POPULATION STATUS, HABITAT PREFERENCES AND CROP DEPREDATION BY NILGAI (*Boselaphus tragocamelus* PALLAS, 1766) IN LUMBINI DEVELOPMENT AREA, RUPANDEHI DISTRICT, NEPAL

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Submitted to

Central Department of Zoology

Institute of Science and Technology

Tribhuvan University

Kirtipur, Kathmandu

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28, December 2017

DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author (s) or institution (s).

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RECOMMENDATION

This is to recommend that the thesis entitled "**POPULATION STATUS, HABITAT PREFERENCES AND CROP DEPREDATION BY NILGAI (*Boselaphus tragocamelus* PALLAS, 1766) IN LUMBINI DEVELOPMENT AREA, RUPANDEHI DISTRICT, NEPAL**" has been carried out by Jay Raj Binadi for the partial fulfilment of Master's Degree of Science in Zoology with special paper Ecology. This is his original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

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CONTENTS

Pages

LIST OF TABLES

LIST OF FIGURES

Figure

LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
ANOVA	Analysis of variance
CBS	Central Bureau of Statistics
CITES	Convention on International Trade in Endangered Species Of Wild Fauna and flora
DNPWC	Department of National Park and Wildlife Conservation
GPS	Global Positioning System
IUCN	International Union for the Conservation of Nature and Natural resources
LDA	Lumbini Development Area
LDT	Lumbini Development Trust
masl	Meter Above Sea Level
NEC	Nepal Engineering College
NPWC	National Park of Wildlife Conservation
NRM	Natural Resource Management
SPSS	Statistical Package for Social Sciences

ABSTRACT

Nilgai is regarded as the pest of the agriculture due to high amount of crop raiding. Crop depredation is a major form of human–wildlife conflict that affects livelihoods of farmers living close to forest areas. The present study was carried with objective to find population status, habitat preferences and crop depredation by Nilgai in Lumbini Development Area (LDA), Rupandehi district from July to August 2017 based on line transect, indirect evidence collection and questionnaire survey methods. Total 59 Nilgai were observed from 9 transects with mean herd size 2.18 and density 7.512 individuals/ km^2. Adult Female to Adult male ratio was 9.33. Distribution pattern of Nilgai was uniform type among studied samples. Maximum (n=4) Fecal matters and Nilgai (n=28) were recorded in human encroachment area but least Fecal matter (n=2) and Nilgai (n=5) were found in riverine and water logged area. Fifty seven percentage of the respondent stated that the damage is increasing every year. They have stopped planting Potatoes, Rahar, Pea and Grams. Crop depredation was found high in Madhuwani and Tenuhawa. Only 39.48% of the respondents used the protective measures, which is also not effective. Most of the respondents use Bamboo fencing as protective measures. Whereas guarding overnight, producing sound, scare crow, chasing Nilgai, tape film rounding, cattle dung spray and rotten fish spray were the traditional method applied to protect crop depredation. Disease, competition among the Nilgai, forest fire, habitat destruction, poisoning and killing of Nilgai were threats stated by the respondents.

Key words: Effectiveness, Lowland Nepal, Nilgai, Protective measures

1 INTRODUCTION

1.1 Background

Nilgai or Blue Bull (*Boselaphus tragocamelus*) is one of the largest Asian antelope found in the Lumbini area of Rupandehi district, representing family bovidae of order cetartiodactyla (IUCN, 2016). It has great evolutionary history as it looks intermediate between cattle and sheep/goat (Chalise, 2016). Blue Bull is sexually dimorphic; adult males are dark gray but varying from bluish to brownish gray except mane and Body measures 1.4m whereas tail 1.75m (Chalise, 2016). Male has a cone like horn about 20cm long and has a curious pendent tuft of coarse hair on throat. Female are hornless and noticeably small. Both sexes carry a short dark mane have white rings above the hoof and pale buttocks (Bayani, 2016)

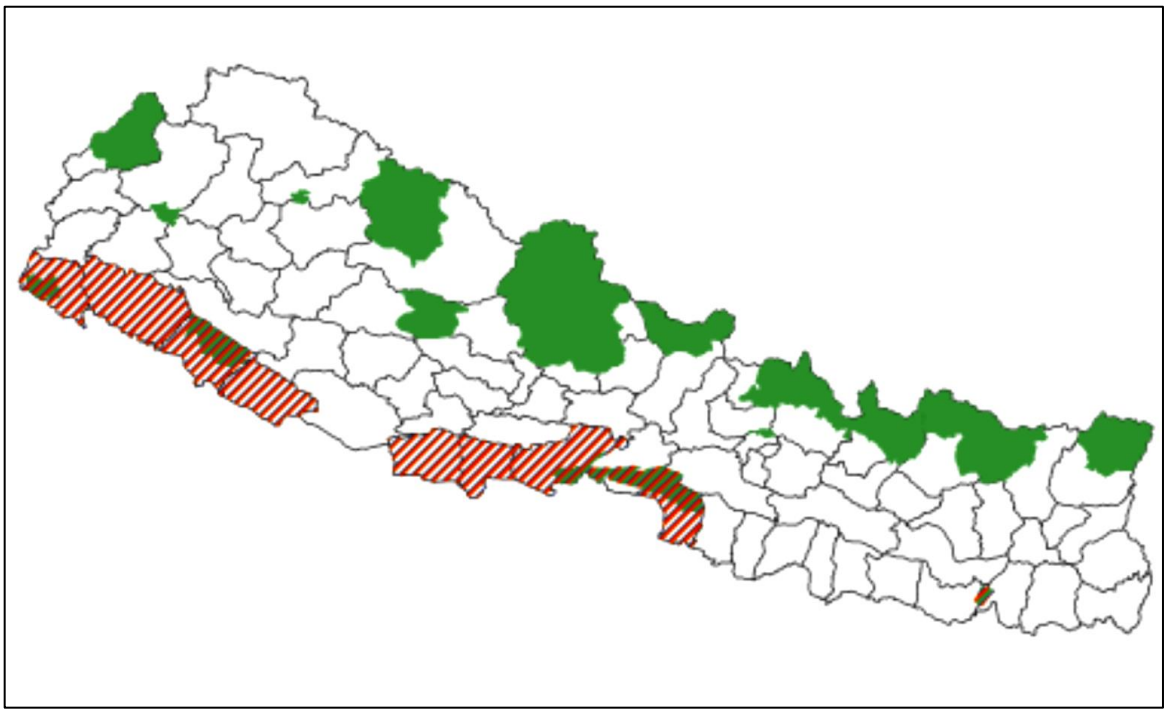
In Nepal, problems associated with locally overabundant wildlife species have emerged as important management issues for reason of some species losing their natural habitat and adapting themselves to the man-altered situation (Bhattarai and Basnet, 2004). Crop-raiding by locally overabundant populations of Nilgai has been reported in many lowland of Nepal (Aryal, 2007). In Nepal, after the introduction of the DNPWC and NPWC act and through associated management actions, the populations of many wildlife species have increased considerably, and a few of them have decidedly become locally overabundant (Khatri, 1993). Those that have been successful in adjusting to the man-altered habitats have thrived, and in many places, such species have become serious pests of Agricultural crops and are competing for resource utilization with domestic stock (Ghosh *et al.,* 1987).

Nilgai, an antelope, is afforded holy and sacred rites by Hindus, and has rapidly grown in numbers outside protected areas. Agricultural crop damage by Nilgai and blackbuck has been widely reported from lowland of Tarai (Khatri, 1993; Sen, 1999; Aryal, 2007; Bayani, 2016; Khanal *et al.*, 2016).

In India they have declined drastically because of habitat destruction and over-hunting (Schaller, 1967). Blue Bulls have been recorded in the LDA area since the early 1990s (Aryal, 2007) and are believed to have come from Kakrahawa forest (Indian side), which is approximately 10 km away from the LDA's southern boundary. Nilgai, however, required a more nutritious diet than cattle and consumed a higher percentage of forbs and browse (Sheffield, 1983).Grazing competition between livestock, reduces the amount of palatable species available to Blue Bulls and has encouraged the introduction of unpalatable species in the area, causing the Blue Bull to move to private lands in search of food (Aryal, 2007).

1.2 Distribution

Boselaphus tragocamelus is endemic to the Indian subcontinent (Corbet and Hill, 1992). Native range of *B. tragocamelus* includes the foothills of the Himalayas in Nepal (Dinerstein, 1979), northeastern Pakistan (Mirza and Khan, 1975) and almost all of India except eastern Bengal. Introduced *B. tragocamelus* also exist in southern North America where latitude, climate, and habitat characteristics are comparable to those of India (Ables and Ramsey, 1972; Sheffield *et al*., 1983).



Source: (Jnawali, *et al*., 2011)

Figure 1: Distribution of Nilgai in Nepal

1.3 General Descriptions of Nilgai

Adult male Nilgai is dark gray but varying from bluish to brownish gray except mane (Prater, 1971) but females, calves, and young males are tawny brown with the same white markings as males (Schaller, 1967). Both sexes have a short and bristly mane that extends the length of the neck and terminates in tuft at the base of the neck (Sclater and Thomas, 1900); the mane is darker and more prominent in adult males than females (Blanford, 1888; Schaller, 1967).Nilgai are large, generally confine themselves to open or park-like areas, and are not greatly disturbed by the presence of man (Schaller, 1967). They spent much of their time on open short grassland/ savanna (Berwick, 1974) rather than in the contiguous tall grass-revering forests (Blanford, 1888; Prater, 1971; Sankar, 1994; Pokheral and Thapa, 2008) where visibility is poorer, escape more difficult, and predators numerous. Combination of high poaching, tiger predation and habitat deterioration are the major causes of decline of Blue Bull (Khatri, 1993) and therefore, conservation of Blue Bull is a national and global concern (Subedi, 2001). They were also once common throughout India (Adams, 1858 and Blanford, 1888) like most large mammalian fauna of India.

1.4 Ecology and Behaviours

Densities of *B. tragocamelus* in Nepal vary widely depending on habitat conditions, competition with domestic livestock, predation, and degree of protection. In Royal Karnali-Bardiya Wildlife Reserve, Nepal, densities were 3.2 individuals/km^2 during the hot-dry season and 5.0 individuals/km^2 in April (Dinerstein, 1979); 8 individuals/ km^2 in LDA area, Lumbini (Aryal, 2007); 0.228 individuals / km^2 in the Tinau River at Rupandehi (Aryal *et al.*, 2016); 0.23–0.34 individuals/km^2, Indravati National Park (Pandey, 1988); 0.40 individuals/km^2, Pench Tiger Reserve (Biswaas and Sankar, 2002); and 7.0 individuals/km^2, Keoladoe National Park (Bagchi *et al*., 2004).

In southern Texas, densities of a population in about 10,000 hector of fenced private property were 3.05–4.04 individuals/km^2 and 3.74–4.76 individuals/ km^2 from helicopter and ground surveys, respectively (Brown, 1976). Maximum life span is 12–13 years in the wild (Berwick, 1974; Mungall and Sheffield, 1994; Mungall, 2000) and 20–21 years in captivity (Grzimek, 1990; Jones, 1982).

Survival patterns between male and female of *B. tragocamelus* are similar to those of other ungulates (Brown, 1976) but vary depending on population density and status of particular populations (Sheffield *et al.*, 1983). As a tropically adapted species, *B. tragocamelus* cannot endure low temperatures and maintains meagre winter fat reserves (Schmidly, 1994).

Nilgai is a habitat generalist (Mathai, 1999) but tends to occur in ‘‘thin bush with scattered low trees or alterations of scrub and open grassy plains, rarely in thick forest but often on cultivated areas (Blanford, 1888). In agricultural areas, it will feed throughout the night in open fields and retreat to the cover of forests during the day (Prajapati and Singh, 1994).

In southern Texas where confinement to large tracts of fenced land does not limit habitat availability, *B. tragocamelus* avoids dense woodlands and frequents improved pasture, sparse forests of live oak (*Quercus virginiana*) and scrub, and coastal prairies (Ables and Ramsey, 1972). *Boselaphus tragocamelus* is not as gregarious as other herding ungulates and occurs in relative small groups throughout the year. Adult males segregate from females and sub adults during nonbreeding seasons. Male prevalence in groups during breeding in Nepal is 1 male, 37%; 2 males, 28%; 3 males, 20%; and 4 males, 15% (Dinerstein, 1980).

It is polygamous, and mature adult males breed most often. It describes a territorial system with adult males forming breeding groups of 2–10 females (Schaller, 1967). Solitary breeding males are not ‘‘spatially fixed’’ but maintain an ‘‘area of dominance’’ around themselves as they move among different groups of females; the system results in ‘‘mutual avoidance’’ (Fall, 1972; Sheffield *et al*., 1983) and temporary dominance (Owen-Smith, 1977) among breeding males.

1.5 Threats and conservation

International Union for the Conservation of Nature and Natural resources (IUCN) has categorizes the Nilgai as of least concern (IUCN, 2016). While it is common in India, the Nilgai occurs sparsely in lowland of Nepal and Pakistan. The major reasons behind its decimation in these two countries and extinction in Bangladesh are rampant hunting, deforestation and habitat degradation in the 20th century.

Numbers in India is about 100,000 but have always been low in lowland Nepal (Adams, 1858; Dinerstein, 1979); this species is rare in Pakistan (Mirza and Khan, 1975) and extinct in Bangladesh. Nilgai is highly adaptive antelope. Naturally diurnal, it goes for crop raiding in evening and at night (Chauhan and Singh, 1990). Nilgai caused extensive damage to most agricultural crops. The signs of hoof marks, broken plants, uprooted plants, damaged crop and feeding marks give the indirect evidence of presence of Nilgai in crop field from dusk to dawn (Goyal and Rajpurohit, 2000).

It recognizes the farmer and new man. It afraid from new man in comparison of farmer (Gautam and Bissa, 2014). The herds of Nilgai have been observed shifting from one area to another, depending upon the availability of crops (Goyal and Rajpurohit, 1999).

1.6 Objectives:

General Objective

To determine population status, habitat preferences and crop depredation by Nilgai (*Boselaphus tragocamelus*) in Lumbini Development Area, Rupandehi district, Nepal.

Specific Objectives

- To find the population and distribution of Blue Bull.
- To determine general habit and habitat utilization.
- To assess the crop depredations by Blue Bull in LDA surrounding areas.

1.7 Rational of the Study

Wildlife management is the major problem of today. Nilgai preference to the open farmland has produce the major challenges for the wildlife managers and local farmers. The crop depredation by Nilgai has been creating the Sanctuary-people conflict in Lumbini. Few research has been done about Nilgai in Nepal and research activities on Nilgai outside the National parks and a wildlife reserve are almost negligible. Nilgai being grazer and browser species generally come to destroy agriculture field that have caused great economic loss. Thus the present study deals with the population status, habitat preferences and crop depredation by Nilgai in Lumbini Development Area and tries to find out the management strategy used by indigenous people to stop crop depredation.

1.8 Limitations

- Heavy rain fall limits the access of all area inside LDA.
- Communication language problem during questionnaire survey.

2 LITERATURE REVIEW

Nilgai being one of the largest Asian antelope, prefers open habitat. In Nepal they are distributed throughout the Tarai. Khatri (1993) estimated total 57-86 individuals in nine different semi-isolated sub-population in and around RBNP during 1992-1993, reflecting a decline of 80-90%, since the 1970's whereas Dinerstein (1979) estimated about 200 Nilgai in 45 km^2 of savanna grassland in Karnali Bardiya using line transect method. Similarly Lasiwa (1999) estimated about 52-64 individuals in twelve different sub-populations of RBNP in 1997. Subedi (2001) counted only 11 Blue Bulls in the LDA area. Counting were done in accessible road by transect method from Bhairawaha-Taulihawa. Whereas Bagale (2003) conduct thesis on population status of Nilgai and Nilgai-livestock-people interaction: a case study on Lumbini and found 37 Nilgai in 3 square miles but Aryal (2007) estimated total of 41 Blue Bulls in the 7.51km^2 in LDA of which 10 males, 15 females and 16 juveniles with population density of 8 individuals/km^2 and male to female sex ratio was 2:3..Another study done by Gosai (2007) found 17 Nilgai in the same area through direct observation method. Aryal, *et al* (2016) Studies the population status, Distribution and potential threats to the Blue Bull along the Tinau River at Rupandehi District in western Nepal along six transect lines in the forest and recorded 40 Blue Bulls with average group size five and average density 0.228 individuls/km^2. Similarly Khanal, *et al* (2016) found total 303 Nilgai in Rupandehi district. Singh, *et al* (2017) studied the population status of ungulates in Keoladeo National Park, Bharatpur, Rajasthan and found Nilgai density 3.21 individuals/km^2.

Nilgai are considered as vermin and agriculture pest. They cause extensive damage to agricultural crops; among these, gram, wheat seedlings and moong were the most preferred ones (Chauhan and Singh, 1990) in Nahar of Hariyana. The estimated crop loss to wheat, gram and mustard crops was to be 24.3, 56 and 42.4 percent respectively (Singh, 1995) in Four districts of Haryana, viz. Hissar, Bhiwani, Rohtak and Mahendragarh. Similarly crop loss was at serious level during 1997/1998 production year with total economic loss of about Rs. 879826.25 in the Tenuhawa VDC of Rupandehi district (Sen, 1999) and loss for Paddy, Wheat, Mustard, Rahar, Musuhroo and Kerau was 11.125, 25.89%, 23.95, 35%, 27.87% and 22.595% respectively but (Bagale 2003) estimated destroy of 6.6% paddy, 17.97% wheat and 58.84% mustard in Lumbini. Crop damage and extent of damage varies according to the season (Aryl, 2007) generally, damage occurred during the winter months was found to be higher than during the summer as Nilgai cause 5% of total production damaged in LDA. The extent and pattern of crop depredation gradually reduce with the distance from the forest (Bayani, 2016) and the damage was over 50% to the adjacent field along the western boundary of Tadoba-Andhari Tiger Reserve in the state of Maharashtra, central India. Similarly Khanal, *et al* (2016) found the major problem of crop raiding by the Nilgai in Rupandehi and found 68633$ projected crop yield loss from March 2015 to March 2016. Kumar, et al (2017) studied the Patterns of crop raiding by wild ungulates and elephants in Ramnagar Forest Division and found guarding was to be ineffective in decreasing crop raiding, with no statistical difference in the mean area of damage between guarded and unguarded fields.

Sheffield (1983) conducts 2-year food habitat study of the Nilgai antelope (*Boselaphus tragocamelus*) and its forage selections in RBNP and found Nilgai preferred to feed on large open areas interspersed with cover and pounded water. They were grazers, their average diet consisting of 60% grasses, 25% forbs, and 15% browse and Noor, *et al* (2013) Study the winter habitat selection by two sympatric species chital and Nilgai in the semi-arid environment from January 2006 for four months in India and found less preference to dense forest. Goyal and Rajpurohit (2000) found Nilgai as the serious agriculture pest as they can jump relatively 6-7 ft. high barriers and cause damage to crop by trampling but Nilgai did not cross 1.25 m high cattle fences parallel to paved highways (Aaron, *et al*., 2017) but did cross other fence types. Nilgai and White tail Deer are active during morning followed by evening (Nirbhay, *et al*.,2017) whereas minimum activity was seen in the heat of the afternoon but Nilgai were more active at night than White tail Deer.

Meena *et al* (2014) studies the indigenous measures developed by farmers to curb the menace of Blue Bull in district Rajsanmand in India and found the most common method adopted were use of Scarecrows, live fencing of Indian spurge tree locally known as Thor (*Euphorbia neriifolia*) and Velvet mesquite locally known as Vilayari babul around their field boundaries, beating bells in crop fields, use of animal excreta especially of Blue Bull excreta is a wonderful repellent for themselves, using the mixture of donkey excreta, cow urine and others like rotten vegetable leaves producing foul smell to ally Blue Bull, use of crackers, use of forate insecticides granules and spray of phenyl solution as repellent and making fence of reels of shining tapes like Video/audio tapes around the crop field.

Lasiwa (1999) pointed high degree of habitat deterioration both inside and outside the park in RBNP indicating the marked reduction of Nilgai population within two decades and Khanal, *et al* (2016) also noted habitat deterioration, illegal hunting, poisoning and electric fences as major threats but Aryal, *et al* (2016) noted not only habitat destruction as threat he also recorded overgrazing, conflict, flooding and accident were major threats along the Tinau River. Another study done by Abbas, *et al* (2017) found this vulnerable species is near threatened in Pakistan due to decrease in Nilgai numbers by rampant hunting, deforestation and habitat degradation.

Nilgai numbers are increasing in the Bihar, Uttar Pradesh of India where they are considered as vermin and culling of Nilgai is common. In Nepal they sow fluctuating numbers but inside the LDA their numbers has increased within a decade leading the huge amount of crop depredation around the surrounding places of LDA.

3 MATERIALS AND METHODS

3.1 Study area

The study area covers the LDA (7.85km^2) area and the surrounding places, Ekala (1.80 km^2), Madhuwani (1.042 km^2), Lumbini (1.68 km^2), Tenuhawa (1.46 km^2), Khudabagar (7.78 km^2). It lies in the Rupandehi district, western development region of Nepal. The geographical location specifically marked site of Study area is in the Central Tarai of southern part of Nepal at 83° 16' 40.5" easting, 27°29' 16.7" northing and 99 meter high from the mean sea level (masl).

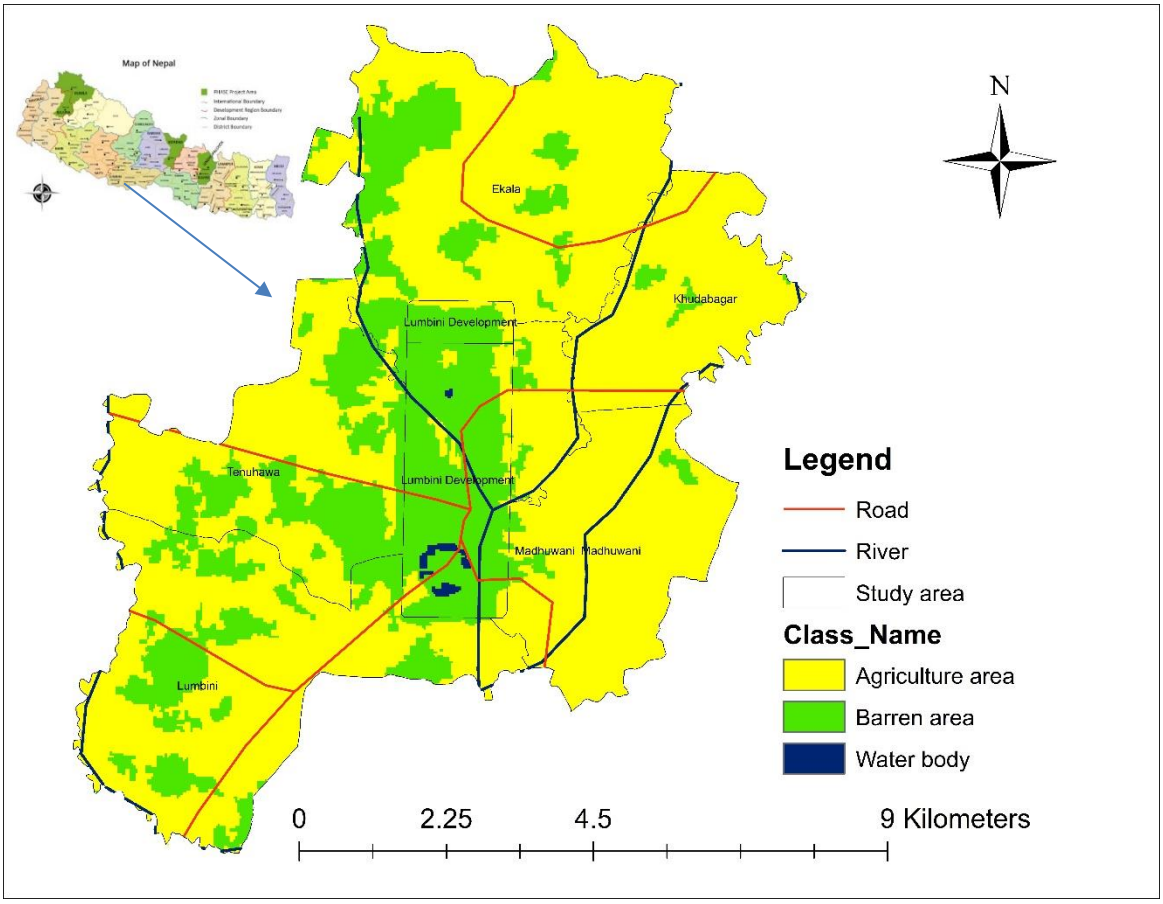


Figure 2: Lumbini Development Area (LDA) and surrounding places

LDA covers the foothills of the Siwalik range and the birth place of the Buddha. It covers wide varieties of shrubs, herbs, flowers and plants, more than 250 birds' species including the world tallest flying bird Sarus crane (*Antigone antigone antigone*) and threatened animals like Python, Bengal fox (*canis lupus*) Wild cat (*Felis chaus*) (DDC, 2003).

3.1.1 Physical features

Lumbini is 4.8km in length and 1.6km in width. The site of Lumbini is boarded by a large monastic zone in which only monasteries can be built but after the implementation of the master plan it has been divides in to three regions; Scared pond zone, Lumbini village zone,

Monastic zone. Hotel, restaurants, Helipad, Public parking has developed in Lumbini village zone.

It is separated into an eastern and western monastic zones by central canal the eastern having Theravandin monasteries and western having Mahayana and Vajrayana monasteries (Lumbini Development Area, 2014). The holy site of Lumbini has ruins of ancient monasteries, a scared Bodhi tree, an ancient bathing pond, the Ashoka pillar and the Mayadevi Temple, where the supposed place of birth of Buddha is located. From early morning to evening many pilgrims from different countries perform chanting and meditation at the site.

3.1.2 Climatic features

Lumbini has three types of climate region mainly lower tropical, upper tropical and subtropical climatic region. The climatic region in this district varies from below 300 meter to 2000 meter (DDC, 2013). The average annual rainfall is around 1665 mm with fluctuating pattern for total of 30 years between 1987 and 2013 A.D. In the year 1998, there was maximum average rainfall of 2409 mm. And the lowest average rainfall was at year 1992 where the average rainfall accounted to 1180.7 mm (DDC, 2013). Similarly minimum (34.51^{o}c) average annual temperature of LDA area was in 2015 (Figure 4). In last 30 years the yearly maximum average temperature has been varied from 23.50^{o}c to 34.51^{o}cwith fluctuating pattern (NASA, 2017).

3.1.3 Biological characteristics

A total of 65 species of tree (angiosperms and gymnosperms) including nine unidentified were found in the garden of LDA. *Dalbergia sisoo* is most dominant tree species that accounted for 85 % of total tree stands, which is followed by *Callistemon citrinus* and *Albizzia lebbek* that accounted for 2.8 % and 1.98 % of total number of tree stands respectively (Bhattarai and Baral, 2007).

Seventy-nine percent of the potential habitat of Blue bull is covered by forest and the other 21% is grassland or open land in LDA and approximately 43% of the study area had dense crown cover (75-100%), 27% had moderate crown cover (50-75%), 14% had sparse crown cover (25-50%) and the remaining 16% had very sparse crown cover Aryal (2004).The garden is rich in its flora and fauna compositions, vegetation of this area can be classified as: terrestrial and aquatic. *Nymphea* sp. and Trapa sp (DDC, 2000).

Grasslands and afforested forest patches characterize the terrestrial habitats of the garden. Grassland occupies 53% of the total area of the garden and 40% if occupied by afforested trees (DDC, 2013). The grassland is mainly composed of *Imperata* sp. and *Saccharum* sp. other species comprise of *Cynodon, Kans* etc. Afforested are mainly comprise *Dalgergis sissoo,* including *Anthocphalus* sp., *Bmbax ceiba, Mahgifera indica, Dendrocalamus* sp. (DDC, 2000). About 238 species of birds, including threatened Sarus crane, 30 species of reptiles, 13 mammalian and 6 amphibians have been recorded (DDC, 2013). Among mammals Nilgai (*Boselaphus tragocmelus*) and Jackal (*Canis aureus*) are common.

3.1.4 Outside the Garden:

Lumbini is the birthplace of Lord Buddha. Lumbini Development Area Act, 2042 (1985) has defined "Lumbini Development Area" which are directly or indirectly related with the life of the Lord Buddha and his birth place. That has included Tilaurakot (ancient Kapilvastu), Gotihawa, Niglihawa, Sagarhawa, Sisaniyakot, Araurakot, Kudaan (Kapilvastu), Devadaha (Rupandehi), Ramgram (Nawalparasi), (GoN, 1985). The Lumbini Development Area is surrounded by Ekala, Madhuwani, Khudabagar, Padariya, and Tenuhawa (Figure 2).

3.1.5 Land use and cropping pattern:

Most of the land outside the area is cultivated by agriculture crops but this area occupied by many house after the Fight between the Maoist and government; many people migrate to that place from hill and land use pattern is change little bit but also it occupies many agriculture field. Rice (*Oryza sativa*) is grown majority in the rainy season while in winter mainly Wheat (*Triticum aestivum*), Mustard (*Brassica compestries*), Pea (*Pisum sativum*), Gram (*Cicer arietinum*), and vegetables like Radish (*Raphanus raphanistrum*), Carrot (*Daucus carota*), Potatoes (*Solanum tuberosum*), Cauliflower (*Brassica oleracea*), Beans (*Phaseolups vulgaris*) are grown.

3.1.6 Lumbini Development Area surrounding places demography in 2011.

According to 2011 census data of VDC level there was 58,131 total populations with 62 different ethnic groups. Among them Muslim were the dominant group comprised 33.6%

Table 1**:** Distribution of Human Population around LDA, 2011

Place	Others	Muslim	Total
Bhagawanpur	8576	1492	10068
Ekla	6174	3091	9265
Khudabagar	3143	1450	4593
Lumbini	4768	3686	8454
Madhuwani	4900	616	5516
Masina	2650	2011	4661
Tenuhawa	2430	6821	9251

CBS, 2012

3.2 Materials:

Digital camera (Cannon EOS Kiss X7, 50-250mm lens), GPS (ertx, 30) Binoculars (80x12).

3.3 Methods:

The present study basically follows descriptive method. Using the descriptive methods, data acquired and information collected were analysed and results were derived.

3.3.1 Nature and sources of data:

The study was based on primary as well as secondary data. The primary data was collected through direct field observation, indirect evidence collections and questionnaire. On the other hand, the secondary data was collected through Central Library of Tribhuvan University, Lumbini Development Area office and previous thesis.

3.3.2 Sampling procedure:

Stratified random sampling was used to collect the data of Nilgai population and fecal matter. The study area was divided in four Block. From each stratum Nilgai population and fecal matter deposition were recorded.

Block 1: North of Bhairahawa-Kapilvastu highway that passes through the LDA area
Block 2: West of the central canal
Block 3: East of central canal (riverine and water lodged area)
Block 4: Behind and around the Maya Devi temple (dense forest area)

3.3.3 Data collection techniques/ instruments:

3.3.3.1 Population status

Population status of Nilgai was determined by direct field observation methods making line transect. The study area was stratified in to four Block i.e. Human encroachment Block, Monastery Block, Riverine and water logged Block; and dense forest Block. Human encroachment Block consist of 3 transect each of 1.5km, Monastery area consist of 2 transect each of 2.4km, Dense forest Block consist of 2 transect each of 1.5km and; riverine and water logged Block consist 2 transect each of 2.40km. Total 9 transect were surveyed which range from 1.5km to 2.40km. The counts were carried out early morning, (6am-11am) after sunrise and at the evening time (2pm-6pm) in which animal movement is highest. While walking for identification of potential habitat for Nilgai, the effort was targeted to find out their population, fecal matters, and feeding habitat in each stratum/plot (Martin and Bateson, 1993; Mukherjee, 2007).

Age and sex composition

Age and sex of the animal was determined by direct observation using the following body characteristics (Sankar and Goyal, 2004)

Females have a short yellow-brown coat. Male-coat gradually darkens to grey-blue and has white spots in the cheeks and white ring at the edge of the lips. Females are hornless and noticeably smaller than male.

1. Sub-adult individuals: Individuals of 1 to 2 years are classified as sub-adults. The body size of sub-adult is remarkably large than the calves.

a. Sub-adult female: Sub-adult female reach above the central body line of the adult female. Colour is same as sub-adult male but don't pose horn.

b. Sub-adult male: They are larger than female sub-adult and body colour starts to darken from yellow/light brown to grey-blue, they possess noticeable horns, neck with white neck hair tuff.

2. Adult individuals: Adults of the both sexes are estimated to be over 2 years of the age and are distinguished from sub-adult by their body size and colour.

a. Adult- female: Adult female could be distinguished from the sub-adult female, as they have longer snouts and large head and yellow-brown in colour.

b. Adult male: Could be distinguished easily forms the sub-adult male as they have large head with conical and smooth longer horns, dark grey-blue colour, black leg.

3.3.3.2 Questionnaire survey

Questionnaire survey was carried out in the ward 9, 2, 3, 7 and 8 of Padariya, Ekala, Khudabagar, Madhuwani and Tenuhawa respectively to assess the crop depredation trend by Nilgai. Total 195 household were selected randomly. The list of households in the study area (Table 2) was available from CBS website and the sample size for the study was determined based on the numbers of the households in the study site. The numbers of the household present and sampled are shown in the table below.
Structured questionnaire consisting open-end and close-end question (Annex 1) which were designed to know the crop depredation trend, time and period of crop depredation and management strategies developed by local people to protect crop depredation by Nilgai.

Table 2: Numbers of sampled household.

Ward No.	Place	Total households
9	Lumbini	200
2	Ekala	185
3	Khudabagar	145
7	Madhuwani	216
8	Tenuhawa	200
Total		946

3.3.3.3 Indirect Evidences Collection:

The sign of Droppings i.e. fecal matter was recorded in the various habitats for their habitat mapping keeping in mind that the individual Nilgai excrete at the same place regularly (Chalise, 2016). The fresh fecal matter gave the sign of their presence. Fecal matter was classified as old fecal matter and new fecal matter based of the smoothness of the fecal matter. Fresh fecal matter were smooth compared to old one. All those noticeable evidence of the field was recorded by camera and GPS too and filled out in the appropriate format. The indirect evidences were supported by the local people information generated by the group survey or interviews.

3.4 Data analysis

3.4.1 Population status

The population of the Nilgai were differentiating according to sex and development stage. Male to female ratio, density and abundance was calculated.

$$\text{Density} = \frac{Total\ Nilgai\ found}{\text{Total area survyed}}$$

3.4.1.1 Distribution pattern

Data of Nilgai recorded in each habitat type were used to determine distribution pattern. The distribution pattern of the Nilgai 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.

Distribution pattern (DP) = ($S^2/\bar{}X$)

If,

($S^2/\bar{}X$)=1, distribution is random,

(S2/$\bar{}$X)> 1, distribution is clumped

(S2/$\bar{}$X)< 1, distribution is uniform

Where, S^2= Variance, $\bar{}x$= Mean

3.4.1.2 Herd size

$$\text{Mean Herd Size (MHS)} = \frac{Total\ \text{numbers of animal observed (N1)}}{Number\ of\ Herds\ observed\ (N2)}$$

3.4.2 Habitat preference

Habitat preference was calculated by using following formula

- Habitat preference (HP) = PPE/TPP×100

Where,

PPE = Fecal matter present (%) in each habitat type

TPP = Total Fecal matter present (%) in all the habitat type.

F- Test was done with "R-studio" used to judge the significance of association between the different habitats utilized by Nilgai.

3.4.3 Crop depredation:

Interviewed data was analysed with SPSS, Depredation frequency of various crop was shown by pie-chart, and time of depredation and mitigation measures applied were find out.

4 RESULTS

4.1 Population status and distribution:

Total 59 Nilgai were observed in 9 transect covering 4 different Block (Annex 2). Highest numbers (47.45%) were found in Block 1 and lowest (8.47%) in Block 3 (Figure 5). Nilgai abundance was 4.75 with density 7.51 individuals/km^2. In the observed population composition of the Nilgai, adult female were maximum followed by Sub adult female, Sub adult male and Adult male. The male to female sex ratio was 18:41 with average 6.55 Nilgai per transect. Among the 9 transects deployed for the study, the number of Nilgai recorded significantly varied ($P < 0.05$) among the various transects over the course of the study (Table 3).

Table 3: Nilgai observed in various Transect in Lumbini Development Area

Transect	Male	Sub adult male	Female	Sub adult female	Total
1	1	1	3	2	7
2	1	5	2	2	10
3	2	2	4	3	11
4	2	1	5	1	9
5	1	1	2	3	7
6	0	0	3	1	4
7	0	0	1	0	1
8	1	0	7	1	9
9	0	0	1	0	1
Total	8	10	28	13	59
Percent %	13.55%	16.49%	47.45%	22.03%	100%
P-value at 5% level of significance	0.0092	0.0730	0.0014	0.0049	0.0007

4.1.1 Distribution pattern of Nilgai

The calculated value of variance to mean ratio was found to be 0.77 which shows uniform (Figure 3) distribution of Nilgai in LDA.

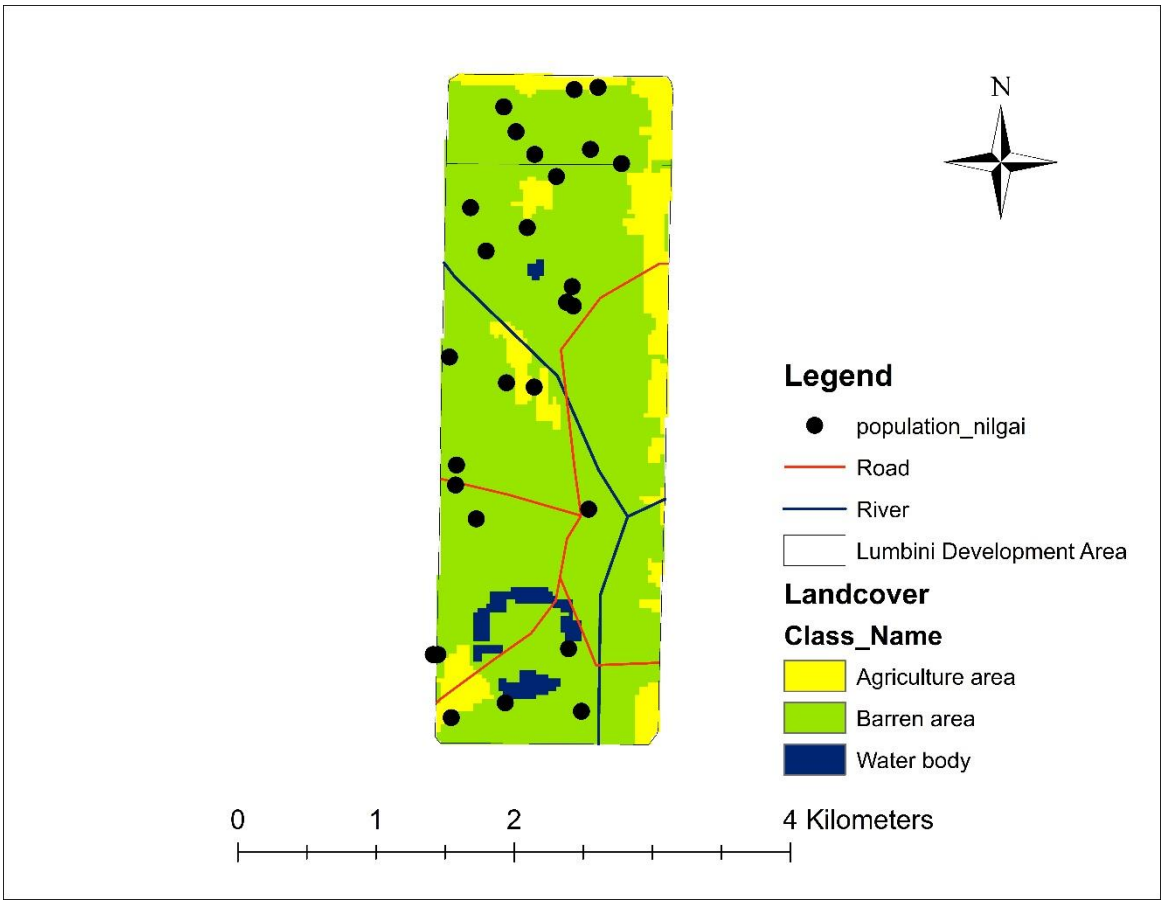


Figure 3: Nilgai distribution in Lumbini Development Area (LDA)

4.1.2 Herd size

Nilgai generally found in small herds or groups. Frequent change in the herd size composition was observed during the study period. During the study period, 27 herds were observed (Table 4); herd size range from 1 to 6 individuals (Annex 2). The mean herd size was 2.518 individuals per herd. The largest herd (n=6) was found east of Maya Devi temple

Table 4: Group composition (Herd size)

S.N	Sampled area	Herd/Group	Total animal	Herd %
1	Human encroachment area	16	28	59. 25
2	Monastery area	5	16	18.51
3	Riverine and water logged area	3	5	11.11
4	Dense community forest	3	10	11.11
Total		27	59	100

4.1.3 Habitat preferences

Human encroachment Block consists of tress like Sissoo (*Dalbergia sissoo*), Khair (*Aegle marmelos*), Bel (*Aegle marmelos)*, Jamun (*Syzgium cumini*) and open grassland with scattered forest patches which is highly used by people for fodder and firewood. Monastery Block consists the area west of Central canal and bears many religious Monastery like Korean Monastry, Chinese Monastery, Lotus Temple etc. Riverine and water logged Block consists of dense Khar (Sacrum), Sissoo (*Dalbergia sissoo*) and the area remains logged with the water in the rainy season also one river pass through the Block. Dense Block is south of Maya devi temple it bears mixed dense forest and army residents.

Population distribution of Nilgai significantly varied (Annex 2) inside the Lumbini Development Area (LDA). In the present study, 47.45 % Nilgai found in human encroachment area, 27.11% in Monastery area, 8.47 in riverine and water logged area and 16.49% in dense community forest (Figure 4).

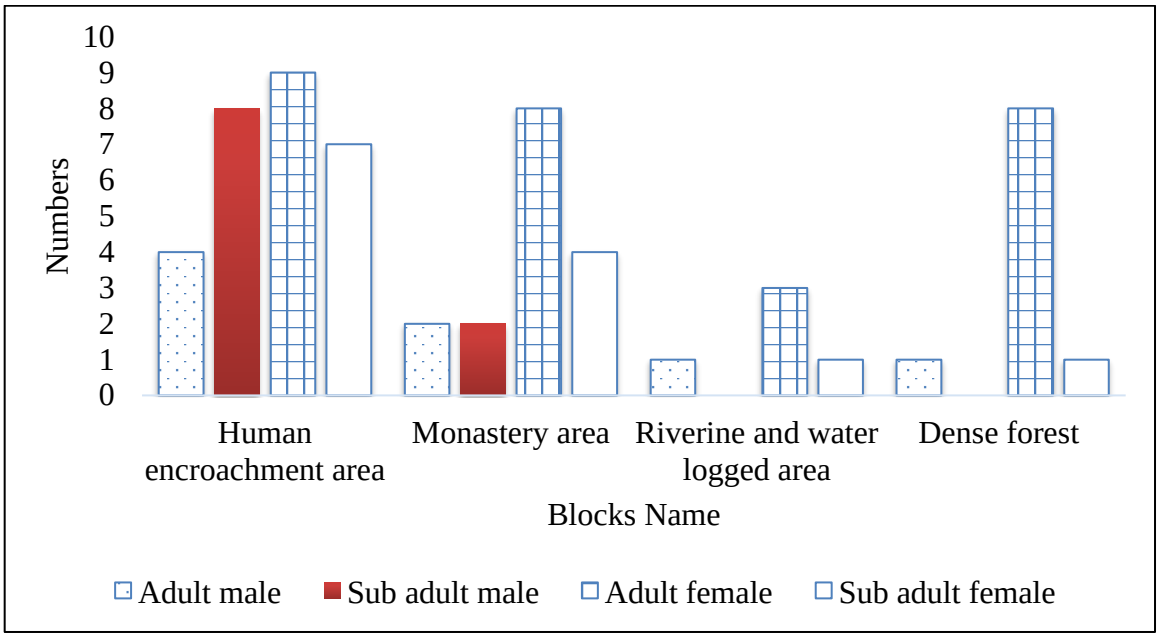


Figure 4: Habitat wise distribution of Nigai numbers

Total 19 fecal matters were recorded of which 31.57% fecal were old and remaining 68.42% fecal were new with mean fecal matter diameter 58.26cm (Annex 2). Human encroachment area was highly (47.36%) preferred but riverine and water logged area was least preferred (10.52%) whereas monastery area and dense forest were equally preferred (21.05%) by Nilgai (Figure 5).

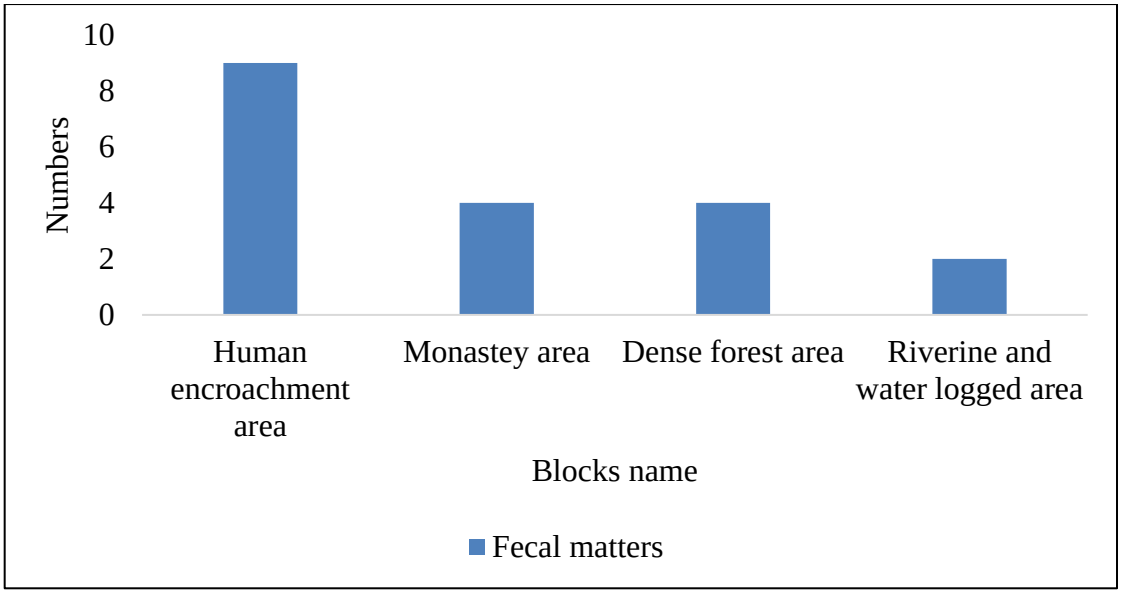


Figure 5: Fecal matters of Nilgai recorded in different blocks of LDA, 2017

During the study, 26 different herds of Nilgai were found grazing and 2 individuals of one herd were resting. They were found grazing grass, twinges and leaves of trees and shrub. Nilgai were seen feeding on the following vegetation during the study period (Table 6).

Table 5: Plant species observed feeding by Nilgai during study period

Tree		Herb	
Scientific name	Local name	Scientific name	Local name
Aegle marmelos	Bel	*Cynodon dactylon L.* Pers	Dubo
Dalbergia sissoo	Sissoo	*Desmotochyabipinnata (L.) stapf.*	Kush
Syzgium cumini	Jamun	*Saccharum spontanum* L.	Kansh
Athocepharus cadamba	Kadam	*Imperata cylindrical*	Siru
Acacia catechu	Khair		
Albizia sp	Siris		

4.2 Crop depredation

The main agriculture products in rainy season were Rice, Chilly and Bodi as stated by 96.4%, 73.84% and 11.71% respondents respectively and Wheat, Okra and Lentils in winter season as stated by 84.61%, 64.41 and 18.97 % of respondents respectively. Out of 195 respondent 171 respondent reported the problem of crop depredation. The crop depredation was high in Madhuwani and Tenuhawa but low in Ekala.

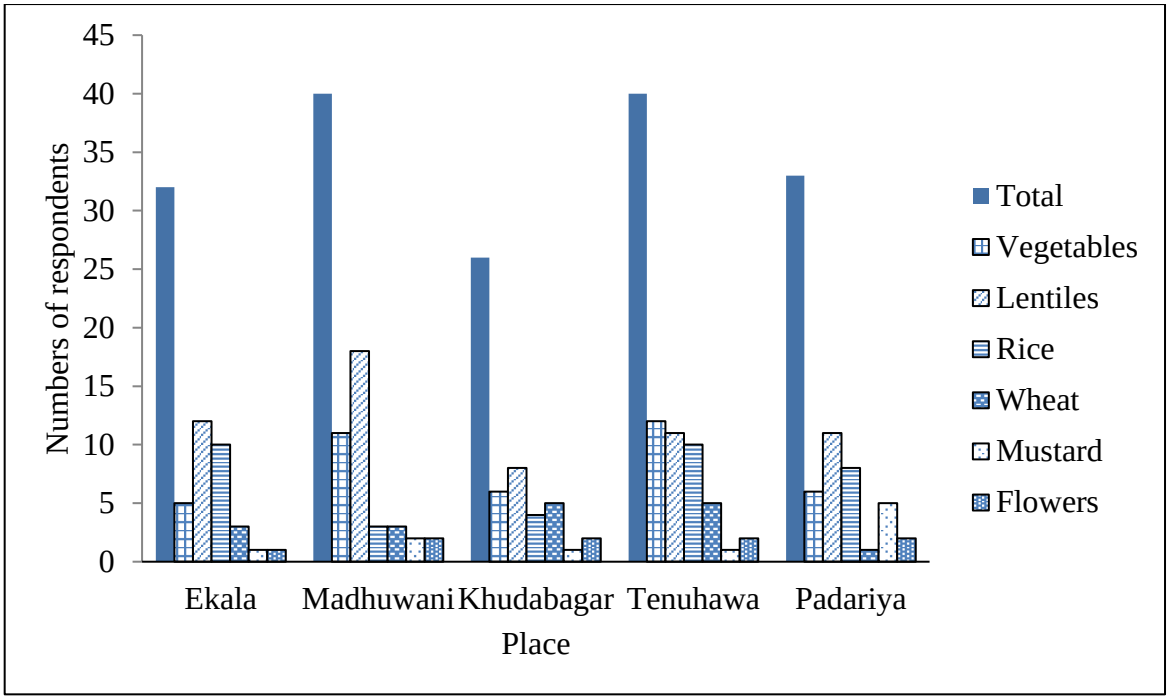


Figure 6: Crop damage cause by Nilgai around LDA surrounding places.

4.2.1 Time and frequency of crop depredation

Questionnaire with local people and field observation found different time and frequency of Nilgai field visit and crop depredations. Out of 195 respondents, only 12.03% respondents stated no crop damage by Nilgai as their filed was swampy in rainy season and left barren in winter.

Nilgai used to visit agriculture field in the morning as told by 31.57% people, 26.90% people told they visit in the night, whereas 27.48% people told they came in the evening and remaining 5.26% people told they visit in the day time (Figure 7). Group size engaged for crop depredation varied from single individuals to group of few individuals. Most (147) of the people stated Nilgai comes in group for crop raiding.

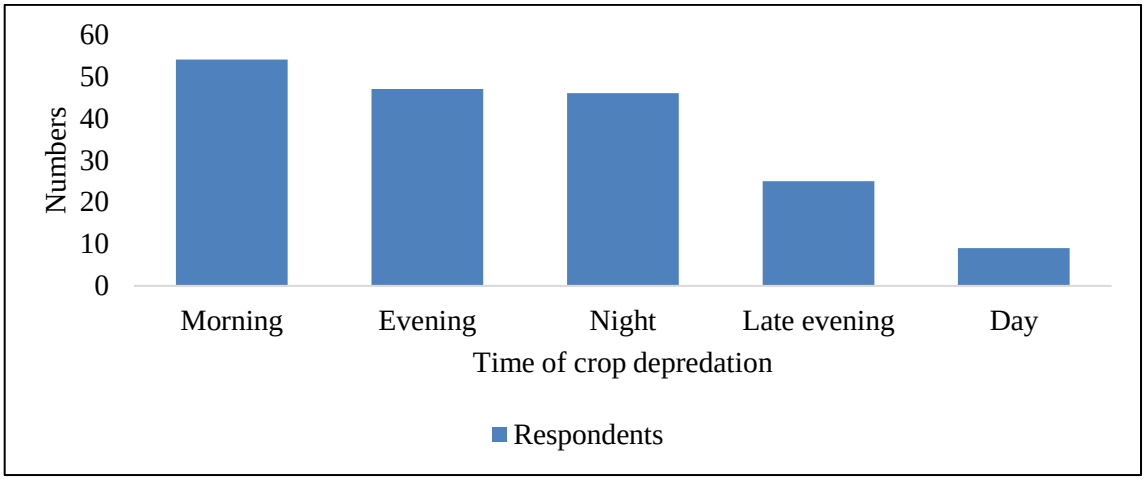


Figure 7: Time of Nilgai visit to field around the surrounding places of LDA, 2017

The frequency of Nilgai visit also differs. Total 87.69% respondent told the problem of Nilgai crop depredation. Nilgai used to visit every day in their field as stated by 53.80% (n=92) of respondent, 21.05% people told they come twice a week, 15.20% people told they come occasional and remaining 9.94% people told they come once a week (Figure 8).

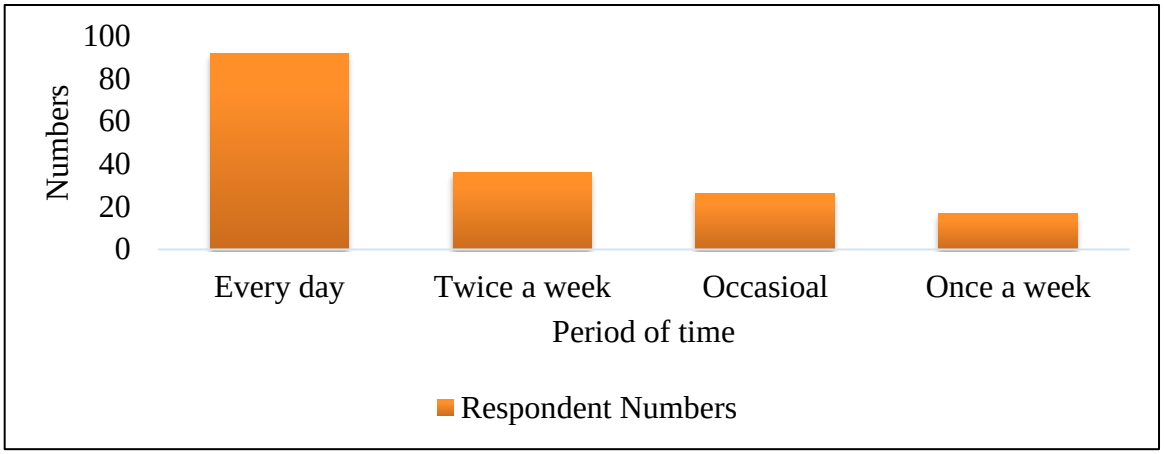


Figure 8: Visit period of Nilgai to field according to local respondents

4.2.2 Crop preference by Nilgai

Among total 195 respondent 35% respondents told Nilgai prefer Lentils, 23% respondents told Nilgai prefer Vegetables, 21% respondents told Nilgai prefer Rice, 10% respondents told Nilgai prefer wheat, 6% respondents told Nilgai prefer mustard and 5% respondents told Nilgai prefer flowers (Figure 10). Fifty-seven percentage of the respondent stated that the damage is increasing every year. They have stopped planting Potatoes, Rahar, Pea, Grams. Crop depredation done by Nilgai was identified by farmers through various methods. Most of people (40%) identify by seeing the animal in field, 24.61% people observed Fecal in field and 23.07% people observing the tracks.

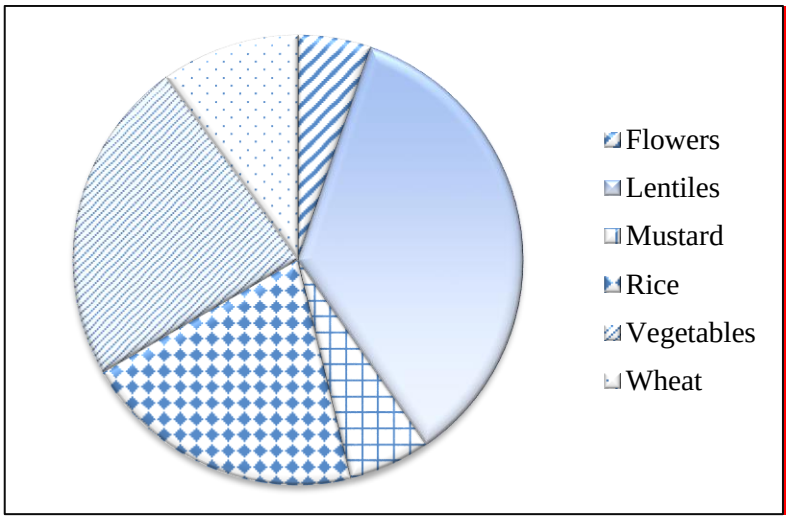


Figure 9: Crop preferences by Nilgai in LDA according to respondent view

4.2.3 Technique of crop protection and effectiveness

Nilgai come in the groups as stated by the 147 peoples of LDA surrounding areas and cause wide range of crop destruction by feeding and trampling. Killing of animal is difficult due to social/religious sentiments. Therefore, local farmers around LDA of Rupandehi districts have searched out and tried certain unique innovative methods by using indigenous knowledge's. Only 39.48% of the respondents used the protective measures. Different guarding measures employed by farmers in the study area were Machans, Fencings, Scare crow, fecal spray, Guarding, Rotten fish spray, Chasing and Film rounding. Machans are temporary night shelters in fields usually made of wood above the ground where farmers stay during the night to guard their crops. Film rounding was done for small field nearby home. Fencings is one type of boundary which is up to 6 feet high. Fencing was done with strips of chopped bamboo or sari or net. Bamboo fencing was mostly used protective measures. Net fencing was found to be most effective than other fencing. Fecal of cattle's used to spray as it acts as the repellents for few days only due to its foul smell. Whole rotten fish was used to grind to make paste and water was added on it to spray. Guarding overnight was done for the nearby field of home for this they use to hang the electric bulb in the field and used to guard the field. Chasing was done by throwing stone to Nilgai, producing loud voice and with sticks.

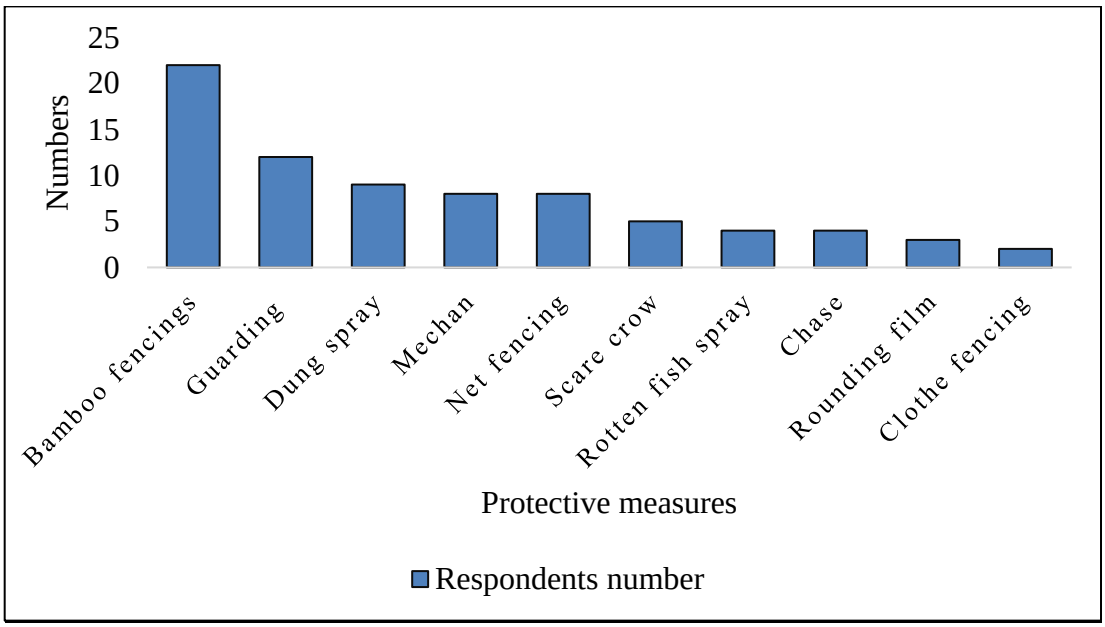


Figure 10: Protective measures applied by the farmers against Nilgai crop depredation

The protective methods applied varied according to the crops verities. Fencing, film rounding, guarding overnight and construction of Mechan was done for Vegetables whereas chasing/throwing stone for protecting rice, wheat, lentils and vegetables; cattle Fecal spray and rotten fish spray was done in rice and wheat only.

Protective method applied by the local farmers were not effective to protect the crop depredation done by Nilgai those methods only control domestic cattle. Total 77 people

applied different protective methods, 64.93% respondent state applied methods were partially effective and 35.06% respondents state not effective (Annex 2). Chasing, rounding film, scare crow in field and rotten fish spray were even not partial effective. Bamboo fencing and guarding overnight were much effectives then other as majority of the people also used these methods (Figure 11).

4.2.4 Suggested method to control crop depredation by respondents

The broken wall of the LDA and height of the wall at some place facilitates Nilgai to come out from the garden for crop depredation. Many people have negative perception toward the LDA office as it only focuses on the development of the area but never focus on the problem caused to local people by the Nilgai. Out of 195 respondents, 53% respondent suggested to repair the broken wall of the LDA, 15% respondent suggested to shift the animal, 20% respondent suggested to make an enclosure inside the LDA and remaining 12% people didn't suggest any control measures (Figure 12).

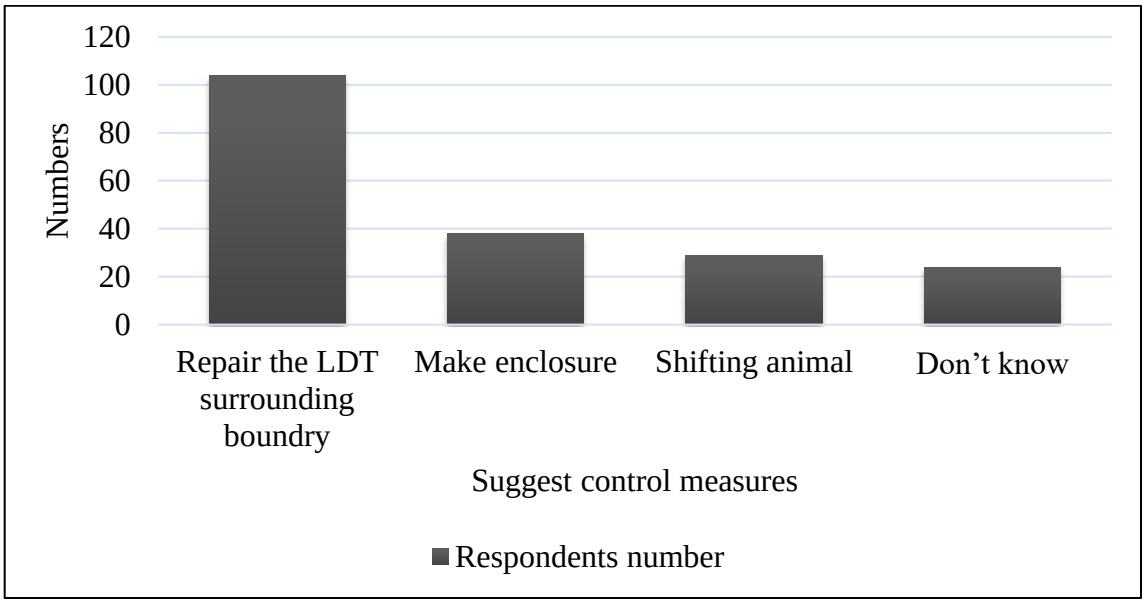


Figure 11: Suggested crop depredation control measures from Nilgai by respondents

4.3 Threats to Nilgai

Among the 195 respondent, 42.05% respondents stated disease like Khoret and FMD as major threat, 11.28% respondents stated competition among Nilgai as threat, 8.20% respondent stated forest fire as threat, 2.56% respondents stated poisoning as threat, 1.53% respondents stated killing as threat, 10.25% respondents stated habitat destruction as threat, 24.10% respondent told they don't know the threat.

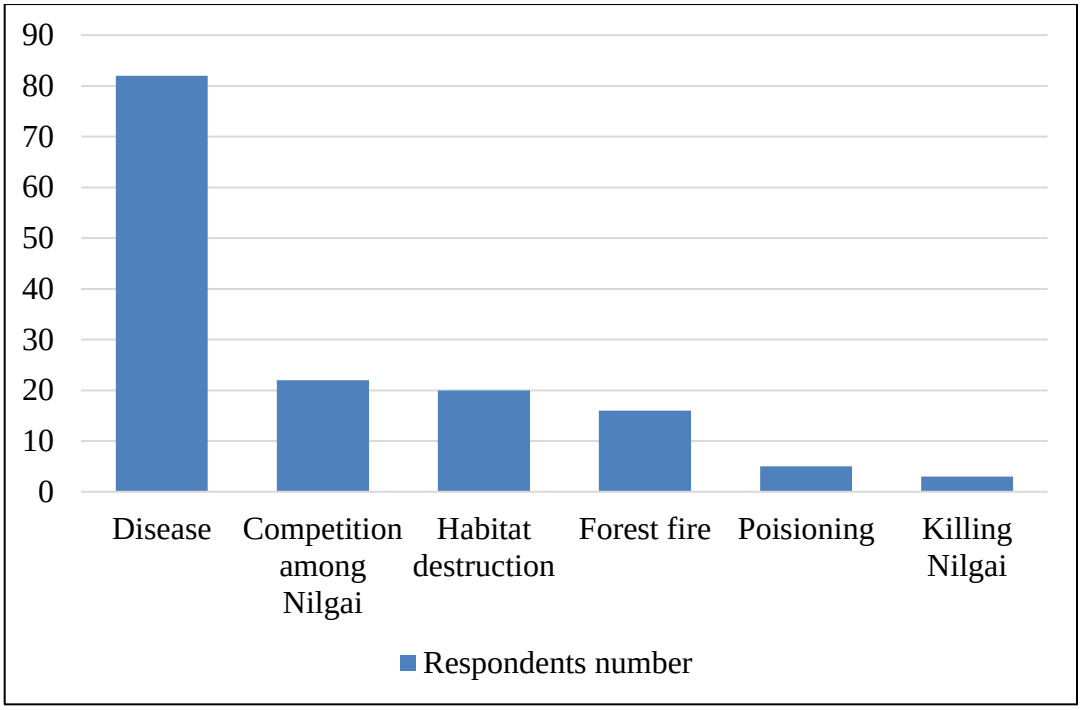


Figure 12: Threats to Nilgai as perceive by farmers of LDA surrounding places, 2017

5 DISCUSSION

5.1 Population status and distribution

Nilgai has the great evolutionary significance, as it looks intermediate between sheep and horse (Chalise, 2016). Population of Nilgai keep decreasing up to 2001 (Subedi, 2001) due to mass mortality of Nilgai by disease FMD. The present study showed the population of Nilgai has increased and reached up to 59 within one decade as Aryal (2007) has estimated 41 Nilgai , Subedi (2001) counted 11 Nilgai, Bagale (2003) counted 37 Nilgai and Gosai (2007) counted 17 Nilgai in LDA. Afforestation and restriction of human in collecting Forbes and cattle grazing to some extent, along with presence of no predator of Nilgai, cultural believe, prolonged breeding activity, high rate of multiple births, might have increased Nilgai numbers considerably and become locally overabundant.

The semi opened habitat and scattered forest patches and grasslands inside the garden has provided good home for Nilgai populations, since the immigration of few individuals in the early 1990's. Male to female ratio was 43:100 in present study, which is low then previous ratio 81:100 Khanal (2016) in Rupandehi , 50:100 (Katri, 1993 and Lasiwa, 1999) in BNP, 59:100 in Keolado Ghan Sanctuary Rajsthan, Indai (Schaller, 1967), 66:100 Aryal (2007) in LDA. The ratio was grater then Aryal, *et.al* (2016).The study found Density of 7.52/km^2 which is low than Aryal (2007) who had found density of 8 individuals/km^2 in LDA and also less than Aryal, *et al* (2016) who found average density 22.8 individuals/km^2 along the Tinau River at Rupandehi District in western Nepal. Similarly it differs from the Bagale (2003) found mean heard size 3.7 in Lumbini and Khanal (2016) found mean herd size 5.61 in Rupandehi; which is high from this study. The mean herd size of Nilgai in present study was 2.18. It was low than the south western section of BNP where mean herd size was found 2.75 individuals per herd (Khatri, 1993) and 2.5 individuals per herd (Lasiwa, 1999).

The largest herd was 6 during the study period which is high than SWR (Bist, 2012) and BNP (Lasiwa, 1999) where herd size was of 5 individuals in both areas, but it was 7 individuals in BNP (Khatri, 1993).

The distribution pattern was found to be uniform which differs from Khanal, *et al* (2016) who found clumped distribution in Rupandehi Aryal, *et al* (2016) who also found clumped distribution in Tinau river of Rupandehi and Chauhan and Singh (1990) who found random distribution of Nilgai in Uttar Pradesh. The clumped distribution in the Rupandehi district might be due to the presence of the predator, presence of small patchy community forest, presence of riverine forest or inability of offspring to independently move from their habitat and the random distribution in the Uttar Pradesh might be due to lack of social interaction among the individuals of the same species. The lack of social interaction might trigger by the consistent environmental conditions and available resources. Whereas, the uniform distribution pattern of Nilgai in the present study might be due to the maximum spacing between them for food, territory maintaining or social interaction between the individuals within the population.

5.2 Habitat preferences

Nilgai occur near human settlement and crop fields outside protected areas. They are found in a variety of habitats, from level ground to undulating hills, in thin brush with scattered trees to cultivated plains, but not in dense forests and steep hills (Blanford, 1888 and Prater, 1971). The study area was divides into four Block of which they prefers most human encroachment area (47.45%) followed by monastery area (27.11%)) and dense habitat (8.74%) but riverine and water logged are was least (16.49% preferred. Human encroachment area was semiarid and open grassland with few Sissoo (*Dalbargio sissoo*) and entire land was covered with Khar (S*acrum,* sp.) and had some water logged area. The area was used for grazing cattle's and collecting Forbes. Cattle grazing in the garden have resulted in the appearances of the productive short grass vegetation, in the garden and phantas.

Riverine and water logged Block was least preferred as Nilgai generally prefer semi-arid habitat. Similarly low preference to dense area was due to the chances of predation specially by fox and Jackal to offspring. The present result concede with finding of Bist (2012) in Suklaphanta National Park and Lasiwa (1999) in Bardiya National park where preference was high in semi-open land as these habitat provide the risk of predation .

Goyal and Rajpurohit (2000) who found overgrazing in the range land by domestic cattle as the cause of Nilgai number increase also match with present finding as human encroachment area was highly used for cattle grazing in LDA. The finding differs from Noor, *et al* (2013) showed high utilization of thickest forest with high tree density in India and Lasiwa (199) who found high preference to Riverine area. The high preference to high tree density area in India might be due to the presence of preferred browse species and lack of predator whereas, high preferences to riverine are in the Bardiya National Park might be due to preferred browse species and their fruits in the hot dry season. Apart from this that the riverine forest had also provides shades and covers because large part of grassland might be enclosed by riverine forest area in Bardiya National Park.

5.3 Crop depredation:

Nilgai is becoming one the main problem for the farmers. The farmers around the LDA are suffering the problem of crop depredation every year. LDA provide good home for the Nilgai, beside this they are also found along the small forest patches along the riverside. Telar River provides good home range for the Nilgai stated by the 42.22% of the respondent. Nilgai is a highly adaptive antelope. Naturally diurnal, it goes for crop-raiding in the evenings and at night. It is found to damage most agricultural crops to a considerable extent. Extent of crop damage is variable, perhaps depending upon the animal numbers and crop protection strategy followed in the area. In LDA surrounding areas, according to villagers, the damage is increasing every year.

The species is often a serious agricultural pest in Nepal and India (Khanal *et al.*, 2016; Khatri, 1993; Sen, 1999; Bagale, 2003; Bhattarai and Basnet, 2004; Bohra *et al*., 1992; Goyal and Rajpurohit, 1999) and is responsible for depredation of wheat (*Triticum*), sorghum (*Sorghum*), mung (*Phaseolus*), vegetables and Mustard, which revels with the present finding

Among total 195 respondent 35% (n=60) told Nilgai prefer Lentils, 23% (n=40) told they prefer Vegetables, 21% (n=35) told they prefer Rice, 10% (n=17) told they prefer wheat, 6% (n=10) told Nilgai prefer mustard and 5% (n=9) told Nilgai prefer flowers. The finding match with Sen (1999) who found high percentage loss of Rahar (*Canjanus canjan*, 35%) followed by Masuro (*Lens culinris*, 27.87%), Paddy (*Oryza sativa*, 11.125%) and Wheat (*Trichum sativum*, 25.89%) in Tenuhawa VDC of Rupandehi district. Similarly it also match with the Chauhan and Singh (1990) finding in the Nahar, India who found extensive damage of lentils by Nilgai. It also concedes with study of Singh (1995) and Bagale (2003) who found major destruction to lentils than paddy and wheat. Khanal, *et al* (2016) also found major problem of crop raiding in Rupandehi by the animal in that area and found 68633$ projected crop yield loss from March 2015 to March 2016.

Crop depredation was found high in Madhuwani and Tenuhawa matched with Aryal (2004) it might be due to presence of patchy and community forest along with riverine forest in Madhuwani whereas community forest in Tenuhawa. Ekala don't have any riverine and community forest but the area is much swampy compared to others. Nilgai not only destroy crop by not only raiding it but also by trampling them as told by 87.69% of the respondent which is similar to Goyal and Rajpurohit (2000) who also found Nilgai damage crops by trampling in India. Similarly the depredation was high in the Tenuhawa and Madhuwani area (Figure 10) as they were near the LDA area and beside this Madhuwani bears small forest patch too. The finding match with the Bayani (2016) along the western boundary of Tadoba-Andhari Tiger Reserve in the state of Maharashtra, central India.

5.4 Protective measures and management trials

Their habitats are so destructive that they eat less and waste more, killing of animal is difficult due to social/religious sentiments. So, local farmers around LDA of Rupandehi district have searched out and tried certain unique innovative methods by using indigenous knowledge. Only 77 (39.48%) of the respondents used the protective measures. The study revealed the most common methods prevalent in the surrounding area of LDA are fencing vegetable by clothes and net, scary crow in paddy and wheat cultivated areas, throwing stone, producing sound, guarding overnight, construction of Machan in the maize cultivated field, cattle Fecal spray, rotten fish spray and shinning film rounding.

During the study period it is observed fencing is effective against cattle but it rarely restricts Nilgai coincide with the study of Chauhan and Singh (1990) in the Haryana, India. Fencing of bamboo, clothe and net were used by 41.54% respondent which differs from Meena, *et al* (2014) who found Live fencing as effective method in Rajsanmand, India. Guarding overnight was done by 15.58% respondent as effective tools differs with finding of Kumar, *et al* (2017) in16 villages of India.

Out of 195 respondents 85 respondents told damage to wheat (*Triticum aestivum*) and mustard (*Brassica campestris*) were not only by foraging but also through trampling and resting in field which match with Chauhan and Singh (2011). Nilgai used to eat the wheat plant up to seedling stage but when it goat ripen they destroy by trampling match with the finding of Goyal and Rajpurohit (2000). Trampling of wheat at ripen stage might be due to its rough bristle which might make Nilgai annoying. Nilgai generally prefers young stage soft vegetation to feed.

Fifty seven percentage of the respondent stated that the damage is increasing every year. Concede with Khanal, *et al* (2016) who also state damage is increasing every year. The increase in the crop depredation might be increase in the Nilgai numbers in Rupandehi or lack of food inside LDA. Nilgai are also not afraid of human than others antelopes whicih have make them easy to visit the farmland and destroy the crops. The local farmer's around LDA surround area have stopped planting potatoes, rahar, pea, grams as they mostly love lentils. Many of the farmers identify the crop depredation of Nilgai by seeing the animal (40%), Fecal finding in field (24.615%), and observing the tracks (23.076%).
During the course of the study, the animals were found seeking other place for shelter than crop fields, where they remained under stress due to farmers chasing them out of crop areas. Generally, the animals come out of LDA through certain strategic points along the boundaries in the evenings and at night and tend to jump the barrier to enter into the crop fields. Selective reduction of Nilgai populations would normally be the logical control strategy. Although hunting of these animals is legally banned but realizing the seriousness of the damage problem, this state-wide ban needs to be reviewed. Areas most seriously affected by the problem where such trials would be locally acceptable area required to be identified and then culling of the animals may be carried out either by experts from wildlife staff or hunters hired by the forest department.

6 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

- The population of Nilgai seems to be increased in Lumbini Development Area.
- Maximum (n=28) Nilgai were found in north of the Bhairahawa-Taulihawa highway which pass through the LDA.
- Uniform distribution of Nilgai was found with mean herd size 2.518 and density 7.51km2.
- Fecal matters were found in all 9 transect. Out of 17 pallet groups, 9 were in human encroachment area, 4 were in Monastery area, 2 were in riverine and water logged area and 4 were in dense forest indicating high preference to human encroachment area (47.36%) and lest preference to riverine and water logged area (10.52%).
- Crop raiding problem of Nilgai is increasing every year.
- Only 39.48% of the respondents used the protective measures, which are also not effective as Nilgai can jump 6-8 feet high.
- Bamboo fencing was highly used protective measures followed by guarding fields, dung spray, mechan, net fencing, scare crow, rotten fish spray, chasing, film rounding and cloth fencing.
- Disease, competition among the Nilgai, forest fire, habitat destruction, poisoning and killing of Nilgai were threats stated by the respondent

6.2 Recommendations

- There should be effective physical barriers as fencing and trenching around LDA. Lumbini Development Area must repair the broken wall and animal should be kept well caged inside the garden.
- Fencing higher than 8 feet must be constructed to avoid crop depredation by Nilgai.
- Census at regular interval is necessary in order to monitor changes in its population.

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ANNEX 1: QUESTIONNAIRE FORM

i. Questionnaire for farmers

Name: Gaunpalika /Nagarpalika:
District: Place:
V.D.C.: Ward No.:

1. Have you seen Nilgai?
   Yes ( ) No ( )
   If yes, specify:
2. How many were there?
3. What were they doing there?
   Grazing
   Walking
   Running
   Others
4. What are main crop you cultivate on your field in summer and winter?
5. Do you have practice mix cropping system
   Yes ( ) No ( )
   If yes which crop do you plat together?
6. Do you get full production from your land? If not what are the causes?
7. Is there any animal damage due to which you are not getting full production? If yes which is that animal?
8. How often does Nilgai visit your farm?
   Every day ( ) twice a week ( )
   Once a week ( ) occasionally ( )
   Never ( )
9. When does the animal enter in the field?
   Morning ( ) ` day time ( )
   Evening ( ) late evening ( )
   Night ( )
10. Does the animal come alone or they come in group?
    Single ( ) group ( )
11. Which crop do they prefer?
    Rice ( ) mustard ( ) wheat ( )
    Lentils ( ) vegetables ( ) pulses ( )
    Others ( )
12. When do they generally damage the crop?
13. Is there any crop you do not grow because of Nilgai? If yes which is that crop type?
14. How do you find that damage was made by Nilgai?
    By observing tracts ( ) watch directly ( )
    By their Fecal ( ) all of the above ( )
    None of the above ( ) others ( )

15. Have you applied any protective measures to stop the damage?
    Yes ( ) No ( )
16. If yes, what are the measures?
    Chase them by throwing stones
    Shout and make noise
    Guarding over night
    Scare crow
    Others
17. Are the Nilgai visiting the field like before?
    Yes ( ) No ( )
18. Are these techniques effective?
    Yes ( ) no ( ) partially effective ( )
19. Do you think the damage problem is growing every year?
    Yes ( ) No ( )
20. Have you ever got any compensation for your damage?
    Yes ( ) No ( )
21. Where do you complain this problem?
    Management of garden
    District forestry officer
22. What do they suggest?
23. What do you suggest to control this problem?
    Shifting the animal
    Compensation
    Others
24. What do you think the cause of decrease in Nilgai population?
    Habitat loss
    Poaching
    Poisoning
    Others

ANNEX 2: STATISTICAL ANALYSIS

Table 1 : $Winter crop Frequencies

	Responses		
	N	Percent	
winter_bhinti	126	19.6%	66.0%
winter_wheat	165	25.7%	86.4%
winter_mustarad	18	2.8%	9.4%
winter_lentiles	37	5.8%	19.4%
Winter_cabbage	49	7.6%	25.7%
winter_cauliflower	114	17.8%	59.7%
winter_radish	104	16.2%	54.5%
winer_potato	29	4.5%	15.2%
Total	642	100.0%	336.1%

Table 2: $Rain crop Frequencies

	Responses		
	N	Percent	
rain_rice	188	49.6%	96.9%
rain_radish	23	6.1%	11.9%
rain_cucumber	15	4.0%	7.7%
rain_bodi	23	6.1%	11.9%
rain_brinjal	16	4.2%	8.2%
rain_chilly	114	30.1%	58.8%
Total	379	100.0%	195.4%

ANOVA

Table 3: Herd size

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	20.774	3	6.925	6.836	.002
Within Groups	23.300	23	1.013		
Total	44.074	26			

Table 4: Protective methods applied and their effectiveness

Methods	Numbers of people	Effectiveness		
		Effective	Partial effective	No effective
Bamboo fencings	22	-	17	5
Chase	4	-	-	4
Clothe fencing	2	-	2	-
Fecal spray	9	-	5	4
Guarding overnight	12	-	12	-
Net fencing	8	-	7	1
Rounding film	3	-	-	3
Scare crow	5	-	-	5
Rotten fish spray	4	-	-	4
Machan	8	-	7	1
Total	77	0	50	27

Table 5: Numbers of Nilgai observed inside LDA during July-August, 2017.

S. N	Place	Male	Sub adult male	Female	Sub adult female	Total
1	Behind shanti stupa	0	0	1	0	1
2	West of Shanti stupa	1	0	0	0	1
3	West of Shanti stupa	0	0	1	0	1
4	North of shanti stupa	0	0	0	2	2
5	North of shanti stupa	0	1	1	0	2
6	North of staff colony	0	0	1	1	2
7	West of staff colony	1	0	0	1	2
8	West of staff colony	0	2	0	0	2
9	Behind hokke hotel	0	1	0	0	1
10	Near gate no 7	0	0	1	0	1
11	Behind hotel kasai	0	2	0	0	2
12	East of Thai monastery	1	0	2	0	3
13	Near China monastery	1	0	0	0	1
14	West of Korean temple	0	0	0	2	2
15	Behind museums	0	2	1	1	4
16	Tenauhawa forest	0	0	1	0	1
17	Sal forest	1	1	1	2	5

18	East of Srilanka temple	0	0	1	1	2
19	Near Lotus temple	0	1	1	1	3
20	West of Parsa chowk	0	0	2	0	2
21	Gate no 3	1	0	3	0	4
22	Army quarter	1	0	1	0	2
23	Gate no 5	0	0	1	1	2
24	Maya Devi south	0	0	1	0	1
25	May Devi temple south	1	0	2	0	3
26	May Devi temple east	0	0	5	1	6
27	May Devi temple west	0	0	1	0	1
	Total	8	10	28	13	59
	Percentage	13.55 %	16.94%	47.45 %	22.03%	100 %

Table 6: Nilgai Fecal matter recorded in different Block of LDA, 2017

Block/plot	Transect	Transect length (km)	Status	Fecal pile diameter (cm)
Human encroachment	1	1.5	Old	52
	1	1.5	New	50
	1	1.5	New	90
	1	1.5	Old	42
	2	1.6	New	85
	2	1.6	New	53
	3	1.5	New	53
	3	1.5	New	44
	3	1.5	Old	54
Monastery area	4	2.4	New	66
	5	2.4	Old	42
	5	2.38	Old	59
	5	2.4	New	63
Riverine and water logged area	6	2.4	New	58
	7	2.4	New	56
Dense forest	8	1.5	Old	80
	8	1.5	New	44
	8	1.5	New	63
	9	1.5	New	53

ANNEX 3: PHOTO PALATE

Figure 1: Measuring the distance between two Fecal pile (A), Old Fecal matter (B), Fresh Fecal matter (C), Fecal matter destroy by beetle (D), Fecal matter in wetland (E), Measuring the diameter of Fecal pile (F)

Figure 2: Adult male (A) and adult female (B)

Figure 3: Sub adult male (A) and sub adult female (B)

Figure 4: Net fencing (A), coir fencing (B), film rounding (C), Bamboo fencing (D), broken wall of LDA (E), questionnaire survey (F)

ANNEX 4: DATA SHEET

1. Nilgai Faecal matter data sheet, Lumbini Development Area 2017.

District: Place:

Zone: Date:

S.N	Latitude	Longitude	Elevation	Datum	Time	Dung pile diameter	Numbers of Faecal	Fresh faecal matter	Old faecal matter	Habitat/ strata

2. Nilgai population monitoring data sheet, Lumbini Development Area 2017.

District: Place:

Zone: Date:

S.N	Date	Latitude	Longitude	Elevation	Datum	Time of animal seen	Adult male	Sub adult male	Adult female	Sub adult female	Herd size	Habitat/strata	Activities	Other animal observed