The Four-Horned Antelope: The Distribution Patterns, Resource Selection and Immediate Threats in Chitwan National Park

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Ref. No. 9748-1

Chitwan, Nepal

2012

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Abstract

The four-horned antelope (*Tetracerus quadricornis* Blainville, 1816) also known as Chausingha or Chauka which is endemic to the Indian sub-continent is listed as vulnerable species in IUCN redlist and on CITES Appendix III in Nepal. It is one of the least studied, sexually dimorphic small structured boselaphid with two pairs of antlers in males only. The systematic line transect method was used to assess the use/available habitat variables which were believed to influence the occurrence of four-horned antelope. Data gathered using this method was then used to develop a distribution pattern and the habitat factors influencing the four-horned antelope occurrence in Chitwan National Park. Statistical tools used were variance to mean ratio to find the distribution pattern and logistic regression analysis to estimate resource selection probability function and habitat use. Out of 290 plots, only 36 plots were found to be used by antelope during the field study which was conducted in April to June 2011. The result showed the clumped distribution patterns of the four-horned antelope in Chitwan National Park. The best fit habitat model showed that hill sal forest is positively related while tree height, shrub height, presence of muntjak and presence of dense shrubs were negatively related to the occurrence of this species. Conservation efforts in Chitwan National Park and other potential areas should be focused on the Hill sal forest. Additional research should be carried out on this species to find out its extent of distribution and its biology to ensure a more successful conservation effort.

Key words: Four-horned antelope, Line-transect, habitat model and Hill sal fores

Chapter I

1. Introduction

1.1 General background

A resource selection function (RSF) is defined as any function that is proportional to the probability of use by an organism (Manly et al., 1993). Natural resources include materials found in nature that permit a species survival. Differential selection of available resources is one of the primary factors that allow species to co-exist, and is therefore a priority in the preservation of endangered species (Rosenzweig, 1981). Studies of resource selection, mainly to identify resources that are critical to an animal population, are useful to predict the incidence of the species (Cardozo et al. 2010) and form the basis for much of our understanding of wildlife habitat requirements (Manly et al. 2002). Information about relationships between wildlife populations and their preferential habitats are used for many purposes, including characterization of long-term resource requirements and prediction of potential impacts of habitat change. In addition to this, resource selection function (RSFs) can be used to predict the relative probability of use across a landscape based on mapped distributions of resources or to assess the relative influence of different habitat characteristics on species distributions. One of the most powerful and commonly used tools for wildlife management and ecology is logistic regression, which contrasts used versus available or used versus unused resource units (Anderson et al. 2005, Johnson et al. 2006, Long et al. 2009).

Wildlife managers often require estimates of abundance and information on factors that affect abundance over time. Direct methods of estimation are often impractical, especially in closed-forest environments, so indirect methods such as dung or nest surveys are increasingly popular (Laing et al. 2003). Surveys of dung are typically conducted using quadrat sampling (Bailey & Putman 1981, Putman 1984), strip transect sampling (Plumptre & Harris 1995) or line transect sampling (Barnes et al. 1995; Marques et al. 2001). Cromsigt et al. 2009, suggests that direct observational counts are not optimal method to monitor diversity. Dung counts seem to better represent diversity (including rare species) and are less labour-intensive.

RSF models often are fitted using generalized linear models (GLMs), although a variety of statistical models might be also used. Information criteria such as the Akaike Information Criteria (AIC) or Beyesian Information Criteria (BIC) are tools that can be useful for selecting a model from a set of biologically reasonable candidates. Statistical inference procedures, such as the likelihood-ratio test, can be sued to assess whether models deviate from random null models.

But for most applications of RSF models are used, their usefulness is evaluated by how well the model can predict the location of specific organisms on a landscape (Boyce et al. 2002).

1.2 Study species

The four horned antelope (*Tetracerus quadricornis* Blainville, 1816) also known as “Chausingha or Chauka” is endemic to the Indian subcontinent. According to IUCN redlist this is vulnerable species with decreasing population trend (Mallon 2008). The Four-horned Antelope has a wide distribution, occurring in scattered populations from the Himalayan foothills to peninsular India (Rahmani 2001). It has been recorded in Chitwan and Bardia National Parks within Nepal (Bolton, 1975; 1976) and may be found in small numbers outside reserves in the forested areas of Bara and Banke Districts (Heinen & Yonzon 1994).

The four-horned antelope has a golden brown coat that darkens after the monsoon season and fades after winter. There is a dark stripe running down the front of each leg and it sports a conspicuous white ring just above the hooves (Burton 1898, Sharma & Rahmani 2003). The adult is up to 60cm tall at shoulder height and 20kg in weight. The antlers are conical, nearly straight and pointed upwards. The anterior pair of antlers which measure approximately 1-2.5 cm is always shorter than the posterior pair which can reach 8-12 cm in length. The front pair of antlers may fall off in older animals, or may merely be represented by nodules of black, hairless skin (Prater 1971, www.ultimateungulate). The female is similar to the male in all aspects but has no horns.

Four horned antelope is non-migratory, probably a sedentary (Krishnan 1972) and territorial species occupying restricted home ranges (Sharma and Rahmani 2004). It is generally a solitary but sometimes can be seen in a small group of three to five animals. It is elusive and difficult to observe in wild. It has peculiar anti-predatory behaviour where it prefers to hide than run, making it obscure (Sharma et al. 2009). It is herbivorous with a ruminal digestive system. *T. quadricornis* is a selective forager and eats healthy plant parts such as fruits, flowers, and fresh leaves (Berwick 1974; Sharma 2006).

The Four-horned Antelope, hereafter FHA, has a tendency to defecate on middens that might be communal which is shared not only by one or more individuals, but also by different species. Nilgai (*B. tragocamelus*), chinkara (*Gazella bennettii*) and four-horned antelopes were frequently seen defecating on certain middens at different times of the day in India (Sharma et al. 2005).

1.3 Rationale

This endemic species is categorized as vulnerable species by IUCN and is listed in CITES Appendix III in Nepal. Furthermore this species is one of the least known mammalian species in Nepal and as such its management is largely hampered by a lack of basic information on this species. Realizing these facts, this study has been carried out with the aim of focusing on FHA to increase the biological knowledge of this species.

1.4 Purpose/Hypothesis of the study

Primarily, this study was conducted by collecting information on FHA from Nepal with the main focus on habitat features. The specific objectives of the study were to;

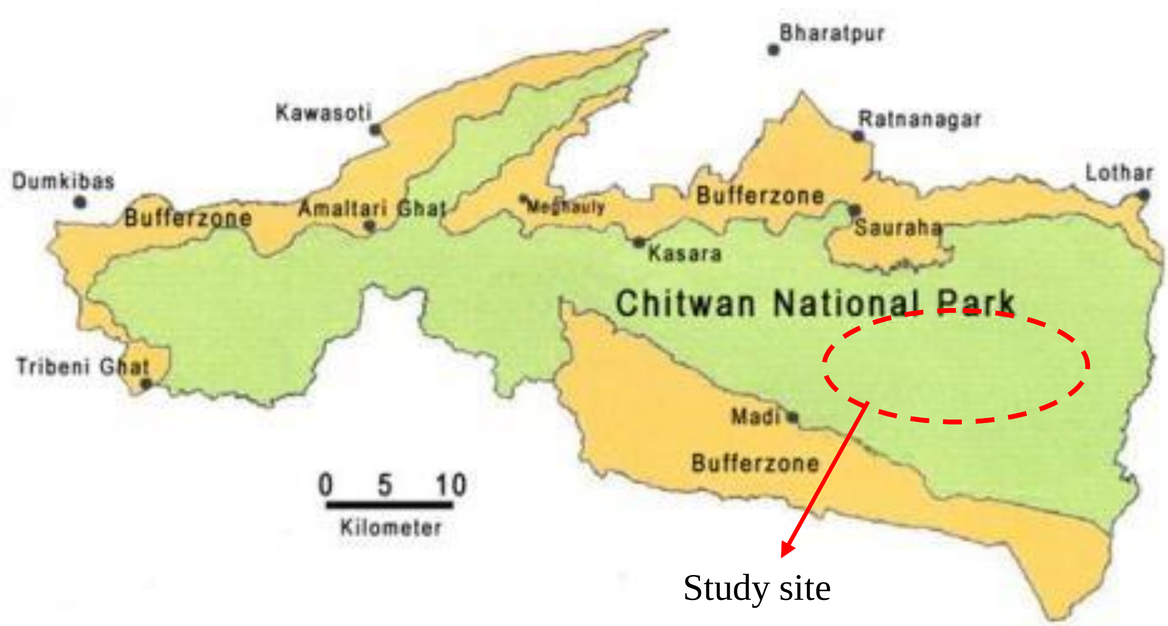
- find out a distributional pattern of FHA in Chitwan National Park, Nepal
- record the habitat used by FHA
- highlight specific habitat variables associated with the presence of FHA
- point out the major threats to wildlife including FHA in CNP
- share the information obtained from the research to the different stakeholders
- to record the other mammalian species noticed during field survey

The main hypothesis of this study was; FHA distribution is uniform throughout the study area. To test this hypothesis, mean to variance ratio was used. In addition to this study question, another hypothesis was set, which states that FHA uses all available resources randomly and the resource use is independent to the habitat features such as vegetation composition, tree height, topography, effect of fire, human disturbance and presence of other mammals especially ungulates. To test this hypothesis, logistic regression function was employed. If any of the predictable/independent variables are significantly associated with habitat features that are used more by FHA, then the final output of logistic regression analysis can be used as an estimation of the resource selection probability function. At the same time, those significantly associated predictable variables are considered as those variables which can explain the presence of FHA.

2. Methods

2.1 Study Area

The study was focused on southern part of the Chitwan National Park (CNP). The park which was established in 1973 is situated in between $83^{0}83'$ to $84^{0}74'$ E and $27^{0}34'$ to $27^{0}68'$ N in the Chitwan Valley, the inner Terai lowland of Nepal. The area was gazetted as the country’s first national park in 1973. UNESCO declared the park as the World Heritage Site in 1984. Initially, it covered an area of 544km^2 but later it was extended up to an area of 932km^2 in 1977 (www.dnpwc.gov.np, www.wikipedia.org). In 2006, Royal Chitwan National Park (RCNP) became Chitwan National Park (CNP) after the fall of direct rule of the King.



Map 1. Showing the study sites in Chitwan National Park (map source: Wikipedia.org).

The park has a subtropical monsoonal climate with three distinct seasons; monsoon, winter and dry. Summer monsoon starts from June through September followed by winter or dry cool season that lasts for mid of February with minimum daily mean temperature of 15^{0}C in January. Hot and dry season starts from March to June with the maximum daily mean temperature reaching up to 43^{0}C. Mean annual precipitation is about 1900mm with 80% falling as heavy rainfall in the monsoon (Nakarmi 2007 and www.dnpwc.gov.np). During dry season there are frequent forest fires during March and April that burn almost all the forest floor. Pre-monsoon rain during May makes the vegetation bloom and the environment becomes lovely.

2.1.1 Flora and Fauna

The floral diversity of the park consists of more than 500 species of plants. The forest area in Chitwan national park is distinguished into two major types, Sal forest and riverine forest. In sal forest where *Shorea robusta* (sal) is dominant tree species covers about 70% of the park while other associated species includes *Terminalia alata, Buchanania latifolia, Schleicheria trijuga, Dalbergia latifolia, Lagerstromea parviflora, Syzygium cumini, Bauhinia vahli,* and *Dillenia pentagyna*. Riverine forest is characterised by mixed forest with top canopy of *Bombax ceiba, Trewia nudiflora, Eretia laevis, Litsea monopetala, Mallotus phillipensis, Ficus racemosus* etc. Those forests types are intermingled with grassland which is mainly distributed in center and eastern part the park (DNPWC/CNP resource profile 2000). Grassland is dominated by *Saccharam sps. Phragmites karka,* and *Imperata cylindrica*. The forest in Chitwan is highly disturbed by exotic species such as *Eupatorium odoratum* and *Mikania micrantha.* Those are degrading the habitat quality of the park for wildlife and other native plant species.

The park is home to more than 50 mammals, over 525 birds and 55 herpetofauna. Large herbivores recorded in the study area include rhino (*Rhinoceros unicornis*), wild elephant (*Elephas maximus*), sambar (*Cervus unicolor*), spotted deer (*Axis axis*), barking deer (*Muntiacus muntjak*), wild boar (*Sos scorfa*), rhesus macaque (*Macacca mulatta*) and Terai grey langur (*Symnopithecus hector*). Large predators found in the area are tiger (*Panthera tigris*), leopard (*Panthera pardus*) and sloth bear (*Ursus ursinus*).

2.2 Materials and Methods

2.2.1 Preliminary Survey

Park people, staffs of Biodiversity Conservation Center, National Trust for Nature Conservation (BCC/NTNC), members of community forest user groups, tourist guides and local people were interviewed to know about the potential areas of the occurrence of four horned antelope. Then, line transects of 200m to 4km with random start was traversed to explore the potential areas of four horned antelope and to get some ideas of the habitat used by the study species. Four people with the gap of about 20m in between were walked along the transect to explore the sign of the study species, mostly the pellets.

Identification of FHA dung/pellets: The pellets from the midden of FHA that were confirmed in Bardia National Park (Pokharel 2010) were taken as reference to avoid the misidentification during further sign survey. There was considerable variation exhibited in the shapes of FHA pellets. As common latrines were used repeatedly, the dung-pile was generally very large. Unlike the typical comma-shaped pellets of barking deer (*Muntiacus muntjak*) (Dinerstein, 1980), FHA pellets is elongated. In some cases the shape of pellet is cylindrical with pointed shape at one end. In such case, the pellet size is generally bigger than the pellet of muntjak. Besides this, the pellet size from soil eaten FHA is much bigger than that from FHA with normal diet. In some middens, there was a mixture of pellets with different shapes and sizes and in some, very small pellets, possibly of young ones antelope, were also observed. The colour of pellets also varied from light grey to black. White pellets were due to the presence of higher soil content in the animals' diet.

a  b  c 

Picture 1. Shows different structure of FHA pellets that were recorded in the field during field study.

2.2.2 Study design and field survey

The systematic line transect method (Buckland *et al.* 2004) was used for the field survey. Random points were selected in the field to start the line-transect. Each transect was laid down with the gap of 200m separating them. Most of the transects traversed in a north to south direction while some traversed in an east to west direction. A total transect length of 50km was covered; this involved spending a total of 160 hours in the field for the data collection from April to June 2011. The length of transect varied from 200m to 4km depending on topography and site accessibility.

Different habitat variables were measured using the point sampling technique in a systematic manner over a 200m distance. All habitat variables were measured within a 20m radius. In case a FHA sign was encountered, the sampling plot was recorded as used as well as available habitat sample unit. Perpendicular distance from the line transect to the midden was recorded to know the FHA sign detection probability (not considered in this study). Only an FHA midden was taken into account during sign survey but not the hoof prints because the size/shape of hoof print was not easily distinguishable from that of muntjak and Chital.

Besides this, information on different habitat variables (Table 1) was measured using the same technique of variable measurement for a 20m radius with dung-pile at centre (fig 1). GPS coordinates of location; especially the dung-piles were recorded to show the distribution pattern of species in the study area.

Fig. 1. Study design for FHA dung survey and habitat assessment. Distance between plot A and B is 200m. In this figure, d represents the perpendicular distance from transect to the midden (M). Regardless the systematic space of 200m between two sampling plots, same technique of habitat assessment was used wherever FHA sign was recorded along the transect.

2.2.3 Variable measurement techniques

Different habitat variables, within 20m of the radius sampling plot, were measured to study the resource selection function and to classify the available and used vegetation associations. Animal signs were recorded as a response variable whereas other variables (Table-1) were measured as predictor variables. Besides this, based on visual density and height of trees, shrubs and grass in each sampling plot, dominant and sub-dominant species were also recorded to categorize the vegetation associations or habitat types. In addition to this, the presence of other mammals' was also recorded to know the extent of competition for the resource and space.

Table-1 Explanatory variables noted down in the field during field survey.

Variables	Variable type	Unit	Description
Vegetation associations	C		Composition of dominant tree species and associated shrubs and grass
Tree height	M	m	Average tree height excluding height of regeneration less than 3m
Canopy	O	%	Average canopy cover
Shrub height	M	m	Average shrubs height including the regeneration of height <3m
Shrub and grass distribution	O		Based on the visual assessment of density; open (<20%), Sparse (<60%) and Thick (>60%)
Grass height	M	cm	Average grass height
Fire	C		Presence of fire within a year prior to the survey
Predators	C		Presence of predators sign such as pugmarks, scraps or scats
Competition	C		Presence of other medium or large sized mammals such as, Chital, muntjak, sambar and elephant
Disturbance	C		Presence of human sign such as lopping/cutting of tree,

			camping site, invasive species
Slope	O	Degree	Slope of mountain and aspect
Altitude	M	m	Altitude from sea-level, GPS record

Where, C stands for Categorical, M = Metric and O = Ordinal variable

During the field survey, slope variables which were measured in degree were classified into intervals of 5°. Therefore, slope 1 does not actually mean 1° but represents the slope of <5°. Similarly, since the slope range was from <5 to 35°, the slope range from 31 – 35° is represented by 7. In addition to this, canopy cover was also assessed in the interval of 5% and altitude was classified into intervals of 100m. Therefore, altitude class 1 represents the altitude of less than 200 m, 2 represents altitude from 200 m to 300 m and in the same way, 7 represent altitude class of 700 m - 800m. Since fires, signs of elephants, humans, sambars, chitals, muntjaks and FHA's are categorical variables, "1" represents their presence while "0" represents their absence. Similarly, for the categorical variable, vegetation association, code 1 to 4 was assigned to represent mixed forest (1), riverine forest (2), hill sal forest (3), and Terai sal forest (4).

2.2.4 Classification of vegetation association

Based on the variables such as dominant and associated tree species, canopy cover, and topography, four different vegetation associations were identified and categorized.

Terai sal forest: This is a mixed forest where the sal (*Shorea robusta*) forms about 50% or more of the total coverage. This type of forest grows in relatively flat and well drained areas and is moist deciduous forest type. The upper canopy trees can reach heights of between 20 to 40 m. Average canopy cover of this forest during study period was estimated to be around 60% and is mainly dominated by *S. robusta* and *Terminalia alata*. These two species form the main upper canopy layer. Common grass species found here are *Eulaliopsis binata, Desmostachya bipinnata* and *Imperata cylindrica*. This type of forest is commonly used by elephant, sambar, chital, wild boar and muntjak.

Riverine forest: This type of forest forms large stands along stream sides and riverbanks. It is a mixed forest of tall and medium height trees with a thick understory of tangled shrubs and grasses. Estimated average canopy cover was around 60% during study period. This type of forest extends from flat area to the area with gentle slope. The forest is mainly dominated by *Syzygium cumini, Bombax ceiba, Acacia catechu, Schleichera oleosa* and *Mallotus philippensis*. *Bauhinia vahlii* is common climbers. Grass distribution varies from sparse to the dense depending on the extent of disturbance from flood and bare rocks. Common grass species found is *Imperata cylindrica*. Muntjak, sambar and wild boar are common in this habitat. Big troops of macaques, especially langur macaques (*Semnopithecus entellus*) are frequently seen there.

Hill sal forest: It is mostly found in hilly area. Average canopy cover was estimated to be around 50% and average height of upper canopy trees, less than 20m. It is mainly dominated by *Shorea robusta*, *Terminalia alata* and *Buchanania latifolia*. *Phoenix humilis*, a shrub species, locally called "*Thakal*", was considered as an indicator of this forest types. *Bauhinia vahlii* is common climber while *Eulaliopsis binata* and *Imperata cylindrica* are common grass species. Sambar, wild boar and porcupine are commonly found mammals in this habitat.

Mixed forest: There is no clear dominance of any tree species in this forest type. It includes large stands. During the study period, the average canopy cover was estimated to be around 60% and height of trees was generally more than 25 m that forms the top canopy layer. The dominating grass includes *Imperata cylindrica*, and *Saccharum sps*.

2.3 Data analysis

2.3.1 Distributional patterns and habitat use

Variance to mean ratio ($S^2/\overline{X}$): The distributional patterns of the FHA was calculated by variance to mean ratio (Odum, 1971), which is based on the fact that in Poisson distribution; the variance (S^2) is equal to the mean.

If $S^2/\overline{X} > 1$; Distribution is clumped

If $S^2/\overline{X} < 1$; Distribution is uniformed

If $S^2/\overline{X} = 1$; Distribution is random

Because of the differences in proportion of available vegetation associations, percentage of sample plot with FHA sign within a particular vegetation association was calculated to estimate the mean and variance of FHA sign distribution by using following method

$$\text{\% FHA sign distribution within a particular veg. association} = \frac{\text{number of plots with FHA sign}}{\text{total number of sample plots}}$$

2.3.2 Resource selection function

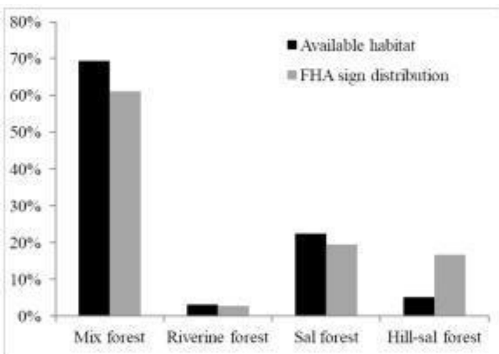
All parameters of interest were used to develop a full model. Since vegetation association and dominant shrubs were categorical variables, "Terai sal forest" and "regeneration" were respectively used as the reference category therefore, estimates for all vegetation associations and dominant shrubs are in comparison with this reference.

A hypothesis of logistic linear regression is that, there is no high correlation between two or more independent variables. Therefore, the correlation analysis was conducted, by estimating the R^2 value of the bivariate correlation for each variable to see if the tolerance value ($1-R^2$) is less than 0.03. None of the variable had such levels of correlation with other independent variables. Then, the binomial logistic regression was performed to estimate the resource selection function. Backward stepwise regression methods were employed through maximum likelihood test (α = 0.05) (Agresti 1996) to estimate the model of resource selection function. For the data analysis, IBM SPSS version 19 (an IBM company, USA) was used.

3. Result

3.1 Distributional patterns and habitat use

Out of 290 sample plots, 36 plots were found to be used by FHA which was recorded from all four types of vegetation associations that were intensively focused. Most of the area was covered by Mix forest (69%), and Terai sal forest (23%) while Riverine forest (3%) and Hill sal forest (5%) were available in relatively very low proportions. Although, the availability of Hill sal forest is very low, the proportion of its use was high. Despite the maximum availability of mix forest, it is less used (fig. 2a). The area in terms of number of sample plots that had been used by FHA was found to be highest in Hill sal forest followed by Riverine forest where 40% and 11.11% of the sample plots were used respectively. Moreover, the abundance of used sample plots in mix forest and Terai sal forest was found to be 10.95% and 10.77% respectively (fig. 2b). The mean percentage distribution of sample plots that had been used by FHA was found to be 18.21 ± 14.52 and the result showed that the distributional patterns of FHA was clumped ($S^2/\overline{X}$ = 11.60).

a 

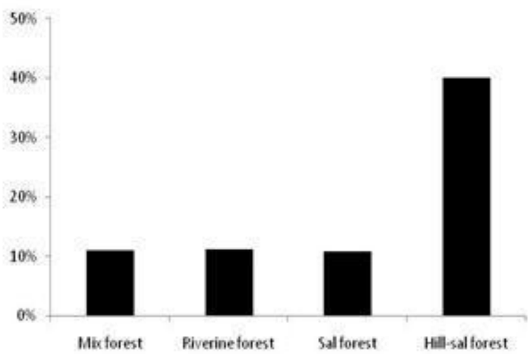
b 

Fig. 2a. *Percentage area of available vegetation associations and percentage distribution of FHA signs in each vegetation associations available in Chitwan National Park.*

Fig. 2b. *Percentage distribution of sample plots used by FHA in terms of sample plots with FHA sign to the total number of available sample plots of a particular vegetation association.*

3.2 Factors influencing habitat selection

3.2.1 Resource selection function

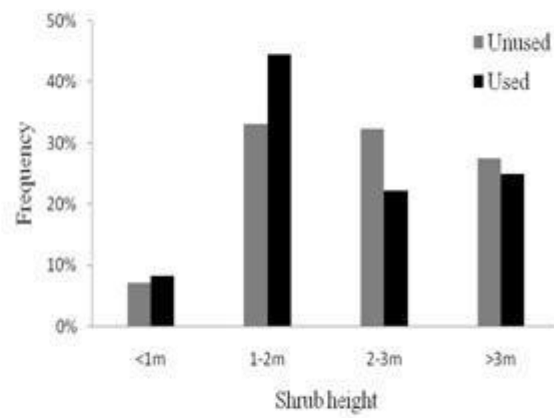
Out of 23 independent explanatory variables 5 were found to be significantly associated with the occurrence of FHA. As per the information from the best-fit model, the probability of selecting hill sal forest and riverine forest was more than the other available vegetation associations. In relation to the Terai sal forest, selecting Hill sal forest and riverine forest was 12.64 and 5.92 times more respectively. Moreover, area with no shrubs was completely avoided while the forest with mix shrubs, *Phoenix humilis*, *Achyranthes bidentata* and *Saccharum sps.* as ground vegetation were also very less used in relation to the area with more regeneration. Similarly the probability of occurrence of FHA decreases by 44% with the increase in shrub height by 1m (Table – 2, more details in Annexes).

Table –2. Estimated coefficients for the Resource Selection Function (RSF) habitat model for Four-Horned Antelope. Reference category for the forest type is 'Terai sal forest' and dominant shrub is 'regeneration'.

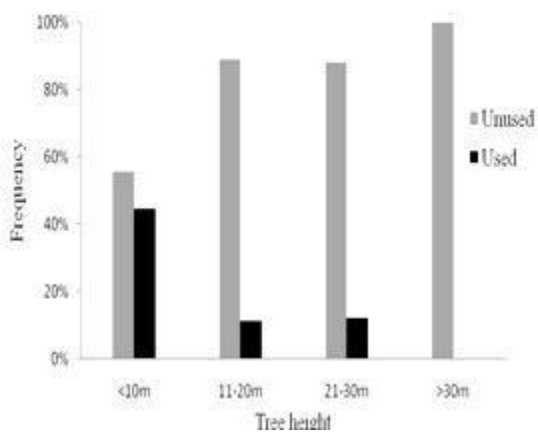
	B	S.E.	Wald	Sig.	Odd ratio/Exp(B)
Mix forest	-.185	.488	.143	.705	.831
Riverine forest	1.779	1.400	1.614	.204	5.921
Hill sal forest	2.537	.788	10.377	.001	12.644
Tree height	-.082	.042	3.874	.049	.921
No shrubs	-22.245	17926.216	.000	.999	.000
Mix-shrubs	-1.428	.610	5.475	.019	.240
Phoenix humilis	-1.556	.486	10.259	.001	.211

Achyranthes bidentata	-1.324	.817	2.624	.105	.266
Saccharum sps.	-2.393	1.297	3.408	.065	.091
Shrub height	-.443	.191	5.374	.020	.642
Muntjak	-1.782	.700	6.482	.011	.168

As can be seen in the fig. 3A, the abundance of FHA sign was higher in the area with shrub height of up to 2m while FHA uses more resources from area with tree height less than 10m (fig. 3B). Likewise, probability of FHA occurrence is higher in the area with canopy cover (20 – 40)% where the frequency of use is more than its availability while the abundance of FHA sign is less in the habitat with canopy cover less than 20% and more than 60% (fig. 3C).

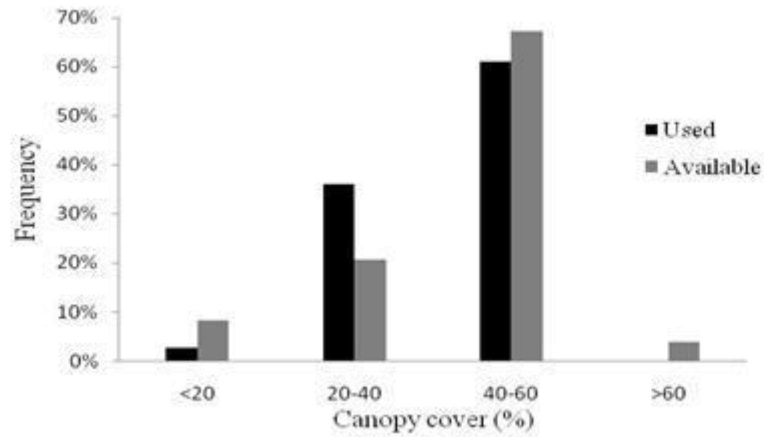


A



B

Fig. 3 Shows frequency of FHA sign in relation to the height of Shrub A. and Tree B.



C

Fig. 3C. Percentage distribution of FHA signs in relation to the percentage availability of average canopy cover in Chitwan National Park.

3.4 Other mammals

During the field survey, both large and small mammals other than FHA were also recorded. Some of them were directly sighted and some were identified by indirect signs such as pug marks and scraps.

One horned rhinoceros (*Rhinoceros unicornis*) and wild-elephant (*Elephas maximus*) were occasionally encountered. Rhinoceros were sighted mostly in the grassland while elephant were encountered almost everywhere. The signs of wild elephant were recorded even on the hilly areas with gentle slope. Barking deer were also observed many times especially along the riverine forest. Sambar (*Rusa unicolor*) was noticed almost everywhere from lower valley region to the top of the Churia hills. Usually, they were alone or in a small group of 2 to 4 members. In addition to this, chital (*Axis axis*) were frequently encountered in the *Phantas* mostly in big groups of more than 30 individuals especially during early morning and in the evening. In addition to this, they were also observed inside the dense forest, but in smaller groups of less than 10 members. Besides this, Langur macaques (*Semnopithecus hector*) were also commonly seen.

Table – 3 List of mammals noticed during field survey in Chitwan National Park.

S.N.	Name	Scientific name
1.	Asian Wild Elephant	*Elephas maximus*
2.	Barking Deer	*Muntiacus muntjak*
3.	Chital	*Axis axis*
4	Gaur	*Bos gaurus*

5.	Golden Jackal	*Canis aureus*
6.	Indian Crested Porcupine	*Hystrix indica*
7	Jungle cat	*Felis chaus*
8	Langur macaque	*Semnopithecus hector*
9.	Large Indian Civet	*Viverra zibetha*
10.	Leopard	*Panthera pardus*
11	One-horned rhinoceros	*Rhinoceros unicornis*
12.	Rhesus Macaque	*Macaca mulatta*
13.	Sambar Deer	*Cervus unicolor*
14.	Sloth Bear	*Melursus ursinus*
15.	Tiger	*Panthera tigris*
16.	Wild Boar	*Sus scrofa*

4. Discussion

4.1 Distributional patterns and habitat use

Species presence/absence are commonly used in ecology and conservation management, yet they can never be used to confirm that a species is absent from a given location (MacKenzie et al. 2002). According to Gu & Swihart 2004, failure to detect a species' presence in an occupied habitat patch is a common sampling problem when the population size is small, individuals are difficult to sample, or sampling effort is restricted. Detecting FHA is difficult because of its cryptic nature and small body size. In addition to this, thick understory vegetation, especially tall grass and shrub layers made the FHA sign detection more difficult. Moreover, rainfall may wash out the FHA pellets especially in hilly terrain with steep slope that may lead to negative observation i.e. the used habitat might have been recorded as unused. The latter reason is considerable in this study because, during field survey, there was pre-monsoon rain for few days.

Nature is heterogeneous. It consists of a mosaic of various habitat types and most organisms differentially use this heterogeneity for their survival, resulting in an uneven distribution of species over space (Sanderson *et al.* 2002, Jackson *et al.* 2008).The clumped pattern is common in nature, almost the rule, when individuals are considered. Random distribution, relatively rare in nature, occurs where the environment is very uniform whereas uniform distribution occurs where competition between individuals is severe or where there is positive antagonism which promotes even spacing (Odum 1971). Animals use those habitats which meet their life requisites such as cover, forage and space. Moreover, animals select that habitat which is more suitable for their survival, reproduction, and population persistence; therefore it is influenced by various biotic and abiotic factors also (Block and Brennan, 1993). In Chitwan national park, natural resources such as food, water resources and cover are not distributed uniformly. Besides this, there is a relatively higher level of inter-specific competition from species such as chital, sambar, and muntjak in the lower region. Moreover, the lower flat area is the habitat of tiger as well. These might be the main reasons of uneven and clumped distribution of FHA. In addition to this, there are numerous perennial water sources, though they are localized in gorges.

FHA is a habitat generalist (Berwick 1974 and Sharma 2006). However, it mostly lives in dry deciduous mixed forest with hilly terrain and avoids any area/s with human disturbance (Prater 1980, Sharma et al. 2005). In Gir, India, FHA use dense hilly areas as a habitat (Khan et al. 1996) while in Panna National park, India, it uses all the available habitats, except the human disturbed area/s, in accordance with their availability (Sharma et al. 2005). In Chitwan National Park, FHA uses almost all vegetation types available in the study area. Though it seems to be a generalist, it has a higher preference for the hill sal forest and riverine forest while other forest types are avoided. It is reasonable that, mix forest which have denser canopy with taller trees and less grass density on forest floor for forage in relation to other forest types. Moreover, it avoids the open areas with very low canopy cover. This limited use of such habitats is possibly because of the shy nature and anti-predatory behaviour.As far as anti-predatory behaviour is concerned, FHA depends largely on making itself inconspicuous and in the presence of predators; it freezes, lies down and freezes, or runs to cover and freezes (Sharma *et al.* 2009). In such ungulates, their coats may help them blend in with the surrounding rocks or vegetation (Wood 1992 and Caro et al. 2004). Therefore, FHA might have used hill sal forest more, where there is neither too dense canopy as in mix forest nor as open as grassland and savanna.

In CNP, FHA sign were mostly (77% of the total signs) recorded from the area that suffers from forest fire during dry season. This finding is similar to the finding of Pokharel 2010 in Bardia National Park, Nepal and Krishna et al. 2008 in Bandipur National Park, India. In Bardia National Park, it uses hilly region which is drier more and are subject to frequent forest fire during dry season. It seems that the properties of vegetation association in the area that are used more by FHA are managed by fire because, most of the plant species found in the hilly region are fire tolerant and their growth is possibly maintained by fire to a low breast height diameter and a stunted height. However, because of the limited information on the effect of fire regime on habitat features of FHA, more research is needed on this issue.

Hence, our hypothesis of "uniform distribution of FHA throughout the study area and no preference to a particular habitat type or vegetation association" is rejected. This finding of a preference for hilly areas by FHA is similar to the findings of Pokharel 2010 in Bardia National Park, Nepal and Khan et al. 1996 in Gir, India where, FHA inhabits hilly area.

4.2 Resource selection function

From the model (Table 2) it can be inferred that hill sal forest is the best predictor of the occurrence of FHA among all other variables measured in the field study. The occurrence of species is negatively correlated to tree height. It is further explained by fig. 3B which shows that FHA avoids the site with tree height more than 30m but it uses the site with average tree height of up to 20m. Then the probability of use of resources from those sites where tree height is more than 20m is lower in relation to their availability. In CNP, the lower flat region had taller trees and a dense canopy while, in hilly region, there were relatively shorter trees with a low dbh. Moreover, the area was drier and almost all understory vegetation was subjected to intermittent fire at least once a year during dry season. Therefore, the growth of regeneration and height of trees seem to be controlled by fire. Besides this, lower flat area consists of high amount of *Saccharum sps.* and invasive species like *Lantana* while hilly area is highly dominated by *Phoenix humilis* and *Achyranthes bidentata.* As the shrub height of more than 2m reduces the probability of FHA occurrence (fig. 3A) in the area. This might be the possible reason of very low occurrence of FHA in CNP.

The presence of muntjak is negatively associated to the occurrence of FHA but there is not much influence of sambar (*Rusa unicolor*), elephant (*Elephas maximus*) and other small and medium sized mammals. There is substantial overlapping of habitat of FHA and sambar but overlap with muntjak and chital is less (Leslie & Sharma 2009). In the case of the muntjak, there is some sort of overlap in the home range of both ungulates but the degree of overlap is not yet explored. But according to Lislie & Sharma (2009), habit overlap is almost nonexistent because muntjak dwells exclusively in moist deciduous and evergreen forest (Berwick 1974; Sharma et al. 2005). In comparison to chital, density of sambar is low (Khan et al. 1996; Shrestha 1997) therefore, chital seems to be a stronger competitor with FHA than sambar. Besides this, the habitat used by chital is open *Phantas* in flat areas and avoids hilly region (Shrestha 1997). Therefore, habitat use of these two species is distinctly different.

With an increase in the thickness of understory vegetation the probability of the occurrence of FHA decreases (fig 3A). During the field survey, it was realised that the detecting sign in the area of thick understory vegetation is difficult due to poor visibility. In relation to the dense understory vegetation, the range of visibility is wider in the areas which have a low understory vegetation density, resulting into the higher detection probability of sign from wider range. Although, FHA mostly deposits its dung on exposed surface (Krishna et al. 2008) many signs which did not lie exactly along the line transects may have remained undetected due to the dense shrubs.

4.2.1 Model performance

The most important application of Resource Selection Function (RSF) model is prediction and if a model reliably predicts the locations of an organism, it is considered as a good model (Boyce et al. 2002). RSF model constructed from use-availability data is the best choice for mobile species, where a census of all used units is difficult or impossible and the method is valuable for studying wildlife – habitat relationships (Johnson et al. 2006). Though, the use-availability data was used to develop the RSF model, the overall model is not very strong in predicting the occurrence of FHA i.e. only around 8% however, overall model performance is around 88%. Therefore, it is thought that there should be some weaknesses during designing the field study and/or considering the habitat variables to be noted down and incorporated into the model.

Some points that might improve the strength of a model if incorporated are as follows:

i. Species–habitat relationships include several hierarchical levels of spatial scale, and different habitat features which may be relevant to a species at different scales (Bissonette 1997). This model was built on small-scale variables of forest structure and without any deliberation of landscape patterns. The inclusion of both small-scale and landscape-scale characteristics in models would enhance the conservation strategies (Mazerolle and Villard 1999), explaining and predicting the distribution and abundance of vertebrate species (Storch 2002) more precisely.
ii. Ecological processes near habitat edges often differ from processes away from edges and predation rate is higher along edges for both mammalian and avian predators (Donovan et al. 1997). The edge effect is an ambiguous, though sometimes convenient concept (Hanley 1983) and might have a considerable impact on selecting a habitat by an animal. Similarly, water is a basic need of living organism and the availability of water resources would play an important role in selecting the habitat by an organism. Therefore, incorporating the variables like "distance to nearest forest or edge" and "distance to nearest water resources (creek, stream or river) would significantly improve the model performance. Though these variables could easily be obtained through well defined

digital map programmes by using ArcMap (ESRI), the limited time frame and lack of proper maps prevented this from happening.

iii. During the field survey, only a plot with human sign/s was noted as human disturbance and its effect on larger spatial scale was not considered. But in reality, the spatial extent of human disturbance would not have such a small scale influence. Certainly, there would be impact of human presence on larger scale. Therefore, it is believed that, an extended consideration of human disturbance to the nearest eight sample plots would improve the predictability of model significantly. Incorporation of the same technique to assess the effect of predator would play an important role on predicting the probability of resource use by FHA under the influence of predator.

iv. Due to lack of information on species' ecology, there was no more information on the home range of FHA. Therefore, there is a possibility that the study design did not cover the whole home range of animals and missed some valuable information on habitat variables.

Chapter II

5. Conservation Activities

5.1 Poster publication

450 copies of poster entitled with "**Let's save the Four-Horned Antelope *Tetracerus quadricornis***" have been published in the form of flex print (to make the posters more durable). 150 copies of the posters were distributed in the field to local people, local organisations and academic institutions such as school and colleges. 150 copies were provided to the Department of National Parks and Wildlife Conservation so that the flex can be distributed to all other government bodies along with local park office working in conservation sector together with DNPWC. 50 copies were distributed to the different organisations (NGOs) working with wildlife conservation. Similarly, 50 copies were distributed among the different departments of universities in Nepal. Those included Central Department of Zoology; Botany and Environmental Science; Tribhuvan University and the Department of Natural Science, Kathmandu University, Dhulikhel. Rest of the 50 copies are in stock to distribute/use in future.

5.2 Conservation education program

Most of the people in Chitwan were unaware of the presence of the four-horned antelope there in Chitwan National Park. Therefore the conservation education programmes were conducted in two different ways.

5.2.1 Awareness programme among different stakeholders

Members of community forest user groups, park staff, staff from Biodiversity Conservation Center, School teachers and tourist guides were the target people for conservation program and community outreach program. Staffs from national park and biodiversity conservation center were met individually or in a group and talked about the occurrence and general ecology of the four-horned antelope while members of different buffer zone community forest user groups (such as Kumrose, Mrigakunja and Baghmara Buffer Zone Community Forest User Groups) were met in their own contact office organising a meeting/discussion. In some cases, such education programme included a visit to a museum managed by BCC/NTNC, "Wildlife Display and Information Center" at Sauraha to explain them more about the wildlife.

Chitwan National Park is one of the most famous national park for wildlife safari in Nepal. Therefore a discussion program was organised with local tourists' guides too. That included the different issues such as interest of visitors on wildlife, probable threats to wildlife from visitors and vice versa. At that time, local tourist guides were informed about identification of FHA and the probable area of its occurrence. Similarly, they were informed about the precaution measures to be taken during exploring the wildlife in forest and not to disturb them.

5.2.2 Poem competition

With the help of *Mrigakunja* Community Forest User Group and "*Prakriti – Pathshaala sanjal*", an interschool poem competition was organised in Chitwan. The main topic for the poem competition was "the importance of nature, natural environment and wildlife". A total of 13 secondary schools from inside and outside the Buffer zone were requested to send their secondary level students (1 boy and 1 girl) along with a teacher from respective school to participate in the poem competition and interaction programme. The programme covered the area of *Bachhauli* VDC, *Ratnanagar* Municipality and *Kumjose* VDC targeting the school students and teachers with the belief that the information would be conveyed to the local people and/or guardians of school students.

Table 4. Participated students (Secondary level) from different schools. 18 Students from a total of 9 schools participated in the Poem competition organised in Chitwan.

SN	School	Students	Class

1.	Bairiya MV	Sadhana Kattel	10
		Sharmila Paudel	10
2.	Kaparphori MV	Hari Gurung	10
		Srijana Upadhyaya	10
3.	Mohana HSS	Suraj Paudel	10
		Bhawani Khanal	10
4.	Bakulahar MV	Namrata Bhujuel	10
		Bishal Sharma	9
5.	Bachhauli HSS	Ashrit Adhikari	9
		Sujan Acharya	10
6.	Chitrasari MV	Ramchandra Mainali	10
		Shanti Giri	9
7.	Kapiya MV	Chanamati Rai	10
		Nabin Pande	10
8.	Panchakanya HSS	Sonimaya Syanbo	10
		Miru Kumal	10
9.	Nepal HSS	Ajita Pandit	10
		Pramila Bhatta	10

Where MV stands for "Secondary School" and HSS for "Higher Secondary School".

Poem of Ramchandra Mainali from 'Chitrasari MV' won the first prize while Ashrit Adhikari from 'Bachauli higher secondary school' and Ajita Pandit from 'Nepal higher secondary school' respectively won the second and third prize. Since the main aim of the programme was to attract the students mind to the field of conservation rather than a "competition", all other participating students were also rewarded for their active involvement to the programme. It was believed that, besides their own motivation, those students would act as a messenger to convey the conservation messages to their homes /family members and friends.

Besides students and the teachers from different school, there was activate participation of members/representatives from different organisations such as Chitwan national park; *Prakriti – Pathshala sanjal,*; BCC/NTNC; Regional Hotel Association, Nepal; Wildlife Conservation, Chitwan Branch; Bird Education Society, Nepal; and some local NGOs working on the field of wildlife and environment.

In addition to the scheduled tasks of every programme/meetings, there used to be a short discussion on threats to natural environment and wildlife. Since most of the people in Chitwan were least known about the presence of the four-horned antelope, a short talk on presence and general ecology of that species was also given by displaying the posters of the species.

5.3 Threats to wildlife

During the field survey for FHA sign and then during the discussion with different stakeholders, the major threats noticed for the wildlife in general are discussed here.

Forest of Chitwan national park is highly affected by invasive species such as *Mikania micrantha* and *Lantana sps.* As the four-horned antelope avoid the area with such invasive species (Krishna et al 2008 and current study), the rapidly spreading those notorious species are the main reasons for the habitat destruction for the native species including the FHA. In addition to the invasive species, fire during dry season would be another major threat for the survival of wildlife in lowland including Chitwan National Park. It is because; the fire at that season burns almost all the ground vegetation that leads to the severe scarcity of food at that time. Mostly, the fire is set in the grassland for the purpose of grassland management but the fire uncontrollably spreads all over the forest. Though the fire might play an important role as a habitat management tool, it destroys the food for the herbivores.

Because of the weak economic conditions, many people are engaged in illegal activities to supplement their income, and poaching might be one of those consequences. CNP is also facing the problem of illegal activities. Though the park management is actively devoted to control the illegal activities inside the park, it seems without uplifting the economic conditions of locals and making them more aware of the importance of natural resources like forest and wildlife, the control measures would not be successful. In addition to this, it was realised that even the park management is highly focused on conserving the rhinos and tigers. It is very good that those extremely threatened species should be given more priorities, but being highly concentrated on tourism and certain wildlife species only, conservation of other wildlife species might have been put in shade.

5.4 Feedback and remarks

Even in the past such community outreach and education programmes used to be organised in Chitwan but most of them used to be organised in Sauraha. This time, the conservation awareness campaigns were conducted even in the remote villages Kumrose, Baghmara, Tandi and Kasara. Local people were happy to hear about the importance of natural resources/wildlife and their importance. Mostly, they used to have a similar kind of complains, i.e. loss of their agricultural products and sometimes casualties due to wildlife that sometimes leads to the loss of human life. Though the park management has managed to pay for the loss, locals are not happy with the tedious formalities that are to be over crossed to get the subsidies. In addition to this, they have another major problem of unemployment.

Since the Churia range in CNP where FHA is found, is completely intact forest from local people, therefore, they were least known about its presence.

Picture 2. General landscape of the study site in Chitwan National Park

a.  b. 

Picture 3. Chromolaena odorata, an invasive species (a) and general habitat of FHA (b) in CNP.

a  b. 

Picture 4. Local people participating in education and awareness program, visiting the museum at Biodiversity Conservation Center, Sauraha (a), members of community forest user group attending a discussion program at a meeting hall of Mrigakunja community forest use group.

a. 

b. 

Picture 5. Tourist guides after participating the education program in their own office at Sauraha (a). Students from different schools after participating the "interschool poem competition" in Chitwan.

Picture 6. Students from different school (in front) and the teachers from "prakriti – pathshaala sanjal" during the conservation education programme in Chitwan.

a 
b 

Picture 7. Prize distribution to the winner/participating students in a poem competition (b) and hand over of flex print to a representative from BCC/NTNC (b).

Chapter III

6. Conclusion and Management Implications

6.1 Conclusion

There is a clumped distributional pattern of four-horned antelope in Chitwan National Park. The preferential habitat use of four horned antelope in their home range is hill sal forest. Tree and shrub height; and occurrence of muntjak are negatively associated with the occurrence of this species. For the efficient management of this species, information on the extent of its distribution, habitat requirements and the effect of fire on its habitat is required. Developing a good habitat model by the use of automatic cameras and/or radio equipments to study animals' ecology would be a good effort for the conservation of this vulnerable species.

6.2 Management implications

The antelope is most abundant in hilly terrain with deciduous forest which is subject to occasional fires. Besides this, poaching appears to be a critical threat. Thus, future conservation plans should be focused on controlling the human induced fire and improving the economic condition of local people to reduce illegal activities.

There might be several factors that influence the habitat selection of a species. It may be related to the individuals' needs especially during growing age or during maternity. Therefore, an intensive study on individuals is needed to know more details about their requirements. As individual marking may not be feasible technically or even ecologically because of the high risk of injury and sometimes leads to death of an individual during trapping, time-intensive monitoring with automatic cameras should be used to get more efficient information.

Acknowledgements

I am thankful to the Department of National Park and Wildlife Conservation (DNPWC) for the permission, The Rufford Small Grant Foundation for the financial support and National Trust for Nature Conservation/Biodiversity Conservation Center (NTNC/BCC) for supporting the research through various ways. My deep respect and heartfelt thanks goes to Prof. Dr. Ilse Storch and Prof. Albert Reif (university of Freiburg, Germany) for their continuous support and excellent scientific guidance. I am greatly indebted to Dr. Bibhuti Jha (Kathmandu University, Nepal) for the encouragement. Many thanks to Menuka Basnyat, Mitra Pandey and the research team members whose support made this study possible.

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Annexes

Annex 1. Geographic positions of the areas of FHA sign recorded during the field survey in CNP(last four values are UTM values)

SN	longitude	latitude	SN	longitude	latitude
1	27.52675	84.47341	19	27.50741	84.47718
2	27.5188	84.47728	20	27.50741	84.48759
3	27.51564	84.47819	21	27.50373	84.49066
4	27.50893	84.47822	22	27.50727	84.49175
5	27.50848	84.4795	23	27.50867	84.48859
6	27.49861	84.4855	24	27.50345	84.50114
7	27.49913	84.48274	25	27.49552	84.50128
8	27.50141	84.48235	26	27.49272	84.50171
9	27.50412	84.48216	27	27.51103	84.50444
10	27.5071	84.48239	28	27.51322	84.50462
11	27.51372	84.48165	29	27.52159	84.50447
12	27.52257	84.48098	30	27.52316	84.50465
13	27.52454	84.481	31	27.52537	84.50366
14	27.50953	84.48173	32	27.51509	84.5014
15	27.50008	84.48028	33	548718	3044143
16	27.49499	84.48038	34	548763	3044744
17	27.49261	84.48004	35	548778	3044883
18	27.48963	84.47756	36	548799	3045259

Annex: 2. Result of Omnibus Tests of Model Coefficients showing significance-value of removing variables from analysis at each step of Backward Stepwise Regression.

		Chi-square	df	Sig.
Step 1	Step	56.649	35	.012
	Block	56.649	35	.012
	Model	56.649	35	.012
Step 2[a]	Step	-.003	1	.957
	Block	56.646	34	.009
	Model	56.646	34	.009
Step 3[a]	Step	-.008	1	.927
	Block	56.638	33	.006
	Model	56.638	33	.006
Step 4[a]	Step	-.013	1	.910
	Block	56.625	32	.005
	Model	56.625	32	.005
Step 5[a]	Step	-.024	1	.877
	Block	56.601	31	.003
	Model	56.601	31	.003
Step 6[a]	Step	-.034	1	.853
	Block	56.567	30	.002
	Model	56.567	30	.002

Step 7[a]	Step	-.068	1	.795
	Block	56.499	29	.002
	Model	56.499	29	.002
Step 8[a]	Step	-.073	1	.787
	Block	56.426	28	.001
	Model	56.426	28	.001
Step 9[a]	Step	-.118	1	.731
	Block	56.308	27	.001
	Model	56.308	27	.001
Step 10[a]	Step	-1.603	3	.659
	Block	54.705	24	.000
	Model	54.705	26	.001
Step 11[a]	Step	-.587	1	.444
	Block	54.119	23	.000
	Model	54.119	23	.000
Step 12[a]	Step	-.845	1	.358
	Block	53.274	22	.000
	Model	53.274	22	.000
Step 13[a]	Step	-1.142	1	.285
	Block	52.132	21	.000
	Model	52.132	21	.000
Step 14[a]	Step	-1.248	1	.264
	Block	50.884	20	.000
	Model	50.884	20	.000
Step 15[a]	Step	-.818	1	.366
	Block	50.066	19	.000
	Model	50.066	19	.000
Step 16[a]	Step	-.927	1	.336
	Block	49.139	18	.000
	Model	49.139	18	.000
Step 17[a]	Step	-2.983	1	.084
	Block	46.156	17	.000
	Model	46.156	17	.000

A negative Chi-squares value indicates that the Chi-squares value has decreased from the previous step.

Annex. 3. Model summary

Step	-2 Log likelihood	Nagelkerke R Square	Step	-2 Log likelihood	Nagelkerke R Square
1	160.903	0.336	10	162.846	0.326
2	160.906	0.336	11	163.433	0.323
3	160.914	0.336	12	164.278	0.318
4	160.927	0.336	13	165.42	0.312
5	160.951	0.336	14	166.667	0.305
6	160.985	0.336	15	167.485	0.3
7	161.053	0.335	16	168.413	0.295
8	161.125	0.335	17	171.396	0.279
9	161.243	0.334			