under Pemagatshel district. The data were collected through total enumeration using semi-structured interviews from 80 households. Wilcoxon's signed-rank test showed that the electric fence (EF) has a significant difference (p=0.00, M=50) to farmers in reducing their common crop loss to wildlife and protected staple crop damages (maize). However, bitter buckwheat and radish continued attacking by barking deer. EF reduced both day and night guarding time significantly to all common crops. On the contrary, the unfenced farmers have suffered from increasing pressure from the wildlife after the establishment of EF in their community. Maize and potato damage have significantly increased after EF. There was a significant difference in maize and potato's day and night guarding time before and after EF. Only night guarding time has a significant difference between sweet buckwheat and bitter buckwheat before EF and after EF. Therefore, it emphasizes the need to cover the whole community by EF promoting crop production and reducing crop guarding against wildlife to avert similar issues in other communities.

Keywords: Crop-Damaged, Dungmin, Electric-Fencing, Fenced, Guarding-Time, Unfenced, Wildlife

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## Introduction

Human-wildlife conflict (HWC) has been existing as early as human civilization (Anand and Radhakrishna, 2017). These issues are currently challenging for both humans and wildlife especially in developing countries of the world such as South and Southeast Asia (Anand and Radhakrishna, 2017). HWC imposes serious problems on millions of people across the world risking life, agricultural crops, and livestock that consequently impact the security of livelihood (Barua et al., 2013). HWCs are expected to increase due to anthropogenic activities with a growing population when disturbing the wildlife habitat (Tobgay et al., 2019), and now, it is common in urban, suburban, and rural areas (Anand and Radhakrishna, 2017). This research contextualized the guarding time allocated in the sites with electric fencing and sites without electric fencing.

In Bhutan, Human-wildlife conflicts have direct and indirect consequences in terms of household food security, livelihoods, and socio-economic conditions of the rural farmers. Some of the indicators of these problems are the increasing rate of abandoned agricultural land and rural-urban migration (Penjor et al., 2014). Every year, Bhutan experiences an annual crop loss of up to 25% of total household income due to crop raids by foraging animals and about 10-19% through livestock predation (Sharma et al., 2020).

Many farmers have been adopting various mitigating measures to protect agricultural crops. However, in developing countries, farmers largely remain inhibited to traditional mitigation measures which are less effective and labor-intensive (Feuerbacher et al., 2021). Moreover, traditional mitigation measures increased health risks, especially with malaria infection (Hill, 2004) due to sheltering in open and dirty areas guarding tine crops at night. One of the biggest drawbacks of wild boar in Bhutan is the labor required to scare them away, which is why current approaches are so time-consuming. Scarecrows, can-bashing, night guarding, shouting, stretching reels, hanging cans, and the use of dummy tigers are some traditional techniques (National Plant Protection Centre [NPPC], 2017). Having realized the complications of the traditional approaches of HWC mitigation measures, the Bhutan Electricity Authority (BEA), Bhutan Power Corporation (BPC), Bhutan Standard Bureau (BSB), and the Ministry of Agriculture and Forests (MoAF) have agreed with the establishment of EF to use as one of the crop protection methods (Nima and Gurung, 2018)

Now the applications are made by numerous agents including government, private companies, and Non-Governmental Organizations (NGOs) to encourage use, especially by the farmers to mitigate the conflict with wildlife (Penjor et al., 2014). EF is reported to be very effective as long as there is good management and maintenance. However, it is also presumed to have the possibility of spillover effects by shifting the animals' behavior due to EF (Kioko et al., 2008).

Operation of any mitigating measures without complete knowledge of the affecting species' behavior and human social factors often fails to achieve the results and even increases the conflicts (Tobgay et al., 2019). In Bhutan, several debates on the EF approach have arisen over the years. While there are media reports and studies on farmers appreciating its effectiveness, there are also unsuccessful stories (Nima and Gurung, 2018). EF has been established as a mitigating measure in Bhutan, but not yet covered in all farming areas of Bhutanese farmers. Although several studies have been conducted on the effectiveness of EF in the fenced community, no comparative studies have been conducted with unfenced neighboring households. People have benefited from EF, but could be a problem for unfenced neighboring households. Therefore, the study focused on gathering both benefits and effects of EF in fenced and unfenced areas respectively.

## Materials and methods

### *Study area*

The study was conducted in the southwestern region of Pemagatshel district, Dungmin Geog with longitude and latitude of 91°19'45.29''E and 25°59'03.11'' N, respectively, covering an approximate area of 109.98 sq. km. Pema Gatshel, meaning "Blissful Land of the Lotus", is one of the least developed and remotest Dzongkhag located in the southeastern part of the country. It shares its borders with the Dzongkhags of Trashigang in the north and north-east, Mongar in the north and north-west, Zhemgang in the west, Samdrup Jongkhar in the south and southeast (Pemagatshel Dzongkhag Administration, 2018). It has an elevation ranging from 1,000 - 3,500 masl, and experiences an average annual rainfall of 1,500 – 3,000 mm. The total area of 87.65% is under forest cover, comprising mainly coniferous and broadleaf species.

The climate of the district is hot and humid during the wet season and moderately cold during the dry season. Land holdings are dominated by dry land with a negligible wetland. The soil types are sandy loam to loam soil which is slightly acidic with pH values less than 6.5. Overall fertility potential / inherent fertility can be classified as slightly poor. The Geog consists of five Chiwogs with sparsely distributed settlements of 14 villages with 382 households consisting of 1630 males and 1622 females. All the gewog centers are connected with roads making it easier to transport goods and communicate with service centers, especially Dzongkhag and Dungkhag administrations.

The steep slopes and deep gorges, and sparsely scattered settlements characterize the topography of the Gewog. Tseri and dry land dominate agricultural land use with negligible wetland cultivation. Agriculture and livestock are the main sources of livelihood and the majority of the farmers follow an integrated subsistence farming system. Maize is their staple crop and mandarin, ginger, and potato are grown as cash crops. The Geog is suitable for growing cardamom due to its humid climatic condition and topography (Local Government Portal, 2018).

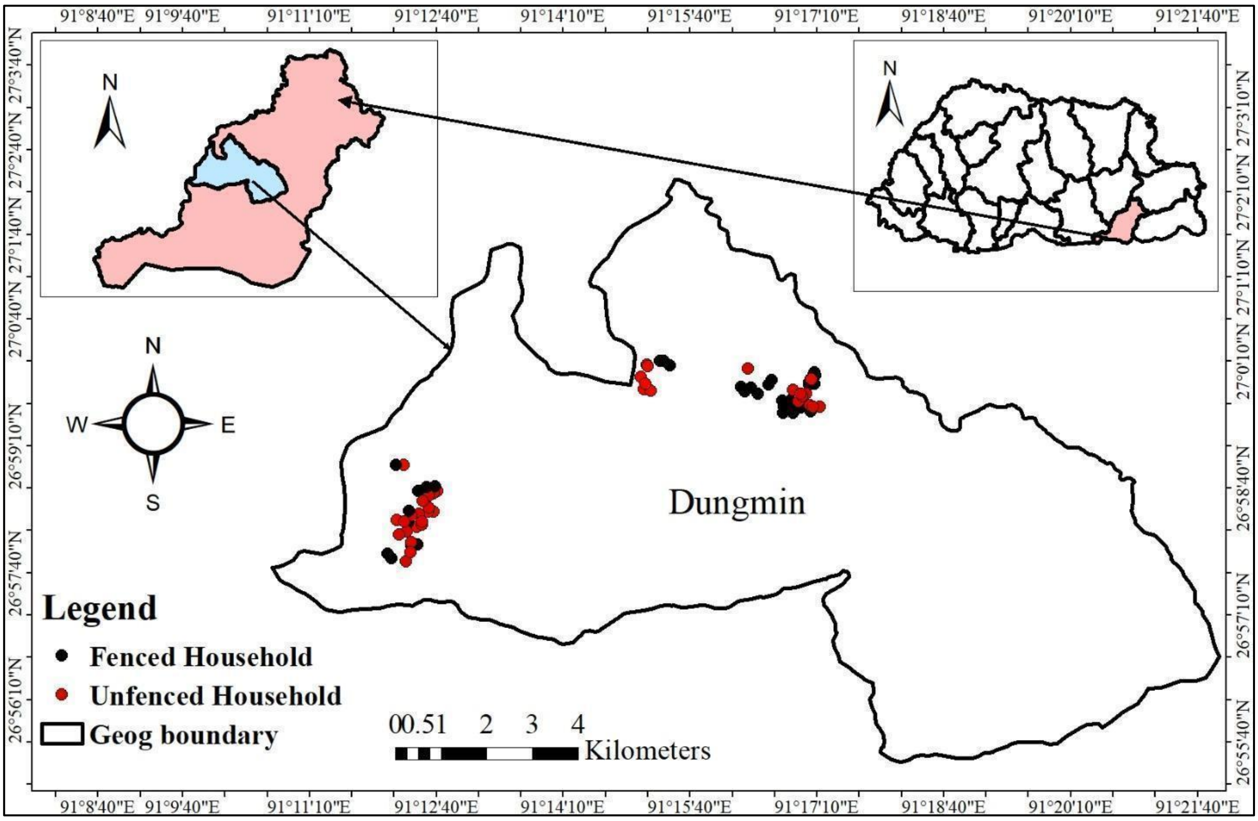


**Figure 1:** Map showing the study rea

***Data collection***

Out of five, three Chiwogs were decisively selected for the study (Laniri, Durungri, and Balnang Goenpa). The community is geographically surrounded by forests where human-wildlife conflict is prominent. Moreover, all three Chiwogs have a mixture of electric-fenced and unfenced households together in the community to understand the details of the impact of EF. Common crops damaged in three Chiwogs by wildlife were taken into account. Maize (*Zea mays*), sweet buckwheat (*Fagopyrum esculentum*), bitter buckwheat (*Fagopyrum tataricum*), potato (*Solanum tuberosum*), and radish (*Raphanus sativus*) are five different common crops grown by the farmers.

The information was collected through total enumeration methods using semi-structured interviews separately for fenced and unfenced households both before and after the installation of EF. The head of the household was interviewed for every household with the age ranging from 46 - 80 years old with the prior consensus from Gup (head of local government). Therefore, a total of 80 households were enumerated from the three Chiwogs by deploying three interviewers in each chiwog. Interviewees were inquired about the effectiveness of EF and associated problems for the farmers and their income from the farm before and after the EF.

*Data analysis*

The data were punched into a Microsoft Office Excel spreadsheet and analyzed using Statistical Package for the Social Sciences (SPSS). The descriptive statistical tool was employed to describe the number of respondents from both EF and None-Electric Fenced (NEF) together with the rate of male and female respondents along with the area covered by EF in each Chiwog. Whereas inferential statistical tools of paired sample t-test (Wilcoxon signed-rank test) was employed to analyze the data on farmers' opinion on crop loss to wildlife, cost incurred, and crop guarding time before and after the electric fence was established in both fenced and unfenced communities.

## Results and discussion

### *Respondents' information*

*A* total of 80 households were interviewed consisting of 42 respondents with EF and the remaining 38 households without EF. Respondents with EF had 24 (57.14%) males and 18 (42.86%) females, whereas 26 (68.42%) males and 12 (31.58%) females were from 38 NEF respondents. Respondents estimated a cumulative total of 103.66 of farmland is EF which was funded by the Agriculture Research and Development Centre (ARDC) (Table 1).

**Table 1:** Description of EFR and NEFR

| *Chiwog* | *EFR* | *NEFR* | *EFA(Acres)* | *Year(E)* | *FS* |
|---|---|---|---|---|---|
| Laniri | 28 | 11 | 60.66 | 2019 | ARDC |
| Balnang goenpa | 3 | 6 | 4 | 2019 | ARDC |
| Durungri | 11 | 21 | 39 | 2019 | ARDC |
| **Total** | **42** | **38** | **103.66** | | |

**Where: EFR-Electric Fenced Respondents, NEFR-Non-Electric Fenced Respondents, EFA-Area Covered by EF, Year(E)-Year of Establishment, FS-Funding Source**

### *Wildlife Attack Frequencies*

The Electric-Fenced Respondents (EFR) reported that the frequency of all the six-common wildlife attacks has decreased after the establishment of EF. Asian black bear (*Ursus thibetanus*) and sambar deer (*Rusa unicolor*) were two large mammals completely protected by EF (Figure 2). However, to Non-Electric Fenced Respondents (NEFR), except bear, all other four-common wildlife attacks have increased to their crops after the establishment of EF in their community (Figure 3)

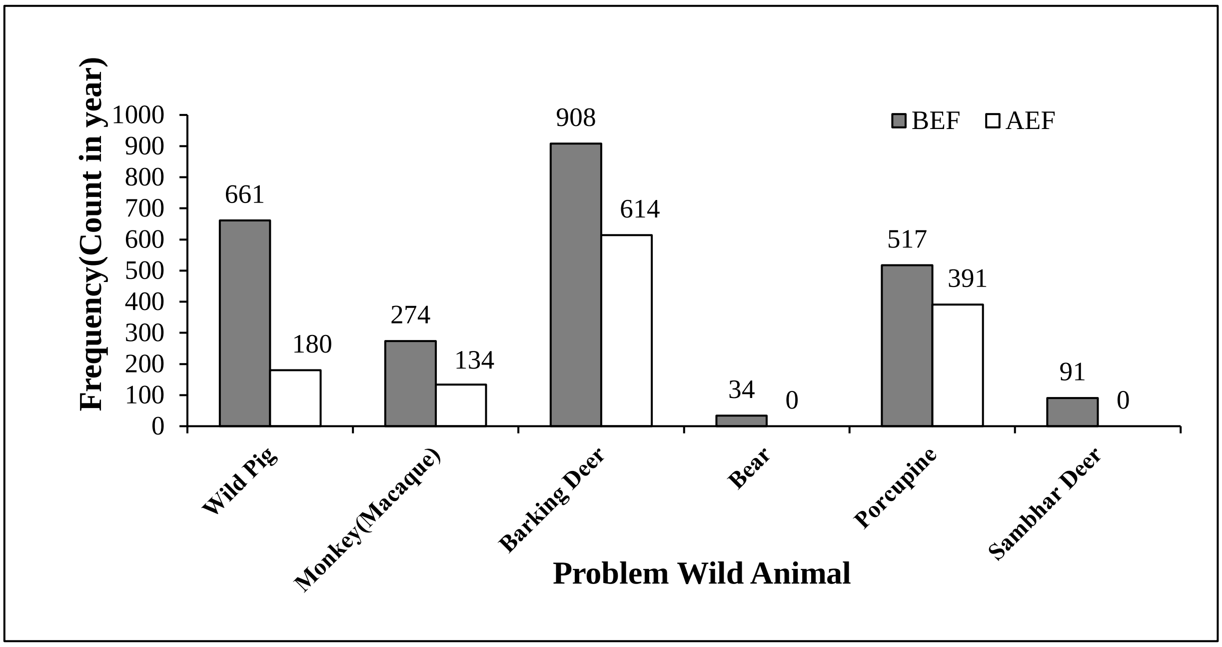


**Figure 2:** Total wildlife attack frequency to the crops of EF Respondents. Where: **BEF-**Before Electric Fencing, **AEF**-After Electric Fencing

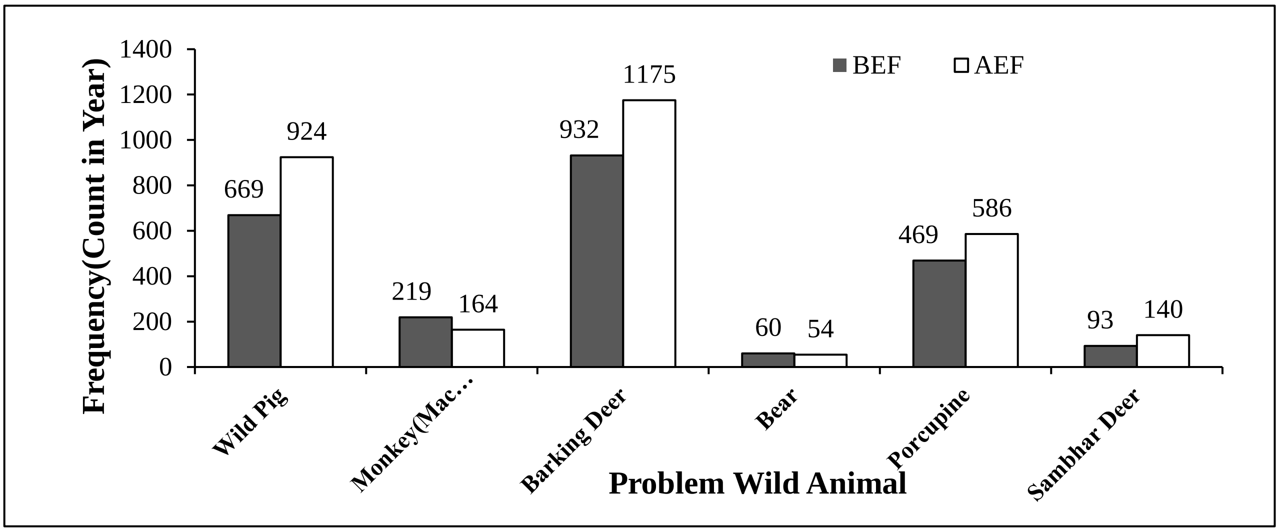


**Figure 3:** Total wildlife attack frequency to the crops of NEF Respondents. Where: **BEF-**Before Electric Fencing, **AEF**-After Electric Fencing

## *Crop damage to EFR*

Maize is the most important staple crop grown by every farmer in the study area. Farmers also do maize double cropping in a year. Wilcoxon signed-rank test was conducted to compare the maize loss before and after the installation of EF to each individual animal. Maize damage reduction was statistically significant for all common problem animals (Table 2; Figure 4). The farmers reported that the boar is the most destructive wild animal for maize and now EF has protected the boar from crop-raiding. Thus, there was a significant difference in maize crop damage before EF (*Mdn* = 165.5, Z = -5.5 p = .000) and after EF (*Mdn* = 50, *Z* = -5.5, *p* = .000). Similar case was reported by the Ministry of Agriculture and Forest (MoAF, 2017) where wild pig's crop damage was controlled up to 90% by installing EF.

Similarly, the Wilcoxon signed-rank test was conducted to compare the loss of sweet buckwheat, bitter buckwheat, potatoes, and radish to wildlife before and after EF. Unlike maize, boar and barking deer were the two animals that caused damage to these crops and vegetables. Except for radish and bitter buckwheat, all other crop damages were reduced significantly after EF (Table 2; Figure 4). The finding supports Chhetri et al. (2013) and Nima and Gurung (2018) that EF is typically a sound modern crop guarding technique in reducing crop-raiding by wild animals.

Essentially, the current findings of EF as a mitigating strategy to crop damage from wild animals agreed with the findings of Feuerbacher et al. (2021) that EF is more effective the larger nuisance and high crop-damaging wildlife species such as sambar deer and bear, but not so effective against small animals like barking deer, Assam Macaques and Asiatic brush-tailed Asiatic brush-tailed porcupine. Therefore, a combination of electric fences with other repellent methods can enhance their effectiveness.

**Table 2:** Wilcoxon signed-rank test table of common crops damaged for EF farmers

| *Crop Types* | *Animal Types* | *N* | *M (B)* | *M (A)* | *Z* | *p* |
|---|---|---|---|---|---|---|
| Maize | Wild Pig | 42 | 162.5 | 50 | -5.55 | .00* |
| | Barking Deer | 42 | 25 | 25 | -3.17 | .00* |
| | Sambar Deer | 42 | 37.5 | 0 | -4.68 | .00* |
| | Assam Macaque (Monkey) | 42 | 75 | 50 | -4.25 | .00* |
| | Bear | 42 | 50 | 0 | -2.80 | .00* |
| | Asiatic brush-tailed porcupine | 42 | 50 | 25 | -3.50 | .00* |
| S. Buckwheat | Wild Pig | 42 | 15 | 0 | -3.74 | .00* |
| | Barking Deer | 42 | 3 | 2 | -2.48 | .01* |
| B. Buckwheat | Wild Pig | 42 | 15 | 0 | -3.65 | .00* |
| | Barking Deer | 42 | 3 | 2 | -1.57 | .11 |
| Potato | Wild Pig | 42 | 15 | 0 | -3.01 | .00* |
| | Barking Deer | 42 | 3 | 1 | -2.95 | .00* |
| Radish | Wild Pig | 42 | 20 | 25 | -1.48 | .13 |
| | Barking Deer | 42 | 20 | 2 | -2.18 | .02* |

Where; **S. Buckwheat**-Sweet Buckwheat, **B. Buckwheat**-Bitter Buckwheat**,** **N**-Number of respondents, **M(B)**-Median before EF, **M(A)**-Median after EF, **Z**-Z-Score, **p**-significant value (.05*)

### *Crop damaged to the unfenced farmer*

*A s*imilar test was done on unfenced farmer's crop attacks from wild animals. Wilcoxon's signed-rank test (Table 3) result showed that the maize damage has increased significantly from all the six-common wildlife, except with Assam Macaques and bears. It indicated that EF has increased the wildlife attack on crops of neighboring unfenced households (Figure 5). Besides, maize and potato damage has also increased significantly. The finding of Feuerbacher et al. (2021) finding was in line with current study results where the degree of wildlife attack on crops for unfenced households has increased significantly after the fencing for neighboring household's farms. Farmers believed that the increase in crop damage is solely due to the establishment of EF for neighboring households.

In addition, a comparative study on badger damage to maize crops in electeric-fenced and unfenced maize fields by Poole et al. (2002) reported a similar result to the current study that the frequency of foraging is more in unfenced fields than the electric fenced field.

**Table 3:** Wilcoxon signed-rank test table of common crops damaged for unfenced farmers

| *Crop Types* | *Animal Types* | *N* | *M (B)* | *M (A)* | *Z* | *p* |
|---|---|---|---|---|---|---|
| Maize | Wild boar | 38 | 150 | 162.5 | -2.02 | .04* |
| | Barking Deer | 38 | 25 | 75 | -4.02 | .00* |
| | Sambar Deer | 38 | 75 | 100 | -2.52 | .01* |
| | Assam Macaque (Macaque) | 38 | 100 | 125 | -.47 | .63 |
| | Bear | 38 | 50 | 50 | -1.78 | .07 |
| | Asiatic brush-tailed porcupine | 38 | 50 | 62 | -2.30 | .02* |
| S. Buckwheat | Wild boar | 38 | 10 | 15 | -.70 | .48 |
| | Barking Deer | 38 | 4.5 | 6.75 | -1.61 | .10 |
| B. Buckwheat | Wild Pig | 38 | 5 | 10 | -.76 | .44 |
| | Barking Deer | 38 | 4.25 | 7.5 | -1.32 | .18 |
| Potato | Wild boar | 38 | 3 | 5 | -2.55 | .01* |
| | Barking Deer | 38 | 1.75 | 3 | -1.18 | .02* |
| Radish | Wild boar | 38 | 2 | 3 | -1.82 | .06 |
| | Barking Deer | 38 | 1 | 2 | -1.86 | .38 |

Where: **S. Buckwheat**-Sweet Buckwheat, **B. Buckwheat**-Bitter Buckwheat, **N**-Number of respondents, **M(B)**-Median before EF, **M(A)**-Median after EF, **Z**-Z-Score, **p**-significant value ($.05^{*}$)

### *Additional crop damage to EF farmers of Durungri*

Farmers of Durungri cultivate pineapple, beans, and tapioca that are not grown by farmers of other chiwogs. Wild boar was reported to prefer pineapple and tapioca; barking deer and sambar deer with only beans and

Asiatic brush-tailed porcupine preferred only tapioca. Statistically, the Wilcoxon signed-rank test indicated that there was a significant difference in crop damage BEF and AEF except for damage of beans and tapioca by barking deer and Asiatic brush-tailed porcupine respectively (Table 4; Figure 6). Because barking deer are known to easily pass through in between wire strands (Wangdi, 2016), and Asiatic brush-tailed porcupines were reported to enter a field from beneath the electric wires by burrowing the earth and damaging the crops (Nima and Gurung, 2018).

**Table 4:** Wilcoxon-sign rank test table for crop damaged of EF farmers of Durungri

| *Crop Types* | *Animal Types* | *N* | *M (B)* | *M (A)* | *Z* | *p* |
|---|---|---|---|---|---|---|
| Tapioca | Wild boar | 11 | 175 | 50 | -2.82 | .00* |
| | Asiatic brush-tailed porcupine | 11 | 3 | 2 | -1.36 | .17 |
| Beans | Barking Deer | 11 | 5 | 2 | -.95 | .33 |
| | Sambar Deer | 11 | 1 | 0 | -2.22 | .02* |
| Pineapple | Wild Pig | 11 | 20 | 7 | -.84 | .3.96 |

Where: **M(B)**-Median before EF, **M(A)**-Median after EF, **Z**-Z-Score, **p**-significant value (.05*)

### *Additional* crop *damage to* u*nfenced farmers of Durungri*

*A s*eparate analysis of crop damaged BEF and AEF for unfenced farmers was compared (Table 5). The test result showed that all three crops were attacked by the wild pig, deer, and sambar and significantly increased after EF was installed in their neighboring households (Figure 7).

**Table 5:** Wilcoxon signed-rank test table for additional crop damaged of NEFR of Durungri

| *Crop Types* | *Animal Types* | *N* | *M (B)* | *M (A)* | *Z* | *p* |
|---|---|---|---|---|---|---|
| Tapioca | Wild Pig | 21 | 20 | 30 | -3.5 | .00* |
| | Asiatic brush-tailed porcupine | 21 | 5 | 7 | -.39 | .69 |
| Beans | Barking Deer | 21 | 7 | 8.5 | -3.3 | .00* |
| | Sambar Deer | 21 | 10 | 7.5 | .00 | 1.00 |
| Pineapple | Wild Pig | 21 | 10 | 20 | -3.5 | .00* |

Where: **M(B)**-Median before EF, **M(A)**-Median after EF, **Z**-Z-Score, **p**-significant value (.05*)

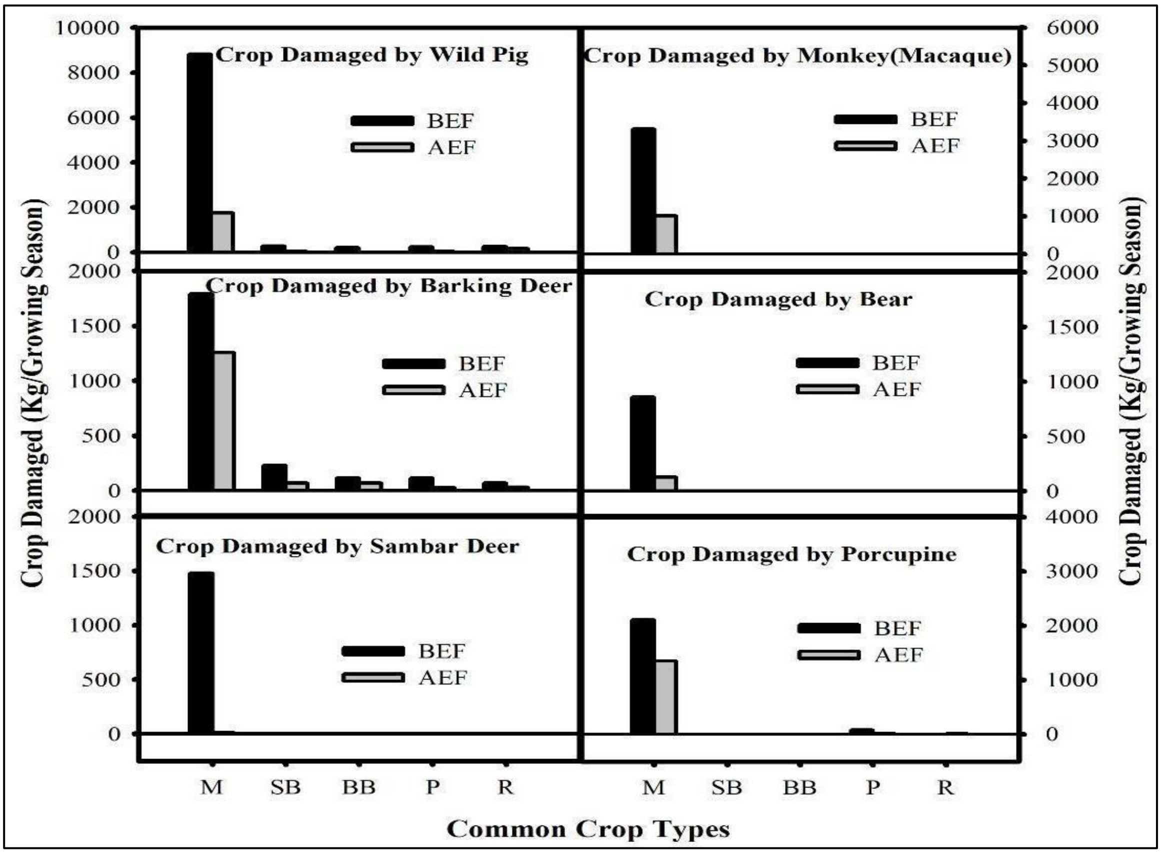


**Figure 4:** Total seasonal crop damaged by different wildlife before and after EF for electric fenced farmers. where; **M-**Maize, **SB-**Sweet Buckwheat, **BB-**Bitter Buckwheat, **P**-Potato and **R-**Radish

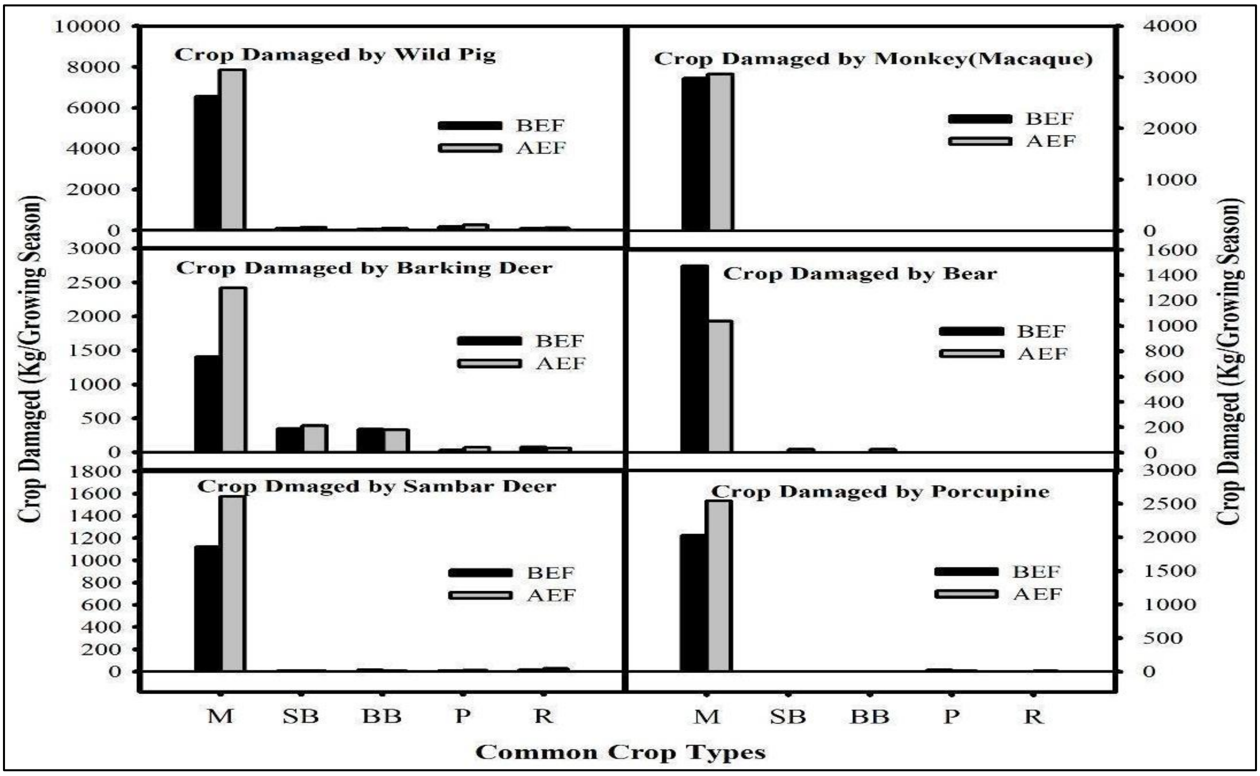


**Figure 5:** Total seasonal crops damaged by different wildlife before and after EF for unfenced farmers. where; **M-**Maize, **SB-**Sweet Buckwheat, **BB-**Bitter Buckwheat, **P-**Potato and **R-**Radish

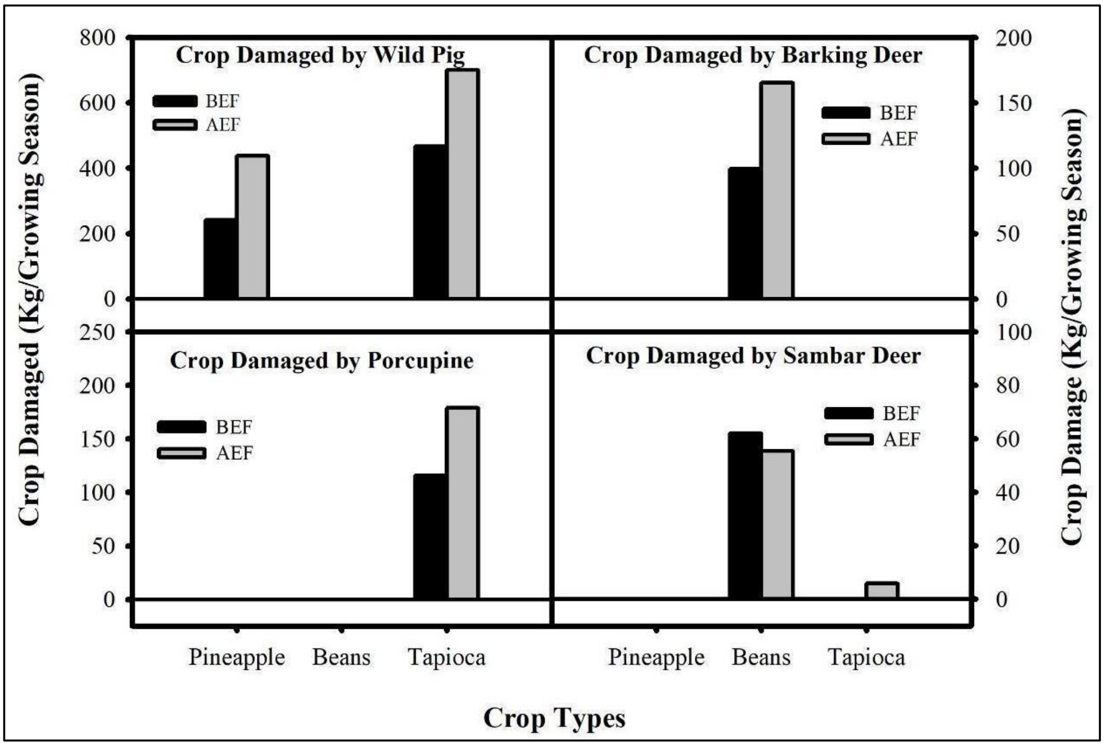


**Figure 6:** Total seasonal crops damaged by different wildlife before and after EF for electric fenced farmers of Durungri

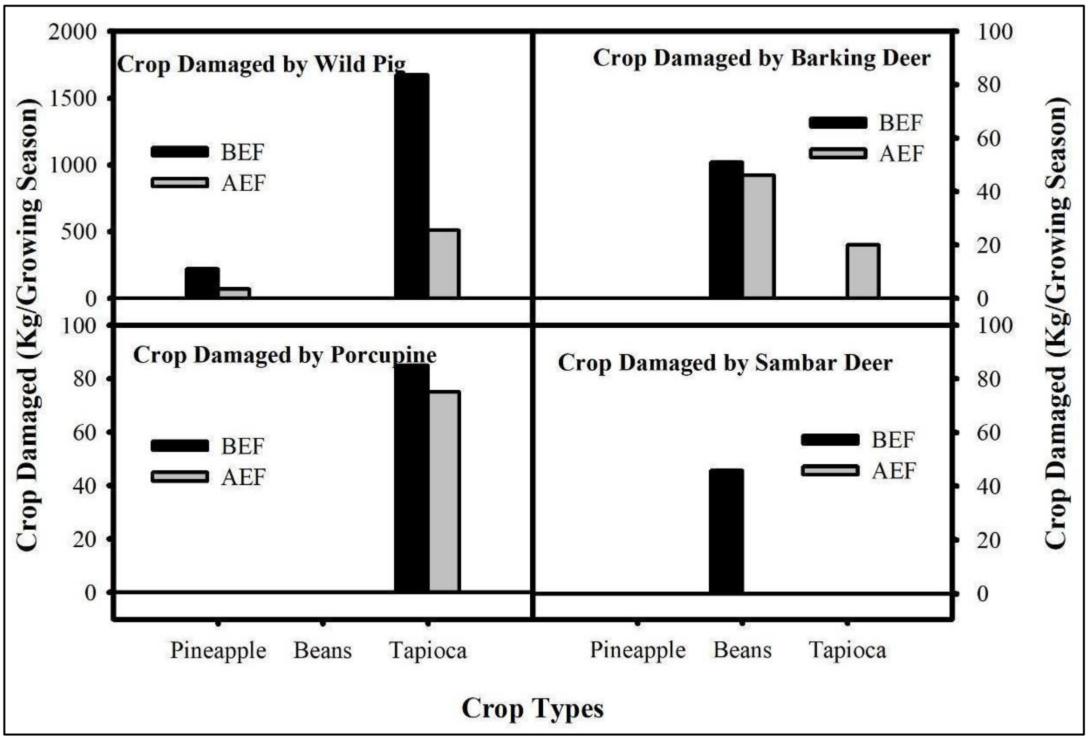


**Figure 7:** Total seasonal crops damaged by different wildlife before and after EF for unfenced farmers of Durungri

***Impact of EF to crop guarding time for fenced farmers***

Wilcoxon's signed-rank test was conducted for crop guarding time for five common crops and additional three crops of Durungri (Table 6). Their guarding time has statistically reduced after electric fencing, both day and night guarding time.

Sapkota et al. (2014) have found that EF saved a considerable amount of crop guarding times, which benefited the farmers in terms of crop saving and solving labor shortages. The current study also showed a similar result saving a lot of time from crop guarding and also benefiting in saving crops. In terms of monetary value, the crop guarding time reduction translated to the total amount of Nu. 26,122.3 (Table 6). The addressing labor shortage by EF is especially important, as work deficiencies cause a huge impact not just in Bhutan but also in numerous other developing countries (Barua et al., 2013).

According to Choden and Namgay (1996), Bhutanese farmers normally spend an average of more than two months guarding maize and paddy in a year. The finding of this study was in line with a report by the Ministry of Agriculture and Forest (2017) that the time spent on crop guarding has drastically reduced after EF. However, beneficiary farmers spent a few weeks guarding maize during day time since the crop damages are not fully protected from Assam Macaque (Nima and Gurung, 2018).

**Table 6:** Statistics of crops guarding time for EF farmers

| *Crop Types* | *Guarding Time* | *N* | *M(B) (Hour)* | *M(A) (Hour)* | *Z* | *p* |
|---|---|---|---|---|---|---|
| Maize | Day | 42 | 26.5 | 9.5 | -5.65 | .00* |
| | Night | 42 | 50 | 17 | -5.64 | .00* |
| Potato | Day | 42 | 5.5 | 0 | -5.68 | .00* |
| | Night | 42 | 7 | 4 | -5.53 | .00* |
| Sweet Buckwheat | Night | 42 | 9 | 2 | -5.65 | .00* |
| Bitter Buckwheat | Night | 42 | 12 | 1 | -5.66 | .00* |
| Reddish | Night | 42 | 5 | 0 | -5.69 | .00* |
| Pineapple | Night | 42 | 19 | 3 | -2.94 | .00* |
| Beans | Night | 42 | 17 | 0 | -2.94 | .00* |
| Tapioca | Night | 42 | 11 | 4 | -2.95 | .00* |
| **Total (Man-days)** | | | **162** | **40.5** | | |
| **Rates of Man-Days (Nu)** | | | **215** | **215** | | |
| **Total (Nu)** | | | **34,830** | **8,707.7** | | |
| **Total Money Saved by EF [Total M(B)-Total M(A)]** | | | **26,122.3** | | | |

Where: ***N***-Number of respondents, ***M(B)***-Median day guarding time before EF in hour, ***M(A)***-Median of day guarding time after EF in hour, ***Z***-Z-Score, ***p***-significant value (.05*), **Man-Days (Nu)**-Money Value per man-days based on minimum wage rate of Bhutan (MOLHR, 2019).

***Impact of EF on* guarding *time for* unfenced farmers**

Oipova et al. (2018) have predicted that an electrified fence could shift the crop-damaging pattern due to modification of the animals' behaviors and increased guarding costs to the farmers. This study indicated that statistically, both day and night crop guarding time has increased after EF almost to all the crops except radish and beans (Table 7). In the translation of man-days crop guarding time to monetary value, it increased by Nu. 8,062.5. Many unfenced farmers complained about the increase in crop damage after EF in their community. It is also possible that farmers' attitudes towards wildlife would have changed and faced conservation challenges by retaliation of animals.

**Table 7:** Statistics of crops guarding time for unfenced farmers

| *Crop Types* | *Guarding Time* | *N* | *M(B)* | *M(A)* | *Z* | *p* |
|---|---|---|---|---|---|---|
| Maize | Day | 42 | 26.5 | 9.5 | -5.65 | .00* |
| | Night | 42 | 50 | 17 | -5.64 | .00* |
| Potato | Day | 42 | 5.5 | 0 | -5.68 | .00* |
| | Night | 42 | 7 | 4 | -5.53 | .00* |
| Sweet Buckwheat | Night | 42 | 9 | 2 | -5.65 | .00* |
| Bitter Buckwheat | Night | 42 | 12 | 1 | -5.66 | .00* |
| Reddish | Night | 42 | 5 | 0 | -5.69 | .00* |
| Pineapple | Night | 42 | 19 | 3 | -2.94 | .00* |
| Beans | Night | 42 | 17 | 0 | -2.94 | .00* |
| Tapioca | Night | 42 | 11 | 4 | -2.95 | .00* |
| **Total (Man-days)** | | | **162** | **40.5** | | |
| **Rates of Man-Days (Nu)** | | | **215** | **215** | | |
| **Total (Nu)** | | | **34,830** | **8,707.7** | | |
| **Total Money Saved by EF [Total M(B)-Total M(A)]** | | | **26,122.3** | | | |

where: ***N***-Number of respondents, ***M(B)***-Median day guarding time before EF in hours, ***M(A)***-Median of the day guarding time after EF in hours, ***Z***-Z-Score, **p**-significant value (.05*), **Man-Days (Nu)**-Money Value per man-days based on the minimum wage rate of Bhutan (MOLHR, 2019)

Therefore, it is recommended that, while installing electric fencing, it is necessary to consider all the households in the community or region. Such coverage would increase crop production and reduce crop guarding against wildlife to all the households living in the same community.

## Conclusions and recommendation

This study investigated the impact of EF on both fenced and unfenced households within the community. The results showed a significant positive impact of EF on every fenced household in protecting their agricultural crop-raiding from wildlife and reducing crop guarding time. On the other hand, farmers without EF in their fields have significantly increased negative impacts by shifting the pressure of wildlife attacks to their agriculture crops and their crop guarding time.

Electric fencing has significantly reduced their crop loss to wildlife, especially to the larger mammals such as wild boar, sambar, and bear, but has not proved effective against small animals such as Assam Macaque, deer, and Asiatic brush-tailed porcupine. The main concern of the farmers about maize and other common crops decreased significantly. Another important benefit of EF was a reduction in crop guarding time. After the establishment of EF, total crop guarding time in a year has reduced from 162 man-days to 40.5 man-days.

However, it has diverted the wildlife to the unfenced community which increased the damages significantly to almost all the common crops, especially to the staple crop (maize). Furthermore, both day and night guarding time has increased significantly. Farmers have been spending an average of 155.5 man-days for all crop types before EF in guarding their crops and now increased to 193 man-days.

**Conflict of interest**

None

**Authors' contribution statement**

Sangay Chedrup conceived the general idea, collected and analyzed data, and wrote and edited the content. Tashi Dendup, Ugyen Dorji, Cheten Tshering, and Santa Maya Tamang contributed ideas, insights, and suggestions for better results and edited the content

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