Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.3, No.10, 2012

Economic Loss Analysis of Crops Yield due to Elephant Raiding: A Case Study of Buxa Tiger Reserve (West), West Bengal, India

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Abstract
The aim of this study is to analyze the pattern of crop damage by elephant raiding that has been prevailing around Buxa Tiger Reserve (BTR), West Bengal, India, particularly at its western parts due to growth of substantial quantity of nutritious food. The work has been done based on the data collected from official records and through a structured questionnaire , the analysis of those shows that the extent of damage is highly significant from economic point of view and a huge amount of financial loss is realized by the farmers living here very often. To handle this loss, few conservative proposals have been suggested.
Keywords: Buxa Tiger Reserve, Crop damage, Elephant Raiding, Crop coverage

1. Introduction

Human - wildlife conflict (HWC) is a term commonly used by conservationists to describe friction between wild animals and people. The conflict emerges when wildlife and human requirements overlap with consequential costs to humans and/or the wild animals (Osei-Owusu & Bakker 2008). The commonest type of HWC seems to be crop raiding by wild animals, especially large mammals like elephants. In many parts of the world, crop raiding by wild animals gives rise to significant conflict between local communities and wildlife conservation (Woodroffe *et al*. 2005). This phenomenon of conflict is not new. Rather it is as old as the human civilization itself. But in today's world, this issue has grabbed serious concern due to the fast decrease in elephant population worldwide (Bhattacharjee 2012). An elephant is a huge animal requiring 250-300 kg. of fodder every day. In forests, it may spend 16-20 hours daily to gather its food. In agricultural land, however, it gets substantial quantity of nutritious food over a smaller area with minimal effort. Once an elephant has had a taste of agricultural crops, it will prefer to raid agricultural fields, more so if there is a scarcity of fodder in the forests. The paddy, which is the principal agricultural crop in the study area, is quite a favorite with the elephants. With better availability of quality seeds and irrigation facilities in recent years, farmers of this region have been growing two or more crops in a year and the elephants have also been spending more time in the agricultural fields now than in the past (Bist 1994). The huge amount of crops is destroyed in this region due to elephant raiding because it takes heavy meals. Their diet is varied, consisting of grasses, foliage, bamboo, roots, bark, wood and fruits. Adult elephants require about 160 liters of water per day. Crop raids by elephants elicit sometimes very wide different emotions. At one extreme, elephants capture memorable and unflinching affection by those who view them for pleasure but at the other extreme they generate animosity, intimidation and fear (Whyte *et al*. 1998). The latter is true of some rural areas of villages that surround BTR (W) where food security and livelihood of poor and marginalized communities is often threatened by elephants. So, human - elephant conflict (HEC) becomes a primary threat to elephant survival (Hoare 1995; Kangawa 1995; Barnes 1996; Western 1997). With the decrease of protected habitats available for elephants, crop raiding is anticipated to increase and play a significant role in the decline of elephant populations (Hoare 1999). Crops provide dense amount of food in one area and are convenient for elephants. The incidences of crop raiding by elephants cause huge damages to the crops which results in the financial loss of villagers living around Buxa Tiger Reserve. Ensuring farmers' livelihoods and food security through reduction of HWC is an internationally agreed goal and conservation managers today are required to tackle this complex issue in collaboration with communities in order to achieve conservation objectives (Parker *et al*. 2007). The experimental deterrents include warning systems, barriers and active deterrents and are designed to increase the capacity of farmers to detect and repel elephants. Individual experimental methods are more effective at deterring elephants than other methods and the integrated strategy significantly reduce the total crop damage in study villages. The complex nature, the site specific and animal- specific causes make it obvious that there cannot be one formula for solving man elephant conflict which results in this crop damages (Osborn & Parker 2002). The study has assessed the crop raiding by elephants (*Elephas maximus*) around Buxa Tiger Reserve (BTR), which is located in the Alipurduar subdivision of West Bengal, India.

2. Study area

Buxa Tiger Reserve (BTR) is located in the Alipurduar subdivision of West Bengal, India. It comprises of entire forest area of erstwhile Buxa Forest division (created in 1877-78) and some territory of neighbouring Coochbihar forest division. The reserve lies between $23^0$30' N to $23^0$50'N latitude and $89^0$25'E and $89^0$55'E longitude. A

number of tea gardens fringe the western and southern boundary. The total area of BTR is 760.92 sq km. forests are moist tropical. Temperature varies from 15^0C to 39^0C. Rainfall varies from 3570 mm to 5600 mm. The lowest point is 125m above MSL, and highest point 1750 mt above MSL. Most rainfall is received June to September. Pre-monsoon showers occur during May. Weather is sultry through out the year. BTR is administrated by two divisions: BTR (West) and BTR (East) .BTR is representative of North East Indian habitat. In comparison to the BTR (E) the BTR (W) faces more and continuous problems of elephant raiding. This is the reason of selecting the area as a unit of study.

3. Database and Methods

The entire frame of the study has been categorically built on rigorous field survey based on a structured questionnaire and observation. In addition, data has been collected from the official documents of respective departments. However, along with it, some secondary sources of data like books and journals, etc have also been consulted to prepare the paper. Obtained information has been mathematically calculated and statistically established to derive the findings.

4. Discussion and Analysis

The area of Buxa Tiger Reserve is 760.92 sq km, which is small in size. Besides, the increasing population pressure has lead to large scale human settlement in the periphery areas of BTR and many small villages have come up in the region by encroachment. The elephants have natural tendency to move in search of food. This movement of the elephants happens through the tea gardens and the village settlements which have grown in the periphery of the forest areas. In comparison to the BTR (E) the BTR (W) faces more and continuous problems of elephant raiding as stated earlier. In this region, there are at least 51429 families having a total population of 222991, cultivating over 14400 ha of agricultural land .This area offers two main cropping seasons. Rabi crops or Rabi harvest refers to agricultural crops sown in autumn and harvested in the winter season. The main Rabi crops of this region are wheat, potato, mustard, peas etc. A Kharif crop refers to the agricultural crops sown in starting of monsoon and harvested in the autumn. Kharif crops of this region are paddy, maize, jute etc. Due to continuous dearth of food for animals for deforestation and expansion of human habitat, animals like elephant are compelled to enter in the agricultural land of the surrounding villages and damage crop, which is highly variable in space and time. It is affected by many factors and is little understood. However, through extensive research several key patterns have been discerned, including peaks of seasonal activity and intense conflict at specific locations, as described here.

4.1 Pattern of crop damages due to elephant raiding

4.1.1. Spatial pattern

Elephants damage crops in a way that varies greatly from location to location, and also over time. There are few spatial trends, making it difficult to predict where conflict will take place. For example, one village may be heavily damaged by elephants while the next village may receive no damage at all. However, despite this variation, several spatial patterns have been identified. Crop damage is more likely to occur along the boundaries of BTR (W) and usually decreases with increasing distance from the boundary. Elephants from the protected area raid crops closest to the boundary because the risk of detection is lowest there. Elephants have an acute spatial awareness and it is likely they are able to recognize the transition between ‘safe’ forest and ‘dangerous’ farm land. Few elephants will take risk of going deep into the farming area, so the majority of damage occurs on the farms bordering BTR (W).

Crop damage also occurs along established elephant pathways of the study area. Crop damage is positively correlated with migration patterns of elephants, suggesting that elephants raided crops are opportunistically found on the way as they move. Sources of permanent water are a further interface for conflict to occur, being a resource that both humans and elephants directly compete for.

Elephants are highly water-dependent and where water is limited, the potential for conflict is high. Crop damage at water holes may be incidental; elephants coming to water may discover crops there and raid those.

4.1.2. Temporal pattern

Crop damage displays broad inter-year variation, meaning that areas that are heavily affected by crop damage one year may not be affected in the next, and vice versa. But despite this variation, strong seasonal patterns can still be identified. Crop damage usually exhibits a peak of activity which coincides with crops reaching maturity. Mature crops are targeted by crop-raiding elephants because their fruiting bodies and seeds are highly nutritious. Indeed, mature crops are far more nutritious than natural forage that is available to elephants.

4.2. Crop targeted by elephants

Elephants have a natural preference for derivatives of plants from the *Gramineae* family, which includes maize, paddy, wheat and *Solaneceae* family, which include potato and some vegetables. Such food crops are attractive to wild animals because the selective breeding of wild plants over centuries has reduced naturally-occurring

defense chemicals, spines and thorns, and fibrous tissues, making them more palatable. Maize ripens uniformly and presents a super-rich patch of food and is consequently highly vulnerable to predation.

Of major crops destroyed by elephants across villages of BTR (W), potato ranks first. However, despite of this, paddy, maize, wheat and vegetables are also destroyed. Huge amount of crop is damaged through out the year which causes severe financial loss to the poor farmers.

4.3. Behavior of crop raiding elephants

4.3.1. Group Size

Crop raiding is usually carried out by small groups of elephants. In BTR (W) maximum of crop-raiding incidents are due to small groups of elephants of 1-10. There may be several explanations for the small group size of crop-raiding elephants.

First, bull elephants are believed to be responsible for the majority of crop-raiding incidents, and they naturally form smaller groups than cows.

Second, elephants may avoid forming large groups because smaller groups are stealthier and hence are less likely to be detected by farmers.

4.3.2. Timing of Crop Raiding

The majority of elephant crop-raiding occurs during the hours of darkness (Sukumar 1992). All recorded crop raids occurred between 19:00 and 05:00, with a peak of activity at 20:00 in the study area. This peak of crop-raiding activity in the evening may be explained in two ways.

a. Elephants using the cover of darkness to increase their chances of success.

b. An elephant's feeding activity would naturally increase through the afternoon and evening, peaking around 21:00. Thus, the majority of crop-raiding occurs during the period that elephants would be naturally feeding.

4.3.3. Differences in Behavior between Bulls and Cows

In case of crop-raiding, bull elephants are found to be five times more than that of cows. It has been hypothesized that bull elephants are more likely to take risks than cows, in order to increase their nutritive intake and thus maximize their reproductive success. In addition, female elephants with calves may be less willing to expose their offspring to the higher levels of risk associated with crop-raiding for close proximity to settlement.

5. Management Strategies to prevent Crop damage

Human - Elephant Conflict (HWC) is increasing in Asia. It is now a major focus of international attention. The methods of mitigation ranging from simple, traditional methods used by villagers to modern, expensive technologies implemented by state agencies have been described and classified by many authors (Nelson *et al*. 2003; de Silva & de Silva 2007; Fernando *et al*. 2008). But it should be remembered that mitigation strategies should be conservative, but not destructive so that animals like elephant can live within their habitable forest area with required food for survival and side by side poor villagers of the surrounding areas of BTR (W) can get rid of the cruelty exerted by elephants. A brief overview of conservative measures to minimize the extremity of this issue is given here under.

Use of Fence – Metallic fences or fences made up of thorny bushes are the initial resistant that can be used to hinder the entry of elephant in the agricultural fields.

Buffer zone – Buffer zone of a five meter wide strip around fields or villages may be helpful. The making of buffer zones of unpalatable crops e.g. chilli, sesame, tea, tobacco, citrus may be useful to resist elephants to enter in the locality.

Watch-towers - at strategic points or at half kilometer intervals along intrusion borders, with communication (e.g. whistles) to alert other farmers

Light or fires – This system may be fruitful at strategic entry points. Burning chilli or chilli seeds and dung, as strong flashing lights, light shining on compact disks hung on string have proved efficient tactics to hinder elephant movement.

Making noise - Banging on metal, firecrackers, drum beating etc. help to frequent elephant raiding significantly.

Land-use planning - Lack of proper planning has resulted in a marked increase in competition between humans and wildlife for land, feed and water resources and is the root cause of increasing crop damage in most countries (Nelson *et al*. 2003). The two main factors that bring humans and elephant into situations of increasing confrontation here are: (a) expansion of human settlements and agriculture into forest areas; (b) loss of elephant habitats and blocking of traditional migration routes. These confrontations invariably lead to aggressive behavior in both humans and elephants, thus escalating HEC. Traditional land use patterns such as the slash-and-burn. Cultivation practiced in some Asian countries has proven to be elephant-friendly, and could be suitably applied for mitigating HEC this issue in the area under study.

6. Conclusion

The villagers of BTR (W) have been suffering from continuous problem of elephant raiding. Elephants raid crops close to the boundary of BTR (W) as a means of minimizing risk. Crop-raiding usually peaks when crops

are mature because of lessening in the nutritive quality of grasses. The elephant's catholic diet extends to crops - a wide variety of crops are damaged but paddy is usually favored over all others in the study area. Crop-raiding occurs in different seasons and exerts different impacts upon rural communities. Elephants tend to raid crops in small groups, and while there may be habitual raiding. Each year a huge amount of crop damage and resultant financial loss is caused and it increases significantly in last few years. Compensation paid by the government is not adequate in respect of the crop damage caused by elephant raiding. The complex nature, the site specific and animal- specific causes make it obvious that there cannot be one formula for solving man elephant conflict which results crop damages. A pragmatic approach that combines economic incentives with cultural pride and traditional knowledge with modern technology to promote coexistence between humans and elephant is the need of the hour.

References

Barnes, R.F.W. (1996), "The conflict between humans and elephants in the central African Forest", *Mammal Review* **26**, 67-80.

Barnes, R.F.W. (2008), "The design of crop raiding studies", *Gajah* **28**, 4-7.

Bhattacharjee, S. (2012), "The scenario of man- elephant conflict in Hoollonpar Gibbon Wildlife Sanctuary of Assam, India", *International Journal of Scientific and Research Publication* **2**(8), 1-3.

Bist, S.S. (1994), "Management of problem population of elephants in the northern part of West Bengal; Report submitted to Chief Wildlife Warden of West Bengal", *Mimeo*, 41.

Bist, S.S. (2002), "An overview of elephant conservation in India" *The Indian Forester* **128**, 121-136

De Silva, M. & De Silva, P.K. (2007), "The Sri Lankan Elephant: It's Evolution, Ecology and Conservation", Colombo, WHT Publications.

Fernando, P., Kumar, M.A., Williams, A.C., Wikramanayake, E., Aziz, T. & Singh, S.M. (2008), "Review of Human-Elephant Conflict Mitigation Measures practiced in South Asia", AREAS Technical Support Document Submitted to World Bank, World Wide Fund for Nature.

Gowariker, V., Krishnamurthy, V.N., Gowariker, S., Dhanorkar, M., Paranjape, K. & Borlaug. N. (2009), "The Fertilizer Encyclopedia", John Wiley and Sons.

Hoare, R.E. (1999), "Determination of human-elephant conflict in a landuse mosaic" *Journal of Applied Ecology* **36**, 689-700.

Kangawa, K. (1995), "Human elephant conflict: The challenge ahead", *Pachyderm* **19**, 11-14.

Monney, K.A., Dakwa, K.B. & Wiafe, E.D. (2010), "Assessment of crop raiding situation by elephants (*Loxodonta africana cyclotis*) in farms around Kakum conservation area, Ghana", *International Journal of Biodiversity and Conservation* **2**(9), 243-249.

Nelson, A., Bidwell, P. & Sillero-Zubiri, C. (2003), "A Review of Human Elephant Conflict Management Strategies", *People and Wildlife Initiative*, Wildlife Conservation Research Unit, United Kingdom, Oxford University Press.

Osborn, F.V. & Parker, G.E. (2002), "Community based methods to reduce crop loss to elephants: experiments in the communal lands of Zimbabwe", *Pachyderm* **33**, 32-38.

Osei-Owusu, Y. & Bakker, L. (2008), "Human –Wildlife Conflict. FAO", *Elephant Technical Manual,* 45.

Parker, G.E., Osborn, F.V., Hoare, R.E. & Niskanen, L.S. (2007), "Human-Elephant Conflict Mitigation", *A training course for Community-based Approaches in Africa. Participant's manual elephant pepper development Trust*, Livingstone, Zambia

Sukumar, R. (1989), "The Asian Elephant: Ecology and Management". Newyork, University of Cambridge.

Western, D. (1997), "In the Dust of Kilmanjaro", Washington DC, Island Press.

Whyte, I., Van Aarde, R.J. & Primm, S.I. (1998), "Managing the elephants of Kruger National Park", *Animal Conservation* **1**, 77-83.

Woodroffe, R., Thirgood, S. & Rabinowitz, A. (2005), "People and wildlife - Conflict or coexistence", Newyork, Cambridge University Press.

Table 1.The crop coverage and crop production of BTR (W)

Name of Crops	Crop coverage(hectares)	Crop production (kg/hectares)
Paddy	5342	6050
Wheat	100	1950
Maize	2200	2250
Vegetable	400	13312
Potato	150	21000

Source: Forecast report of agricultural office, Kalchini Block

Information obtained from Table 1 reveals a total of 8192 hectares of land produces 44562 kg crops in BTR (W). Among the crops produced here are Paddy, Wheat, Maize vegetables and Potato etc. If the total production of these crops are considered, it is noticed that potato (2100 kg/ hectare) ranks first followed by vegetable (13312 / hectare) Paddy (6050 kg / hectare), Maize (2250kg / hectare) and Wheat (1950kg / hectare). This shows a clear dominance of potato production in the study area if per hectare production is considered.

Table 2. Average crop production (kg) in between the year 2007-2011in BTR (W)

Name of Crops	Total production(kg)	Average price in Rs/kg	Net income from the crops (in lacs)
Paddy	32319100	10	3232
Wheat	195000	12	23.40
Maize	4950000	9	445.5
Vegetable	5324800	20	1064
Potato	3150000	7	220.5
		TOTAL	4985.4

Source: Forecast report of agricultural office, Kalchini Block

Table 2 shows an average picture of crop production (in kg) during the year 2007-2011 wherein it comes into notice that the production of Paddy supersedes all others crops if its average production is considered during the year 2007-2011 followed by vegetable, Maize, Potato and Wheat. If average price per kg for each of the crops produced here is multiplied, the net income of the crops mentioned comes to 4985.4 lacs, out of which Paddy (3232 lacs) vegetable (1064 lacs) Maize (445.5 lacs), Potato (220.5) and Wheat (23.40 lacs) are remarkable.

Table 3. Economic Analysis of Crops Loss in the Study area

Name of the crops	Average % of crop damages due to elephant raiding during 2007-2011	Total amount of crop loss due to elephant raiding during 2007-2011(kg)	Average price in during 2007-2011(Rs/kg)	Net loss due to elephant raiding (in lacs)
Paddy	27	8726157	10 Rs/kg	872.60
Wheat	15	29250	12 Rs/kg	3.51
Maize	20	990000	9 Rs/kg	89.10
Vegetable	15	798720	20 Rs/kg	159
Potato	32	575040	7 Rs/kg	402.50
			TOTAL	1526.71

Source: Forecast report of agricultural office, Kalchini Block

Table 4. Compensation paid by the Govt. during 2007-12

Tear	Area of Crop damage in Bigha	Compensation paid (in lacs)
2011-2010	657	7.19
2010-2009	551	3.78
2009-2008	209	4.75
2008-2007	186	2.89

Source: Annual Report of field director office of BTR, Alipurduar

Now, if an analysis is made to assess the economic loss of crop damaged for elephant raiding some interesting findings come out. During 2007-11, 27% of produced paddy, 15% of produced wheat, 20% of produced maize, 15% of produced vegetables and 32% of produced potato lying in the agricultural field at harvested position are damaged by elephant raiding. The total amount of the crop loss during 2007-11 (in kg) was 11,119,167, out of which paddy (87261057 kg) wheat (29250 kg), maize (990000 kg) got damaged. If average price rate is

multiplied with each of the crops damaged, it is found that, an amount of Rs. 1526.71 lacs is the net loss out of which, Rs. 3.51 lacs from wheat, Rs. 89.10 lacs from Maize, Rs. 159 lacs from vegetables and Rs. 402.50 lacs from potato (Table 3). This indicates the severity of economic loss that has to face by the cultivators in this part and can also assume their miserable livelihood. But what is interesting is that despite this economic loss, Govt. provides a few compensation to them (Table 4) which is very much negligible and never meet the loss.

Table 5. Crops damaged by Elephants as per Respondents' view

Name of Crops	No. of Respondents	Percentages of Respondents (%)
Paddy	176	88
Wheat	56	28
Maize	78	39
Vegetable	104	52
Potato	182	91

Source: Field Study

Table 6. Extent of average annual damage by elephant as per respondents' view

Crops	Observed	Expected	Chi values	P-Value
Paddy	67.76	100	10.394176	0.0343
Wheat	0.48	100	99.042304	0.0001
Maize	11.36	100	78.570496	0.0001
Vegetable	13	100	75.69	0.0001
Potato	7.4	100	85.7476	0.0001

Source: Field Study

While interacting with the villagers, (200 in number) of the crop raided area located adjacent to BTR (W), 91% of respondents opine that elephants cause damage to potato, 88% put the view that they cause damage to paddy, 52% agreed that they cause damage to vegetable, while 28% and 39% reported that elephants cause damage to wheat and maize respectively (Table 5). This indicates the cultivators engaged in production of potato and paddy suffers significant economic loss than others. If the extent of damage is analyzed as presented in Table 6, it is found that the damage come to paddy, wheat maize, vegetable and potato are extremely significant as statistically proved using Chi-square test.