Indian Journal of Animal Sciences **92** (4): 484–491, April 2022/Article
https://doi.org/10.56093/ijans.v92i4.124173

Economic assessment of crop damages by animal menace in mid hill regions of Himachal Pradesh

RAJESH KUMAR THAKUR[1], ADITI WALIA[1], KANIKA MEHTA[1]✉, VIRENDER KUMAR[1] and HARBANS LAL[1]

CSK Himachal Pradesh Krishi Vishvavidyalya, Palampur, Himachal Pradesh 176 062 India

Received: 10 December 2020 ; Accepted: 27 December 2021

ABSTRACT

The present study assessed the extent of animal menace and its impact on the economic losses of crops in mid-hill regions of Himachal Pradesh. The study was conducted in Kangra district of Himachal Pradesh and was based on the primary data collected from 60 farm households selected through three stage random sampling process. It was observed that in the existing scenario, due to animal menace, the net and total cropped area has declined by 12.66 and 17.35%, respectively in comparison to the before menace period. Out of the total cropped area, 33.03% was prone to animal menace out of which 54.69 and 45.31% was affected by wild and stray animals, respectively. The extent of animal menace varied across the crops. On an average, 45.76, 43.07 and 31.25% of total area under maize, wheat and paddy, respectively was prone to animal menace and it was relatively lower in vegetable crops vis-a-vis cereals. The overall productivity levels of cereal crops decreased by about 16 to 24% due to the problem of animal menace in the study area. The total cost of cultivation of field crops in menace prone areas and overall situation (menace prone + non menace prone) was significantly higher compared to the non-menace prone areas due to the cost of watch and ward and fencing activities on sample farms. The total economic losses on account of animal menace in field crops were estimated at ₹ 25358/farm in which the share of wheat was highest (32.48%), followed by paddy (13.27%) and maize (12.22%). In the total economic loss, the share of loss in production was slightly higher (53.63%) compared to increase in total cost of cultivation on account of management of animal menace.

Keywords: Animal menace, Crop losses, Economic losses, Stray cattle, Wild animals

Himachal Pradesh is a mountainous Himalayan state having undulating topography and diversified agro-climatic conditions suitable for the cultivation of wide range of crops. Through the concerted efforts of the government and farming community, the state has emerged as a model hilly state in the country as far as development of agriculture is concerned. Over the last four decades, the state has witnessed remarkable transformation in agriculture through quality fruits and off- season vegetable production (Sood and Kumar 2019). Efforts are afoot to make the state self sufficient in agricultural production and also in improving the socio-economic conditions of the farmers (Mehta *et al.* 2020). However, the state is in the vortex of various serious threats to farming such as climate change, shrinking land holdings, land degradation, increasing cost of cultivation and unpredictability of marketing forces. Apart from this, in the recent past, the problem of animal menace has emerged as the major challenge to the growth and sustainability of agriculture.

The persistent infringement of human beings in forests, common lands and other natural inhabitations of wild animals have created a severe competition for natural resources between wild animals and the local communities (Manral *et al.* 2016, Mehta *et al.* 2018). Due to hilly terrain, the majority of inhabited villages and agricultural lands in the state are adjacent to forests, rivulets, etc. which act as hideouts for wild animals. The availability of flora and fauna in forests and common lands has declined due to infestation by the obnoxious weeds and frequent fires during summer months. Thus, the extent of raids and crop damages by wild animals has increased to a greater extent during the last decade. Regmi *et al.* (2013) and Mamo *et al.* (2021) had reported that the frequency of crop raiding increases with the increase in proximity of fields to the forests. Monkeys, wild boar, sambar, nilgai and stray cattle are among the major animal species responsible for the crop raids and damages in different parts of the state. Tripathi and Rao (2016) also reported increasing problem of higher vertebrates, like Nilgai (blue bull), wild boar, monkeys, etc. in agriculture in many regions across the country. About 71% of the total panchayats in state are suffering from the problem of monkey menace. Similarly, the problem of stray cattle is also emerging as a serious concern in the state with Kangra district having the highest population. According to the Directorate of Agriculture, Himachal Pradesh, the problem of animal menace has forced the farmers to abandon crop cultivation in 19,563 ha land area. The wildlife wing of the state has estimated an annual loss of worth ₹ 300-450 crore in the

Present address: [1]CSK Himachal Pradesh Krishi Vishvavidyalya, Palampur, Himachal Pradesh. ✉Corresponding author email: rkthakurkvk@yhaoo.co.in

agriculture and horticulture sectors due to crop raiding. This estimate can rise to ₹ 1,500 crore if expenditure on watch and ward and fencing is also taken into consideration. The problem of animal menace is therefore negatively impacting the farming community on account of crop losses, man days put in by the farmers for watch and ward and area abandoned due to various reasons including attack by wild animals. Therefore, increasing the scientific understanding of the extent of animal menace, crop raiding behaviour and its impact on socio-economic conditions of the farmers is important as it has a negative impact on people's livelihoods and can lead to farmer reprisal (Findlay and Hill 2020). Keeping above factors into consideration, the present study was conducted to analyse the extent of animal menace and its impact on yield loss, cost of cultivation and economic losses in major crops in the study area.

MATERIALS AND METHODS

The present investigation has been conducted in foothills of Western Himalayan region. The Kangra district of Himachal Pradesh was purposively selected for the study as it represents the average situations of the region with respect to agro-climatic conditions and has the highest number of holdings and stray cattle population among different districts of the state. The study is based on the primary data collected from 60 farm households selected through three stage random sampling design (blocks, villages and farmers). The detailed information with respect to land use, cropping pattern, cost of cultivation and crop losses, etc. were collected through personal survey on specifically designed and pretested survey schedule. The data were analysed using simple tabular methods.

Estimation of economic loss in crops: The losses in crop production on account of animal menace mainly comprise of production losses and incurrence of additional costs for watch and ward and fencing in menace prone areas. The total economic losses for major crops have been expressed using following functional equation:

$$TEL_i = \sum PL_i + \sum ACWF_i$$

where TEL_i, Total economic losses in i^{th} crop (₹/ha); PL_i, Production loss in i^{th} crop (₹/ha); $ACWF_i$, Additional cost (labour and material) on fencing and watch and ward incurred in i^{th} crop (₹/ha).

Production losses: The total production losses were estimated by taking into account the differences in the productivity levels (main and by-product) of different crops under non-menace, menace prone and overall situations (non- menace + menace prone).

$$\text{Total Production Loss } (TPL_i) = Pm_i\,(PNm_i - POm_i) + Pb_i\,(PNb_i - POb_i)$$

where TPL_i, Total production loss in i^{th} crop (₹); Pm_i, Average price of the main product of i^{th} crop (₹/q); Pb_i, Average price of by-product of the i^{th} crop (₹/q); PNm_i, Productivity of main product of i^{th} crop under non-menace area (q/ha); POm_i, Overall existing productivity of main product (menace & non-menace area) of i^{th} crop (q/ha); PNb_i, Productivity of by-product of i^{th} crop under non-menace area (q/ha) and POb_i, Overall existing productivity of by-product (menace and non-menace area) of i^{th} crop (q/ha).

The value of POm_i and POb_i was estimated as:

Overall existing productivity of main product (POm_i) =

$$\frac{(PNmi*ANi)+(PMmi*AMi)}{(ANi+AMi)}$$

Overall existing productivity of by-product (POb_i) =

$$\frac{(PNbi*ANi)+(PMbi*AMi)}{(ANi+AMi)}$$

where AN_i, Non-menace prone area under i^{th} crop (ha/farm); AM_i, Menace prone area under i^{th} field crop (ha/farm).

Additional cost on watch and ward and fencing (ACWF): In order to minimize the losses in menace prone crop fields, the farmers were found to perform watch and ward and fencing the crop fields. The expenditure on these components on labour and materials were the additional expenses over the non-menace prone farming situation.

Cost of cultivation

The cost of cultivation has been calculated for the major crops grown by the sample households, i.e. maize, paddy, wheat, berseem, oats, potato, onion and cauliflower. The costs have been calculated for non-menace, menace prone areas and overall farm situation as mentioned below.

Cost of cultivation on non- menace prone areas: The total cost of cultivation for the crops mentioned above was estimated as

Total Cost (TC) = Total Fixed Cost (TFC) + Total Variable Cost (TVC)

Total fixed cost: The total fixed cost was expressed using the following functional form:

$$T_f = I+D+R$$

where I, Interest on initial fixed investment (₹/ha) was charged @ 10% per annum on total investment on major and minor implements and tools; D, Depreciation on major and minor implements (₹/ha) was worked out by using straight line method and was charged @ 10% in case of major implements and @ 20% on minor implements; R, Rental value of owned land (₹/ha) was taken as average value at which the farmers were leasing out land for cultivation purposes and was estimated at ₹ 8500/ha.

Total variable cost: The recurring or variable cost included the expenditure on seeds and planting materials, human and bullock labour, tractor charges, manure and fertilizers, irrigation charges, plant protection chemicals, charges of thresher, miscellaneous expenses and interest on total working capital calculated for half of the crop period.

$$TVC = \sum_{i=1}^{n} P_i X_i + \left(\sum_{i=1}^{n} P_i X_i \right) * r \times K_i/2$$

where TVC, Total Variable Cost (₹/ha); P_i, Price of i^{th} input per unit (₹/ha); $X_{i,}$ Quantity of i^{th} input used (q/ha); $K_{i,}$ Crop period of i^{th} crop in months; r,Monthly interest rate charged on working capital @ 5% per annum (₹/ha).

Cost of cultivation in menace prone areas:

Total Fixed Cost = Same as in case of non-menace area

Total Variable Cost = Total variable cost of non-menace Area+ Additional cost of watch and ward and fencing

Cost of cultivation on overall situation (non- menace and menace prone areas): The total variable costs in case of overall existing situation (menace and non-menace areas) for different crops were estimated by using the following formula while the total fixed cost was same to that of menace and non-menace situations.

$$TVCo_i = \frac{(TVCNi*ANi)+(TVCMi*AMi)}{(ANi+ AMi)}$$

where $TVCo_i$, Total variable cost in overall existing situation for i^{th} crop (₹/ha); $TVCN_i$, Total variable cost in non-menace prone area for i^{th} crop (₹/ha); AN_i, Area under non-menace prone area for i^{th} crop (ha/farm); $TVCM_i$, Total variable cost in menace prone area for i^{th} crop (₹/ha); AM_i Area under menace prone area for i^{th} crop (ha/farm).

RESULTS AND DISCUSSION

Changes in acreage of crops due to animal menace: The cropping pattern of the sample households was analyzed for existing and before menace period. In the existing situation, there had been a decline of about 17% in the total cropped area, which indicates that the farmers were keeping their fields fallow due to the problem of animal menace (Table 1). Pandey *et al.* (2019) also reported a transition in agriculture from mixed cropping to mono-cropping or fallow lands due to the problem of animal menace, particularly the wild pig (*Sus scrofa*), in the Indian Himalayan Region. This decline in area under cultivation had been reflected in all the cereals, fodder and vegetable crops except for that of okra, ginger, turmeric and garlic where the area had increased by 50.76, 15.79, 50.54 and 25.53%, respectively. The extensive damage to crops such as wheat, maize, paddy, potato, vegetables and other horticultural crops have also been observed by Hill (2000), Sahoo and Mohnot (2004), Veeramani *et al.* (2004) and Ghimire and Chalise (2018). The increase in area under okra, ginger, turmeric and garlic could be attributed to their less or non-preference by the stray cattle and wild animals in the study area. Hence, it is suggested to incorporate such non-preferential crops as alternative field crops to reduce conflicts between farmers and wild animals. The use of non-preferential field crops has also been recommended by Gross *et al.* (2016).

Extent of animal menace: The land holdings in hills are highly fragmented and scattered. Therefore, the fragments which were approachable to wild and stray animals were categorized as menace prone areas and which were safe from them were categorized as non-menace prone (Table 2). The proportion of area affected by animal menace was 33.03% of the total cropped area. It was found that on an average 45.76, 43.07 and 31.25% of total area under maize, wheat and paddy, respectively was prone to animal menace. Similar observations had also been reported by Chauhan and Sawarkar (1989), Hill (2000) and Fungo *et al.* (2010). Many other human-wildlife conflict studies such as Adeola *et al.* (2018), Alemayehu and Tekalign (2020) and Long *et al.* (2020) have reported maize as the most raided crop by animals. Soybean was the only oilseed crop grown by the sample households and 40.56% of the area was prone to animal menace. Devault *et al.* (2007) also observed extensive crop damage on soybean fields due to animal menace. The table further indicates that in case of vegetables, the animal menace prone area was relatively low as compared to the cereals. It varied between 9.50% in case of okra to 29.14% in case of brinjal. On the basis of proportion of area prone to animal menace, vegetables could be divided into two groups. The first group included vegetables like potato, cabbage, cauliflower, radish, brinjal, cucumber, onion and tomato in which the proportion of menace prone area varied between 20.02 to 29.14%. The second group included the vegetables like okra, garlic, ginger and turmeric where the proportion of menace prone area varied between 9.5 to 12.57%.

Table 1. Changes in cropping pattern on sample farms (ha/farm)

Crop	Existing scenario	Before menace	% change over existing area
A. *Cereals*			
Maize	0.1255	0.1721	-37.13
Paddy	0.1597	0.2028	-26.99
Wheat	0.2608	0.3023	-15.91
B. *Oilseeds*			
Soybean	0.0198	0.0354	-78.79
C. *Vegetables*			
Okra	0.0197	0.0097	50.76
Tomato	0.0138	0.0238	-72.46
Cucumber	0.0077	0.011	-42.86
Brinjal	0.0071	0.0103	-45.07
Ginger	0.0171	0.0144	15.79
Turmeric	0.0647	0.032	50.54
Potato	0.0247	0.0303	-22.67
Cabbage	0.021	0.0304	-44.76
Cauliflower	0.023	0.0334	-45.22
Radish	0.0058	0.0105	-81.03
Garlic	0.0423	0.0315	25.53
Onion	0.0338	0.0449	-32.84
D. *Fodder crops*			
Sorghum	0.013	0.0217	-66.92
Oat	0.0549	0.0601	-9.47
Berseem	0.0471	0.0517	-9.77
Total cropped area	0.9615	1.1283	-17.35
E. Net area sown	0.5008	0.5642	-12.66
F. Cropping intensity (%)	191.99	199.98	

Table 2. Extent of animal menace in different crops on sample farms (ha/ farm)

Crop	Menace prone area			Non-menace area	Total existing area
	Wild animal	Stray cattle	Total		
Maize	0.0373	0.0201	0.0574	0.0681	0.1255
	(64.98)	(35.02)	(45.76)	(54.24)	(13.05)
Paddy	0.0299	0.0200	0.0499	0.1098	0.1597
	(59.92)	(40.08)	(31.25)	(68.75)	(16.61)
Wheat	0.0674	0.0449	0.1123	0.1485	0.2608
	(60.02)	(39.98)	(43.07)	(56.93)	(27.12)
Soybean	0.0048	0.0032	0.0080	0.0118	0.0198
	(60.00)	(40.00)	(40.56)	(59.44)	(2.06)
Okra	0.0010	0.0009	0.0019	0.0178	0.0197
	(52.63)	(47.37)	(9.50)	(90.50)	(2.05)
Tomato	0.0018	0.0017	0.0035	0.0103	0.0138
	(51.43)	(48.57)	(25.32)	(74.68)	(1.44)
Cucumber	0.0010	0.0006	0.0016	0.0061	0.0077
	(62.50)	(37.50)	(20.22)	(79.78)	(0.80)
Brinjal	0.0013	0.0008	0.0021	0.0050	0.0071
	(61.90)	(38.10)	(29.14)	(70.86)	(0.74)
Ginger	0.0011	0.0007	0.0018	0.0153	0.0171
	(61.11)	(38.89)	(10.66)	(89.34)	(1.78)
Turmeric	0.0049	0.0032	0.0081	0.0566	0.0647
	(60.49)	(39.51)	(12.57)	(87.43)	(6.73)
Potato	0.0040	0.0027	0.0067	0.0180	0.0247
	(59.70)	(40.30)	(27.01)	(72.99)	(2.57)
Cabbage	0.0032	0.0022	0.0054	0.0156	0.0210
	(59.26)	(40.74)	(25.56)	(74.44)	(2.18)
Cauliflower	0.0028	0.0018	0.0046	0.0184	0.023
	(60.87)	(39.13)	(20.02)	(79.98)	(2.39)
Radish	0.0008	0.0005	0.0013	0.0045	0.0058
	(61.54)	(38.46)	(22.50)	(77.50)	(0.60)
Garlic	0.0026	0.0018	0.0044	0.0379	0.0423
	(59.09)	(40.91)	(10.35)	(89.65)	(4.40)
Onion	0.0041	0.0027	0.0068	0.0270	0.0338
	(60.29)	(39.71)	(20.21)	(79.79)	(3.52)
Sorghum	0.0006	0.0036	0.0042	0.0088	0.0130
	(14.29)	(85.71)	(32.11)	(67.89)	(1.35)
Oat	0.0029	0.0164	0.0193	0.0356	0.0549
	(15.03)	(84.97)	(35.10)	(64.90)	(5.71)
Berseem	0.0022	0.0161	0.0183	0.0288	0.0471
	(12.02)	(87.98)	(38.78)	(61.22)	(4.90)
Total cropped area	0.1737	0.1439	0.3176	0.6439	0.9615
	(54.69)	(45.31)	(33.03)	(66.97)	(100)

Note: Figures in parentheses indicate percentages to total in each category.

The results further revealed that out of the total menace prone area, the incidence of wild animals, especially monkey and wild boar was higher (54.69%) in comparison to the stray cattle population (45.31%). As per the report of the Forest Department of Himachal Pradesh, monkeys alone were prevalent in more than 80% of the total panchayats of the study area. It was observed that in case of cereals and vegetables, the attack of wild animals especially monkey and wild boar was higher (more than 50% in all crops) than that of the stray cattle. Rao *et al.* (2002), Chhangani and Mohnot (2004), Wang *et al.* (2006), Chauhan and Pirta (2010) and Saraswat *et al.* (2015) have also observed the extensive crop damage due to crop raiding by monkeys and wild boars. Deodatus (2000) highlighted that most of the crop losses especially in productivity and cropping systems were mainly caused by smaller pest species, such as monkeys and rodents. However, in case of fodder crops, the wild animal attack was reported to be lesser than that of stray cattle due to different food preferences.

Changes in productivity of different crops: The productivity levels of different crops grown by sample households were analyzed for menace and non-menace prone areas. The results indicated a considerable decline in the productivity of different field crops on sample farms due to animal menace. The decrease in productivity of cereals varied between 52 to 60% and 48 to 50% due to wild and stray animals, respectively (Table 3). The overall decrease in productivity among the cereals was highest in wheat (24.11%) and it varied between 15.72 and 24.11%. In case of vegetables, the decrease varied between 1.11 to 41.6% and 1.05 to 38.76% due to wild and stray animals, respectively. The overall decrease in productivity was highest in brinjal (8.74%) followed by onion (8.18%). On the other hand, okra, ginger, turmeric and garlic were almost unaffected as the decline in productivity levels was quite low, ranging between 0.12 to 0.39%. The decrease in productivity of fodder crops varied between 34.36 to 39.98% and 56.79 to 59.78% due to wild and stray animals, respectively. In case of fodder crops, berseem suffered a productivity decrease of 22.02% in productivity followed by oat (19.99%) and sorghum (17.46%). The overall decrease in productivity of fodder crops varied between 15.79 to 24.01%. Sekhar (1998) observed that the decline in the crop yield was about 30 to 35% more than when there was no major damage near the Tiger Reserve, India.

The table further indicates that as compared to those damaged by stray cattle, the productivity of cereals and vegetables (excluding ginger and radish) were lower in areas infested by wild animals. Whereas, the productivity levels of fodder crops in wild animals menace prone areas were higher (214.00 to 344.91 q/ha) compared to the stray cattle prone area (143.40 to 211.97 q/ha). It was also reported by the respondents that most of the vegetable crops were not preferred by both the categories of animals except monkey, but they caused damage through physical injuries to crops while they raid the fields of other preferred crops.

The monetary losses on account of decrease in productivity levels of different crops due to animal menace varied from ₹660/ha in case of garlic to ₹58,100/ha in case of cabbage (Table 3). Among the cereal crops, the losses were highest in case of wheat ₹17,873/ha) followed by maize (₹10,987/ha). In vegetable crops, the losses were found to be considerably high in case of cucumber, brinjal and cabbage (₹50,000 to ₹58,000 per ha) as compared

Table 3. Productivity of different crops in non-menace and menace prone areas on sample farms

Crop	Productivity of crops (q/ha)					Percentage decrease in productivity over non-menace area			Losses due to decreased productivity (₹/ha)
	Non–Menace Area	Menace Area			Overall productivity	Wild Animals	Stray cattle	Overall	
		Wild Animals	Cattle	Average					
Maize	31.45	14.92	15.79	15.22	24.06	52.56	49.79	23.50	10987
Paddy	27.86	13.41	14.28	13.76	23.48	51.87	48.74	15.72	7364
Wheat	28.29	11.35	14.26	12.51	21.47	59.88	49.59	24.11	17873
Soybean	14.37	5.92	7.50	6.55	11.11	58.80	47.81	22.69	16887
Okra	115.55	113.38	114.29	113.81	115.23	1.88	1.09	0.28	1664
Tomato	240.83	205.91	205.07	205.5	231.88	14.50	14.85	3.72	22375
Cucumber	170.67	111.70	119.67	114.69	158.44	34.55	29.88	7.17	55035
Brinjal	123.47	85.45	86.85	85.98	112.68	30.79	29.66	8.74	53950
Ginger	105.67	104.50	103.57	104.14	105.26	1.11	1.99	0.39	7380
Turmeric	95.23	93.97	94.23	94.07	95.05	1.32	1.05	0.19	2340
Potato	350.62	260.20	270.47	264.34	327.13	25.79	22.86	6.70	35235
Cabbage	178.76	125.90	143.40	133.03	167.14	29.57	19.78	6.50	58100
Cauliflower	125.00	95.43	98.88	96.78	119.57	23.66	20.90	4.34	10860
Radish	125.65	100.78	103.16	101.70	120.69	19.79	17.90	3.95	11904
Garlic	50.65	50.09	49.97	50.04	50.59	1.11	1.34	0.12	660
Onion	150.16	87.69	91.96	89.39	137.87	41.60	38.76	8.18	22122
Oat	356.54	214.00	143.40	154.01	285.25	39.98	59.78	19.99	8555
Berseem	525.45	344.91	211.97	227.95	409.77	34.36	59.66	22.02	17352
Sorghum	475.28	295.34	205.37	218.22	392.31	37.86	56.79	17.46	11616

Table 4. Cost of cultivation of selected crops grown on sample farms

(₹/ ha)

Particulars	Maize	Wheat	Paddy	Oat	Berseem	Potato	Onion	Cauliflower	Others
Non-menace prone area									
Fixed costs									
Interest on fixed capital	4360	4360	4360	4360	4360	4360	4360	4360	4360
Depreciation	4829	4829	4829	4829	4829	4829	4829	4829	4829
Land rent	4250	4250	4250	4250	4250	4250	4250	4250	4250
Total	13439	13439	13439	13439	13439	13439	13439	13439	13439
Working Capital									
Material inputs	10360	11066	9622	12956	7588	63169	50507	22712	23498
Human labour	19782	23640	16532	16706	17262	34054	37780	36322	25260
Bullock labour/Tractor charges	12003	23043	13359	5094	5656.5	6967.5	11964	10608	11087
Total working capital	42145	57749	39513	34756	30507	104191	100251	69642	59844
Interest on working capital @ 5%	527	722	494	434	381	1302	1253	871	748
Total variable cost	42672	58471	40007	35190	30888	105493	101504	70513	60592
Total cost (Fixed cost + Working Capital)	56111	71910	53446	48629	44327	118932	114943	83952	74031
Menace prone area									
Total fixed cost	13439	13439	13439	13439	13439	13439	13439	13439	13439
Total working capital	42145	57749	39513	34756	30507	104191	100251	69642	59844
Watch and ward and fencing	40997	40997	40997	40997	40997	40997	40997	40997	40997
Interest on working capital @ 5%	1039	1234	1006	947	894	1815	1766	1383	1261
Total variable cost	84181	99980	81516	76700	72398	147003	143014	112022	102102
Total cost (Total Fixed cost + Total Variable cost)	97620	113419	94955	90139	85837	160442	156453	125461	115541
Overall situation									
Fixed cost	13439	13439	13439	13439	13439	13439	13439	13439	13439
Total working capital of non-menace area	42145	57749	39513	34756	30507	104191	100251	69642	59844
Watch & ward and fencing	13544	13544	13544	13544	13544	13544	13544	13544	13544
Interest on working capital @ 5%	696	891	663	604	551	1472	1422	1040	917
Total variable cost	56385	72184	53720	48904	44602	119207	115217	84226	74306
Total cost (Total Fixed cost + Total Variable cost)	69824	85623	67159	62343	58041	132646	128656	97665	87745
% increase TC of MPA over NMPA	42.52	36.6	43.71	46.05	48.36	25.87	26.53	33.09	35.93
% increase in OS over NMPA	24.44	19.07	25.66	28.2	30.94	11.53	11.93	16.33	18.52

MPA, Menace Prone Area; NMPA, Non- Menace Prone Area; OS, Overall Situations.

to the vegetables like garlic, onion, radish, turmeric and tomato, etc.

Cost of cultivation: Based on resource use pattern in normal crop production and additional expenditure on watch and ward and fencing in menace prone areas, the cost of cultivation for non-menace prone areas, menace prone area and overall farm situation of different crops was worked out (Table 4). It can be observed from the table that total cost of cultivation in menace prone area was quite high. Among cereals, it was ₹97,620; ₹1,13,419 and ₹94,955 per hectare, for maize, wheat and paddy, respectively. In case of fodder crops such as oat and berseem, the cost of cultivation was ₹90,139 and ₹85,836 /ha, respectively. In vegetables such as potato, onion and cauliflower the cost of cultivation was ₹1,60,441, ₹1,56,453 and ₹1,25,461per ha, respectively. The cost of cultivation in case of menace prone area was quite high in comparison to non-menace area because of the additional expenditure on watch and ward and fencing activities. The preventive measures like watch and ward, making loud noises and farm fencing for deterring the crop raiding have also been discussed by Kagoro-Rugunda (2004), Malugu (2010) and Veeramani *et al.* (2004).

Due to animal menace there was an increase of 24.44, 19.07 and 25.66% in the cost of cultivation of cereals like maize, wheat and paddy, respectively on overall situation compared to the non-menace areas. In case of oats and berseem, the increase was 28.20 and 30.94%, respectively. On the other hand, the extent of increase in cost of vegetables was comparatively low compared to other cereals and fodder crops: 11.53, 11.93 and 16.33% in potato, onion and cauliflower, respectively. Also, increase in total cost of cultivation over non-menace area was significantly higher in menace prone area compared to overall situation. In menace prone areas, it varied between 25.87% in case of potato to 48.36% in case of berseem. Therefore, it can be concluded that the animal menace was responsible for increasing the cost of cultivation of different crops and has adversely affected the profitability of crops.

Total economic losses associated with animal menace: The losses in the production and increase in cost of cultivation on account of animal menace were estimated (Table 5). Evidently, on an average the total losses from all the crops taken together were ₹25,358/farm out of which about 53.63 and 46.37% were on account of decrease in total production and increase in cost of cultivation of different crops, respectively. The distribution of total losses among different crops was highest in case of wheat i.e. ₹8237/farm accounting for 32.48% of total crop losses followed by paddy (13.27%) and maize (12.22%). The results further indicated that in the total losses of each crop, the share of production loss was higher as compared to increase in cost of cultivation; these were 56.69, 55.84, 71.96 and 61.77% in wheat, berseem, potato and onion, respectively. On the other hand, in case the crops like maize, paddy, oats and cauliflower, the share of increase in cost of cultivation was higher compared to production losses; about 55.52, 65.06, 61.57 and 55.75%, respectively of total losses.

Further, per hectare total losses associated with the animal menace varied between ₹16,312 in paddy to ₹ 44,696 in potato. These were estimated at ₹18,048 in maize and ₹25284 in wheat. Among fodder crops, the per hectare losses in berseem (₹25,308) were about 49% higher as compared to oats (₹16,995).

Therefore, it can be concluded that the problem of animal menace was contributing to the economic losses in the study area substantially. Similar results have also been reported by Weladji and Tchamba (2003), Kaswamila *et al.* (2007) and Mwakatobe *et al.* (2014).

The study indicated that there had been a considerable decline in the productivity levels of major crops and it ranged between 16 to 24% in case of cereals and 17 to 22% in case of fodder crops. Among the different crops, the decline in the productivity levels in case of okra, tomato, ginger, turmeric, cauliflower and garlic was below 5%. Overall, the increase in cost of production to restrict animal menace on account of watch and ward and fencing ranged from 26% in case of potato to 48% in case of berseem. The total loss among major crops was found to be highest in potato (₹44696/ha) and lowest in paddy (₹16312/ha). In order to reduce the economic losses, the farmers should be motivated to increase the area under the crops like okra, garlic, ginger, turmeric, etc. which are less preferred by the stray and wild animals. Watch and ward and fencing

Table 5. Pattern of economic losses as a result of animal menace in different crops on sample farms

(₹)

Crop	Yield losses/ farm	Increase in cost of cultivation/ farm	Total economic losses/farm	Total losses/ ha
Maize	1379 (44.48)	1721 (55.52)	3100 (12.22)	18048
Wheat	4661 (56.59)	3576 (43.41)	8237 (32.48)	25284
Paddy	1176 (34.94)	2190 (65.06)	3366 (13.27)	16312
Oat	470 (38.43)	753 (61.57)	1223 (4.82)	16995
Berseem	817 (55.84)	646 (44.16)	1463 (5.77)	25308
Potato	870 (71.96)	339 (28.04)	1209 (4.77)	44696
Onion	748 (61.77)	463 (38.23)	1211 (4.78)	32515
Cauliflower	250 (44.25)	315 (55.75)	565 (2.23)	21261
Others	3228 (64.77)	1756 (35.23)	4984 (19.65)	21483
Total	13599 (53.63)	11759 (46.37)	25358 (100.00)	26373

Note: Figures in parentheses indicate percentages in total in each category.

were reported to be very difficult for an individual farmer, therefore, it is suggested that these should be done on a community basis and government should provide incentives to the farmers for solar/ electric fencing. In order to address the problem of wild animals, the department of forest should take initiatives for planting or rejuvenating the wild fruit tree species in the forest areas. This will check the movement of monkeys to inhabited and agricultural areas.

REFERENCES

Adeola A J, Ibrahim A O, Adeola A N, Alaye S A, and Akande O A. 2018. Primates associated with crop raiding around borgu sector of Kainji Lake National Park, Nigeria. World News of Natural Sciences **18**: 223–31.

Alemayehu N and Tekalign W. 2020. Prevalence of crop damage and crop-raiding animals in southern Ethiopia: The resolution of the conflict with the farmers. *Geo Journal* **1**: 1–15.

Chauhan A and Pirta R S. 2010. Public opinion regarding human-monkey conflict in Shimla, Himachal Pradesh. *Journal of Human Ecology* **30**(2): 105–09.

Chauhan N P S and Sawarkar V B. 1989. Problems of over-abundant populations of nilgai and blackbuck in Haryana and Madhya Pradesh and their management. *Indian Forester* **115**(7): 488–93.

Chhangani A K and Mohnot S M. 2004. Crop raiding by wild boar (*Sus scrofa*) in and around Aravalli and its management in Rajasthan. *Tiger paper* **31**(2): 1–5.

Deodatus F. 2000. Wildlife damage in rural areas with emphasis on Malawi. *Wildlife Conservation by Sustainable Use, Conservation Biology Series, Springer, Dordrecht* **12:** 115–40.

Devault T L, Beasley J C, Humberg L A, Macgowan B J, Retamosa M I and Rhodes O E. 2007. Intra-field patterns of wildlife damage to corn and soybeans in Northern Indiana. *Human–Wildlife Conflicts* **1**(2): 205–13.

Findlay L J and Hill R A. 2020. Baboon and vervet monkey crop-foraging behaviors on a commercial South African farm: preliminary implications for damage mitigation. *Human–Wildlife Interactions* **14** (3): 505–18.

Fungo B, Eilu G and Tweheyo M. 2010. Patterns of crop raiding around Mabira Forest Reserve, Uganda. *Research Journal of Biological Sciences* **12**(5): 785–92.

Ghimire S C and Chalise M K. 2018. Status of crop raiding by Assamese monkeys (*Macaca assamensis*) along the Budhigandaki river, central Nepal. *Journal of Natural History Museum* **30**: 294–305.

Gross E M, McRobb R and Gross J. 2016. Cultivating alternative crops reduces crop losses due to African elephants. *Journal of Pest Science* **89**: 497–506.

Hill C M. 2000. Conflict of interest between people and baboons: Crop raiding in Uganda. *International Journal of Primatology* **21**(2): 299–315.

Kagoro-Rugunda G 2004. Crop raiding around Lake Mburo National Park, Uganda. *African Journal of Ecology* **42**(1): 32–41.

Kaswamila A, Russell S and McGibbon M. 2007. Impacts of wildlife on household food security and income in North-eastern Tanzania. *Human Dimensions of Wildlife* **12** (6): 391–404.

Long H, Mojo D, Fu C, Wang G, Kanga E, Oduor A M O and Zhang L. 2020. Patterns of human-wildlife conflict and management implications in Kenya: a national perspective. *Human Dimensions of Wildlife* **25**(2): 121–35.

Malugu L T. 2010. 'Assessment of human-elephant conflicts in areas adjacent to Grumeti-Ikorongo Game Reserves, Northern Tanzania'. MSc Dissertation, Sokoine University of Agriculture, Morogoro, Tanzania.

Mamo A, Lemessa D, Diriba O H and Hunde D. 2021. Pattern of crop raiding by wild large mammals and the resultant impacts vary with distances from forests in Southwest Ethiopia. *Ecology and Evolution* **11**: 3203–09.

Manral U, Sengupta S, Hussain SA, Rana S and Badola R. 2016. Human wildlife conflict in India: A review of economic implication of loss and preventive measures. *Indian Forester* **142**(10): 928–40.

Mehta K, Thakur R K and Guleria J S. 2020. Socio-economic impact of protected cultivation on tomato growers of Himachal Pradesh. *Economic Affairs* **65**(1): 01–07.

Mehta P, Negi A, Chaudhary R, Yasmin J and Thakur P. 2018. A study on managing crop damage by wild animals in Himachal Pradesh. *International Journal of Agriculture Sciences* **10**(12): 6438–42.

Mwakatobe A, Nyahongo J, Ntalwila J and Eivin R. 2014. The impact of crop raiding by wild animals in communities surrounding the Serengeti National Park, Tanzania. *International Journal of Biodiversity and Conservation* **6**(9): 637–46.

Pandey L, Arunachalam A and Joshi N. 2019. Challenges of hill farming due to crop-raiding by wild pigs in the Indian Himalayan region. *Current Science* **116**(6): 1015–19.

Rao K S, Maikhuri R K, Nautiyal S and Saxena K G. 2002. Crop damage and livestock depredation by wildlife: A case study from Nanda Devi Biosphere Reserve, India. *Journal of Environmental Management* **66**(3): 317–27.

Regmi G R, Nekaris K A I , Kandel K and Nijman V. 2013. Crop-raiding macaques: predictions, patterns and perceptions from Langtang National Park, Nepal. *Endangered Species Research* **20**: 217–26.

Sahoo S K and Mohnot S M. 2004. A survey of crop damage by rhesus monkey (*Macaca mulatta*) and human langur (*Semnopithecus entellus*) in Himachal Pradesh, India. *Tiger paper* **31**(4): 1–5.

Saraswat R, Sinha A and Radhakrishna S. 2015. A god becomes a pest? Human-rhesus macaque interactions in Himachal Pradesh, Northern India. *European Journal of Wildlife Research* **61**(3): 435–43.

Sekhar N U. 1998. Crop and livestock depredation caused by wild animals in protected areas: The case of Sariska Tiger Reserve, Rajasthan, India. *Environmental Conservation* **25**(2): 160–171.

Sood S and Kumar V. 2019. Agricultural diversification for rural development in Himachal Pradesh. *Administrative development. A Journal of HIPA, Shimla* **6**(2): 47–56.

Tripathi R S and Rao V V. 2016. Vertebrate pest management in agriculture. Human Animal Conflict in Agro-Pastoral Context: Issues and Policies. Indian Council of Agricultural Research, New Delhi.

Veeramani A, Easa P S and Jayson E A. 2004. Socio-economic status of cultivators and their interface with wild animals: A case study of Marayur Forest Range, Kerala. *Indian Forester* **130**(5): 513–20.

Wang S W, Curtis D P and Lassoie J P. 2006. Farmer perceptions of crop damage by wildlife in Jigme Singye Wangchuck National Park, Bhutan. *Wildlife Society Bulletin* **34**(2): 359–65.

Weladji R B and Tchamba M N. 2003. Conflict between people and protected areas within the Benoue Wildlife Conservation Area, North Cameroon. *Oryx* **37**(1):72–79.