ECOLOGY OF BANDARJULA ISLAND AND ADJOINING BUFFERZONE GRASSLANDS OF ROYAL CHITWAN NATIONAL PARK, NEPAL

A Dissertation Submitted to
Central Department of Botany, for Partial Fulfillment of
Requirement for the Degree of Master of Science
(M. Sc.) in Botany

By
Nir Bahadur Gurau
T.U. Reg. No. : 22926-93
Roll No. : 1228
Central Department of Botany
Tribhuvan University
Kirtipur
2004

TRIBHUVAN UNIVERSITY

INSTITUTE OF SCIENCE AND TECHNOLOGY

CENTRAL DEPARTMENT OF BOTANY

Ref.No

Kirtipur, Kathmandu
NEPAL

CERTIFICATE

This is to certify that the M.Sc. thesis, entitled **"Ecology of Bandarjula Island and Adjoining Buffer zone Grasslands of Royal Chitwan National Park,Nepal"**, has been carried out by Mr. Nir Bahadur Gurau under my supervision. The entire work is based on the information collected by him in the field as well as in the laboratory and the results have not been submitted for any other degree. I recommend this dissertation work to be accepted as a partial fulfillment for M.Sc. Degree in Botany, Tribhuvan University.

Prof.Dr. S.B. Karmacharya
Central Department of Botany

Date: २४-५-०५

TRIBHUVAN UNIVERSITY

INSTITUTE OF SCIENCE AND TECHNOLOGY

CENTRAL DEPARTMENT OF BOTANY

Ref.No

Kirtipur, Kathmandu
NEPAL

The M.Sc. thesis entitled **"Ecology of Bandarjula Island and Adjoining Bufferzone Grasslands of Royal Chitwan National Park, Nepal"**, submitted by Mr. Nir Bahadur Gurau, has been accepted as partial fulfilment of the requirements for M.Sc. Degree in Botany.

EXPERT COMMITTEE

Supervisor
Prof.Dr.S.B.Karmacharya
Central Department of Botany

Chairman
Prof.Dr.P.K. Jha
Central Department of Botany

External Examiner
Dr.S.R. Joshi
ICIMOD

Internal Examiner
Prof.Dr.H.D. Lekhak
Central Department of Botany

Date: 20.4.04

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF PLATES

ACKNOWLEDGEMENT

I owe depth of gratitude to my supervisor Professor Dr.S.B Karmacharya, Central Department of Botany, Tribhuvan University, for his valuable advice and help throughout the study period.

Heartly thanks to Professor Dr. P.K. Jha, the Head, Central Department of Botany, Tribhuvan University, for providing me the necessary facility for this study and providing me different literatures and advises. Further, I am also thankful to Professor Dr. R.P. Chaudhary and National Herbarium, Godavari for identifying herbarium and to all the teachers and staffs of the Central Department of Botany for their continuous help.

I am grateful to the ITNC i.e. International Trust for Nature Conservation for providing me partial financial support for this study. I am equally grateful to Tiger Tops- Nepal for financing me throughout my M.Sc course and for this study.

Heartly thanks goes to Dr. Chuck Mcdougal, Director of Wildlife Department of Tiger Tops & ITNC and Marcus Cotton, General Manager of Tiger Tops and Tshering Tempa Lama, WWF-Nepal for their continuous assistance, inspiration and encouragement.

I am thankful to Soil Testing and Service Section, Department of Agriculture, Harihar Bhawan, Lalitpur for providing me necessary laboratory facilities for soil analysis.

I gratefully acknowledge the Department of National Parks and Wildlife Conservation (DNPWC), Babarmahal for granting me permission to initiate this study within the Royal Chitwan National Park. Similarly, I want to acknowledge Community Forest User Group (CFUG)- Pithauli for providing me permission to initiate research work in the 'Namuna Community Forest'. I am thankful to all the Park staffs, Rangers, Armies, User Groups, Chaukidars at Pithauli for their cooperative help during the field study. I also like to thank local people Chabi Lal Sharma, Ishwor Mahato, Bijaya Gurau, Hem Raj Gurau, B.Chaudhary, D.B Chaudhary and others for their help in the field and to Chaudamani Burlakoti, Binod Luhar and to all my friends.

I also express my hearty gratitude to my parents for their continuous inspiration and encouragement throughout my whole student life, without which the journey to Central Department of Botany, Tribhuvan University, would not have completed.

Nir Bahadur Gurau
Central Department of Botany
Tribhuvan University.

SUMMARY

Grassland can be defined as the plant community in which the dominant species are grasses or the members of gramineae family and there are few or no shrubs and trees. Grassland covers about 13% of the total area of Nepal and are important areas in terms of bio-diversity and domestic livestock. However this community has been neglected in terms of management, in terms of research or study. Consequently, the grasslands of Nepal are in a declining stage and are largely confined to four protected areas in Terai : Koshi Tappu Wildlife Reserve, Royal Chitwan National Park, Royal Shuklaphanta Wildlife Reserve and Royal Bardia National Park.

Royal Chitwan National Park, established in 1973 AD, is situated in South -Central Nepal in the Terai region having flat area extending over 932 sq. km. and elevation ranging from 150 to 815 m. on the Churia hill range. The Park mainly comprises Sal forest, riverine forest and grassland. The grassland in RCNP covers 20% of the park area and more than 50 different species of grasses have been recorded in RCNP and mainly comprises of *Imperata cylindrica, Sccharum spontaneum and S. munja* in the particular study area. It provides prime habitats for the endangered one-horned rhinoceros (*Rhinoceros unicornis*), and four species of deers viz. sambar deer, spotted deer, hog deer and barking deer.

The study area lies in the grassland of RCNP and adjoining community forest (Buffer zone) and for the study of consumption pattern of park resources by the local people, the adjoining VDC Pithauli was selected. The present study was a short term study to evaluate biomass production, soil characteristics and consumption patterns of park resources by the local people living nearby.

The study was conducted in 3 seasons viz. monsoon, winter and spring of 2002/2003. About a hectare area in each of 5 different plots (P_1, P_2, P_3, P_4 and P_5) was taken as a sampling plot in which the systematic sampling technique was applied. The method of the study was quantitative and biomass was estimated by harvest method.

Aboveground biomass of the grassland of the study area was evaluated as 717.18 g/m^2 and belowground as 667.70 g/m^2. Highest aboveground biomass from all the plots was recorded in monsoon season (1030.61 g/m^2) and least in spring season (343.01 g/m^2). Among the five plots, highest biomass was recorded in plot 5 (934.75 g/m^2) and lowest in

plot 1 (485.96 g/m^2). Similarly, highest belowground biomass from all the plots was recorded in monsoon season (743.48 g/m^2) and lowest in winter season (603.81 g/m^2). Among the five plots, highest biomass was recorded in Plot 3 (803.6 g/m^2) and lowest in Plot 4 (626.57 g/m^2).

Further, quadrate-wise biomass production was also estimated. Highest aboveground biomass from all the plots was found in quadrate 1 (763.73 g/m^2) and lowest in quadrate 2 (655.16 g/m^2). Among the plots, highest biomass was recorded in Plot 5 and lowest in Plot 1. Similarly highest belowground biomass from all the plots was found in quadrate 3 (748.55 g/m^2) and lowest in quadrate 2 (574.63 g/m^2). Among the plots highest belowground biomass was recorded in plot 3 and lowest in plot 4.

Soil characteristics of the study area were also determined as P^H = 7.61, OM = 2.01%, N = 0.09%, P = 17.43 kg/ha, K = 88.46 kg/ha, WHC = 80.64%.

Dealing on the consumption pattern of park resources about 2972 people entered into the park from Pithauli VDC during the 3 days grass cutting season 2003 and harvested a total of 2380.64 tonnes of park resources (Khar, Khadai and firewood) of total monetary value of Rs. 2794304.00. According to the park headquarter, Kasara during the grass cutting season 2003, 43,830 people entered into the park in and around RCNP to harvest park resources and harvested about 35,079.77 tonnes of park resources (Khar, Khadai and firewood) with a total monetary value of Rs. 40430545.00 i.e. US $ 544592.47. During the 3 days grass cutting period- 2003 each person harvested a total of 801 kg of partk resources i.e. 1602 kg per household with monetary value of Rs. 940 per person i.e. Rs. 1880 per household.

There exist a number of problems or threats in any protected area of Nepal which are creating tremendous impact on bio-diversity. Similarly, Royal Chitwan National Park is facing several kinds of threats, viz-succession, flooding, poaching, illegal grazing, pollution, poisoning, crop depredation, human casualty etc. which have generated increasing conflicts between local people and park management which should be solved as soon as possible before it is too late.

ABBREVIATION

Amer.J. of Bot.	=	American Journal of Botany
ANPP	=	Annual Net Primary Productivity
BCN	=	Bird Conservation Nepal
CDB	=	Central Department of Botany
CF	=	Community Forestry
CFUG	=	Community Forest User Group
CG	=	Community grassland
Dec.	=	December
DNPWC	=	Department of National Parks and Wild life Conservation
Feb.	=	February
Fig.	=	Figure
g	=	Gram
Ha	=	Hectare
HH	=	Household
HMG	=	His Majesty Government
ITNC	=	International Trust For Nature Conservation
K	=	Potassium
Kg	=	Kilogram
km	=	Kilometer
KTWR	=	Koshi Tappu Wildlife Reserve
Lit	=	Litre
m.	=	Meter
Max.	=	Maximum
Mg.	=	Milligram
Min.	=	Minimum
Mm	=	Millimeter
N	=	Nitrogen
NCRTC	=	Nepal Conservation Research and Training Center
NP	=	National Park
NPP	=	Net Primary Productivity
NRs.	=	Nepali Rupees
Oct.	=	October
OM	=	Organic Matter
P	=	Phosphorous
P_1	=	Plot 1
P_2	=	Plot 2
P_3	=	Plot 3
P_4	=	Plot 4
P_5	=	Plot 5
PAS	=	Protected Area System
PPP	=	Park-people program
Q_1	=	Quadrate 1
Q_2	=	Quadrate 2
Q_3	=	Quadrate 3
RBNP	=	Royal Bardia National Park
RCNP	=	Royal Chitwan National Park
RH	=	Relative Humidity
Rs.	=	Rupees
RSWR.	=	Royal Shuklaphanta Wildlife Reserve
Sept.	=	September
Temp.	=	Temperature
TU	=	Tribhuvan University
UNESCO	=	United Nations Educational, Scientific and Cultural Organization
VDC	=	Village Development Committee
WHC	=	Water Holding Capacity
Wt	=	Weight
Yr.	=	Year

CHAPTER – 1

INTRODUCTION

1.1 General Background

Nepal, a Himalayan country, is the home of the world's highest mountains, historic cities and the forested plains of rich biological diversity. Situated in south Asia and bounded by the Tibetan autonomous region of China in the north and by India in the south, east and west, the sovereign independent kingdom, of Nepal covers 147, 181 sq.km (between 80^0 4' and 88^0 12' east longitude and 26^0 22'and 30^0 27' north latitude). The length of the kingdom is 885 km east west and it's breadth varies from 145- 241 km with a mean of 193 km north south.

It represents a transitional zone of two bio-geographical realms- the Palaearctic and the Indo-Himalayan. It is also at the crossroads of the southeast Asian, northeast Asian (Chinese) and Mediterranean tracts. Nepal can be divided broadly into three ecological zones : the lowland, the midland and the highland.

Wide altitudinal variation and diverse climatic condition within a small area make the physiography of the country unique in the world. As a result of this the flora and fauna of Nepal shows a wide range of diversity. Ecosystem types ranges from dense tropical monsoon forest of Terai to deciduous and temperate forest of sub-tropical and temperate regions and finally to sub-alpine to alpine. Due to the varieties of ecosystem and rarity of these ecosystem globally, many number of threatened and endangered species all contribute to Nepal, thus ranking one of the most important conservation country amongst the whole world.

Although Nepal occupies only 0.09% of the total land surface of the earth, it is endowed with 2.82% of higher plant species of the world, 4-5% of lower plant species, 9.5% of bird species, 5% of mammalian species and 0.63% of fish species of the world (Jha, 1992).

Poverty compounded by an ever-growing population is the root cause of all environmental problems. Increasing population pressure causes over exploitation of resources and destruction of habitat and ultimately causing different taxa of flora and fauna to be threatened and be in danger of extinction. The situation has been further aggravated by commercial logging, shifting cultivation uncontrolled grazing and encroachments of forest lands. Consequently, annually over 50,000 ha of forest lands are lost. So, to conserve the rich bio-diversity some special protection policy become necessary. To achieve this, a network of Protected Area System (PAS) including National Parks, Wildlife Reserve, Hunting Reserve and Conservation Areas has been established throughout the country since 1973. Protected areas in Nepal are rich in bio-diversity and harbor many vulnerable ecosystems. In Nepal, Rhino (*Rhinoceros unicornis*) population is found in Royal Chitwan National Park and Royal Bardia National Park whereas Wild buffaloes (*Bulbalus bubalis*) are confined to the Koshi Tappu Wildlife Reserve. Likewise Barasinghas (*Cervus duvauceli*) are found in the open grasslands of Royal Shuklaphanta Wildlife Reserve and in the grassland of Royal Bardia National Park.

In Nepal, Vegetation can be roughly divided into 3 major sections as :

1. Grassland
2. Savannah
3. Forest

Generally, grassland can be defined as the plant community in which the dominant species are grasses or the members of gramineae family and there are few or no shrubs and trees. If trees are present, they are fewer than 10-15 trees per hectare (Moore, 1964). Grasses are the chief components of grasslands, which occupy wide tracts of land. The grassland vegetation consists of a number of perennial and annual grasses mixed with legumes and forbes.

Broad area of land is occupied by grasses and they are evenly distributed in all parts of the world. They occur in every soil, in all kinds of situation and under all climatic conditions (Moore, 1964). In certain places grasses form a leading features of the flora. The area of grassland has been estimated to be 27% of the wold's natural

vegetation cover (Knystautas, 1987). Whereas in Nepal, only about 13% of the total area is occupied by grassland (Annonymous,1992).The World's grassland have been classified in many different way, related chiefly to climate (Moore, 1964) and fire (Thomas, 1960). Generally grassland are natural and artificial (Tansley, 1939).

In Nepal, the distribution of grassland follows the great variation in topography and climate from the lowland to highland (Tsuchida, 1983 and Annonymous, 1984).

Tuschida (1983) has classified Nepal's grassland into 4 types :

1. **Tropical Grassland**

It occurs below 1100 m from sea level and floristically characterized by *Imperata cylindrica, Saccharum spontaneum, Cynodon dactylon, Paspalum distichium, Dichanthium annulatum etc.*

2. **Temperate Grassland**

It is found between 1100 to 2600 m from the sea level and is dominated by *Paspalum -Setaria, Ischne – Carex* type.

3. **Sub-alpine Grassland**

It occurs between the altitude of 2600 to 3800 m and is dominated by *Agrostis – Carex* type.

4. **Alpine Grassland**

It occurs above 3800 m from the sea level and is characterized by *Poa sp., Fistula sp. Agropyron sp., Phleum sp.* etc.

Generally, grasslands are either natural or semi-natural (Tansley, 1939). Natural grassland in Nepal is restricted to a part of alpine zone above 3800 m and rest of the grasslands are semi-natural (Jha, 1992). Natural grassland covered approximately 14% of Nepal and are important areas in terms of bio-diversity and

sources of forage for wild ungulates and domestic livestock (Richard et. al, 2000). In Terai, natural grasslands occur along flood plains and terraces. As a result of increasing population pressure in this region, these grasslands only exist in their natural state within the protected areas as neighboring grassland and sub-tropical forest habitats have been rapidly converted into agricultural land and grazing commons. At higher altitude, Trans-Himalayan and alpine range lands are home to a diverse array of wildlife and are grazed by livestock, which are an integral part of the livelihood of several different ethnic groups.

The lowland grasslands in the Indian subcontinent are not in climax but are seral in stage. Their origin is linked to human activities such as deforestation, cultivation, cattle grazing and burning (Dabadghao and Shankaranarayan 1973, Singh and Krishnamurty, 1981). However, palaentological studies have revealed that mesophyllous grasslands existed during the siwalik peirod which ranged from the Miocene to the Plistocene peirod, 20 million years ago (Mathur 1984, Badgely 1984, Gaur 1987).

In Nepal, the grasslands are largely confined to four protected areas in the Terai :Koshi Tappu Wildlife Reserve, Royal Shuklaphanta Wildlife Reserve, Royal Chitwan National Park and Royal Bardia National Park. The tall grasslands of the Terai of Nepal are a unique habitat, dominated by dense stands of graminoids, upto 6 meters tall. They are host to a range of threatened fauna including the greater One-Horned rhinoceros (*Rhinoceros unicornis*), tiger (*Panthera tigris*), swamp deer (*Cervus duvauceli*) and hispid hare (*Caprolagus hispidus*) (IUCN, 1990).

Chitwan grasslands fall within the full range of woody savanna but there are somewhat more treeless swards than wooded savannah. Chitwan grassland should probably called savannah grasslands (Coupland, 1974). Lehmkuhl (1989) preferred more simply to use grassland to describe in a general sense, the Chitwan communities dominated by grass. More than 50 species of grasses have been recorded in Royal Chitwan National Park. The common species are - *Saccharum spontaneum* ,*S. bengalense, Imperata cylindrica, Cynodon dactylon* etc.

A soil moisture gradient appears to be the primary environmental variable controlling among the habitat organization of Chitwan edaphic and successional grassland (Seidensticker, 1976). Tall grasses are found in the most hydric areas and are considered an "edaphic climax" (Dabadghao and Shankaranarayan, 1973). In fact grass conditions occurs within a wide range of soil moisture condition (Lehmkuhl, 1989).

Large mammalian herbivores affect the grassland community primarily as regulations of system process (Chew, 1974; Lee and Inman, 1975; Mac Mahon 1981; Mc Naughton et.al., 1982). There are about 544 rhinoceros in Royal Chitwan National Park (DNPWC, 2000). Rhinoceros are solitary grazers that comprise nearly 85% of Chitwan herbivore biomass (Seidensticker, 1976) and have a high potential impact on the grassland system. There are about 107 domestic elephants (report from Kasara headquarter, 1994) kept by the Park, King Mahendra Trust for Nature Conservation (KMTNC) and Hotel Concessions require substantial amount of grass and tree fodder for their year round subsistance. In addition grasslands of Chitwan are also suitable habitat of 4 species of deers viz Sambar deer (*Cervus unicolor*), Spotted deer (*Axis axis),* Hog deer (*Axis porcinus*) and Barking deer (*Montiacus muntjak*) which rely on the grassland for food and of many grassland bird species.

In Nepal, grasslands are important natural resources which play an integral part of subsistence living in the country (Pokharel, 1993). More than 90% people in the country have subsistence farming which is closely integrated with livestock rearing. Grasslands are the main grazing lands for such live-stock and wildlife. Similarly, members of grass family are of various forms, such as thatch grass, reeds etc. which the local people extract during every winter season. Thatch grasses are used by local people for thatching the roof and reeds for making walls and fences. In addition, different kinds of household materials are prepared from many grass species. Besides, certain grasses are used in festivals and on the occasion of different cultural rituals. Many grasses are consumed by different factory as a raw material. The contribution of grass products from the park to the local village and household economics is nearly 10 million rupees (US $ 451836) (Mishra and Jefferies, 1991). There is an increasing demand for park resources with local population growth.

Crop depredation by wildlife is a great problem for villages living adjacent to the park (Milton and Binney, 1980; Mishra, 1982b). Fences and trenches have been tried with little success for various natural and sociological reasons (Mishra, 1982b).

Royal Chitwan National Park has been a focal site for many in-depth studies of wildlife and their habitats. Research in RCNP has been primarily on the large conspicuous mammals as tiger (Sunquist, 1981; McDougal, 1980; Tamang, 1982; Smith, 1994) and its prey, primarily chital (*Axis axis*) and hog deer (*Axis porcinus*)) (Seidensticker, 1976; Mishra 1982 a; Tamang, 1982; Dhungel, 1985). The rhinoceros has also been the subject of much research (Laurie, 1978; Gyawali, 1986; Dinerstein and Wemmer, 1988; Dinerstein, 1991). Among the aquatic fauna, fishes of the Narayani River were studied by Edds (1989), and gharials by Maskey (1989). Other studies have also been made eg. Park- People interaction by Milton and Binney (1980), Sharma (1986), Gyawali (1986), Sharma (1991), Nepal and Webber (1993). The grassland communities of the park have been studied by Lehmkuhl (1989) and other few researcher. Lehumkuhl has studied the grassland community of Sauraha. Bandarjula a huge island of 40 sq.km or more, formed by the bifurcation at Sikraulighat and joining together at Amaltarighat, is situated about 25 km. west from Kasara, the headquarter of the park. The vegetation mainly comprises of riverine forest with patches of grassland. However, vegetation of Bandarjula Island and adjoining community forest has not been studied yet by other researchers. Therefore present study was carried out in Bandarjula Island area to study about the vegetation composition, aboveground and belowground biomass and park resources used by the local people living nearby. Beside this, this area is under great pressure from human distrubances.

1.2 Biomass of Grassland

Grasslands are highly productive and little of their aboveground biomass is consumed by grazing herbivores (Lehmkuhl, 1989). Grassland productivity, however, varies from one ecosystem to another. In highland grassland, biota are some what perennial and mainly dominated by tuberous species but lowland grassland is generally annual.

Biomass is generally expressed in terms of dry weight and occasionally as ash free dry weight (Trivedy et.al. 1987). Sum of the net production by all individuals plant in a unit area of earth's surface per unit time is net primary productivity. Temperature, moisture, and soil characteristics also play an important role in the growth of vegetation and directly to the production of the amount of biomas. Further, altitude, light intensity and rainfall also effect the biomass production in any grassland. Thus, the difference of biomass in upland pasture, midhill grazing land, lowland grassland and in arid zone can be clearly noticed. Within biomass, aboveground and below- ground biomass of grassland also varies. In addition, any kind of human intervention affects the biomass production in grassland. Conversion of live shoot into dead shoot, litter decomposition rate and destruction by insects can affect the net biomass production. Similarly, biotic interference in grassland by grazing, browsing also alter it.

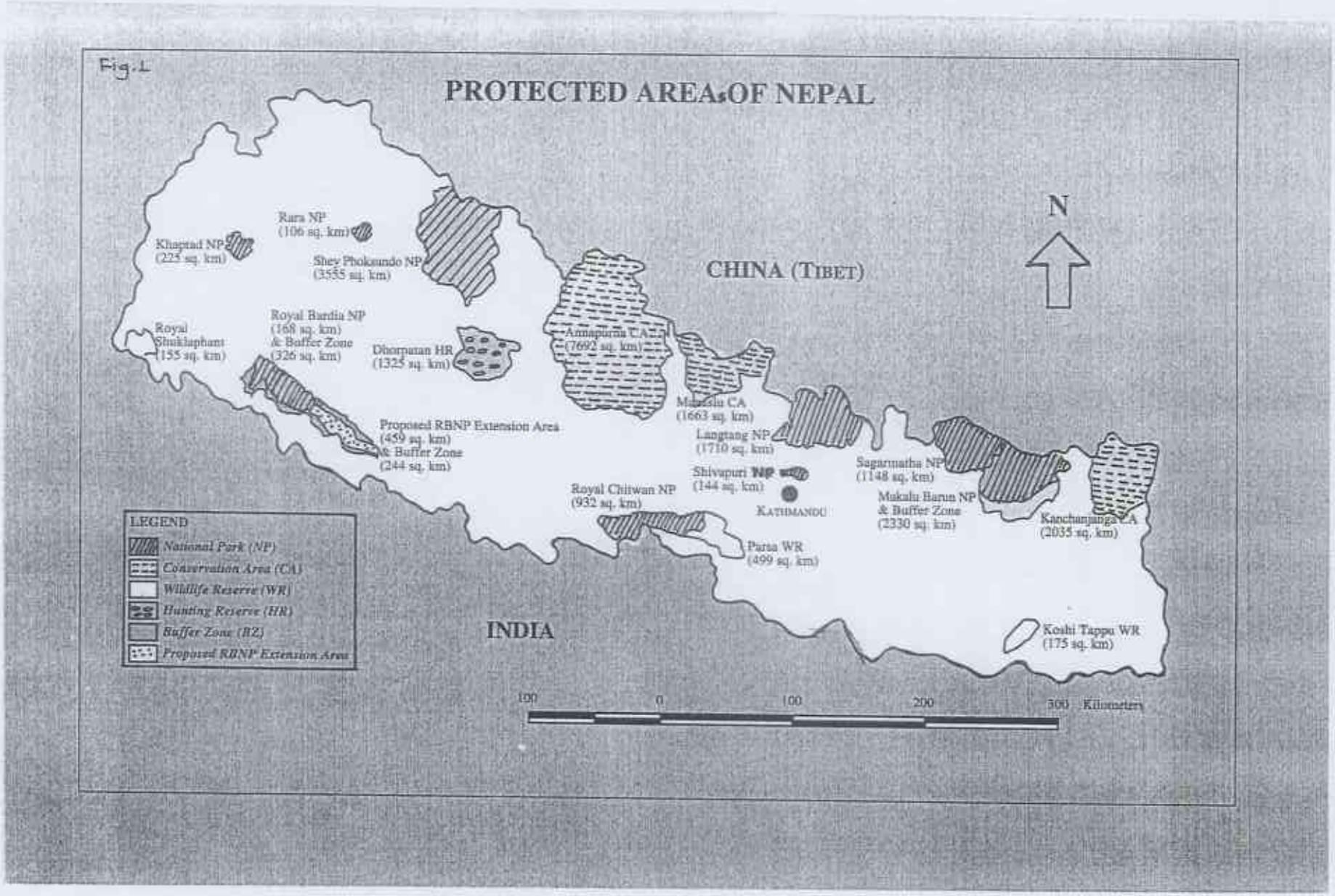
Grass-cutting, burning and ploughing has been an important tool in managing the grassland in Royal Chitwan National Park and adjoining areas.

1.3 Objectives

The main objectives of the study are :

- To estimate the biomass of aboveground and belowground vegetation in different seasons.
- To determine the soil quality parameters in different conditions.
- To account for the socio-economic prospects of the local people and their dependency on grassland.
- To know the attitude of local people towards the park and towards the availability of park resources.
- To enumerate the major threats or issues in and around RCNP.

Fig.1


PROTECTED AREA OF NEPAL
N
CHINA (TIBET)
INDIA
Rara NP
(106 sq. km)
Khaptad NP
(225 sq. km)
Shey Phoksundo NP
(3555 sq. km)
Royal Bardia NP
(168 sq. km)
& Buffer Zone
(326 sq. km)
Royal
Shuklaphant
(155 sq. km)
Dhorpatan HR
(1325 sq. km)
Annapurna CA
(7692 sq. km)
Makalu CA
(1663 sq. km)
Proposed RBNP Extension Area
(459 sq. km)
& Buffer Zone
(244 sq. km)
Langtang NP
(1710 sq. km)
Shivapuri NP
(144 sq. km)
KATHMANDU
Sagarmatha NP
(1148 sq. km)
Royal Chitwan NP
(932 sq. km)
Mukalu Barun NP
& Buffer Zone
(2330 sq. km)
Kanchanjanga CA
(2035 sq. km)
Parsa WR
(499 sq. km)
Koshi Tappu WR
(175 sq. km)
LEGEND
National Park (NP)
Conservation Area (CA)
Wildlife Reserve (WR)
Hunting Reserve (HR)
Buffer Zone (BZ)
Proposed RBNP Extension Area
100 0 100 200 300 Kilometers

CHAPTER – 2

LITERATURE REVIEW

Grasses constitute the most important group of plants. Grasslands have been widely studied throughout the world. However, in Nepal, studies on grasslands are limited either to the enumeration of species or their utilization for grazing the domestic animals. The ecology of grasslands, especially the impact of management activities, are very limited (Lehmkuhl 1989; Karki, 1997; Peet et.al. 1997). Some relevant works done from outside and inside the country Nepal have been reviewed below.

2.1 Works Done from Outside the Country

Singh and Yadav(1972) worked on seasonal variation in composition, plant biomass and net primary productivity of tropical grassland at Kurukshetra, India and pointed out that the maximum aboveground biomass occurred in the month of September and net annual primary productivity as 2976 g/m^2.

Lieth (1975) estimated that the productivity of tropical grassland as about 700 g/m^2 /year while Murphy (1975) reported as 1080 g/m^2/year.

Singh and Ambasht (1975) calculated annual net primary productivity (ANPP) as high as 4046 g/m^2/year from Varanasi *Heteropogon contortus* type of grassland. At the same locality i.e. Varanasi, in *Vetiveria zizaniodes* dominated grassland, Singh and Ambasht (1975) estimated NPP as 1677 g/m^2/year.

Singh and Krishnamurthy (1981) in the review which assesses the emergent properties of the structure and function of tropical grassland vegetation of India and found active build up shoot biomass in monsoon season and peak value ranged from 46 g/m^2 to 1974 g/m^2.

Mishra and Mishra (1984) conducted work in tropical *Aristida setacea* type of grassland at Berhampur. They concluded that shoot biomass peaked in October as 835 g/m^2 and NPP as 1447 g/m^2/year.

Bisht and Gupta (1985) conducted a study on dry matter dynamics in a grassland community of the foothill of Garhwal Himalayas and reported net above ground production as 831 g/m^2/year.

Tiwari (1986) assessed standing crop biomass and net primary productivity of sub-montane and montane grassland of Garhwal Himalaya and estimated the above ground net primary production (NPP) ranging from 219 to 422 g/m^2/year.

In Kanha Wildlife National Park, Madhya Pradesh, India, some studies on utilization of grassland forage by ungulates have been carried out by Pandey et.al. (1987) who concluded that Barasingha are exclusively graminivorous and are common in *Saccharum spontaneum* dominated grassland.

Dagar (1987) studied the impact of overgrazing on species composition, below ground and aboveground biomass in Ujjain. He found that aboveground biomass (g/m^2) in protected area was higher (2252.58) than grazed field 428. 75 g/m^2.

Sinha et. al. (1991) studied growth characteristics, net primary production and energy transfers in two grassland communities and found maximum live shoot biomass in September (820 g/m^2).

Sah et. al. (1994) flashed out seasonal variation in plant biomass and net primary productivity of grazing land in the forest zone of Garhwal Himalaya. In their study, live shoot biomass exhibited unimodel growth pattern with peak live shoot biomass of 165-596 g/m^2 attained in September. Similarly, net primary production was 169-614 g/m^2/year.

Briggs and Knapp (1995) studied variability in primary production in tall grass prairie in NE Kansas and found climate, soil moisture, topographic position and fire as determinants of above ground biomass in grassland. They calculated above ground net primary production, which varied from 179-756 g/m^2 across a variety of sites.

Clement and Maltby (1996) studied plant diversity and ecological variables in moist and wet grassland and concluded that above ground plant biomass was linked with availability of nitrogen and phosphorous in soil.

Ikeda et al. (1997) estimated above ground phytomass in meadow grassland with a growth model using satellite imagery (Landsat TM) and climate data. The result indicated that the measured and estimated yields agreed well.

Many researchers studied biomass in relation to nitrogen and other nutrients. Diaz et al. (1997) carried out a long-term field experiment on the effect of application of several doses of urban solid refuge on the plant colonization, plant cover and biomass production. They found that plant biomass significantly increased in all the amended plots in comparison to the control plots.

Turner et al (1997) conducted research on responses to fire, topography and supplemental N in tall grass prairie in the flint hill region of Kansas and found that N mineralization was greater on unburned than on burned sites and added N consequently increases annual net primary productivity (ANPP).

Zobel and Liira (1997) in their study of richness versus biomass relationship in ground layer plant communities found that small scale absolute richness is mostly determined by the size of the local species pool.

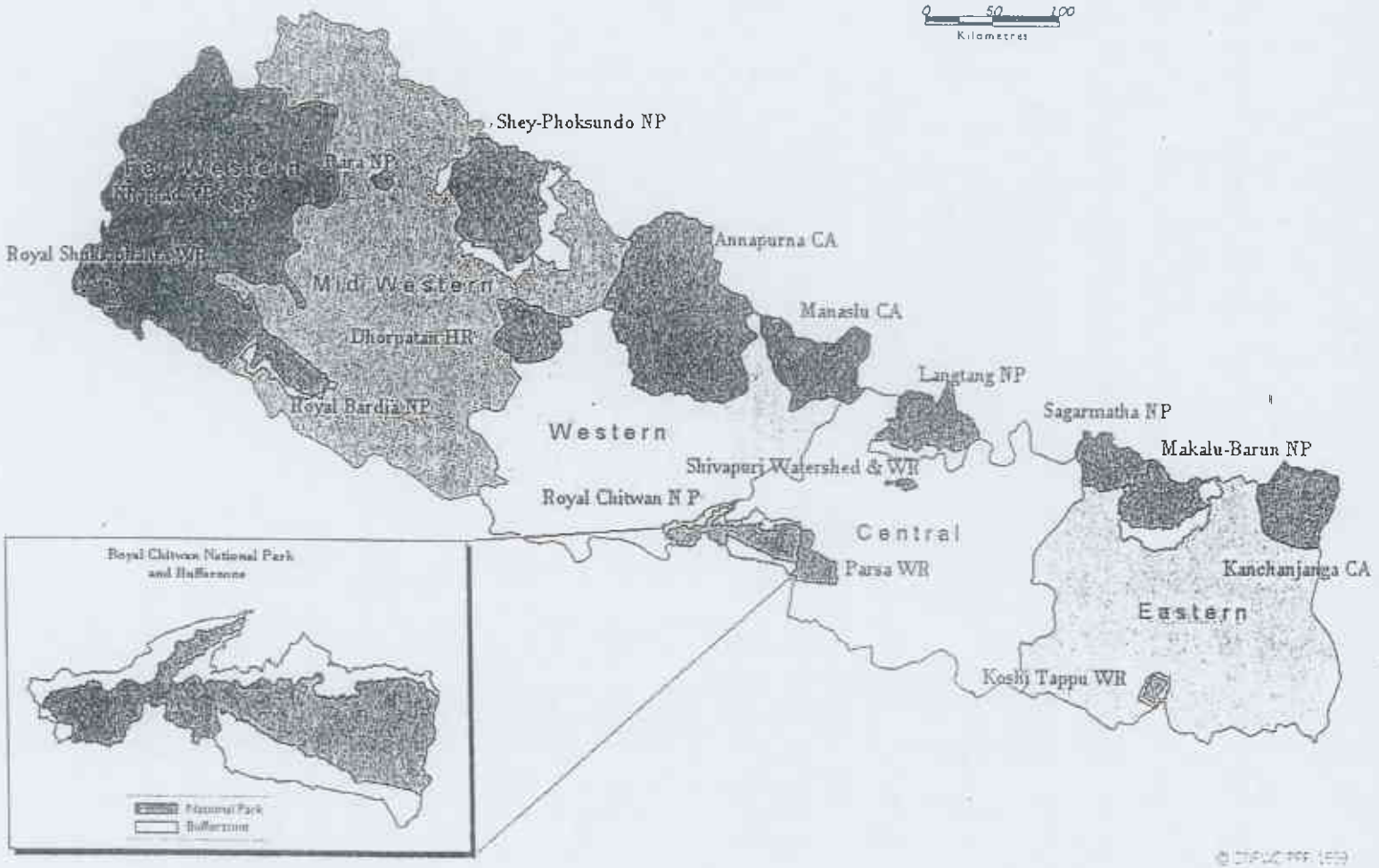
Rusch and Oesterheld (1997) studied the relation between productivity and species and functional group diversity in grazed and non-grazed grasslands and found that grazing of the flooding grassland increased species richness but reduced annual net primary productivity (ANPP).

Biondini et.al.(1998) evaluated impacts of non grazing vs sustainable moderate and heavy cattle grazing and found annual net primary productivity (ANPP) and annual net primary productivity-Nitrogen (ANPP-N) were correlated with rainfall but not with grazing intensity. However, they further realized that heavy grazing led not only to decline in standing dead biomass litter, root biomass and biomass-N but also insitu net soil nitrogen mineralization. According to them grazing pressure lead to removal of 50% of annual net primary productivity (ANPP).

Fig. 2

Royal Chitwan National Park and Bufferzone

LOCATION MAP



Keya (1998) studied for 3 years to determine herbaceous biomass production and its utilization by herbivores in northern Kenya. He calculated mean peak standing biomass for grasses, forbes, dwarf shrubs and total herbaceous layer under non grazed condition.

2.2 Works Done Within the Country Nepal

Many researchers also have worked in the field of grassland of Nepal. Among them, few available relevant works have been described below:

Jha (1972) estimated the net primary production from semi-natural grassland of Tribhuvan Unvierstiy, Kirtipur as 1839 g/m^2/year.

Balson (1976) prepared a general report on RSWR, which included the description of flora and fauna of RSWR including its grassland.

Bhatt and Shrestha (1977) did a detailed study about Shuklaphanta and published a book "Environment of Shuklaphanta" which describes the general ecology of RSWR with the list of plants and animals found in different parts of Shuklaphanta, including the grassland.

Scheaf (1978), described about 4 grassland types viz. dry grassland, seasonally wet grassland, lowland savanna and marsh. He also traced out the relationship of Barasingha with its habitat.

Tsuchida (1983) studied and categorized grasslands of eastern Nepal into 4 zones on the basis of altitude: Zone A (below 1100 m), Zone B (between 1100-2600 m), Zone C (2600-3800 m) and Zone D (above 3800 m).

Dhungel (1985) did some work in grassland of RCNP and estimated the average above ground green biomass as 2.6 kg/m^2 .

In the same National Park ie RCNP Lehmkhul (1989) studied the dynamics of the grassland community and recorded 488 species from the park. He also classified the grassland of RCNP in to eight grassland associations with ten phases. Similarly in his study, biomass in early burned and unburned plots peaked in late July.

Pokharel (1993) investigated floristic composition and biomass production in 5 phantas of Royal Bardia National Park. He estimated total above ground biomass production as 10.27 t/ha.

Pandit (1995) studied the vegetation composition and biomass production of the grassland of RCNP and estimated total above ground plant biomass as 1944. 6 g/m^2 where as Lamsal (1995) estimated the biomass and primary productivity as 1990 g/m^2 in the same year.

Joshi and Jha (1995) also conducted their research on RCNP grassland and estimated 1660 g/m^2 in the month of January. In the month of March biomass decreased to 304 g/m^2 in the month of May, again increased to 523.5 g/m^2

Jha and Jha (1995)studied on seasonal changes in important value index(IVI) and biomass in a lowland Nepalese grassland community, where net production of the grassland was 644.2 g/m^2/year and above and below ground biomass was found to be 407.45 g/m^2 and 104.87 g/m^2 respectively.

Sah (1993, 1997) reported 28 species of grasses and 19 of sedges from Koshi Tappu Wildlife Reserve. He recognized 4 types of grasslands including savanna grassland with scattered trees. According to him, other associations in the grassland were *Saccharum spontaneum – Phragmites karka, Saccharum spontaneum – Tamarix dioica* and *Typha angustifolia –Vetiveria zizanioides.* In his study, he showed the changes of grasslands into different other land uses in 30 years, and finally, he described how flooding, grazing and burning play an important role in maintaining the grassland on the floodplain.

Peet et. al. (1997) divided lowland grassland of four protected areas of Nepal into nine different assemblages with eight phases.

Moe and Wegge (1997) studied the effect of cutting and burning on grass quality and axis deer, use of grassland in lowland Nepal. They found that cut and burned plots had high nutrient than uncut plots in February and in April, while N,P,K were significantly higher in February. On the plots of cut and burned in Januray, Ca

concentration was relatively low while P content fell below required level for domestic stock towards the end of dry season.

Karki (1997) studied on the effect of grass harvest, burning, fertilizer and grazing in three grasslands of RBNP Nepal. He found that addition of fertilizers did not significantly increase green above ground biomass and forage quality. He concluded that cut burnt plots had the highest nutrient quality as indexed by crude protein.

Peet et. al. (1998) recorded 446 species from the grasslands of 4 protected areas of the Terai and reported that RCNP had greatest diversity of assemblage.

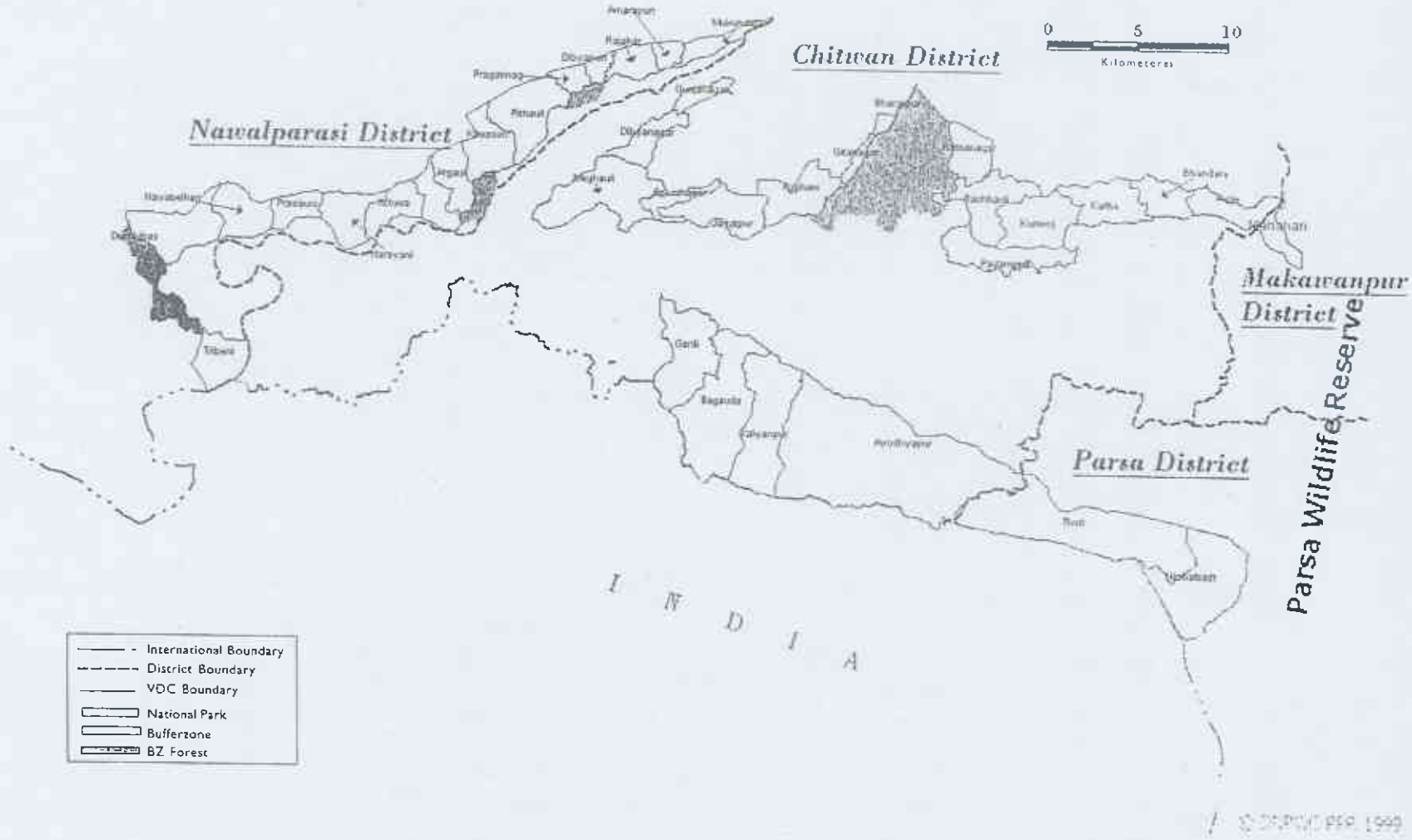
Adhikari (1999) studied on the ecological study of grasslands of Koshi Tappu Wildlife Reserve.

Sharma, (2000) studied on the above ground biomass and primary productivity in the grassland of Royal Shuklaphanta Wildlife Reserve (RSWR), where aboveground biomass was found to be 733.6 g/m^2.

Fig. 3

Royal Chitwan National Park and Bufferzone

BOUNDARY MAP



CHAPTER – 3

STUDY AREA

3.1 Background

Protected areas are created for the preservation of historic, scenic, cultural and wildlife values of the territory. The basic aim of creation and management of protected areas is to improve, maintain and preserve the environment in and around such areas by involving conservation of forest, water, soil, grassland, cultural and ecological heritages. Only 5.19% of earth's land surface is under legal protection which comprises of national parks, scientific stations, wildlife reserves and other categories of reserves (Wilson, 1992). The world National Park Congress in 1982 decided that 10% of the worlds land should be protected in the form of wildlife reserves, national parks and protected landscapes to safeguard the rich bio-diversity on the earth.

National parks are legally designated areas where in natural or cultural phenomenon of national significance are protected from exploitation for private gains. So that they can be enjoyed by the public (Hales, 1989). National Parks have become representative of certain vulnerable ecosystems of the world. Parks today protect vast areas of diverse natural landscapes which are significantly rich in bio-diversity. They are indispensable elements of nature conservation (Mc Neely, 1990).

A full commitment towards the protection of bio-diversity in Nepal was made in 1973 with the establishment of the Royal Chitwan National Park (Bolton, 1975), and it is the first step towards conservation initiatives. To date there are 9 National parks, 3 wildlife reserves, 1 hunting reserve and 3 conservation areas covering an area of about 18.33%(26,971 sq km) of the total area of Nepal. In Terai of Nepal there are

5 protected areas : 3 National Parks and 2 Wildlife Reserves. Royal Chitwan National Park is one of them.

Royal Chitwan National park, established in 1973, is the first National Park in the kingdom of Nepal. The park has long been one of the country's treasure of natural wonders. The park is situated in south-central Nepal in the Terai region covering an area of 932 sq. km. Recognizing its unique ecosystems of international significance, UNESCO declared RCNP a world heritage site in 1984, which comprises of a complex ecosystem of Churia hills, ox-bow lakes and flood plains of Rapti, Reu and Narayani rivers. Only 40 years ago ,this was one of the worst malarial areas in all of Asia. There was almost no settlements except for few small villages of an ethnic group known as "Tharus" the earliest known inhabitants of the region, who apparently have some resistance to malaria.

Geographically the RCNP lies at $27^{0}30'$ North latitude and $84^{0}20"$ East longitude. The shape of the park is irregualar and elongated east to west.The Churia range forms the southern boundary of the park and the Rapti river forms the north boundary until it confluences with the Narayani river, which then forms the north and later west boundary down to the Indian border. In the east the park is connected with Parsa Wildlife Reserve. Altitude ranges from 150 m to 815 m on the Churia hill range.

At that time Chitwan was a private hunting reserve of the Rana family, the former rulers of Nepal. During a hunt over a period of three months in the winter of 1938 to 1939, no fewer than 120 tigers, 38 rhinos, 27 leopards, 15 bears and 10 crocodiles were bagged. Because of present effective conservation strategies, now RCNP comprises of viable population of endangered mammals like rhino and tiger. The diverse habitat of RCNP provides shelter for a large number of mammals, birds, reptiles, amphibians, insects and invertebrates.

Table 1 : Facts on RCNP

Establishment	1973
Park Area	932 sq. km.
Buffer zone establishment	1996
Buffer zone area	750 sq.km.
Elevation	150-815 m
Park HQ	Kasara
Temperature	Daily Average 24.4^0 C Max 43^0 C (March-June) Min 6^0 C (Dec-Jan)
Rainfall	2400 mm per annum

Source : DNPWC, 1998.

Table 2: Species diversity of RCNP

Flora	> 570 spp.
Mammals	56 spp.
Birds	526 spp.
Reptiles	47 spp.
Amphibians	9 spp.
Fish	126 spp.
Butterflies	156 spp.

Source : DNPWC, 1998.

3.2 Geology and Soil

The Narayani and Rapti rivers have markedly influenced the soils of the valley, almost eliminating the original basin deposits (Carson et. al., 1986). Soils are largely alluvial deposits left by shifting river courses. Alluvial soils on recent terraces range from sand and coarse loams on new terraces to sandy and silty clay loam on older terraces (HMG, 1968).Drainage is variable with the water table ranging seasonally from 0-2m (Carson et. al. 1986). Older soils on fans, aprons and ancient river terraces are well drained sandy loam to loam. Hill soils are sandy loam to loamy rubble, with very stony surface less than 50 cm from bed rock (Lehmkuhl, 1989). Because of the nearly flat plains, run off is very slow and well drainage, usually the ox-bow lakes are formed at different places of the park during the monsoon period which are suitable habitats for the water-fowls. Devital, Tamortal, Lamital, Mundatal are the main ox-bow lakes.

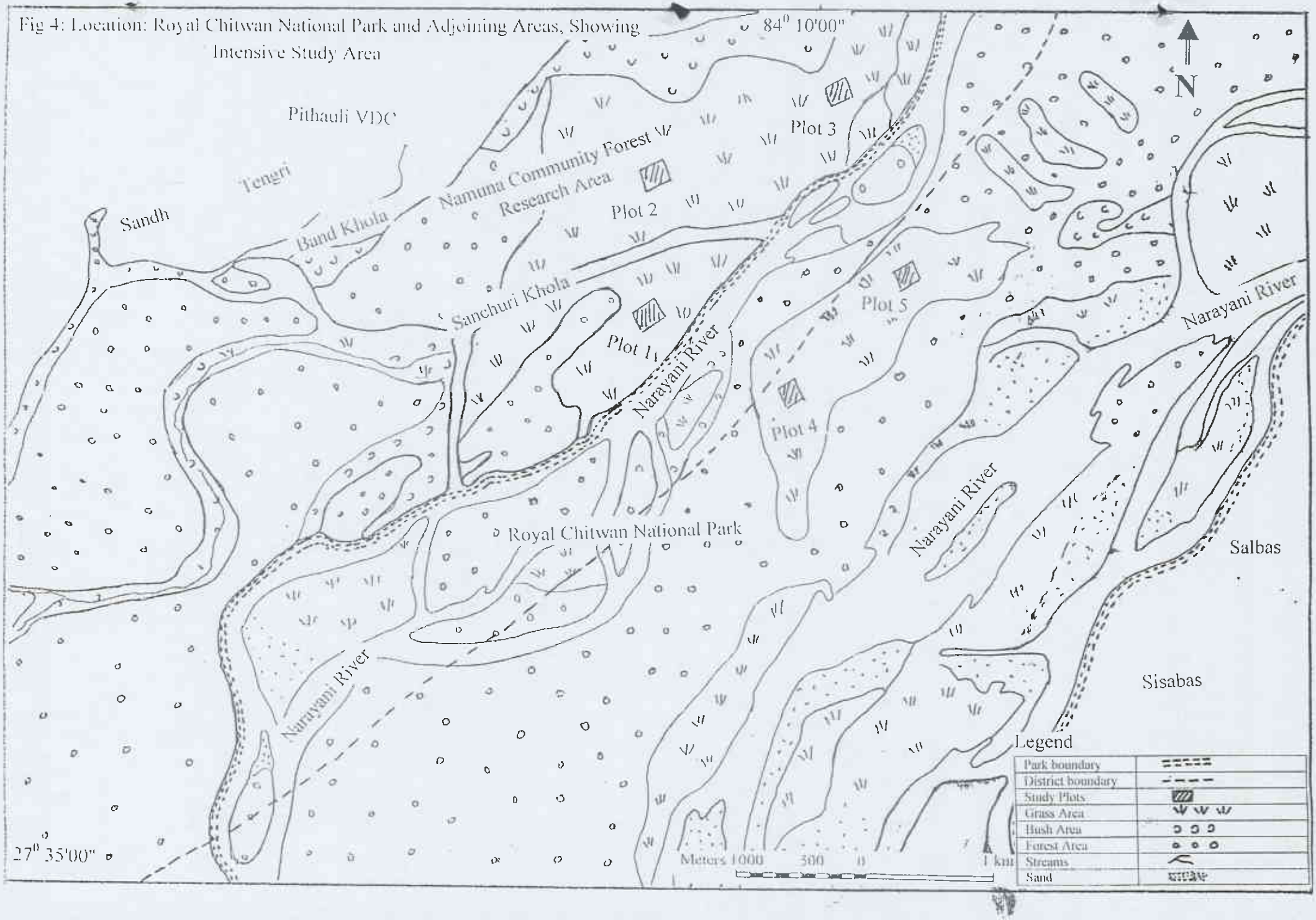


Fig 4: Location: Royal Chitwan National Park and Adjoining Areas, Showing Intensive Study Area
84° 10'00"
N
Pithauli VDC
Tengri
Sandh
Band Khola
Namuna Community Forest Research Area
Plot 3
Plot 2
Sanchuri Khola
Plot 1
Narayani River
Plot 5
Plot 4
Narayani River
Narayani River
Royal Chitwan National Park
Narayani River
Salbas
Sisabas
27° 35'00"
Meters 1000 500 0 1 km
Legend
Park boundary
District boundary
Study Plots
Grass Area
Bush Area
Forest Area
Streams
Sand

3.3 Climate

The climate of Chitwan is humid and warm for much of the year, but there are three quite distinct seasons - winter, a cool dry period; pre-monsoon, the hot dry period and the monsoon which is hot and wet.

Winter occurs from November to February. Dry westerly winds bring low temperature and low humidity. December and January are the coldest months, the average daily temperature is 25^0 C and night temperatures fall to about 5^0 C and frosts sometimes occur. Fog forms in the valleys and during the early morning condenses as heavy dew. Dripping from trees and other vegetation, it sounds much like rain. The cool, wet mist usually blankets the valley until late morning .Winter rains are infrequent and usually light.

The hot dry season begins from late February . Temperatures climb steadily, peaking up to 43^0 C from March to June. Nights are rarely cooler than 20^0 C .Pre-monsoon thunderstorms become more frequent in April and May. They are often accompanied by violent winds and hail and can damage crops, houses and trees. Rainfall is short and heavy.

With the arrival of the monsoon, usually about mid June, the showers and thunderstorms become increasingly frequent. The onset of monsoon rains reduces the temperature however the days are hot of 33^0 C and humid. During this season, rivers become flooded and roads are impassable. The average annual rainfall is about 2400 mm per annum.

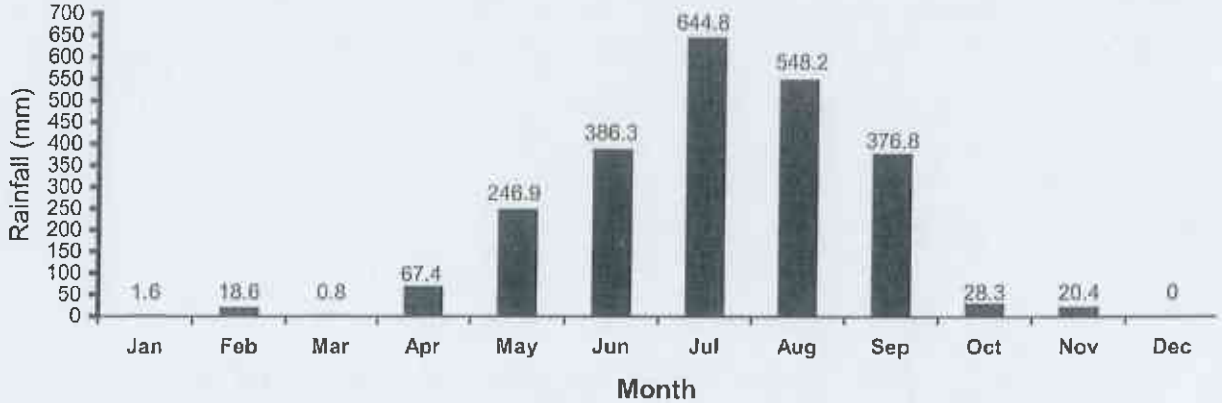


Fig 5 : Mean Monthly Precipitation for 2002, Recorded at Rampur (Source : HMG, 2003 Department of Hydrology and Meteorology)

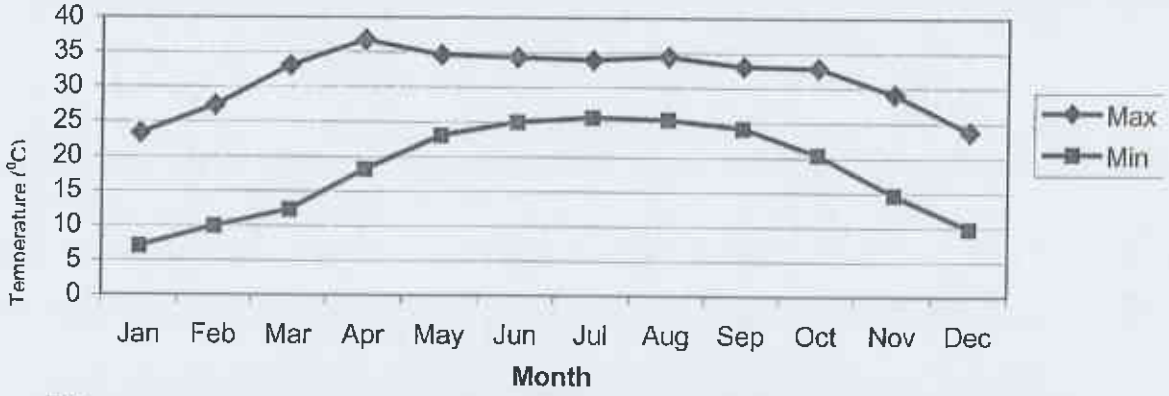


Fig. 6 : Mean Montly Temperature for 2002, Recorded at Rampur (Source : HMG, 2003 Department of Hydrology and Meteorology)

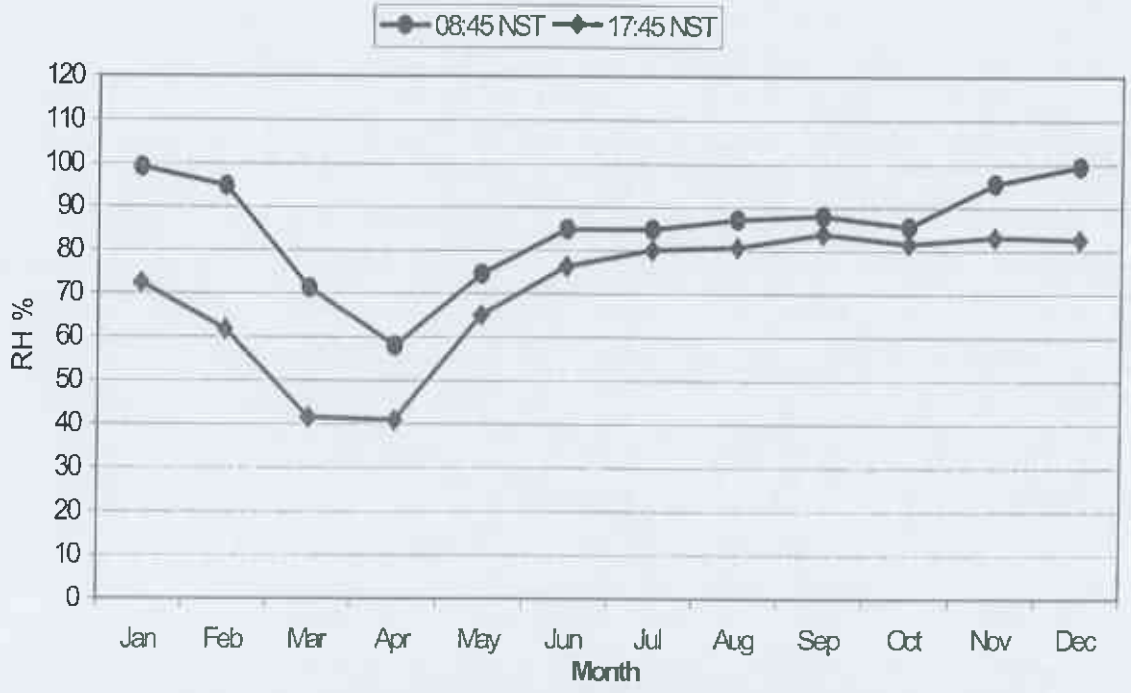


Fig 7 : Mean Monthly Relatively Humidity for 2002, Recorded at Rampur (Source : HMG, 2003 Dept. of Hydrology and Meteorology)

3.4 Vegetation Types

Vegetation in Royal Chitwan National Park is tropical type. Vegetation of RCNP can be divided into following types:

(1) Sal forest

(2) Riverine forest and

(3) Grassland.

3.4.1 Sal forest:

Sal forest is considered as the climax vegetation of the Terai region of Nepal. Sal (*Shorea robusta*) forest covers about 70% of the park area. The Sal commonly grows upto a height of about 25 m and is sparsely associated with trees like *Terminalia bellerica, Garuga pinnata, Dillenia pentagyna, Bridelia retusa, Anogeissus latifolius* and creepers such as *Bauhinia vahlii* and *Spatholobus parviflorus*.

Sal forest is also interspersed with chirpine (*Pinus roxburghii*) in some drier ridges of the Churia range. The ground vegetation is poor with bushes of *Woodfordia fruticosa*. Sal-Pine forest covers an area of about 3% of the park.

3.4.2 Riverine forest:

This types of vegetation occurs along the river banks, water courses and islands in the Narayani and Rapti river (Nepal and Weber, 1993) and occupies about 7% of the park (Mishra, 1982 b). Four types of riverine forests have been distinguished :

(a) Khair- Sissoo forest (*Accacia catechu- Dalbergia sissoo*):

These are the tree species to colonize and stabilize the river banks of recent alluvial deposits. This vegetation cover occurs commonly along the banks of the Rapti, Reu and Narayani rivers (Nepal and Weber ,1993). Undergrowth vegetation comprises of *Pogostemon bengalensis* and a variety of other shrubs, herbs and grasses (Laurie, 1978).

(b) Simal- Bhellar forest (*Bombax ceiba-Trewia nudiflora*) :

These are the two most common tree species in another riverine forest type which represents a later stage in succession & appears as a distinct strip between the khair- sissoo and sal forest. It is a tropical deciduous riverine forest (Stainton,1972) and includes species such as *Bauhinia malbarica, Butea monosperma, Litsea monosperma , Careya arborea, Ficus lacor, Ficus religiosa etc.*

(c) Tropical Evergreen Forest:

This types of forest comprises of *Albizia spp. (A. procera, A. gamblei, A. lucidior), Litsea monopetala, Mangifera indica etc.*

(d) Eugenia wood land:

Almost pure stands of *Syzigium cumini* occur in damp places along the banks of the Narayani river and its old courses. The understorey includes *Colebrookia oppositifolia* and *Murraya koenigii* (Laurie, 1978). The riverine forest has under-storey of *Callicarpa macrophylla, Mimosa rubicaulis, Clerodendron viscosum and Phyllanthus emblica.*

3.4.3 Grassland:

The grasslands comprise of diverse and complex communities of several species and occupy about 20% of the park area (Mishra,1982 b) but it has decreased to only 4% (DNPWC, 2004). More than 50 species of different grasses have been recorded in RCNP. Grasses can be distinguished into 4 types:

(a) *Saccharum spontaneum* is one of the first species to colonise newly created sand banks and grows in pure stands or in association with *Narenga porphyrocoma.*

(b) *Arundo-Phragmites (Arundo donax-Phragmites karka)* association form dense stands upto more than 7 meters high along the stream beds, on the flood plains and around lakes.

(c) *Themeda villosa* forms a tall grass cover upto 6 m high in clearings in the Sal forest, especially on old river courses.

(d) *Imperata* association is comprised of mainly *Imperata cylindrica, Chrysopogon aciculatus*, and *Cynodon dactylon.*

3.5 Fauna

Royal Chitwan National Park is also known as a biological treasure of the world. It is very rich in faunal diversity which harbours 56 species of mammals ,526 species of birds,47 species of reptiles, 9 species of amphibians, 126 species of fish.

The Park is especially renowned for the endangered One–horned rhinoceros (*Rhinoceros unicornis*), tiger (*Panthera tigris*) gharial (*Gavialis gangaticus*) along with many other common species of wild animals. According to Rhino-count –2000, there are about 544 rhinoceros in RCNP and 48 breeding adult tigers which are in the state óf saturaion.

It also harbours endangered species such as gaur *(Bos gauros*), wild elephant (*Elephas maximus*), striped hyena *(Hyaena hyaena*), gangetic dolphin (*Platanista gangetica*), monitor lizard (*Varanus flavescens)* and python (*Python morulus*), wild dog (*Cuon alpinus*). Further RCNP harbours four species of deers ie sambar deer *(Cervus unicolor),* spotted deer (*Axis axis*), hog deer (*Cervus porcinus*) and barking deer (*Muntiacus muntjak*), 2 species of monkey ie common langur (*Presbytis entellus*) and rhesus monkey *(Macaca mulatta*) other include sloth bear, wild boar, fishing cat, palm civet etc.

Among the endangered birds are bengal florican *(Houbaropsis bengalensis*), giant hornbill (*Bucerus bicornis),* lesser florican (*Sypheotides indica*), black stork (*Ciconia nigra)* and white stork (*Ciconia ciconia).* Common birds seen in the park include the peacock, red jungle fowl and different species of egrets, herons, flycatcher, kingfisher, myna, wood pecker, drongo etc. The diverse species of the park show one of the richest faunal composition of the world.

3.6 Research Site

In Royal Chitwan National Park, smaller and larger patches of grassland are scattered here and there. The research site, Bandarjula island, situated about 25 km. west from Kasara, the headquarter of the Park, has been selected. Further, grasslands in the community forests across the Narayani river has been selected for study sites.

Bandarjula island is a huge island which is formed by the bifurcation of Narayani river at Sikraulighat and joining together at Amaltarighat, thus making an isolated area of 40 sq. km. The vegetation mainly comprises of riverine forest with patches of grasslands.

The grassland mainly comprises of *Saccharum spontaneum, S. bengalensis,S. munja, Narenga porphyrocoma* and *Imperata cylindrica* and the grasslands of community forest mainly comprises of *Saccharum spontaneum, Imperata cylindrica* and scattered *Saccharum munja*. These are extensively used by the local people for thatching and construction purposes.

Trees like Simal (*Bombax ceiba*), Khair (*Accacia catechu*) Sissoo (*Dalbergia sissoo*), Bhellar (*Trewia nudiflora*), Jamun *(Syzygium cumini*) are present making the grasslands as savannah type of vegetation. The invasion of tree species in these grasslands is the major problem in the grassland management of RCNP and RCNP has been adopting grass-cutting, firing and ploughing techniques for the grassland management.

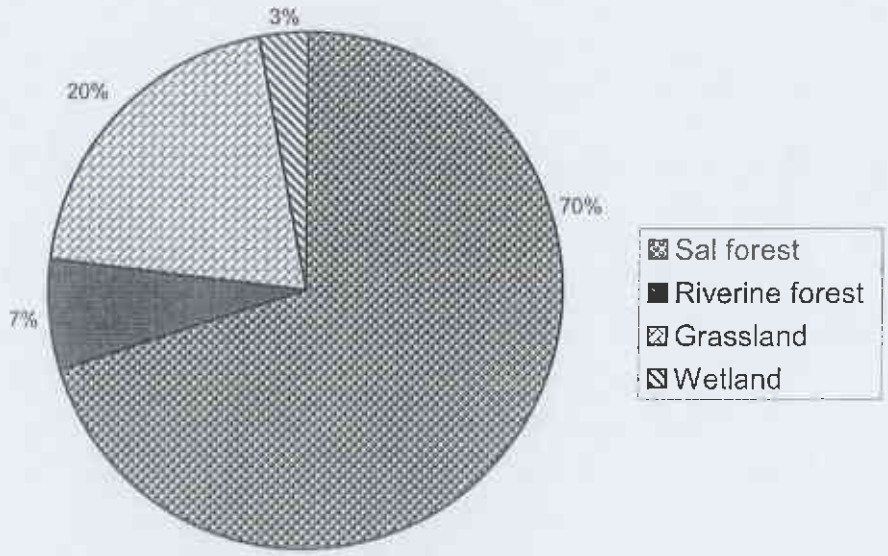


Fig 8 : Habitat composition of RCNP

CHAPTER – 4

METHODOLOGY

Quantitative data collection is one of the prerequisites for research to find out the vegetation pattern and to calculate the ecological parameters such as biomass, primary productivity of any grassland ecosystem. The present research work is also based on field visits, which were carried out in 3 seasons : monsoon ,winter and spring in 2002/2003.

4.1 Selection of Study Sites

First field visit was made during the monsoon and study sites were selected. Two plots were selected in the RCNP and 3 plots in the adjoining community forest and in each plot 3 quadrats were laid through the center of the plot at an equal interval. Thus, there are fifteen quadrats in each phase or season and the study was conducted in 3 seasons. Samples were collected for biomass estimation from the quadrats.

4.2 Biomass Study

4.2.1 Harvest Method

4.2.1.1 Collection of Samples

Samples were taken from the quadrats to estimate standing biomass. In this study aboveground and belowground biomass was estimated by harvest method. In each plot 3 quadrats were laid down. Then, the aboveground plant parts and below-ground plant parts inside each quadrat (1m x 1m) were cut at ground level and uprooted by digging. The green plant parts and roots were then packed in clean polythene bag, labelled and brought to laboratory.

4.2.1.2 Separation of Species and Biomass Estimation

Samples, harvested from 1m x 1m, were separated according to species ie *Imperata cylindrica*, *Saccharum spontaneum* and others were grouped into one group because of their less quantity. All these aboveground and belowground parts were packed, labelled and brought to the laboratory of Central Department of Botany in Kathmandu. These plant samples were then dried in hot air oven at a temperature of 80^0 C for 48 hours and weighed again. Plant samples were again dried until constant weight was obtained. Then, the biomass of the species was calculated on the dry weight basis. Here, cut and weight method given by t'mannatze (1978) has been adopted for the estimation of biomass.

4.3 Soil Parameters

4.3.1 Collection of Soil

Soil samples were taken from each quadrate of the plots. Then, the samples were taken in polythene bags, labelled, packed and brought to the laboratory. These samples were dried in air and then in oven at 80^0 C and following parameters were determined at Central Department of Botany, Kirtipur and at the laboratory of Soil Testing and Service Section, Department of Agricultrue, Harihar Bhawan, Lalitpur.

4.3.2 P^H Content

P^H of the soil was determined by potentiometric method (PCARR, 1980).

For the estimation of P^H, 20 g of weighed soil was taken and dissolved in 20 ml distilled water and stirred thoroughly and left for 1 hour. Then, by using buffer solution having pH 4.0, 7.0 and 9.0, pH meter was calibrated. After that sample suspension was stirred, P^H was immediately determined by dipping the electrode in the suspension.

4.3.3 Water Holding Capacity (WHC)

The water holding capacity of the soil samples was determined by following Zobel et. al (1987) .

For this, 20 g of oven-dried and sieved soil was put in moistened filter paper, placed in funnel. Then, with the help of pipette, water was added to the soil drop wise. A drop of water coming out of the funnel marks the maximum water holding capacity. The water holding capacity was calculated by the following formula:

Water Holding capacity

$$(WHC\%) = \frac{\text{Amount of water retained by soil}}{\text{Weight of dry soil taken}} \times 100$$

4.3.4 Organic Matter Content (OM)

The amount of organic matter content of the soil was determined by Walkiey and Black's rapid titration method (PCARR, 1980).

Here, 1 g of oven-dried and sieved in 0.5 mm soil was taken in a 500 ml conical flask. Then 10 ml. of 1N Potassium dichromate ($K_2Cr_2O_7$) and 20 ml. of conc. sulphuric acid (H_2SO_4) was added successively and mixture was shaked well and was allowed to stand for half an hour in a well ventilated area. After 30 minutes, 2 ml of distilled water 10 ml of phosphoric acid, 0.2 g of sodium fluoride and 1 ml. of diphenyl amine indicator solution was added.

The solution was then titrated with ferrous ammonium sulphate solution until the blue colour changes into brilliant green. The tritration was also done for the blank solution. Organic matter present in the soil was calculated by the following formula.

$$O.M\% = \frac{10\,(S-T) \times 0.0069}{S} \times \frac{100}{\text{wt.of soil}}$$

where, S = ml. of ferrous solution required for blank

T = ml. of ferrous solution required for sample.

4.3.5 Nitrogen (N) Content

The total nitrogen content of the soil was determined by modified Kjeldhal method (PCARR, 1980). This method included 3 steps.

(i) Digestion (ii) Distillation (iii) Titration

For the estimation of nitrogen content in soil, 1 gm of dry soil sample was taken in Kjeldahl flask and moistened with distilled water. Then 3-5 g of digestion catalyst (20 g of $CuSO_4$ $5H_2O$ and 450 g of Na_2SO_4) was taken in a 100 ml Kjeldahl distillation flask. Later, 30 ml. of conc H_2SO_4 was added to the mixture and their digestion was carried out for about 4-5 hours in a mantle heater. To allow, complete digestion, the flasks were rotated several times during heating. After digestion was completed, the flasks were allowed to cool, then distilled water was added to the digestion mixture to obtain 100 ml solution.

Titration was done with 0.05 standard acid (HCl). Colour changed from green to grey. Titration was also done in blank. After distillation and titration, amount of nitrogen was calculated by following formula

$$\text{Nitrogen (\%)} = \frac{(T-B)N \times 14}{S} \times 100$$

Where,

T = Sample titration, (ml) of standard acid

B = blank titration (ml) of standard acid

N = Normality of standard acid

S = Weight of Soil sample taken

4.3.6 Phosphorus (P)

Available phosphorus was determined by using Bray no. 1 method. (PCARR, 1980).

For this, 2 g of air dried soil sample was taken in a 100 ml beaker and 20 ml. of Bray's extractant solution no 1 (0.03 N NH_4 F in 0.025 N HCl) was added and after stirring for few minutes the solution was filtered. Then, 5 ml of filtrate was taken in a 25 ml volumetric flask and 5 ml of molybdate reagent was added to it. Later, the solution was diluted by adding 20 ml distilled water. It was shaked well for few minutes, then 1 ml of dilute stannous chloride solution was added which gave blue colour to the solution. Finally using a sphetrophotometer, available phosphorus was calculated which is as follows :

Phosphorus (kg/ha) = R x F

Were, F = Coefficient factor, calculated from blank solution

R = Reading in spectrophotometer

4.3.7 Potassium (K)

Amount of potassium present in the soil was determined by using flame photometer (PCARR, 1980).

Standard potassium solution was prepared by dissolving 1.5851 g of pure KCl in 1 liter of distilled water. To prepare the working solution, 0, 5, 10 and 20 ml of the stock solution were taken separately and each was diluted to 1 liter with normal neutral ammonium-acetate solution.

The flame photometer was set to 0 and 100 scale reading. Then, the photometer reading for each working solution was determined. These readings were plotted against the respective K content and standard curve was drawn. Then, 5 g of soil sample was dissolved in 25 ml. of ammonium-acetate. It was stirred for 5 minutes and filtered. Then, photometer reading of the filtrate was taken and the amount of potassium content of the filtrate was determined with the help of standard curve.

Potassium (kg/ha) = F x R

Were, F = dilution factor

R = photometer reading.

4.4 Statistical Analysis

Standard Deviation (SD) : Standard deviation of biomass was calculated by using following formula :

$$SD\ (6) = \sqrt{\frac{\Sigma x^2}{N}}$$

where, $x = X - \bar{X}$

Correlation coefficient : Correlation coefficient between parameters was calculated by using following formula :

$$r = \frac{\Sigma xy - \frac{\Sigma x . \Sigma y}{n}}{\sqrt{\{\Sigma x^2 - \frac{(\Sigma x)^2}{n}\}\{\Sigma y^2 - \frac{(\Sigma y)^2}{n}\}}}$$

4.5 Socio-economic, Attitude and Park resources analysis

Field survey was carried out at Pithauli VDC. Simple random sampling method was adopted to determine the household to be surveyed out of 1720 households. A total of more than 60 households were selected for the collection of informations. Some informations were also taken from key persons of the villages e.g. village headman, local social workers and teachers.

To collect primary data and to know the attitude of local people towards the RCNP, interviews were taken by visiting door to door of the concerned villagers. A structured questionnaire was designed to obtain information on various aspects such as collecting materials, if not allowed collect materials what they would do, their positive and negative attitude towards the park.

A survey was also done during the 3 days annual grass-cutting period permitted by the RCNP in 2003. Interviewees provided informations about the amounts of thatch grass (Khar), reed (Khadai) and firewood. Weight of small muthas (small bundles) of khar and khadai was taken inside the park and loads of firewood, khadai and khar were weighed at Pithauli VDC .

CHAPTER - 5

RESULT

5.1 Aboveground Biomass

The aboveground & belowground biomass in five different plots (P_1,P_2,P_3,P_4 & P_5) in 3 different seasons i.e monsoon, winter & spring was determined. Plot 1,2, & 3 were located inside the community grassland & plot 4 & 5 inside the Royal Chitwan National Park. Table 3 .summarizes the total above ground biomass in 3 seasons .

The average total aboveground biomass in the grassland of the study area was found to be 717.18 g/m^2 However, the mean total biomass was highest in phase 1 ie the Monsoon (1030.61±411.51 g/m^2)and lowest in the case of phase 3 ie Spring(343.01±75.18 g/m^2).Similarly, the mean total biomass was highest in the plot 5 ie 934.75±582.2 g/m^2 and lowest in plot 1 of 485.96±170.96 g/m^2 (ie in CF). The maximum biomass was found as 1706.00±557.8 g/m^2 in plot 5 in the monsoon season and minimum biomass was 244.66± 34.12 g/m^2 in plot 1 during spring season.

Table –3 Average aboveground biomass(g/m^2) in the grassland in 3 seasons with Standard Deviation.

Grassland plot	Phase-1 Monsoon	Phase-2 Winter	Phase-3 Spring	Mean.
Plot 1	596.82±115.59	616.4±164.54	244.66±34.12	485.96±170.81
Plot 2	665.33±93.6	555.73±124.81	366.4±46.42	529.15±123.47
Plot 3	917.4±162.18	859.60±213.42	336. ±102.15	704.33±261.51
Plot 4	1267.53±283.25	1058.93±246.54	468.67±90.04	931.71±338.31
Plot 5	1706.0±557.8	798.93±81.07	299.33±75.12	934.75±582.2
Mean	1030.61±411.51	777.91±179.74	343.01±75.18	717.18±283.97

± i.e. Standard Deviation (SD)

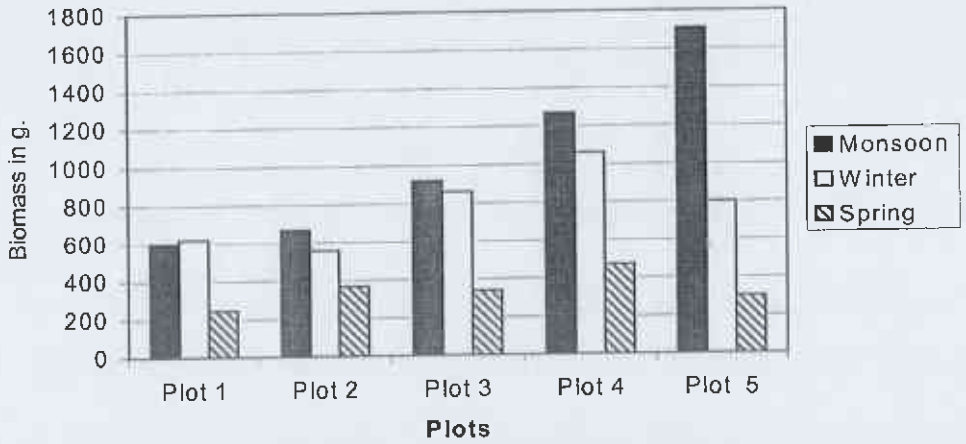


Fig. 9 : Average seasonal aboveground biomass (g/m2) production by five plots

(A) Seasonal Aboveground Biomass Production

5.1.1. Bimass in Monsoon Season:

Average total aboveground biomass of all the plots was found to be highest in Phase-1 ie Monsoon as compared to other seasons. The biomass was found to be 1030.61 g/m^2 and lowest in phase 3 i.e. Spring of 343.01g/m^2 . Similarly, in the same season total aboveground biomass of plot 5 was highest & lowest in plot 1. i.e. 1706.0 g/m^2 & 596.82 g/m^2 respectively.

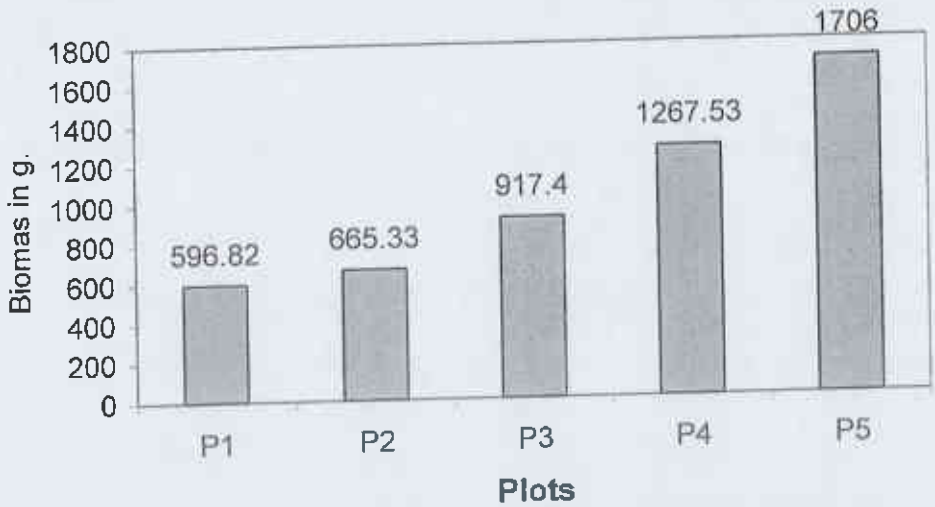


Fig.10 :Average Seasonal Biomass Production by Five Plots in Monsoon Season

Table 4: Biomass of major grasses (*I.cylindrica* and *S. spontaneum*) in different plots in Monsoon (Values in parenthesis are the percentage of the total standing biomass)

Name of Species	P_1	P_2	P_3	P_4	P_5	Mean g/m^2
Imperta cylindrica	323.33 ± 32.22 (54.17)	552.0 ±28.08 (82.97)	790.73 ± 62.63 (86.19)	989.33 ± 12.85 (78.09)	986.4 ± 34.5 (57.8)	728.35 ± 258.35
Saccharum spontaneum	270.56 ± 28.91 (45.33)	108.53 ± 5.3 (16.31)	116.0 ± 1.5 (12.64)	263.13 ± 44.77 (20.77)	679.2 ±135.35 (39.8)	287.48 ± 207.72
Others	2.93 ± 0.1 (0.5)	4.8* (0.72)	10.66* (1.17)	14.4 ± 4.6 (1.14)	41.06 (2.4)	14.77 ± 13.76
Total	596.82	665.32	917.38	1266.86	1706.66	

* Single value

From the above table, it was concluded that mean biomass production of *Imperata cylindrica* was found to be 728.35 g/m^2. Biomass of *I.cylindrica* varied from plot to plot which ranged from 323. 33 g/m^2 to 989.33 g/m^2 in plot 1 & 4 respectively. Th contribution of *I.cylindrica* varied from 54.17% in plot 1 to 86.19% in plot 3.

Mean biomass production of *Saccharum spontaneum* of all the plots was found 287.48 g/m^2. Here, biomass ranged from 108.53 g/m^2 to 679.2 g/m^2 i.e. highest biomass was found in plot 5 of value 679.2 g/m^2 and lowest in plot 2 of value 108.53 g/m^2 .The contribution of *S.spontaneum* varied from 12.64% in plot 3 to 45.33% in plot 1.

Similarly, mean biomass of other species was found 14.77 g/m^2 Here, highest biomass was found in plot 5 of value 41.06 g/m^2 and lowest in plot 1 of value 2.93 g/m^2 i.e. biomass ranged from 2.93-41.06 g/m^2. The contribution of other species varied from 0.5% in plot 1 to 2.4% in plot 5.

5.1.2. Biomass in the Winter Seasoon:

Average total aboveground biomass of all the plots was found to be 777.91 g/m^2. During the winter, total aboveground biomass was found to be highest (1058.93 g/m^2) in plot 4 and lowest as 555.73 g/m^2 in plot 2.

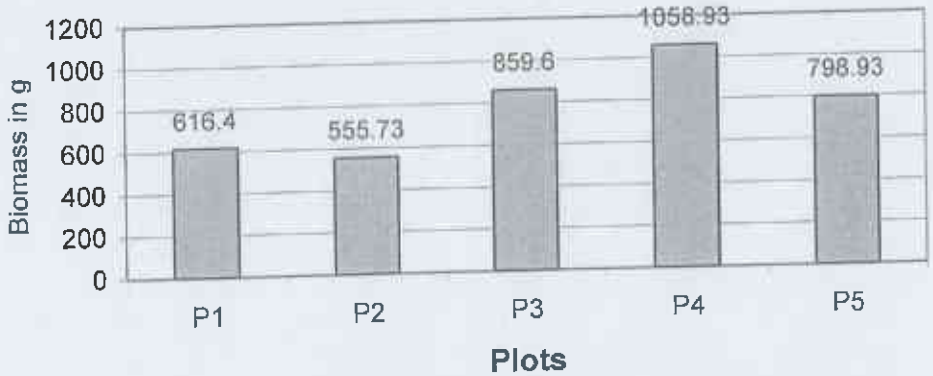


Fig. 11: Average Seasonal Biomass Production by Five Plots in Winter

Table5: Biomass of major grasses *(I. cylindrica* and *S. spontaneum)* in different plots in Winter (Values in parenthesis are the percentage of the total standing biomass)

Name of species	P_1	P_2	P_3	P_4	P_5	Mean g/m^2
Imperata cylindrica	367.33 ±35.85 (59.6)	481.33 ±24.09 (86.61)	674.13 ±78.97 (78.42)	760.8± 3.31 (71.85)	665.87 ±28.90 (83.34)	589.89 ±143.8
S. spontaneum	242.93 ±18.37 (39.41)	72.94 ±13.35 (13.12)	177.2 ±28.42 (20.61)	90.26 ±24.80 (8.52)	114.13 ±17.6 (14.28)	139.49 ±62.63
Others	6.14 ±1.2 (0.99)	1.46* (0.27)	8.27 ±1.36 (0.97)	207.87 ±70.35 (19.63)	18.93 ±5.0 (2.37)	48.53 ±79.87
Total	616.39	555.73	859.60	1058.93	798.93	

* Single value

Above table shows that, mean biomass of *Imperata cylindrica* of all the plots was found 589 g/m^2. Here, biomass was found highest in plot 4 of value 760.8 g/m^2 and lowest in plot 1 of value 367.33 g/m^2 i.e. biomass ranged from 367.33 to 760.8 g/m^2 in different plots. The contribution of *I. cylidrica* varied from 59.6% in plot 1 to 86.61% in plot 2.

Mean biomass of *Saccharum spontaneum* of all the plots was found 139.49 g/m^2. Here, biomass was found hignest in plot 1 of value 242.93 g/m^2 and lowest in plot 2 of value 72.94 g/m^2 i.e. biomass ranged from

72.94 g/m^2 to 242.93 g/m^2. The contribution of *S. spontaneum* varied from 8.52 to 39.41%.

Similarly, mean biomass of other species of all the plots was found 48.53 g/m^2 of highest biomass (207.87 g/m^2) in plot 4 and lowest (1.46 g/m^2) in plot 2. Further, contribution of other species varied from 0.27% in plot 2 to 19.63% in plot 4.

5.1.3 Biomass in Spring Season

During the Spring Season, the total average aboveground biomass of all the plots was found to be 343.01 g/m^2 i.e. lowest of all the 3 seasons. Total aboveground biomass was found to be highest i.e. 468.67 g/m^2 in plot 4 and lowest as 244.66 g/m^2 in plot 1.

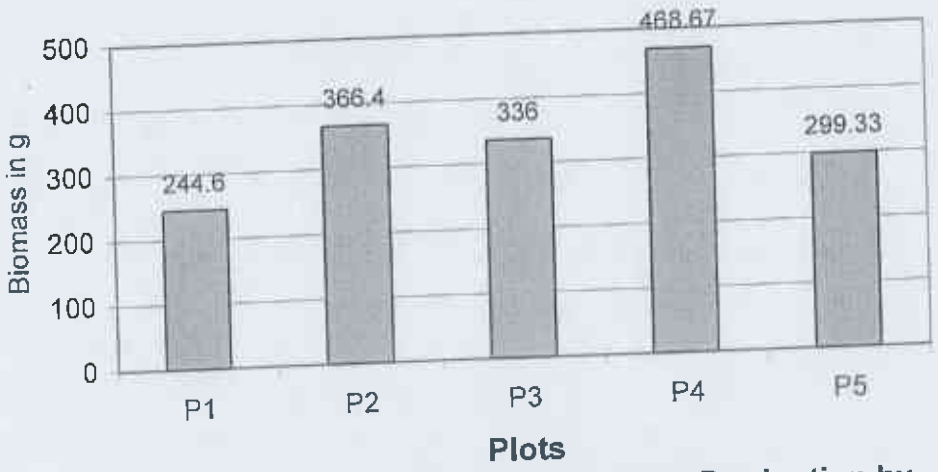


Fig. 12 : Average Seasonal Biomass Production by Five Plot in Spring

Table 6: Biomass of major grasses (*I. cylindrica* and *S. spontaneum*)in different plots in Spring. (Values in parenthesis are the percentage of the total standing biomass)

Name of species	P_1	P_2	P_3	P_4	P_5	Mean g/m^2
Imperata cylindrica	91.87 ± 10.76 (37.55)	326.67 ± 10.70 (89.16)	289.2 ± 22.14 (86.07)	401.87 ± 25.10 (85.75)	250.4 ± 16.25 (83.65)	272.0 ± 103.0
S. spontaneum	150.8 ± 8.33 (61.63)	37.2 ± 4.95 (10.15)	42.8 ± 3.42 (12.74)	46.93 ± 8.70 (10.01)	44.13 ± 3.74 (14.75)	64.37 ± 43.32
Others	2.0 ± 0.15 (0.82)	2.53 ± 0.26 (0.69)	4.0 ± 0.08 (1.09)	19.86 ± 6.85 (4.24)	4.8 ± 0.92 (1.6)	6.63 ± 6.68
Total	244.67	366.4	336.0	468.67	299.33	

Above table shows that, mean biomass of *Imperata cylindrica* of all the plots was found 272.0 g/m^2. Here, biomass was found highest in plot 4 of value 401.87 g/m^2 and lowest in plot 1 of value 91.87 g/m^2.The contribution of *I.cylindrica* varied from 37.55% in plot 1 to 89.16% in plot 2.

Mean biomass of *S.spontaneum* of all the plots was found 64.37 g/m^2. Here, biomass was found highest in plot-1 of value 150.8 g/m^2 and lowest in plot 2 of value 37.2 g/m^2 The contribution of *S. spontaneum* varied from 10.01% to 61.63%.

Similarly, mean biomass of other species was 6.63 g/m^2. Here, biomass was found highest in plot 4 of 19.86 g/m^2 and lowest in plot 1 of 2.0 g/m^2. The contribution of other species varied from 0.69% to 4.24% .

5.1.4 Biomass in Different Quadrates

Aboveground biomass was found different in different quadrates in different plots (Table:7). Highest biomass production was found in

Quadrat 1 and lowest in Quadrat 2 i.e. 763.73 and 655.16 g/m^2 respectively.

Table 7: Average aboveground biomass production (g/m^2) by each quadrat in different plots throughout 3 Seasons.

Grassland plots	Quadrat 1	Quadrat 2	Quadrat 3	Mean (g/m^2)
Plot 1	625.86 ± 244.89	377.69 ± 125.09	454.33 ± 145.64	485.96 ± 103.75
Plot 2	575.86 ± 159.08	518.0 ± 128.75	493.6 ± 115.94	529.15 ± 34.49
Plot 3	618.8 ± 279.08	572.2 ± 192.31	922.0 ± 316.91	704.33 ± 155.08
Plot 4	872.93 ± 290.37	1116.6 ± 550.26	805.2 ± 226.87	931.57 ± 133.72
Plot 5	1125.2 ± 834.58	691.33 ± 283.61	987.73 ± 681.98	934.75 ± 181.04
Mean	763.73 ± 208.75	655.16 ± 251.76	732.57 ± 219.44	717.1 ± 45.64

± i.e. Standard Deviation (SD)

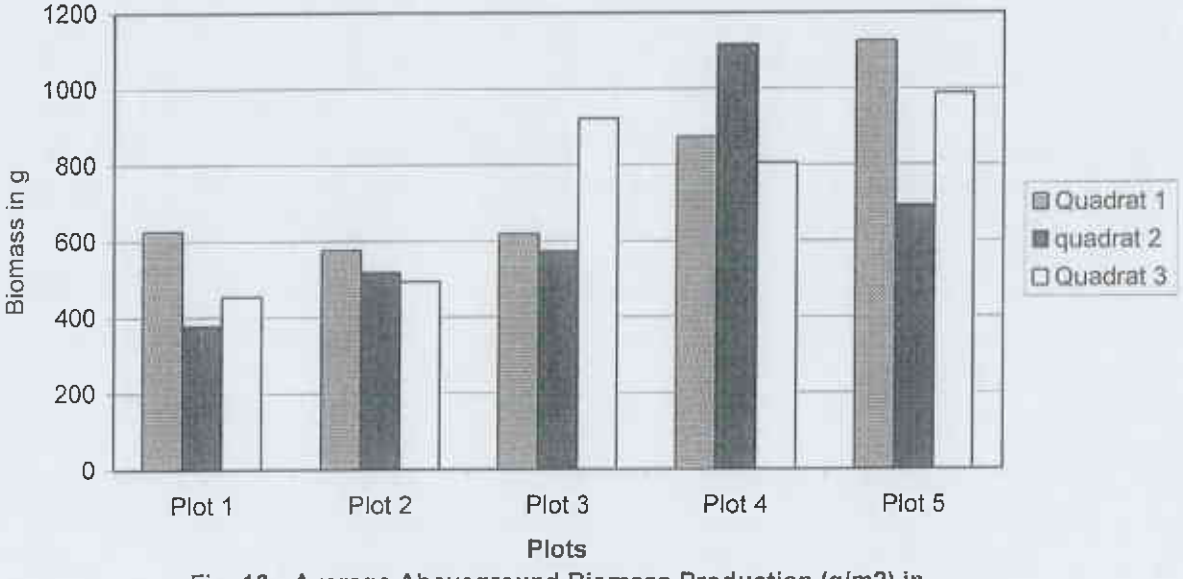


Fig. 13 : Average Aboveground Biomass Production (g/m2) in Different Plots by Quadrats

a. Biomass in Quadrat 1 :

In Quadrat 1, the average total aboveground biomass of all the plots was found to be 763.73 g/m^2. Further, total mean aboveground biomass was found to be highest in quadrat 1. (1125.2 g/m^2) in plot 5 and lowest in quadrat 1 (575.86 g/m^2) of plot 2. (Annex1).

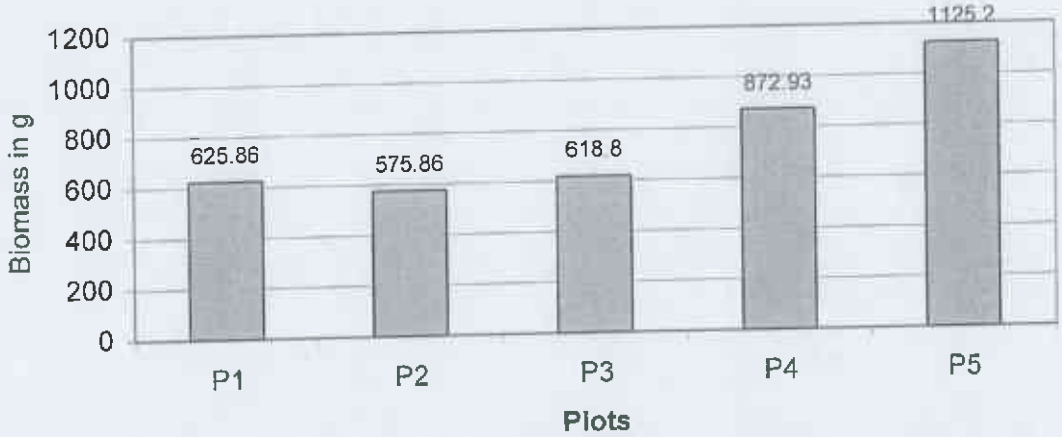


Fig. 14 : Average Biomass Production by Five Plots in Quadrat 1

b. Biomass in Quadrat 2

In quadrat 2, the average total aboveground biomass of all the plots was found to be 655.16 g/m^2 i.e. lowest of all three quadrats. Further, in quadrat 2, total aboveground biomass was found to be highest (1116.6 g/m^2) in plot 4 and lowest of 377.69 g/m^2 in the same quadrat 2 in plot 1. (Annex 1).

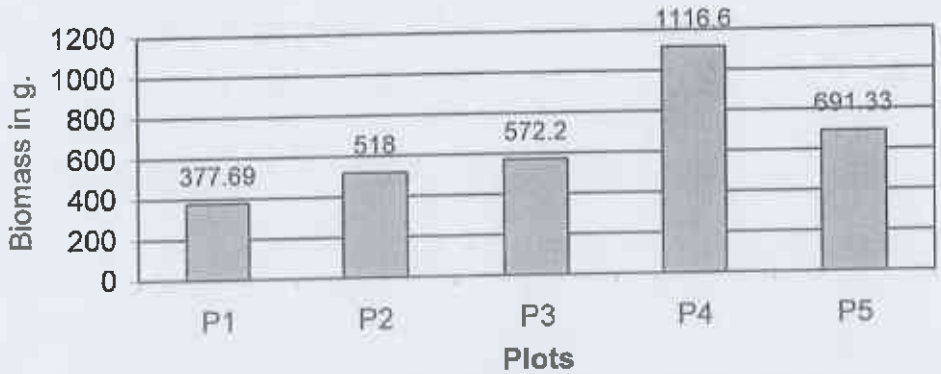


Fig. 15 : Average Biomass Production by Five Plots in Quadrat 2

c. Biomass in Quadrat 3

In quadrat 3, total average aboveground biomass of all the plots was found to be 732.57 g/m^2.Further total mean aboveground biomass in quadrat 3 was found highest i.e. 987.73 g/m^2 in plot 5 and least ie 454.33 g/m^2 in plot 1(Annex:1)

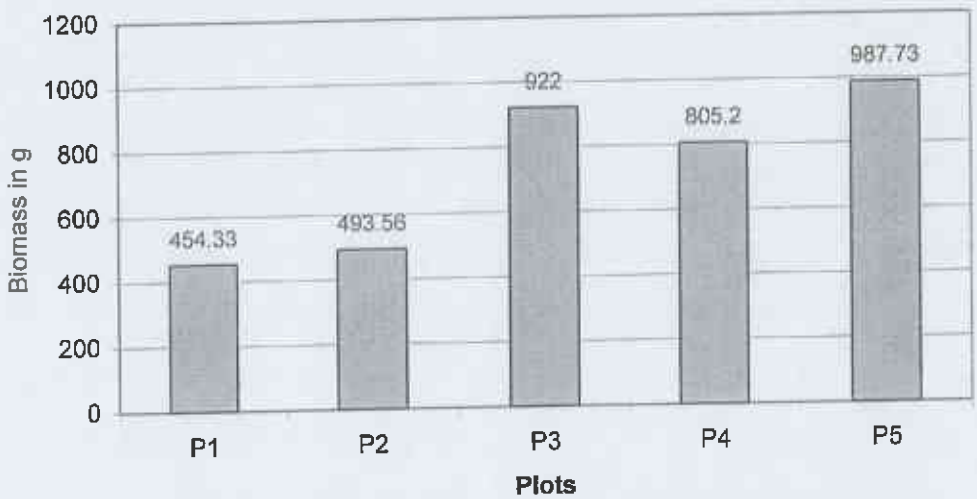


Fig. 16 : Average Biomass Production by Five Plots in Quadrat 3

5.2 Belowground Biomass :

The average total belowground biomass in the grasslands of study areas was found to be 667.70 g/m^2. However, mean total biomass was highest in phase 1 i.e. (monsoon) of 743.48 g/m^2 and lowest in phase 2 i.e. winter of only 603.81 g/m^2.

Further, mean total biomass was highest in plot 3 of 803.60 g/m^2 and lowest in plot 4 of 626.57 g/m^2.

Maximum biomass was found as 873.86 g/m^2 in plot 5 in monsoon season and minimum biomass was found as 541.60 g/m^2 in the same plot 5 in the spring season.

Similarly, maximum biomass was found in Quadrant 3 of plot 3 of 983.61 g/m^2 and minimum in Quadrant 2 of plot 1 of value 440.26 g/m^2.

Table 8 : Average belowground biomass (g/m^2) production in different seasons in different plots with SD

Grassland plots	Phase1 Monsoon	Phase 2 Winter	Phase 3 Spring	Mean (g/m^2)
Plots 1	606.26±262.76	613.6±176.08	665.2±32.39	628.35±26.22
Plot 2	722.08±124.82	550.93±47.83	639.6±65.96	637.53±69.88
Plot 3	817.88±155.84	771.2±204.19	821.73±27.41	803.6±22.96
Plot 4	697.33±59.53	571.33±135.86	611.06±202.98	626.57±52.59
Plot 5	873.86±116.67	512.0±108.71	541.6±87.12	642.48±164.05
Mean	743.48±93.75	603.81±89.88	655.83±92.65	667.70±57.63

± i.e. Standard Deviation (SD)

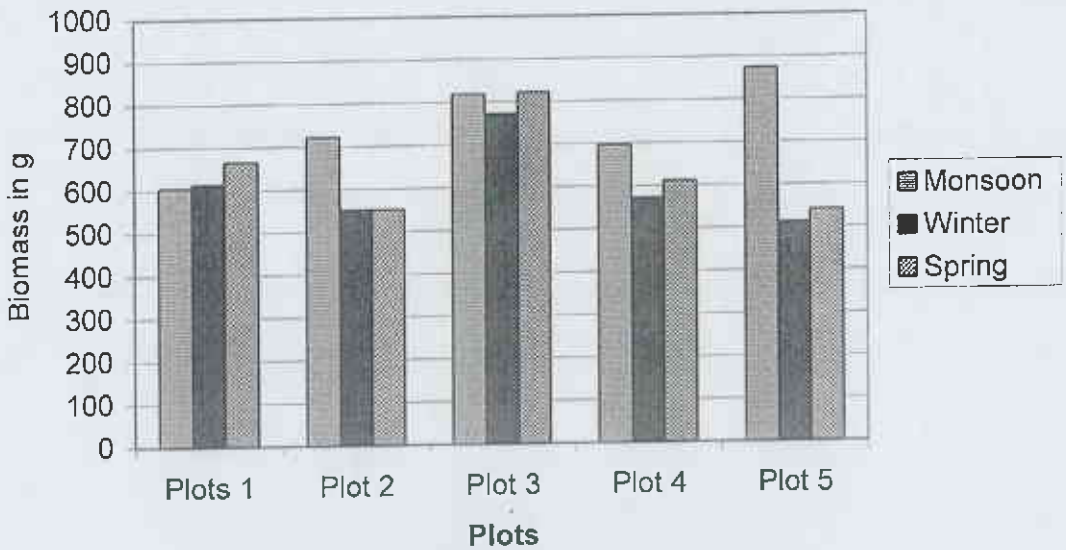


Fig. 17 : Average Seasonal Belowground Biomass Production by Five Plots

(B). Seasonal Belowground Biomass Production:

5.2.1 Biomass in Monsoon Season

Average total belowground biomass of all the plots was found to be highest in Monsoon season as compared to other seasons. The biomass was found to be 743.48 g/m^2.

During the monsoon season, highest mean belowground biomass was found in plot 5 of 873.86 g/m^2 and lowest in plot 1 of 606.26 g/m^2.

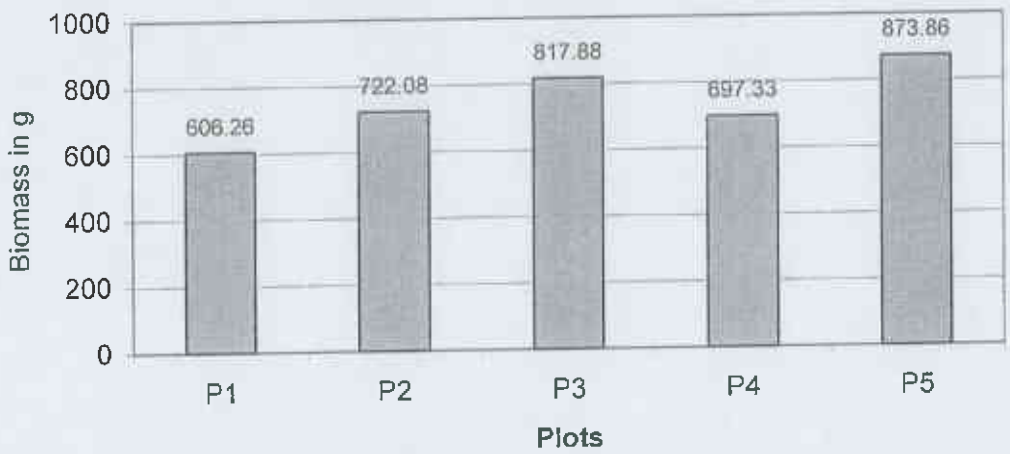


Fig. 18 : Average Seasonal Biomass Production by Five Plots in Monsoon

5.2.2 Biomass in Winter Season

Average total belowground biomass of all the plots was found to be lowest i.e. 603.81 g/m^2.

During the winter season, the total belowground biomass was found highest in plot 3 of 771.20 g/m^2 and lowest in plot 5 of value 512.00 g/m^2.

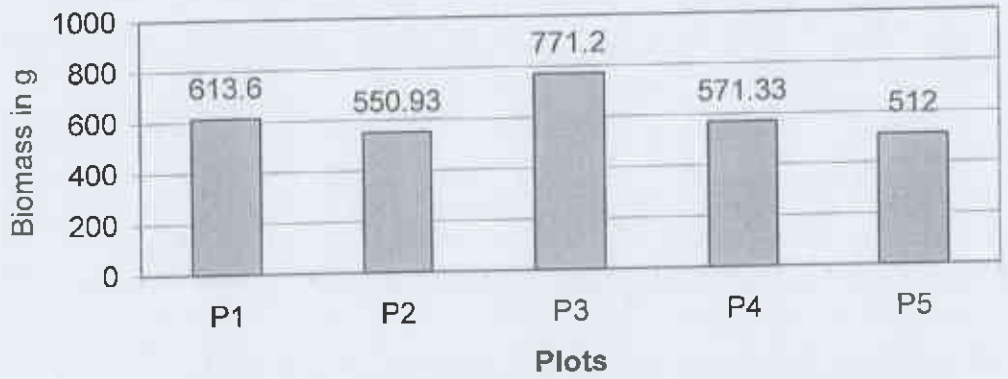


Fig. 19 : Average Seasonal Biomass Production by Five Plots in Winter

5.2.3 Biomass in Spring Season:

Average total belowground biomass of all the plots was found to be 655.83 g/m^2.

Similarly, average belowground biomass was found highest i.e. 821.73 g/m^2 in plot 3 and lowest of 541.60 g/m^2 in plot 5.

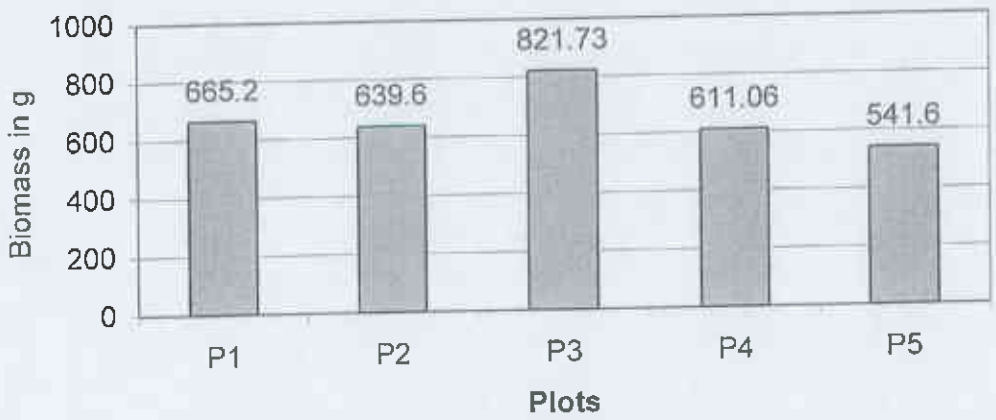


Fig. 20 : Average Seasonal Biomass Production by Five Plots in Spring

5.2.4 Belowground Biomass Production in different Quadrats

Belowground biomass was found different in different quadrats according to different plots. Highest total biomass production was found in quadrat 3 of value 748.55 g/m^2 and lowest in quadrat 2 of value 574.63 g/m^2 . It is shown in table below:

Table 9 : Average belowground biomass (g/m^2) by each quadrat in three seasons

Grasslan d Plots	Quadrate 1	Quadrate 2	Quadrate 3	Mean
Plot 1	666.66 ± 102.36	440.26±129.39	778.13±129.07	628.35±140.56
Plot 2	710.53 ± 74.35	537.2±31.12	664.88±119.29	637.53±73.35
Plot 3	712.53± 67.61	714.66±86.02	983.61±87.97	803.60±127.28
Plot 4	655.06± 210.5	630.66±117.59	594.00±107.11	626.57±25.09
Plot 5	654.93± 263.86	550.4±129.05	722.13±111.83	642.48±70.65
Mean	679.94± 26.14	574.63±92.51	748.55±132.44	667.70±71.52

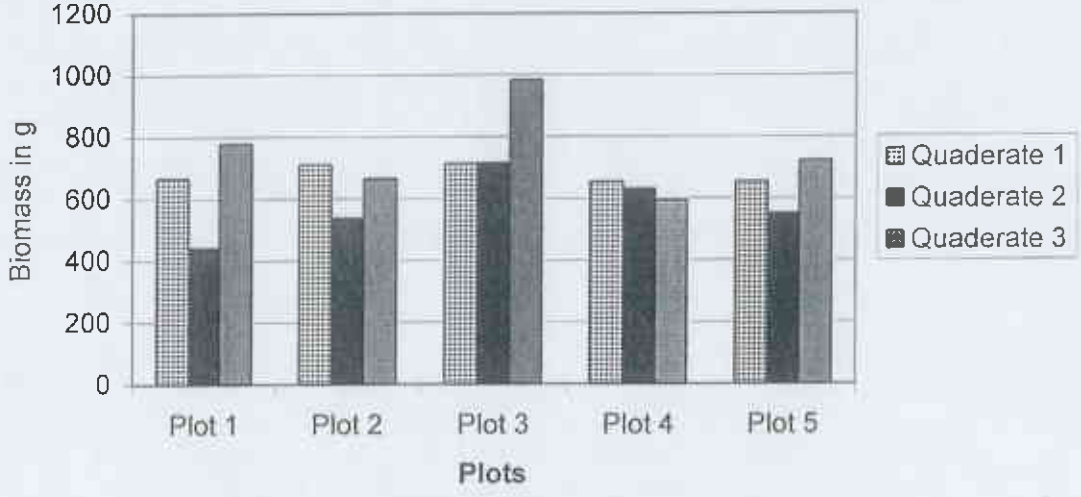


Fig. 21 : Average Belowground Biomass Production in Five Plots by Quadrats

a. Biomass in Quadrat 1

In quadrat 1, total average belowground biomass of all the plots was found to be 679.94 g/m^2 .

Similarly, in quadrat 1 total average belowground biomass was found highest (712.53 g/m^2) in plot 3 and lowest (654.93 g/m^2) in plot 5. (Annex 2)

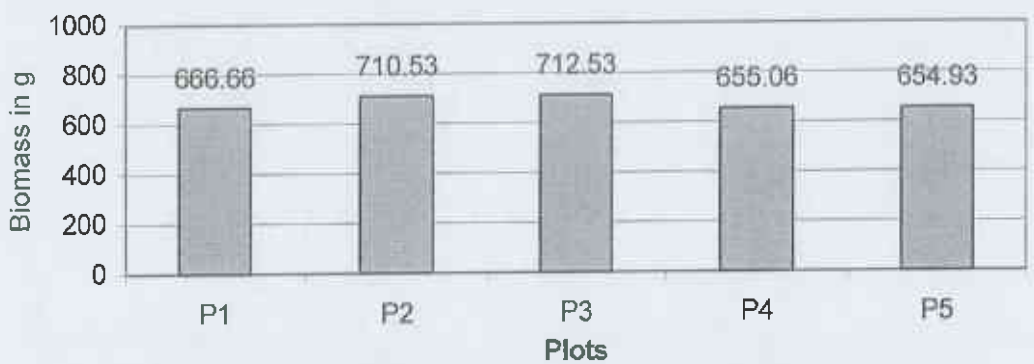


Fig. 22 : Average Biomass Production by Five Plots in Quadrat 1

b. Biomass in Quadrate 2

In quadrat 2, total average belowground biomass of all the plots was found to be 574.63 g/m^2.

Similarly, total average belowground biomass in quadrat 2, was found highest i.e. 714.66 g/m^2 in plot 3 and lowest i.e. 440.26 g/m^2 in plot 1. (Annex 2).

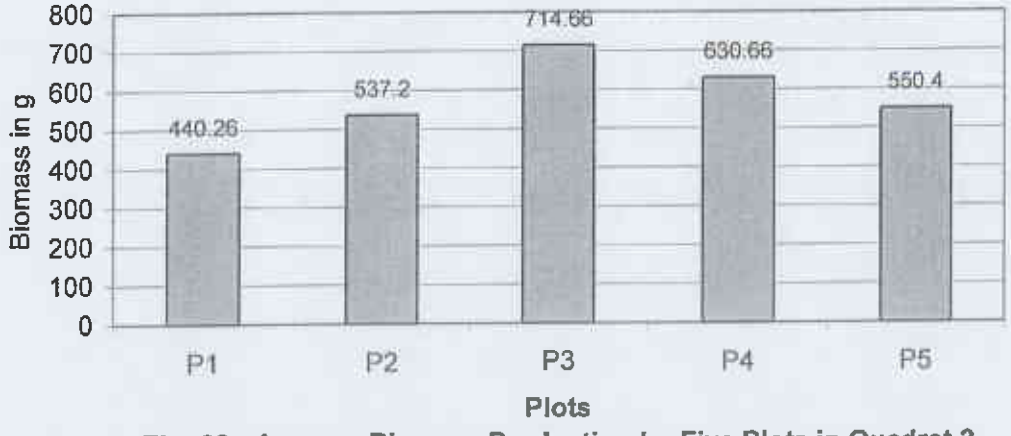


Fig. 23 : Average Biomass Production by Five Plots in Quadrat 2

c. Biomass in Quadrat 3

In quadrat 3, total average belowground biomass of all the plots was found to be highest among all the quadrats i.e. 748.55 g/m^2.

Average belowground biomass in quadrat 3, was found highest of 983.61 g/m^2 in plot 3 and lowest of 594.00 g/m^2 in plot 4. (Annex 2).

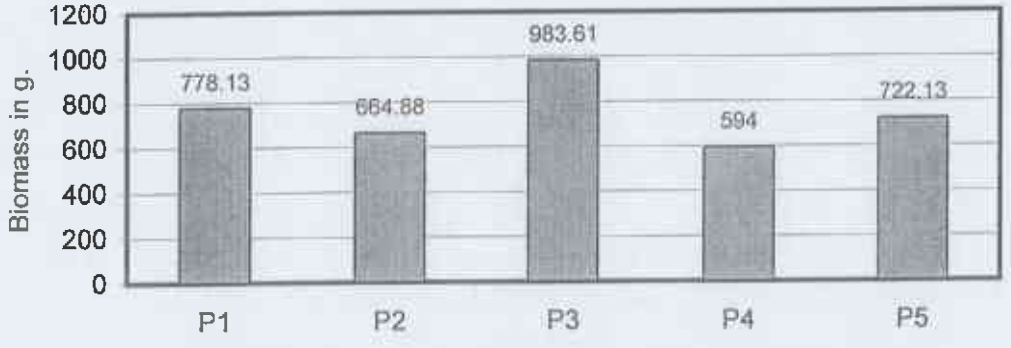


Fig. 24 : Average Biomass Production by Five Plots in Quadrat 3

5.3 Soil Parameters

5.3.1 P^H

P^H of soil of the study site was found neutral to alkaline in all the seasons. During the monsoon season P^H ranged from 7.1 in plot 2 to 7.55 in plot 4. Mean soil P^H in Monsoon season was found 7.32.

Soil P^H, during the winter season, ranged from 7.5 in plot 2 to 7.7 in plots 1 and 3. Mean P^H was found to be 7.63.

Similarly, during the spring season P^H of the soil was found alkaline. Soil P^H ranged from 7.75 in plot P3 to 8.0 in plots 4 and 5. Mean P^H of all the plots was found to be 7.88. (Annex - 4)

P^H of soil of the study area was found 7.61.

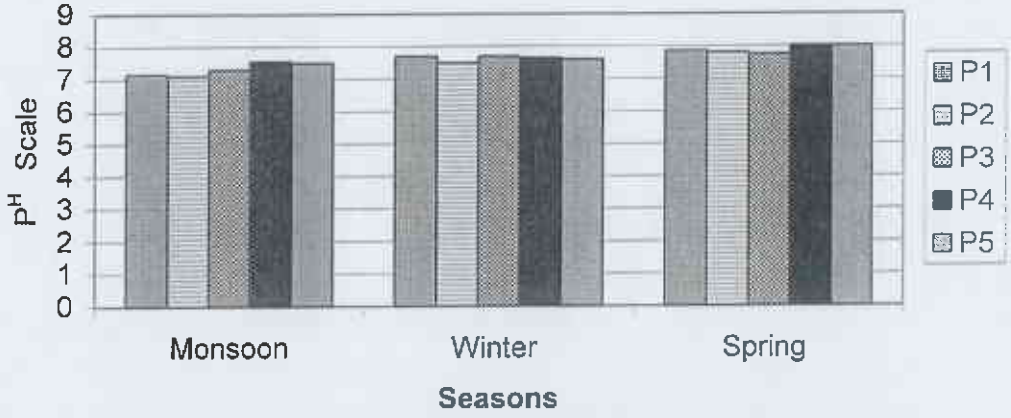


Fig. 25 : PH of Soil in Different Plots in Different Seasons

5.3.2: Organic Matter(OM):

Organic matter(OM) in the soil of the study site was found highest in the winter season than that in monsoon and spring season.

In the monsoon season ,OM ranged from 0.79% in plot 4 to 2.66% in plot 2. The mean OM of all the plots in this monsoon season was found 1.85% .

During the winter season ,OM ranged from 1.14% in plot 4 to 3.29% in plot 2 .The mean OM of all the plots in the winter was found 2.28%

Similarly, during the spring season ,OM ranged from 1.18% in plot 1 to 3.03% in plot2. Mean OM of all the plots was found 1.91%.

Organic Matter of the soil of the study area was recorded as 2.01%.

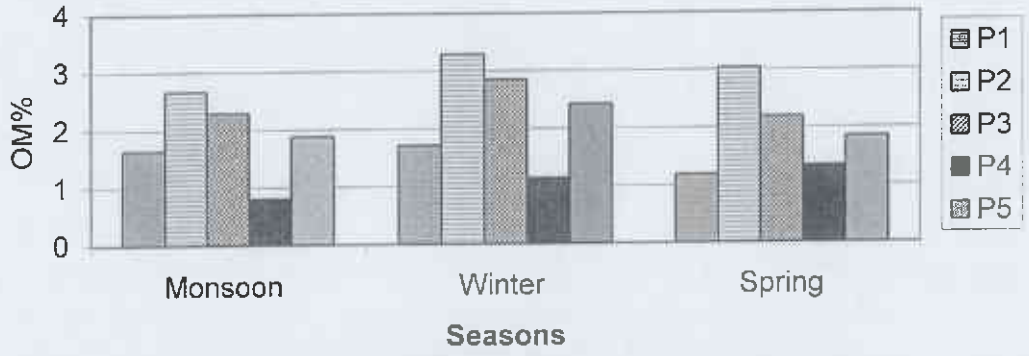


Fig. 26 : Organic Matter of Soil in Different Plots in Different Seasons

5.3.3 Nitrogen (N) :

The amount of nitrogen in the soil was relatively higher during the winter than other two seasons. During monsoon, nitrogen ranged from 0.03% in plot 4 to maximum of 0.13% in plot 2. Mean nitrogen of all the plots was found 0.09%.

Similarly, during winter, N% ranged from 0.05% (lowest) in plot 4 to maximum of 0.16% in plot 2. The mean N% in winter was found 0.11%.

During spring, N% ranged from 0.05% in plot 3 to maximum 0.15% in plot 2. Mean N% in the spring season was found 0.08%.

Nitrogen content of the soil of study area was recorded as 0.09%.

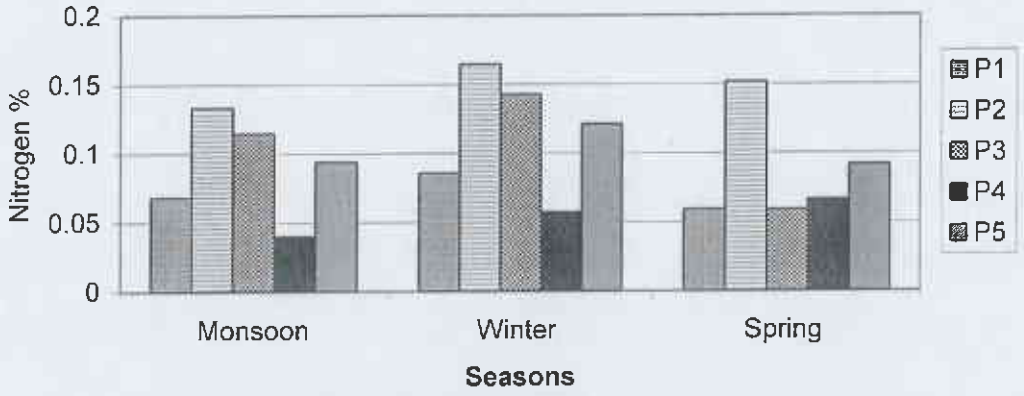


Fig. 27 : Nitrogen Content of Soil in Different Plots in Different Season

5.3.4 Phosphorous (P)

Available phosphorous in the soil was found highest (24.61 kg/ha) in the monsoon season and lowest (11.58 kg/ha) in the spring season.

During the monsoon, phosphorous ranged from 20.17 kg/ha in plot 1 and 3 to maximum 29.42 kg/ha in plot 2. Mean P of all the plots in the monsoon, was found 24.61 kg/ha.

Similarly, during winter, available phosphorus ranged from 12.77 kg/ha (lowest) in plot 2 to 20.17 kg/ha (highest) in plot 1. Mean P of all plots was 16.1 kg/ha.

During spring, available phosphorus ranged from 9.81 kg/ha (lowest) in plot 2 to 14.06 kg/ha (highest) in plot 4. Mean phosphorous of all the plots during spring was found 11.58 kg/ha.

Phosphorus content of soil of study area was recorded as 17.43 kg/ha.

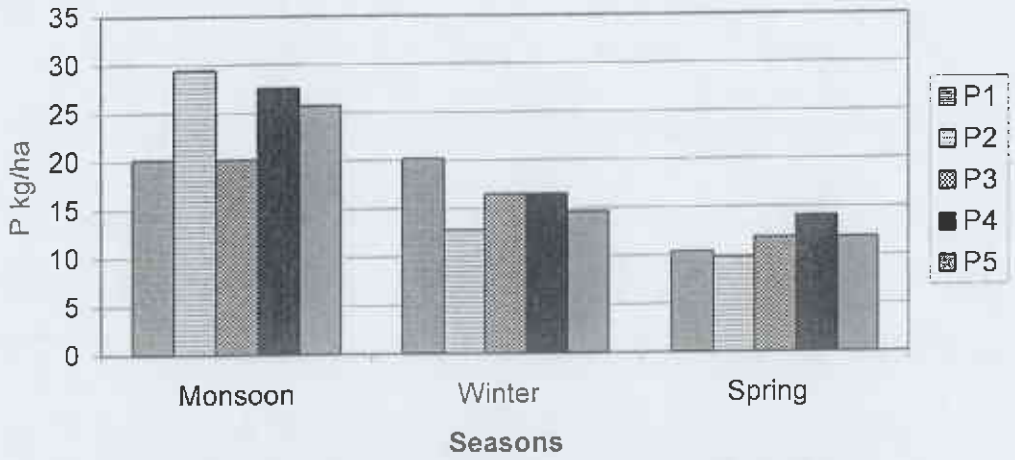


Fig. 28 : Phosphorus Content of Soil in Different Plots in Different Plots in Different Seasons

5.3.5 Potassium (K)

The amount of Potassium was found highest (101. 17 kg/ha) in the winter season and lowest (64.94 kg/ha) in the monsoon season and 99.26 kg/ ha in the spring.

During monsoon, the amount of potassium ranged form 49.59 kg/ha (lowest) in the plot 1 to 87.80 kg/ ha (highest) in the plot 5. The mean amount of potassium of the plots during the monsoon season was found 64.94 kg/ha.

During winter, the amount of potassium ranged from 54.37 kg/ha (lowest) in plot 4 to 197.65 kg/ha (highest) in plot 2. The mean potassium content of all the plots in winter was 101.17 kg/ha.

Similarly, during spring, Potassium ranged from 49.59 kg/ha (lowest) in plot 1 to 145.11 kg/ha (highest)in the plot 5. The mean amount of Potassium of all the plots in spring was 99.26 kg/ha.

Potassium content of the soil of the study area was recorded as 88.46 kg/ha.

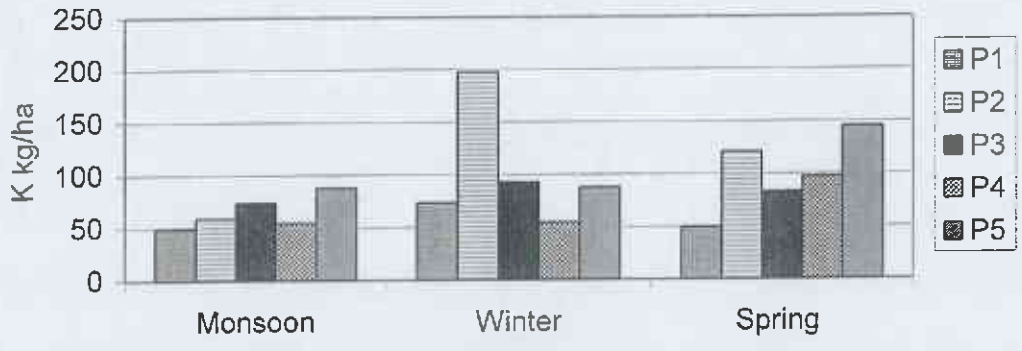


Fig. 29 : Potassium Content of Soil in Different Plots in Different Seasons

5.3.6 Water holding capacity (WHC%)

Water holding capacity of soil of the study site was found relatively similar, however WHC was higher (81.88%) during the winter season and lower (79.32%) during spring and 80.72% in the monsoon season.

During the monsoon season, WHC ranged from 64.8% in plot 4 to highest 92.0% in plot 3. The mean WHC of all the plots during monsoon was found 80.72%.

During the winter, WHC of soil ranged from 68.65% in plot 4 to 90.3% (highest) in plot 2. The mean WHC of all the plots during winter season was found 81.88%.

Similarly, during spring season, WHC of soil ranged from 69.3% in plot 4 to 86.0%in plot 2. The mean WHC of soil of all the plots during spring was found to be 79.32%.

Water holding capacity of soil of the study area was recorded as 80.64%.

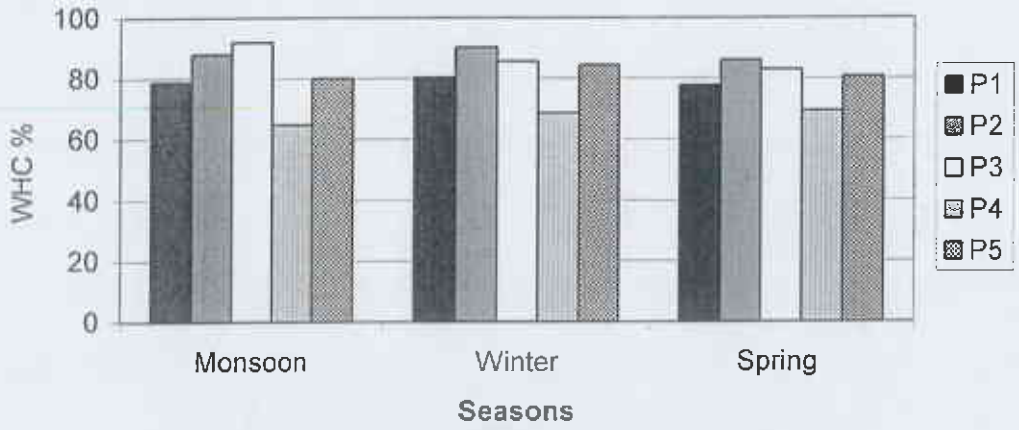


Fig. 30 : Water Holding Capacity of Soil in Different Plots in Different Seasons

5.4 Statistical Analysis

5.4.1 Correlation Coefficient

Correlation coefficient between biomass and soil characteristics

During the monsoon season, aboveground biomass showed significant positive correlation with P^H (r=0.895*) and it showed insignificant negative correlation with OM (r=-0.368) and N (r=-0.444). Further, during the monsoon season, aboveground biomass showed positive correlation which was insignificant with P(r= 0.271) and K(r=0.718).

During the winter season, aboveground biomass showed positive correlation which was insignificant with P^H (r=0.421) and P (r=0.084). Similarly, it showed insignificant negative correlation with OM (r=-0.580), N(r=-0.635 and K(r= -0692).

During spring season, aboveground biomass showed insignificant positive correlation with all the soil parameters i.e. PH (r=0.307), OM (r=0.092), N(r=0.122), P(r=0.683), and K(r=0.268).

During the monsoon season, belowground biomass showed significant positive correlation with K(r=0.968**). Similarly, it showed insignificant positive correlation with P^H (r=0.466), OM(r=0.330), and P

(0.103). Further, it showed insignificant negative correlation with N(r=-0.085).

During the winter season, belowground biomass showed positive correlation which was insignificant with P^H (r=0.636), OM (r=0174), N (r=0.185) and P (r= 0.364). Further, belowground biomass was insignificantly negatively correlation with K(r=-0.181).

During the spring season, belowground biomass showed insignificant positive correlation with OM(r=0.157). further, it showed insignificant negative correlation with P^H (r=-0.831), N (r=-0.344), P(r=-0.117) and K (r=-0.574).

Further, aboveground biomass was correlated with belowground during different seasons. Aboveground biomass showed positive correlation which was insignificant with belowground biomass during monsoon and winter season i.e. r=0.705 and r=0.158 respectively. Similarly, aboveground biomass showed insignificant negative correlation with belowground during spring season.

Table 10 : Correlation coefficient between aboveground biomass, below-ground biomass vs soil characters in different seasons.

Bio-mass	Soil Parameter	Monsoon	Winter	Spring
Aboveground biomass	P^H	0.895*	0.421	0.307
	OM	-0.368	-0.580	0.092
	N	-0.444	-0.635	0.122
	P	0.271	0.084	0.683
	K	0.718	-0.692	0.268
Belowground biomass	P^H	0.466	0.636	-0.831
	OM	0.330	0.174	0.157
	N	-0.085	0.185	-0.344
	P	0.103	0.364	-0.117
	K	0.968**	-0.181	-0.574

5.5 Socio-Economic Aspects

Social Aspects

For the study of socio-economics and resource dependency of the local people, Pithauli VDC adjacent to the National Park was selected. This VDC, having total area 16.85 sq. km. has 9 wards situated in Nawalparasi district.

5.5.1 Population

Pithauli VDC has a total population of 7572. There is higher number of females compared to the male i.e. 52.52% females and 47.48% males. There are 1486 households in Pithauli VDC, with average household size of 5.81 which is more than the national average of 5.6. Ward no 7 is highly populated and no. 3 is least populated ward.

Table 11 : Household and Ward-wise Population Distribution of Pithauli VDC.

Ward no.	Household	Male	Female	Total	Percent
1	123	297	309	606	8.00
2	138	343	345	688	9.09
3	33	94	108	202	2.67
4	190	424	461	885	11.69
5	123	269	308	577	7.62
6	269	597	753	1350	17.83
7	248	664	687	1351	17.84
8	202	495	551	1046	13.81
9	160	412	455	867	11.45
Total	1486	3595	3977	7572	100

Source : CBS, 2001 .

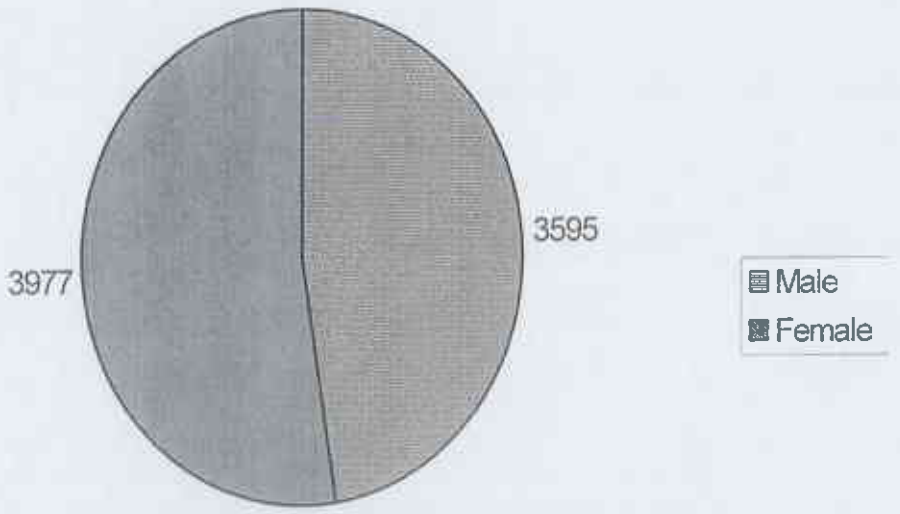


Fig. 31 : Male and Female Populaiton at Pithauli VDC

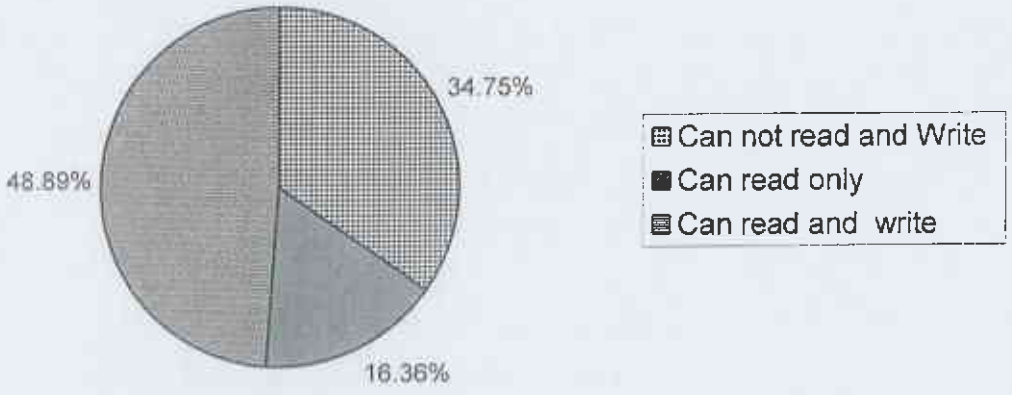
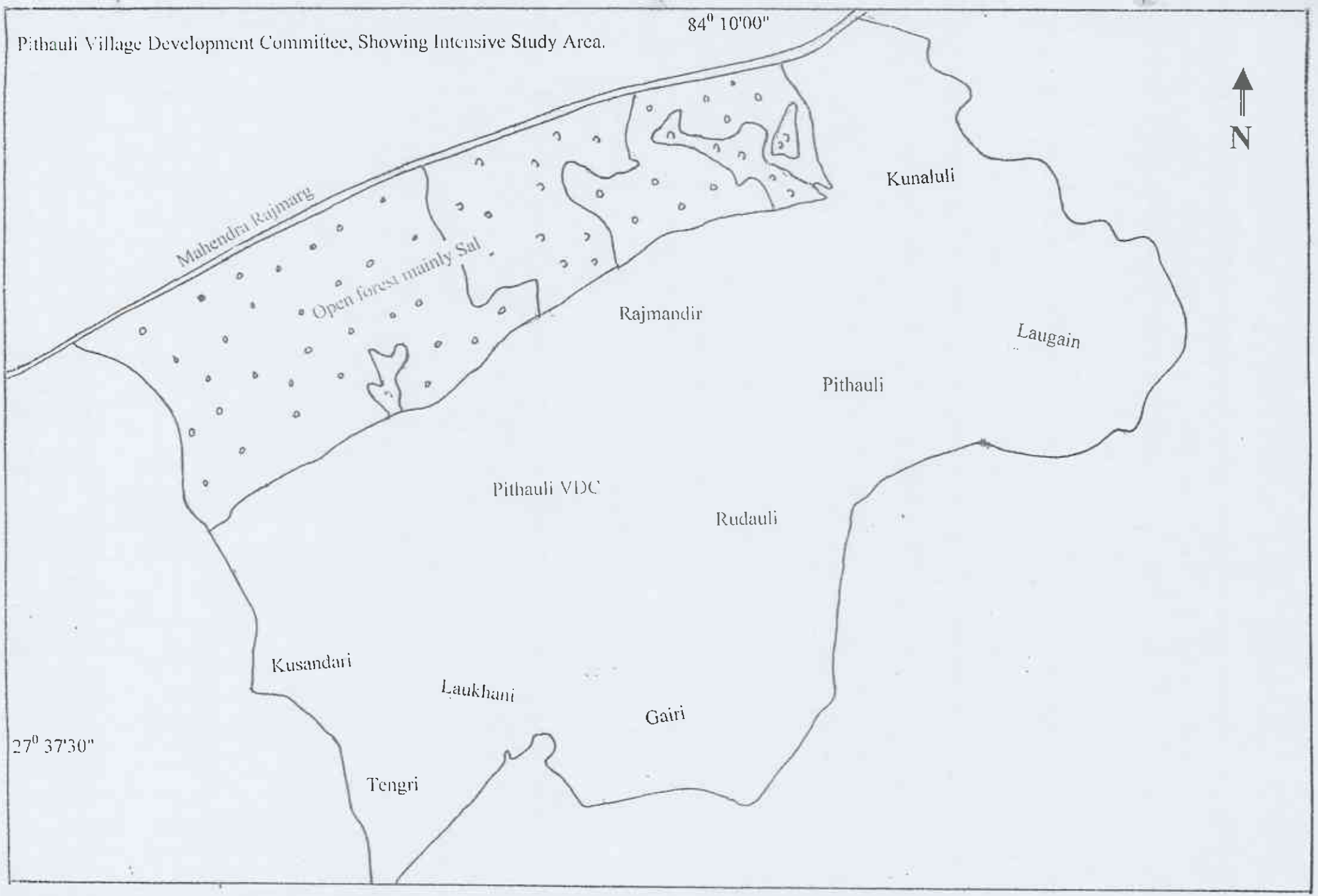


Fig. 32 : Literacy at Pithauli VDC (6 years of age and over)


Pithauli Village Development Committee, Showing Intensive Study Area.
84⁰ 10'00"
N
Mahendra Rajmarg
Open foresa mainly Sal
Kunaluli
Rajmandir
Laugain
Pithauli
Pithauli VDC
Rudauli
Kusandari
Laukhani
Gairi
27⁰ 37'30"
Tengri

5.5.2 Ethnic/Caste Composition

The dominant ethnic group is Tharu in Pithauli VDC with 41.30% population which is followed by Brahmin – Hill constituting 19.25% of total population . Similarly, Gurung, Magar, Rai are other ethnic group . Population by ethnic group in Pithauli VDC is given in table below :

Table. 12: Ethnic composition at Pithauli VDC

Ethnic/caste group	Population	Percent
Tharu	3127	41.30
Brahmin-Hill	1458	19.26
Gurung	744	9.83
Magar	379	5.00
Kami	342	4.52
Damai	188	2.48
Newar	150	1.98
Sarki	105	1.39
Sanyasi	54	0.71
Unidentified Caste	7	0.09
Tamang	103	1.36
Thakuri	27	0.36
Bote	64	0.85
Sonar	26	0.34
Chettri	379	5.00
Mushar	133	1.76
Rai	63	0.83
Darai	18	0.24
Majhi	120	1.58
Gharti/Bhujel	63	0.83
Unidentified dalit	17	0.22
Others	5	0.07
Total	7572	

Source : CBS – 2001.

5.5.3 Literacy

About 34.75% of the total population (6 years of age and over) are illiterate in Pithauli VDC. Similarly, 16.36% of the population can read only and 48.89% can read and write. ie. literacy is 65.25% of the total population (6 years of age and over).

Table 13 : Population of 6 yrs. of age and over by literacy status and sex for Pithauli VDC.

Literacy level	Male	Female	Total	Percentage
Cannot read and write (illetrate)	744	1493	2237	34.75
Can read only	526	527	1053	16.36
Can read & write	1757	1390	3147	48.89
Total	3027	3410	6437	100%

Source : CBS – 2001.

5.5.4 Occupation

In Pithauli VDC, there are 442 house holds having economic activities and 1044 households not having economic activities. Further 10 households are engaged in manufacturing, 120 HH in trade/Business, 12 HH in Transport, 218HH in service and 82 HH is others.

Table 14 : Occupation at Pithauli VDC

No. of Households		Type of Activity				
Having economic activities	Not having economic activities	Manufacturing	Trade/business	Transport	Service	Others
442	1044	10	120	12	218	82

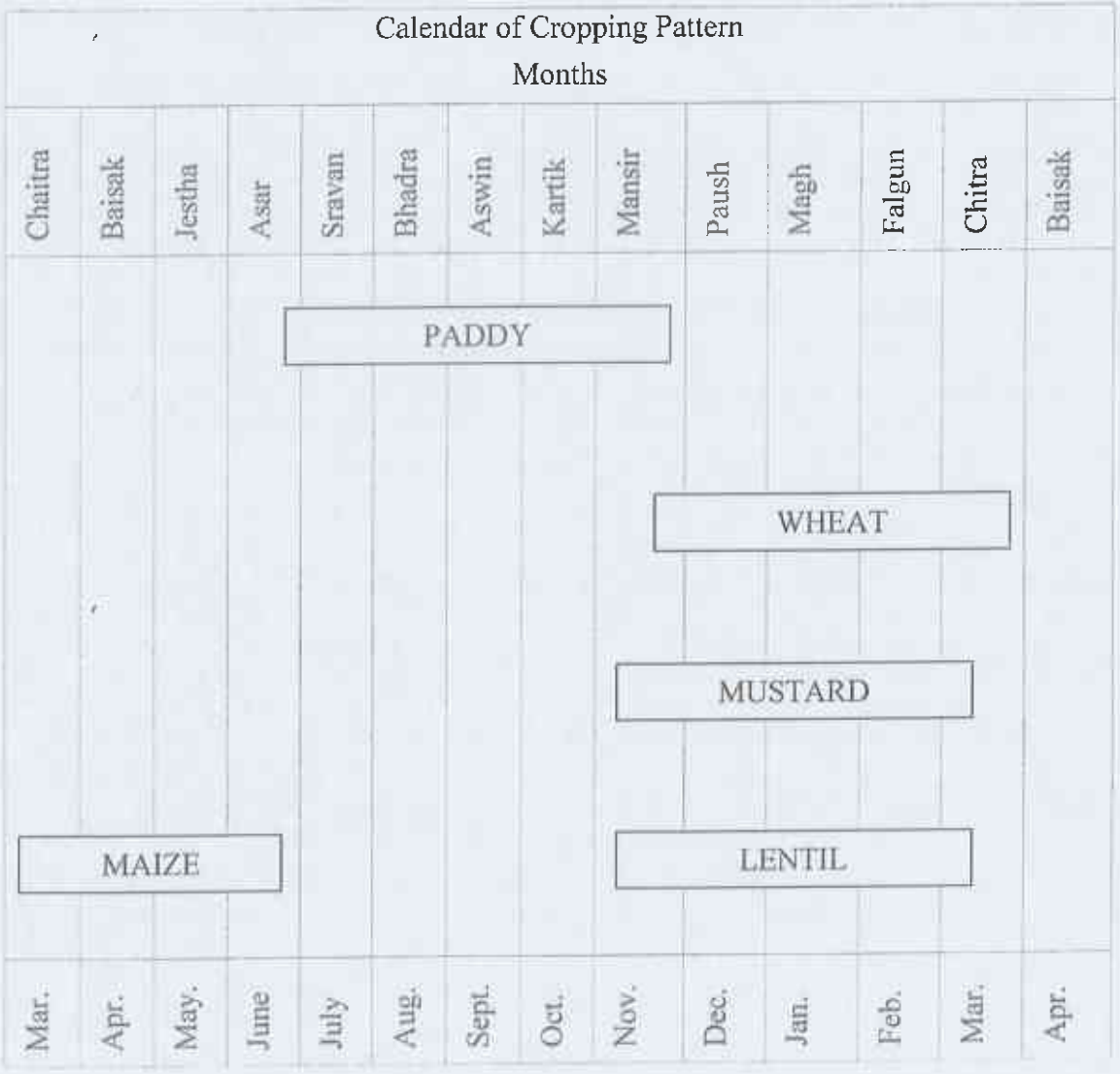
Source : CBS 2001.

5.5.5 Cropping Pattern

Five different crops are grown in the study area they are paddy, wheat, maize, mustard and lentil. These crops are grown in different seasons. Paddy is cultivated in

June and July and harvested in October and November. Mustard and lentil are cultivate in October and November and harvested in March. Similarly, wheat is cultivated in November and harvested in March. Further, maize is cultivated in March and harvested in June. Thus, each crop has its own sowing and harvesting period which is shown in fig. below :

Figure 33 : Cropping pattern at Pithauli VDC



Source : Field Study, 2003.

5.6 Consumption of Park Resources By Local People

Protected areas provide many benefits to the local people and traditional dependence of local people on park resources for their subsistence living. Before the estalishment of protected areas, local people used to collect as much thatch grass, firewood, fodder as they needed. But after the establishment of these areas they were all denied access which has generated an increasing number of conflicts between park and the local people. So, as to minimize the conflicts, the Royal Chitwan National Park has allowed people to collect grasses and grass products from the park during every winter. Each household can harvest as much grass as its members can gather during the cutting season.

Pithauli Village Development Cimmittee is one of the adjoining VDC of the park boundary. Villages of this VDC were also found involved to collect park resources during three days grass cutting period (2003).

Villagers come from as far as 50km away to harvest grass and grass products and consequently, people realize that the park has preserved a valuable resource for them. People from long distance stay in a tented house or with their relatives near the park. Nearly 65,000 people enter the park during grass cutting period every year. The total number of people entered into the park during 2002 and 2003 were 76,242 and 43,830 respectively due to insecurity and low production of park resources in the park and also due to very limited time ie. 3 days only.

After the establishment of Royal Chiwan National Park in 1973, people were completely restricted to enter the park for two years (1973- 1975). From 1976 people are allowed to cut grasses of the park every year however, the duration of the grass cutting season has been dramatically decreased from 20 days to 3 days now ie. 2003.Villagers purchase a permit with a nominal fee i. e. NRs. 10 per permit sold by the authorities of the Royal Chitwan National Park.

During the grass cutting period people harvest different kinds of grasses and shrubs for their various purposes. Khar (*Imperata cylindrica*) is used for thatching roof. *'Saccharum bengalensis, S. spontaneum, Themeda spp* are used for building walls and fences and different household materials by the local people. *Typha angustifolia* is used for making mats and simti *Helicteres isora* is used for making walls and ropes. Ropes made of simti are used for tethering animals and other purposes.

Table 15 : Main grasses and shrubs species used by villagers for their various purposes.

Local mane	Botanical name	Purpose
Kansh	*Saccharum spontaneum*(L.)	Thatching roof and fences
Siru or khar	*Imperata cylindrica*(L.Beauvois)	Thatching roof.
Baruwa	*Saccharum munja* Roxb.	Building walls and fence, leaves used for thatch and baskets.
Phank	*Narenga porphorycoma* (Hance)	Building walls and fences
Dhaddi	*Themeda arundinaceae*(Roxb) Ridley	Building walls and fences
Babiya	*Eulaliopsis binata* (Retz)	Rope, broom
Simti	*Helicteres isora* L.	Making ropes, tether
Amaréso	*Thysanolaena maxicana*(Roxb) O. kuntz	Broom.

Source: Field study, 2003.

On the basis of the information gathered from interviewees from each household, 2 person enter the park to collect forest resources during grass cutting period. It was estimated that during the year 2003 approximately 2972 individuals of Pithauli VDC entered the park to harvest forest resources, during the grass cutting period.

Table 16 : Estimated number of people from each household and total number of people from Pithauli VDC who enter into the park.

Average number of people enter into park from each household	Total number of household	Total number of people who enter into the park
2	1486	2972

Source : Field study, 2003

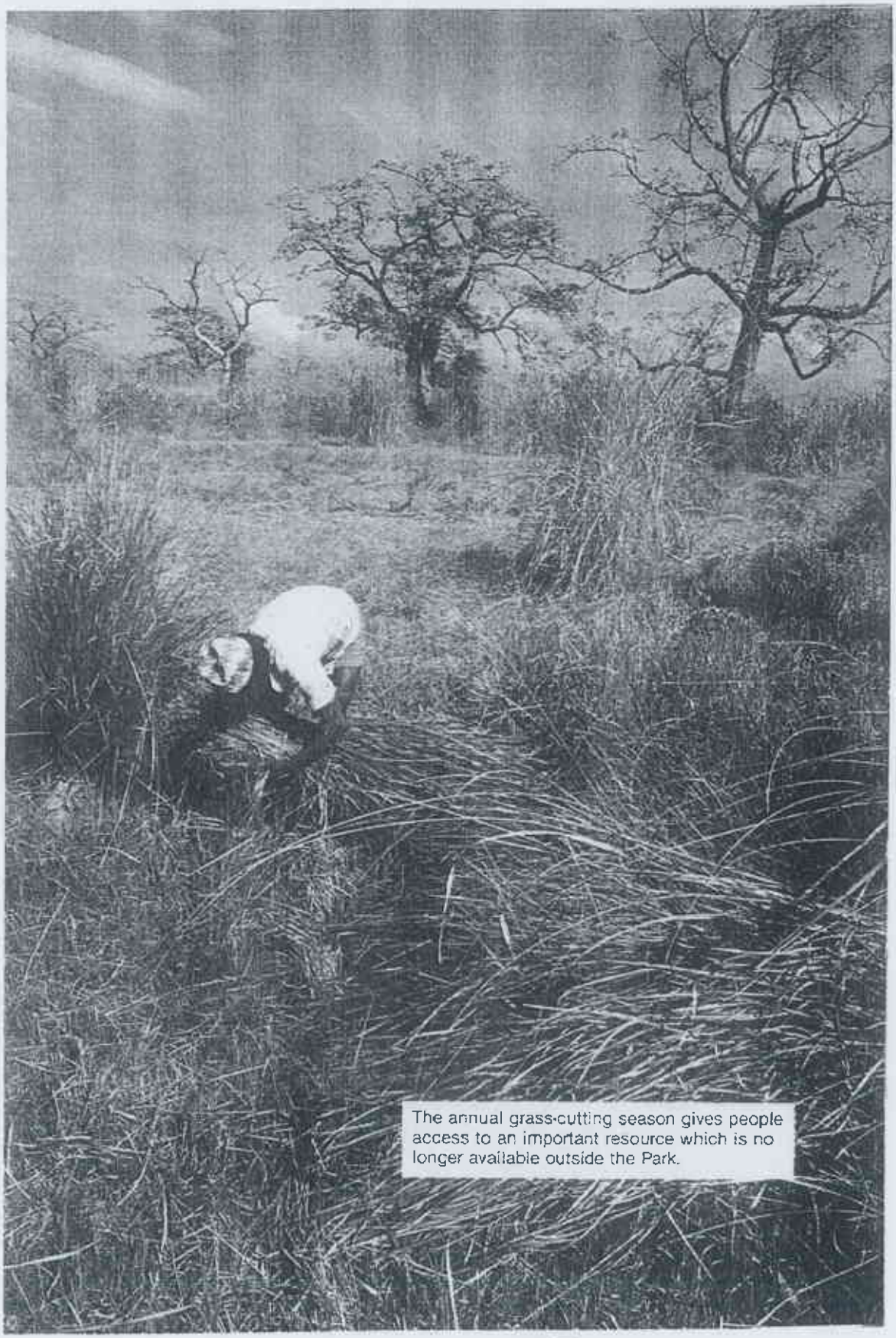
5.6.1 Collection of Khar (Thatch Grass)

Thatch grass (*Imperata cylindrica*) is usually harvested during the first few days of the grass cutting period due to its prime importance to thatch roofs. It was estimated that during grass cutting period average number of mutha harvested by per household was 234.89. At Pithauli Village Development Committee (PVDC), there were total 3,49,046.54 muthas of khar harvested. During the study period weight of one mutha was estimated approximately to 3 kg and hence total weight of khar harvested during grass cutting season 2003 was found to be 1047139. 6 kg.

In each load there were number of locally expressed mutha ie small bundles. During the investigation period, it was estimated that an average each load had 14 mutha and the average weight of each mutha was 3 kg. From this average weight and number of mutha, an average weight of per load can be calculated which is found to be 42 kg.

Table 17 : Average no. of mutha of Khar harvested by per household and total number of mutha and load harvested and weight at Pithauli VDC.

Average no. of mutha harested by per household	Total no. of mutha at Pithauli VDC	Total no. of Load (A)	Average wt. of per mutha	Average Wt. Of per load (B)	Total wt. of harvested Khar (kg.) (AxB)
234.89	349046.54	24931.89	3 kg	42.kg.	1047139.4 kg.



The annual grass-cutting season gives people access to an important resource which is no longer available outside the Park.

5.6.2. Collection of Khadai (Reed)

After cutting the thatch grass (khar), people were found involved in the collection of Khadai (reed). The khadai is used by the local people for building walls, fences and numerous household materials such as baskets, fishing traps etc. It was determined that during grass cutting season an average number of mutha harvested by per household was found 21.61. At Pithauli VDC, there were total 32112.46 muthas of Khadai harvested and each load had 4 mutha. During the study peirod weight of one mutha of Khadai was estimated to be 10 kg and total weight of khadai harvested in Pithauli VDC during grass cutting season 2003 was found to be 321124 6 kg.

Table 18 : Estimated average number of mutha,load harvested by per household and total number of mutha ,load harvested at Pithauli VDC.

Average number of mutha harvested by per household	Total no. of mutha at Pithauli VDC	Total no. of load (A)	Average wt. of per mutha	Av. wt of per load (B)	Total weight of harvested khadai (AxB)
21.61	32112.46	8028.11	10 kg	40 kg.	321124.6 kg.

Source: Field study, 2003

5.6.3 Collection of Firewood

During grass cutting period, people were also found involved in firewood collection. According to the rule and regulations of national park, people are not allowed to extract firewood from the Park, but they collect dry, fallen branches as firewood. However, illegal cutting down of trees is also usual in that area which is frequent during the nighttime. During the grass-cutting season, it was estimated that average number of load harvested per household was 17.032. At Pithauli VDC, 25,309.55 loads of firewood were harvested. During the study period weight of one load of firewood was approximately estimated to be 40 kg. and therefore total weight

of firewood harvested during the grass-cutting season 2003, was estimated 1012382.1kg.

Table 19 : Average no. of load harvested per HH and total no. of loads of firewood at Pithauli VDC.

Average no. of load harvested per household	Total no. of loads (A)	Average wt of per load (B)	Total weight of firewood harvested (AxB)
17.032	25,309.55	40 kg.	10,12382.1 kg.

Source : Field study, 2003

5.6.4 Total Park Resources Harvested

During the grass-cutting period 2003, the amount of Park resources (Khar, Khadai & Firewood)harvested by the local people of Pithauli VDC was 2380646.3 kg or 2380.64 tonnes. The amount of khar, khadai and firewood were 1047.13 tonnes, 321.12 tonnes and 1012.38 tonnes respectively. Khar, Khadai & firewood harvested by each household were 704.66 kg, 216.1 kg and 681.28 kg respectively and total amount of park resources (Khar, khadai & firewood) per household was found to be 1602.04 kg.

Table 20 : Estimates of park resources harvested by people of Pithauli VDC during the grass cutting period – 2003 from the RCNP.

Materials/Park Resources	Total resource harvested at Pithauli VDC.	Resource harvested by per household (kg)
Khar	1047139.6kg= 1047.13tonnes	704.66kg/ HH
Khadai	321124.6kg=321.12 tonnes	216.1kg/ HH
Firewood	10,12382.1kg= 1012.38 tonnes	681.28kg/ HH
Total	2380646.3kg= 2380.64 tonnes	1602.04kg/ HH

Source: Field study, 2003.

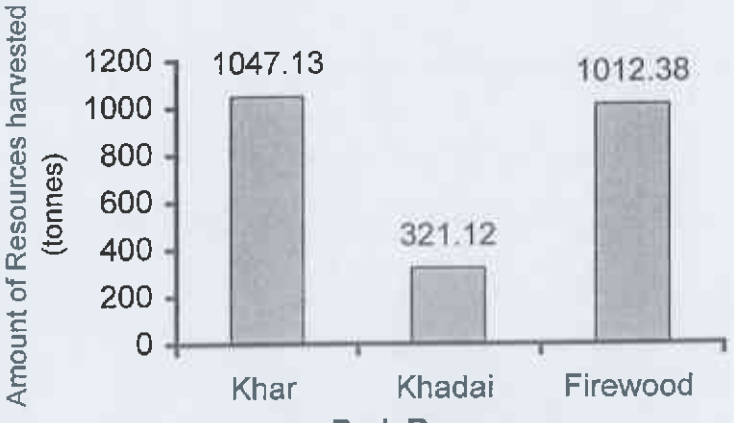


Fig. 34 : Total Park Resources harvested at Pithauli VDC

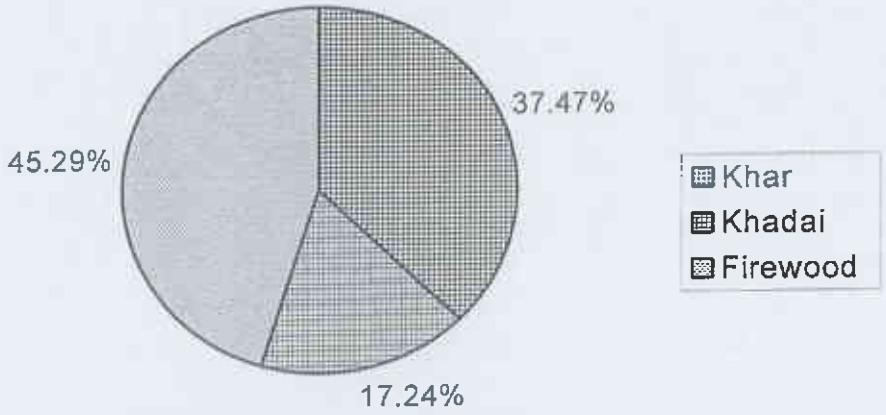


Fig. 35 : Total Monetory Value of Park resources havested at Pithauli VDC.

House walls are made from the hard stems of grass, then plastered with a mixture of mud and cow dung.

5.6.5 Monetary value of Park Resources harvested

The equivalent monetary value of the resources harvested by local people of Pithauli VDC from the Park during grass cutting period in 2003 has been estimated. The price of Khar, Khadai and firewood were fixed by asking with villagers involved in grass cutting at Pithauli VDC. The costs of khar, khadai per mutha were Rs 3 and Rs 15 respectively. Similarly, price of firewood per load was Rs 50.The estimated prices per kg were Rs 1,Rs 1.5 & 1.25 for khar, khadai and firewood respectively.

Table 21 : Estimated prices of the resources collected from RCNP at Pithauli VDC

Resources	Price Rs	Average weight (kg)	Price per kg (Rs)
Khar	Rs 3/mutha	3kg/mutha	1
Khadai	Rs 15/mutha	10kg/mutha	1.5
Firewood	Rs 50/load	40kg/ load	1.2

Source: Field study, 2003.

The total monetary values of Khar, Khadai and fire wood was Rs 2794304.0. The monetary values of khar, Khadai & firewood harvested by villagers of Pithauli VDC were Rs 1047139.6, Rs 481686.9 & Rs 1265477.5 respectively. Each household harvested monetary values of Khar, Khadai and firewood were Rs 704.66, Rs 324.15 & Rs 851.59 respectively. The total monetary values of Park resources (Khar, Khadai & firewood) per household was Rs 1880.4. The cost of khadai was higher than Khar & firewood.

Table 22: Total Prices of resources harvested from the RCNP during 2003 grass cutting period at Pithauli VDC.

Resources	Price per (Rs)	Total resources harvested at Pithauli VDC	Total Price (Rs)	Equivalent amount per household (Rs)
Khar	3/mutha	349046.54 mutha	10,47139.6	704.66
Khadai	15/mutha	32112.46 mutha	481686.9	324.15
Firewood	50/load	25,309.55 load	12,65477.5	851.59
Total			2794304.00	1880.4

Source: Field study, 2003

Thus, an average of nearly Rs 1880.4 is a substantial contribution to the individual households at Pithauli VDC that participate in the grass cutting in the Royal Chitwan National park. More importantly,the thatch grass and reed are critical important resources for many villagers because many of them can not afford to build brick walled houses with tiles or galvanized metal sheets. During the study, it was found that 70% of the total household studied have thatched roofs while 30% of them have tiles and tins.

The total amounts of khar, khadai and firewood harvested by local people in 2003 during grass cutting period organized by Royal Chitwan National Park have been estimated from the information obtained from the Pithauli VDC.In 2003, 43,830 people entered into the park during the grass-cutting season based upon the permits sold according to Park headquarter, Kasara. Total park resources(khar, khadai and firewood)harvested by the local people in RCNP was 35079.77 tonnes .The contribution of khar, khadai and firewood was found 15426.407 tonnes,4733.64 tonnes and 14919.73 tonnes respectively.

Table 23 : Estimates of Park Resources harvested by the local people in 3 days grass cutting period in 2003 in and around RCNP.

Park Resources	Average no.of loads harvested per person	Total no. of loads A	Average weight per load(kg) B	Total resources harvested. AxB
Khar	8.38	367295.4	42.0	15426407 kg 15426.407 tonnes
Khadai	2.7	118341.0	40.0	4733640 kg 4733.64 tonnes
Firewood	8.51	372993.3	40.0	14919732kg 14919.73 tonnes
Total	19.59	858629.7	122.0	35079.77 tonnes

Source : Field Study, 2003.

The monitory values of total resources harvested by local people during the 3 days grass cutting period in RCNP were Rs 15426407.00 ,Rs 7100460.00 and Rs 17903678.00 for khar, khadai and firewood respectively .The total monetary was Rs 40430545.00 for khar ,khadai and firewood harvested in 2003.

Table 24 : Estimated monetary values of Park Resources harvested by local people in 2003 during the 3 days grass cutting period in and around RCNP.

Park Resources	Total monetary values in Rs Total amount in kg x price/kg
Khar	15426407.00
Khadai	7100460.00
Firewood	17903678.00
Total	40430545.00

5.7 Attitude of Local People Towards the Park and Park Resources

Conservationists, particularly since the last decade, have increasingly emphasized that the success of National Parks and protected areas depend upon the extent of support and positive attitudes and perceptions of local people towards such establishment . Before the establishment of RCNP local people faced the problem of using forest resources in the starting years (1973- 1975). From the year 1976, people are allowed to collect forest resources during every winter season. Now, People realize that the Park has preserved valuable resources for them.

From the field survey at Pithauli VDC, about 88.23 % people were found satisfied with the establishment of RCNP, about 7.35% people were not satisfied because of crop and livestock depredation by wildlife and 4.42% people did not say whether establishment of National Park is better or not.

Table 25 : Attitude of local people towards the Park.

Subject	Number	Percent
Establishment of Royal Chitwan National Park is better	60	88.23%
Cropland, Livestock damage by wildlife therefore not so good	5	7.35%
Can not say	3	4.42%
Total	68	100%

Source: Field Study, 2003.

During the field study, adequacy of resources was also surveyed. From this survey 29.4% people could get enough khar & 66.17% people could not, 11.76% people could get enough Khadai & 58.82% people could not and 20.58% people could get enough firewood and 77.94% people could not get. This survey shows that there is an inadequate amount of park resources and inadequacy is further increasing in the recent years.

Table 26 : Attitude of local people towards the park resources.

Resource	Number				Percentage			
	Adequate	Inadequate	Can not say	Total	Adequate	Inadequate	Can not say	Total
Khar	20	45	3	68	29.41	66.17	4.42	100%
Khadai	8	40	20	68	11.76	58.82	29.42.	100%
Firewood	14	53	1	68	20.58	77.94	1.48	100%

The probable causes of inadequacy of Khar and Khadai was also surveyed. The causes of inadequacy were due to great competition, due to succession of riverine forest over grassland resulting into low production of Khar & Khadai, limited time and due to the establishment of Island Jungle Resort which use to harvest maximum amount of grasses for the elephants as well as timber & firewood, before the grass cutting period. Maximum number of people suggested that the cause of inadequacy of resources was limited time ie only 3 days which is not enough to harvest adequate resources. This is followed by low production of resources due to succession of riverine forest over the grassland converting into a savahna type.Local people suggested that grassland has been decreasing at an alarming rate which has caused adverse effect in the wildlife and the local people of that areas.

CHAPTER - 6

DISCUSSION

6.1 Biomass Production

Aboveground standing bio-mass

Aboveground biomass have been determined in 5 different plots viz $Plot_1$, $Plot_2$, $Plot_3$, $Plot_4$ & $Plot_5$ in three different seasons in the grassland of Royal Chitwan National Park and adjoining grasslands. There was not so great variation in aboveground biomass among the plots in different seasons. However, there was found great variation in aboveground bio-mass among the plots in RCNP and community grassland.The above and belowground biomass were found to be 717.18 g/m^2 and 667.70 g/m^2 respectively.

6.1.1. Average aboveground bio-mass:

Average aboveground biomass in all the plots of study area was found to 717.18 g/m^2. Royal Chitwan National Park constitutes an average aboveground biomass as 933.23 g/m^2 and Community grassland constitutes 573.14 g/m^2. However, the average aboveground biomass of the study area (RCNP+CG) was found to be lower than the previous studies conducted in RCNP where it was recorded as 1410 g/m^2 by Lehmkuhl (1989), 1944.61 g/m^2 by Pandit (1995), 1990 g/m^2 by Lamsal (1995) and 2019 g/m^2 by Tripathi (1996). The average biomass in the study area i.e. (National Park and community grassland) was very close to the values recorded in Royal Bardia National Park such as 1027.3 g/m^2 and 739.48 g/m^2 recorded by Pokharel (1993) and Bhattarai (1997) respectively.

The difference in the aboveground biomass in the present study and the others may be due to difference in species -composition in grasslands. Here, the present study was basically concentrated in the short grasses

rather than tall grasses. In Royal Bardia National Park and Royal Shuklaphanta Wildlife Reserve, relatively short grasses are dominant in the grasslands. Therefore, the average biomass of the present study area was found similar to that of RBNP and RSWR i.e. 739.48 g/m^2 & 733.6 g/m^2 recorded by Bhattarai (1997) and Sharma (2000) respectively.

Joshi (1995) has also stated that in RCNP, out of total grassland, 80% area is covered by tall grasses while that is 30% in RBNP and 70% in RSWR. Among nine grassland assemblage identified by Peet et al. (1997), Chitwan grassland has the highest assemblage diversity whilst Bardia and Shuklaphanta are of particular importance for their *Imperata cylindrica* grassland. In Koshi Tappu, assemblages of grassland are limited to early successional grassland resulting from flooding.

Similarly, soil and some other microclimatic conditions also may be responsible for such difference. Soil of RCNP is more fertile than that of RSWR.(Lehmkuhl, 1989).

In the present study, average biomass of all the plots was highest in first phase i.e. monsoon season. (1030.61 g/m^2) followed by 2nd phase i.e. winter (777.91 g/m^2) and least in 3rd phase i.e. spring (343.01 g/m^2) (Table: 3). Many researchers had found the seasonal variation in the standing biomass. Like the present study, Dagar (1987) had also reported aboveground biomass maximum in October at Ujjain grassland. Similarly, Singh & Yadava (1972) estimated maximum aboveground bio-mass in the month of September. Further more, Sharma(2000) determined maximum aboveground biomass in the month of October. It is because of the maturation stage of the grasses and many flowering herbs in this season. Mishra and Mishra (1979) also reported that the aboveground biomass was peaked when the grasses become fully matured and lowest in freshly emerging stage.

As in the present study, Joshi (1995) also found the minimum bio-mass (304 g/m^2) in the early spring and intermediate condition in the summer (523.5 g/m^2). Similarly, Sharma (2000) also found the minimum bio-mass of 480.06 g/m^2 in the spring and intermediate condition in the summer of 708.96 g/m^2. It may be because of the burning of the plots in the early February when live standing as well as dead biomass are destroyed and converted into ash. After few days new leaves of grass are sprouted in those plots and such re-sprouts attract ungulates for grazing (Scheaf, 1978; Mishra, 1982b;Lehmkuhl,1989;Moe and Wegge,1997; Karki 1997). Thus, the early burning followed by the selective grazing by wildlife cause the standing biomass to be less in that season. Later on, when grasses grow, grazing pressure becomes less and the standing bio-mass gradually increases resulting into higher bio-mass in the summer than in the spring.

Taking seasonal wise standing aboveground bio-mass in different plots, highest aboveground was recorded in plot 5 during monsoon period & is followed by plot 4 during winter and spring seasons. Biomass of plot 5 was found 1706.8 g/m^2 during monsoon which is because of relatively more biomass contributed by the grasses.

6.1.2. Average belowground biomass:

Average biomass in all the plots of study area was found to be 667.70 g/m^2. National Park constitutes an average belowground biomass of 634.52 g/m^2 while community grassland constitutes an average biomass of 691.49 g/m^2 However, the average belowground biomass of the study area was found to be higher than the study conducted in Biratnagar by Jha & Jha (1995) who estimated average total belowground biomass of the grassland to be 104.87 g/m^2. But on the other hand the belowground bio-mass of the present study was found to be lower than the study conducted by Singh and Krishnamurthy (1981) in different grasslands of India, where below/ground biomass ranged from 809-1992 g/m^2 at Berhampur, 705-

1381 g/m^2 at Sagar, 542-2368 g/m^2 at Sambalpur, 165-1282 g/m^2 at Varanasi (lowland), 200-788 g/m^2 at Varanasi (upland), 240-780 g/m^2 at Jodhpur, 611-1167 g/m^2 at Kurukshetra, 550-925 g/m^2 at Ujjain. The difference in the belowground biomass in the present study and the others may be due to the difference in species composition in the grasslands. Further, other factors such as rain fall pattern, soil moisture, soil characteristics and some other micro-climatic conditions also may be responsible for such difference.

In the present study, average belowground biomass of all the plots was highest during monsoon season i.e. September (763.48 g/m^2). Like the present study, Jha and Jha (1995) had also reported belowground biomass maximum in September (128.2 g/m^2) and lowest in June i.e. 87.8 g/m^2. This closely paralleled the rainfall pattern and consequently soil moisture. The decrease in biomass during winter may be attributed to the lower temperature, drier condition (Chidumayo,1997) and absence of monsoonic annuals.

6.2. Biomass by Species:

Regarding the aboveground biomass contribution by different groups of plants, grasses were found contributing the highest biomass. It contributed up to 99% in some plots in some seasons.

Mainly graminoides and in graminoides also, especially *Imperata cylindrica* contributed higher biomass in all the plots except plot 1 in spring season in all the seasons. During the monsoon season *Imperata cylindrica* & *Saccharum spontaneum* contributed highest aboveground biomass (99%) as compared to other plant species. During the monsoon, forbs & other plant species' biomass gradually decreased. This may be due to lower penetration of light to be available for ground flora because of dense cover of grass species (Bolton, 1975). This is also supported by the report of Coupland (1974) who described that grass component furnished

90% or more of the total biomass reported. More than 80% total biomass were contributed by grasses in tropical grassland at Berhampur, India (Mishra and Mishra, 1984). Pandit (1995) also estimated 90% graminoides in Royal Chitwan National Park and more than 99% by Pokharel (1993) in Royal Bardia National Park.

In the present study, the contribution by *Imperata cylindrica* in all seasons was relatively higher, then comes *Saccharum spontaneum* and least contribution was made by forbs and other plant species.

6.3. Soil Characteristics

Soil, the basis of living plants, is dependent on biotic as well as physical environment where as soil nutrients are also dependent to the plants and vice versa. There is always a definite relationship between the physical and chemical nature of the soil and the vegetation distribution. This fact has been further strengthened by Young (1934) who demonstrated that heterogeneity in plant distribution is related to the soil heterogeneity. Soil together with soil water and nutrient elements forms the soil solution which is the critical medium for supplying the nutrient with growing plants (Brady, 1960).

Soil P^H

Soil P^H is important parameter since it affects several biological processes occurring in the soil. Soil of the study area was found to be near neutral to moderately alkaline. P^H was found 7.32 during the monsoon season (September), 7.63 during winter (Dec) and 7.88 during spring (May).(Annex 4.)

The fluctuation of P^H values may be due to variation of microbial activity in different seasons .The occurrence of low P^H in monsoon (Sept.) may be due to the high microbial activity causing the release of acid fulvic compounds during monsoon season. The result of soil P^H in

present work is comparable to Tamot (1998) who observed high P^H in June followed by March and December.

P^H of surface soil increases after burning to the extent varying with quality of organic matter burned. Burning and ploughing management activities alter the soil temperature and soil nutrients which ultimately affect the P^H. However, P^H is also directly related with OM. Generally, P^H decreases with an increase in OM, nitrogen and phosphorus content. In the present study, most of the plots showed the same trend. During the monsoon growth rate of plant is higher because of high temperature and rainfall hence content of soil P^H is relatively lower.

Organic Matter (OM)

Organic matter content of the soil is an important parameter for the management of soil fertility because it plays a dominant role in the nutrient supply to the plant. The high amount of soil nutrients are in organic form (FRSR,1980). Organic matter constitutes the amount of organic substances of the soil either from the dead plants or animals.

Soil organic matter (OM) was found different in different sites as well as in different seasons. (Annex: 4). Organic matter (OM) gradually decreased from winter to spring and then to monsoon. Here, winter season has the highest OM content and monsoon season the least. This higher OM during winter season than in rainy season may be due to the effect of temperature and rainfall which mineralize the litter before winter. In other words, the rate of decomposition of organic matter is accelerated by the increase in temperature in monsoon season. Similar result was also obtained by Sigdel (1994) and Tamot (1998), who reported higher soil OM in winter than in monsoon. The least organic matter in monsoon season may be due to the active period of growth of grass and may also due to the incomplete mineralization of litter .

Nitrogen (N)

Nitrogen is the essential element for the growth of plant since it is the constituent of the protein. The natural soils contain between 0.01 and 0.25% nitrogen in the surface layer but less in deep horizon (Bear, 1964).

During the study period, maximum nitrogen was found in winter season (January) and minimum is spring season (May). The maximum nitrogen in winter (January) may be due to deposition of soil nitrogen by nodulus bacteria in the late monsoon. The less nitrogen in the monsoon may be due to the leaching of nitrogen by heavy rainfall. Further, it may be due to its rapid absorption during active growth period of grasses and volatilizing of nutrients. The least nitrogen in May may be due to less microbial activity accompanied by low precipitation. This may also be due to the effect of burning because large amount of nitrogen is lost during burning (Raison, 1979). This result is in accordance with the result of Sigdel (1994) and Adhikari(1999).

Phosphorus (P)

Phosphorus is one of the important micro-nutrient and constituent of many vital molecules as nucleic acid, phospholipids and ATP. So, phosphorus is essential for the living organisms. Natural soil usually contains 0.02% to 0.5% of phosphorus (Bear, 1964).

Ramakrishna (1992), and Nye and Greenland (1960) observed the increase of phosphorus after burning. Phosphorus content in this study increased during the monsoon. The continuous decrease in phosphorus content during winter and spring season (11.58 kg/ha) may be due to the uptake of phosphorus during the plant growth then there was an abrupt increase in monsoon i.e. 24.61 kg/ha which might be due to the effect of ash caused by burning.

A mixture of phosphorus and organic matter increases the productivity of the soil than organic mater alone(Dhar and Bhatt ,1970).Higher biomass production (above and below ground) at plot 5, during monsoon seasson, may be due to the large amount of phosphorous and soil organic matter than other plots.

Potassium (K)

Natural soil contain much more potassium than phosphorus or nitrogen (Black, 1968) who cited the value between 0.3% to 2.5%. The potassium content of the soil is continuously drawn during the active period of plant growth and hence the exchangeable potassium in the soil is reduced. however, the rate of release of fixed potassium is appreciably slower than the rate of uptake. This study shows lower value of potassium during monsoon and spring season which might be due to active growing season of vegetation than that of other seasons. This finding is supported by Turk (1943). Maximum potassium during winter indicates that the vegetation is in inactive stage of growth or matured stage.

Water Holding Capacity (WHC)

Water holding capacity of soil is the amount of water absorbed by a unit weight of absolute dry soil when emmersed in water. WHC is directly related to the soil texture and soil organic matter. Sandy soil possess low water holding capacity while silt, clay and soil rich in organic matter have high values.

In the present study, the average mean WHC of all plots in different seasons was found almost similar (Annex 4). Water holding capacity was relatively higher in plot 3 of monsoon season, plot 2 of winter season and spring season. It may be due to the presence of comparatively higher organic matter in these plots. Water holding capacity gradually increased in the following seasons after spring.

6 .4 Park Resources

It was observed that during grass cutting period organized by RCNP in 2003, 2972 people of Pithauli VDC entered into the park to collect park resources (Khar, Khadai and firewood). The villagers use "Khar" (thatch grass) to thatch their roofs. People use reed or khadai for building walls and fences. For cooking purpose villagers mainly use firewood.

Each person harvested about 8.38 loads of khar, 2.70 loads of khadai and 8.5 loads of firewood during grass cutting period. Khar and firewood had the higher numbers of loads than khadai . Khar is mainly used for thatching roofs because most of the village houses are thatched by khar. Similarly, firewood is one of the most important resource which the local people are wholly dependent on. During the study period, it was found that the total number of house holds that have Bio-gas plants was 42 out of 1486 households in Pithauli VDC which was only 2.8% and the remaining households are totally dependent upon firewood. An average weight of khar, khadai and firewood were estimated to be 42 kg, 40 kg ,40 kg per load respectively.

Sharma (1991) estimated that average number of loads of khar and kahdai harvested by each person were 5.04 and 3.09. This was more or less similar with the estimation made during the present study period. Lehmkuhl et. al. (1988) and Sharma (1991) estimated average weight 39.4 kg and 35.2 kg per load of khar and khadai respectively. Their estimation was by direct weighing of loads of khar and khadai but the present estimation was dependent on average number of mutha per load and average weight per mutha. So that there was slightly difference in the weight of khar and khadai from the result of Lehmkuhl et.al. (1988) and Sharma (1991). Sharma(1991) described that each individual carried about 10.4 loads of firewood with a weight of 46.3 kg during grass cutting period.

But the present study showed different result from that of the study of Sharma because all people cannot carry heavy loads.

The present study indicated that the consumption of 24,931.89 loads of khar, 8028.11 of khadai and 25,309.55 loads of firewood by the villagers of Pithauli VDC. Further, total weight of khar, khadai and firewood were calculated to 1047.13 tonnes, 321.12 tonnes and 1012.38 tonnes respectively and total park resources (khar, khadai and firewood) harvested in Pithauli VDC during grass cutting period 2003 was found 2380.64 tonnes. Share of each house hold of park resources was 704.66 kg/HH of khar, 216.1kg/HH of khadai and 681.28 kg /HH of firewood.

During the grass cutting period 2003, total park resources harvested by the people in and around RCNP was found 367295.4 loads of khar, 118341.0 loads of khadai and 372993.3 loads of firewood with total weight of 15426.407 tonnes of khar, 4733.64 tonnes of khadai and 14919.73 tonnes of firewood with total of 35079.77 tonnes of park resources harvested in RCNP during grass cutting period 2003.

The total monetary values of khar, khadai and firewood was found Rs 2794304.00. The monetary values of khar,khadai and firewood harvested by the villagers of Pithauli VDC were Rs. 1047139.6, Rs 481686.9 and Rs 1265477.5 respectively. Each household harvested monetary values of khar, khadai and firewood were Rs 704.66, Rs 324.15 and Rs 851.59 respectively. The total monetary values of park resources (khar, khadai firewood)per house hold was Rs 1880.4.The cost of khadai was found higher than khar and firewood. Sharma (1991) estimated that each household consumed park resources to the equal monetory value of Rs. 2658.00. In this estimation khar, khadai, firewood, and other resources of the park are all included together.

The total monetary values of the total park resources were estimated on the basis of data of Pithauli VDC. It was observed that there are

variation in monetary values of park resources in different time by different researchers.

1.	Lehmkuhl et. al. (1988) estimate for the Year 1986. (Participating people - 55,379)	US $ 451836.00 NRs. 22591800.00
2.	Sharma (1991) estimate for the year 1990 (Participating people 61,614)	US$ 605831.53 NRs. 30291576.50
3.	Present Study for the Year 2003 (Participating people - 43,830)	US$ 544592.47 NRs. 40430545.00

The estimates made by Lehmkuhl et al (1988) considered only khar and Khadai. The estimates made by Sharma (1991) considered all types of resources and the present study includes khar, khadai and firewood. There were different numbers of people participating in each event. These differences may also be due to different prices of park resources in different time and place.

6.5 Attitude

Since Pithauli VDC is located adjacent to the park, it is heavily effected by the wild animals. But from the field survey at Pithauli VDC it was found that maximum number (88.23%) of people were satisfied with the establishment of the park because park is the only place where their basic needy resources as khar, khadai and firewood are being preserved and they are allowed to collect them once a year during the grass cutting period but they are found unsatisfied with the duration of grass cutting period of only 3 days in this 2003 year. About 7.35% of people were found unsatisfied because of livestock and crop depredation by wildlife and mushars were unsatisfied with the establishment of the park because they are completely denied access for fishing which is their main profession.. Further they said that the losses must be compensated by the government

at any cost and complained that the compensation scheme in Pithauli VDC is not working efficiently at all and during the study period even a single compensated person was not found however the compensation forms were filled up 1-2 years before and there was no sign of getting the compensation of the losses they had .

About 66.17% ,58.82% and 77.94% of the people interviewed in Pithauli VDC reported that thatch grass, khadai and firewood were inadequate respectively. Comparatively the competition to collect khar and firewood was high. The probable cause of inadequacy of khar, khadai were due to great competition among people in a limited area, due to succession of riverine forest over the grassland resulting into low production of khar and khadai, limited time of only 3 days and due to the establishment of Island Jungle Resort which use to harvest maximum amount of khar, khadai as fodder for the elephants as well as harvest maximum amount of timber and firewood prior to opening days of grass cutting period.

Generally, "Tharu" use more khadai (reed) in compare to other ethnic groups. Tharu use khadai for fencing, walls of house and stockyard and supporter for thatch grass in their thatched roofs and to make other different materials as baskets, fishtraps etc.

Consciousness of the local people towards forest and bio-diversity was surveyed where maximum number of people were found conscioused about the forest and degradation of other natural resources .But they are the ones who were found degrading the nearby forests. They said that the root cause of this degradation is the poverty. Unless and until the poverty is not alleviated, the degradation goes on hence poverty alleviation programs must be introduced in this Pithauli VDC in order to protect the remaining forest. They reported that "bio-gas" is the most suitable alternative to the firewood which must be distributed to the local people by giving maximum subsides to them and the present subsidiary scheme is not satisfactory which must be increased at any cost before it is too late.

CHAPTER – 7

MAJOR THREATS/ISSUES IN AND AROUND RCNP

The Royal Chitwan National Park has progressed a lot in preserving several endangered species and their habitat. This success, however, has generated an increasing number of problems/conflicts between local people and park management.

The bio-diversity of Chitwan is facing several kinds of threats. These threats could be categorized into two broad classes :

i) Natural

ii) Man-made threats

Natural Threats :

Succession:

Succession is a natural process of gradual replacement of one type of vegetation in a given area in other words plant succession is an orderly process of community change in an unit area.

Four types of succession can be observed in Chitwan National Park. The first one is the encroachment by tall grasses called elephant grasses over short grasses like *Imperata cylindrica*. Due to this type of succession most of the *Imperata* patches have been replaced by tall grass species like *Saccharum bengalensis, Saccharum spontaneum, Themeda villosa* and *Narenga porphyrocoma.* For example in Bandharjula Island where *Imperata cylindrica* areas are replaced by the tall grasses and as a result during grass cutting period it becomes really hard for the local people to find adequate thatch grass (*Imperata cylindrica)* in that areas and are compelled to collect tall grasses and firewood.

The second encroachment is by *Saccharum spontaneum* on sandy land left by the rivers. In some places of the park river has entered into the grassland and riverine forest, destroying vegetation with the deposition of sand and sediments. Some of the example of this type could be seen in the forests near Jayamangala of Padampur, grassland of the north of Tiger Tops.

The third type of succession is encroachment by fire resistant riverine tree species like *Bombax ceiba, Syzigium cumini, Dalbergia sissoo, Accacia catechu, Trewia nodiflora* etc and shrubs like *Zyzyphus mauritiana, Lantana camera, Eupatorium sp; Pogostemon bengalensis* which has begun to form a savana type of vegetation. This type of succession could be observed in the grassland of south –west of Icharni Island, grassland near Jarneli, grasslands in the north of Tiger Tops and Temple Tiger area.

The fourth type of succession is noticed recently. In this type, *Mikania micrantha*, a climber species is covering the grasslands, swamps and shrub lands and even some forests forming a thick complete mat of this species. This type of succession is seen in the grasslands of Tiger Tops area resulting in the death of all grasses, decreasing the supply of fodder to most of the herbivores, which ultimately affect the carnivores. *Mikania micrantha* is a climber and seems to have entered Nepal from India.It was first noticed in the jungle of Chitwan near Balmiki Temple 10 years ago(Rijal et.al. 2001) but it is only in recent years that it has shown its devastating effects. The greatest effect of this weed can be seen in Koshi Tappu Wildlife Reserve where within 5 years, it has managed to engulf a large chunk of reserve's marshes and terrestrial habitats. This type of vine covers entire forest floor and grasslands by thick layer thus obstructing the sunlight i.e. there is no penetration of sunlight and may have allelopathic effect thus causing the death of grass and shrubs. Similarly, succession in short grass species by tall grass species will effect small herbivores.

Flooding

It is one of the major threats in Royal Chitwan National Park. Narayani, Rapti and Reu are the main rivers constituting the boundry of the park i.e. Narayani river forms the western border and Rapti the northern border of the park. These rivers become flooded during the monsoon having an annual rainfall of about 2400 mm, and washes away large areas of grassland, riverine forest, sal forest and even the agricultural land .Every year, large areas of natural habitats of wildlife are washed away by the flood. Grassland in the north of Baghuwaghera and south of Rapti river, grassland in the north by Reu river in the Tiger Tops area, sal forest in the west of

Tiger Tops by Reu river, sal forest near Seri area and Kasara area is cut every year by flooded rivers. Cutting of Sal forest area is accelerated nowadays due to the construction processes of bridge in Kasara area. Erosion is also taking place in the adjoining villages. This can be seen in Kujauli areas where there is acute erosion of agricultural land and no effective measures have still been stepped forward. Similarly, Gairi areas of Pithauli VDC are also under the erosion impact. Further flooding of Narayani has swept away hundreds of house mainly in Seri areas and Pithauli areas of Nawalparasi and as a result number of landless people is increasing at an alarming rate resulting in food crisis. Last year about 200 houses were swept away in the Seri area, similarly about 100-200 households were affected in Laugai area of Pithauli VDC of Nawalparasi. About 2.6 hectare per year of agriculture land is cut away by erosion (Banskota et. al. 1998) which will jeopardize the livelihood of the farmers increasing their dependency on forest.

Narayani river, during monsoon flooding, brings huge amount of sediments which start sedimentation as it enters the Chitwan valley. As a result there is an increase in the water level, decreasing water depth which could be one of probable reason for the extinction of Dolphins from Narayani river.

Man – Made Threat

This type of threats are either born due to human activities related to traditional practices or due to lack of alternatives. In addition, lack of policy or failure of policies has also affected bio-diversity of the park. Some of the important threats to the bio-diversity are as follows :

Illegal Grazing

Nepal has one of the highest livestock densities in Asia . Animal husbandry is most important component of the local economy. The increased human population has increased the number of livestock in the adjoining villages which sneak into the park every day for grazing. Grazing by large number of grazers increase competition for fodder effecting wild herbivores and through them, carnivores also, thus disturbing the whole ecosystem. Competition from the domestic livestock and probable introduction of diseases from these animals is the cause of extinction of endangered species like Swamp deer and wild water buffalo from Chitwan.

Thatch Grass, Fodder and Firewood Collection

Before the park was established, local people were able to collect as much firewood, thatch grass and cattle fodder as they needed. But after the establishment of the protected area, local people who historically had access to resources were denied access. Now they are forced to burn dung for fuel and cattle are often undernourished through a lack of good grazing, good cattle fodder. The dung burnt on fires for fuel should be used on fields as fertilizers, but now farmers are forced to buy chemical fertilizers to increase the crop productivity. And these chemical fertilizers are really expensive and unaffordable for the farmers. Due to maximum use of chemical fertilizers the quality of soil is lowering and consequently the productivity.

Now, people are allowed to collect thatch grass from the national park for about only one week which seems really limited for the ever increasing growing population to fulfill their daily requirement. It was found that villagers come from as far as 50 km. away to harvest grass since park is the only place where it is available. Consequently, people realize that the park has preserved a valuable resource for them.

Another benefit from the grass cutting is that tall grasses can be used to manufacture paper at Bhrikuti Paper Mill of Nawalparasi district. A side benefit of using grass instead of wood for making paper is that it eases (decreases) the pressure on the forests. The illegal collection of firewood during the grass-cutting season has also been lessened as people prefer to take grass and earn cash.

Poaching

Poaching is the most serious threat to the animals like Rhino, Tiger, Sloth bear. Although due to extensive conservation initiatives, the number of animals poached has decreased these days, but still, it has not completely been stopped. The year 1992 was the year with higher number of rhino poached ie 18. Poaching incidents are scattered to various parts of the park mainly extreme western part, Bandarjula Island and Khangendramalli area on the eastern part of the park. The demanding market for specific animal trophy and weak economy of the people had motivated these activities. Due to high population growth of wild animals, for food

and space come out in the buffer-zone and corridor forest. The corridor forests are highly used by the migratory animals and birds. Past few years data indicates that the poaching of rhino had increased tremendously in the corridor forests. Fines and penalties imposed are not high enough to discourage these activities. Besides this, monitoring of these areas is very poor because of shortage of man-power with one person for 7.5 sq. km.

Pollution

Pollution of water has created an adverse effect on aquatic diversity. The industries located outside the park release their effluent directly into the water system without any treatment. Bhrikuti paper mill, two beer factories are mixing effluent in Narayani river. Besides these, effluent from other several smaller industries and sewerage of Narayanghat city is also being release in the Narayani River. The dolphins, which used to be common in Narayani, has not been observed for more than 5-6 years. It is suspected that pollution of water in Narayani river could be the most probable reason for its extinction from this river. A study of water quality of Narayani near Bhrikuti Paper Mill showed very poor water quality according to NCRTC. Besides, the garbage of the hotels and restaurants of Sauraha are also dumped into the Rapti river. Asian water fowl census – 1999, 2000, 2001,2002 conducted by the Wildlife Department of Tiger Tops/ITNC under the authority of Royal Chitwan National Park and Bird Conservation Nepal (BCN) concluded that there is decline in the number as well as number of species of water fowl both in Narayani as well as Rapti river, most probably due to water pollution, habitat degradation, Gandak Barrage, use of pesticides and chemical fertilizers (Personal Observation). Use of pesticides and chemical fertilizers in agricultural lands by the farmers has been increasing in the adjoining areas of the park. These chemicals from the agricultural field finally get washed away and reach the river system and lakes inviting adverse effect in aquatic diversity. The average use of chemical fertilizers (NPK) in 1998 was 26.6 kg/ha while it was only 7.6 kg/ha in 1975. In the agriculturally prosperous area of eastern Chitwan district, the use of chemical fertilizers is estimated to be 420 kg/ha and altogether 250 types of pesticides are used in Nepal in the field of agriculture (Lekhak and Lekhak, 2003).

Poisoning

Last ten years observation indicates that though there has been some success in the conservation of terrestrial fauna (Banskota et. al, 1998), but, the situation of aquatic fauna is still depressing. The number of wintering birds, fish population and other aquatic species number have decreased (Source: Personal Observation).

Further, people add poison in the carcass of the prey species of tiger to kill tigers and add poison in pumpkin and maize to kill rhinos. Powerful insecticides such as "Metacid" is used to kill fish in the rivers and lakes in and around the park which not only kills the fish but seriously affects the whole aquatic ecosystem. This could be one reason for the decrease in the number of migratory waterfowl.

Crop Damage

Crop damage by the wild animals, in the adjoining areas of the park, has become a most serious problem. As a result of strict habitat protection, rhinoceros, deer, wild boars, etc, have increased dramatically to the extent that they are now regarded as nuisance by the people living on the periphery of the Park. Crop destruction by wild animals ranges from as low as 10 percent to as high as 90% in areas around the park. Rhinos, deer, wild boars are attracted by rice, wheat, maize and mustard crops causing severe damage of the crops. Further, there is no compensation scheme in cash for their crops and livestock loss or injury or death as a result of which the local people are compelled to kill those animals by different methods like electric shock, pit falls, snares, spears, firearms, poison etc. which is very frequent in the adjoining areas of Chitwan and Nawalparasi district.

Human Casualty

Human casualty has increased in the adjoining areas nowadays which has created a negative view towards the animals specially rhino and tiger. Numbers of local residents are killed in accidental encounter with animals in and around the National Park and Buffer zone forest. The number of people killed by rhino and tiger in RCNP in the fiscal year 1998/99 was 8 and 4 respectively.

CHAPTER - 8

CONCLUSION AND RECOMMENDATION

Conclusion

Thus, from the present study undertaken during 2002/2003 in RCNP and adjoining community grassland, above and belowground biomass production, vegetation composition, soil characteristics, social aspects and consumption pattern of the park resources by the local people and major threats in and around RCNP were evaluated.

Regarding the biomass production, aboveground biomass was found higher than the belowground biomass of 717.18 g/m^2 and 667.70 g/m^2 respectively. Aboveground biomass was found highest (1030.61g/m^2) in monsoon season and lowest (343.01 g/m^2) in spring season. Similarly, belowground biomass was found highest (743.48 g/m^2) in the monsoon season and lowest (607.81 g/m^2) in the winter season.

Imperata cylindrica, Saccharum spontaneum, S. munja and Narenga porphyrocoma were found dominant in the study area. However, other plant species of minimum dominancy were also determined. Altogether 81 species of plants were recorded during the study, among them 28 species were grasses, 15 species trees, 22 species shrubs, 12 species herbs, 3 species pteridophytes and 1 species of orchid.

The major biomass producing plants of the study area are *Imperata cylindrica & Saccharum spontaneum* which were dominant in all the studied plots. Similarly, least biomass producing species were *Oxalis corniculata, Desmodium triflorum, Phyllanthus sp; Euphorbia sp. & Equisetum debile.*

Regarding the soil characteristics of the study area P^H, OM, N, P,K were determined

- P^H of soil was found neutral to alkaline, with mean P^H of 7.61.
- Organic matter (OM) of soil of the study area was recorded as 2.01% with maximum in the winter season and minimum in the monsoon season.
- Nitrogen content of the soil of study area was recorded as 0.09% with maximum in the winter season and minimum in the spring season.
- Phosphorus content of the soil of study area was recorded as 17.43 kg/ha with maximum in monsoon season and minimum in spring.
- Potassium content of the soil of the study area was recorded as 88.46 kg/ha with maximum in winter season and minimum in monsoon.

Comsumption pattern of park resources by the local people living and around RCNP was also determined. In Pithauli VDC (study site) a total of 2380.64 tonnes of park resources was harvested, the contribution of Khar was found highst (1047.13 tonnes) & lowest by Khadai (321.12 tonnes) & 1012.38 tonnes by firewood.

Based upon the investigation made in Pithauli VDC, consumption pattern of park resources by the local people in & around RCNP was determined. According to this, a total of 35079.77 tonnes of park resources (Khar, Khadai & firewood) was found harvested. The contribution of Khar was found maximum of 15426.40 tonnes & minimum by Khadai of 4733.64 tonnes & firewood of 14919.37 tonnes.

Total monetary value of park resources in Pithauli VDC was found Rs. 2794304.00 where highest contribution was made by firewood & lowest contribution by Khadai. Similarly, total monetary value of park resources in & around RCNP was evaluated as 40430545.00 or US $ 544592.47 which has a significant effect in the livelihood of the people. Highest contribution was made by firewood & lowest by Khadai.

Further, maximum number of people (88.23%) stated that the establishment of RCNP is better while minimum (7.35%) people stated that establishment of RCNP is not so good because of crop & livestock damage by wildlife.

There exist several threats in and around Royal Chitwan National Park which have exerted a tremendous impact in the bio-diversity .The major threats include succession, flooding, illegal grazing, poaching, pollution, poisoning, crop damage, human casualty etc.

Recommendation

On the basis of present study following recommendations have been proposed to conserve the grassland of RCNP and adjoining areas -

1. As the grassland ecosystem of the RCNP is an important habitat influencing the carrying capacity of the wildlife , regular monitoring of grassland areas should be done and the management plan should be developed accordingly for the better habitat for the wild herbivores as well as for the betterment of local people concerning with the availability of park resources to them.

2. Among the grasses, *Saccharum spontaneum* is perhaps one of the highest quality in the park in terms of for a quality and used by the wild herbivores (Mishra, 1982 a, Dhungel, 1985). The park may be able to play a crucial role in the local economy providing the *S. spontaneum* for paper fiber through grass cutting permits such a program would have to be carefully planned and managed.

3. The practice by Royal Chitwan National Park for allowing people to collect resources that are critical for their livelihood should be continued. This policy and similar local people oriented policies in the future can resolve or reduce the conflicts between park management and local people. Developing mutually beneficial cooperation can enhance the long term stability of the park. The annual grass cutting

program must continue in the future and should be given adequate legal status.

4. The villagers should practice the farm forestry to decrease their pressures on park for fuelwood and fodder. Further, huge population of unproductive cattle should be replaced by the productive ones.

5. Alternative to firewood should be identified. Bio-gas is one of the most suitable technology in that area which must be introduced immediately by providing maximum amount of subsides from the bank.

6. Enforcement of park laws, particularly for stopping illegal firewood, poaching, & fodder thefts from the park and the adjoining forests should be effectively applied in RCNP as well as in the forests and grasslands of the impact zone managed directly by RCNP.

7. DNPWC or RCNP should initiate comprehensive programs to provide information to the general people about our natural resources and their conservation for e.g. Audio-Visual programs have greater audiences and leave long lasting impacts on the simple minds of the local people.

8. DNPWC should pay a serious attention in the administration of RCNP for eradication of mis-concept of the local people towards the park by launching different general awareness programmes.

9. Since, poverty is the root cause of conflict between park and people, proper policy should be developed by government in order to increase the economic condition of farmers which will reduce the dependency of farmers on the park.

10. Threats to bio-diversity is complex in nature with social, economic,ecological and other factors involved, solution should also be holistic in nature. The most important thing is that genuine problems of the people should be addressed properly in the conservation programs because without people's participation

conservation could not sustain. For this, grassroots institution need to be formed, strengthened and mobilized to bring their support in conservation.

11. The conservation programs should have clear vision regarding the limitation of flood control, succession, pollution control, poaching control, clear policy to locate industries ,policy to control fragmentation of land and policy to control population and poverty because these are the root causes of all the problems of bio-diversity conservation.

12. Monitoring of park's areas is very poor because of shortage of man-power with one person for 7.5 sq. km. Hence, man-power for monitoring Park's areas should be strengthened immediately.

REFERENCES

Adhikari, B. (1999). Ecological Study of Grasslands of Koshi Tappu Wildlife Reserve, Nepal. M.Sc. Thesis, Central Department of Botany, T.U., Kathmandu.

Anonymous (1992). Statistical Pocket Book.Central Bureau of Statistics, Kathmandu. HMG, Nepal.

Anonymous, (1984). Tropical Grazing Land Ecosystem, UNESCO/UNDP/FAO, Paris.

Badgely,C. (1984). The palcoenvironment of South Asian Miocene hominids.Pages 787-795 in Whyte,R.O.(ed.),Evolution of the East Asian Environment .Vol.II. Paleobotany, Paleozoology and Palcoanthropology, University of Hong Kong, Hong Kong.

Balson,E.E.(1976).General Report on the Royal Shuklaphanta Wildlife Reserve.HMG/UNDP/FAO, National Parks and Wildlife Projects.Kathmandu, Nepal.

Banskota,K., B.Sharma, U.R.Sharma and A.Rijal (1998). Royal Chitwan National Park after twenty years: An assessment of values ,threats and opportunities. KMTNC,Kathmandu.

Bear,F.E.I.(1964). Chemistry of the Soil. Reinhold, New York.

Bhatt, D.D. and T.K. Shrestha (1977). The Environment of Shuklaphanta, Curriculum Development Center, T.U. Kathmandu.

Bhattarai, D.B. (1997). Analysis of Vegetation and their Utilization in the Wetlands of Royal Bardia National Park (Karnali Chisapani Sector) Bardia, Nepal. M.Sc. Thesis, Central Department of Botany, T.U., Kathmandu.

Biondini, M.E., B. D. Patton and P. E. Nyren (1998). Grazing Intensity and Ecosystem Processes in a Northern Mixed Grass Prairie USA. Biol. Abs. 105(13) July 15.

Bisht, N.S. and S.K. Gupta (1985). Dry Matter Dynamics in a Grassland Community at the foothill of Garhwal Himalayas. Indian Journal of Ecology 12 : 200-204.

Black,C.A.(1968). Soil and Plant Relationships.Wiley Eastern Pvt. Ltd. New Delhi.

Bolton, M. (1975). Royal Chitwan National Park Management Plan, (1975-1979), FAO.NEP/72/02, Project Working Document No. 2. UNDP/FAO of the United Nations. 105 PP.

DNPWC (1998). Royal Chitwan National Park "Twenty-five Years of Conservation".DNPWC.

DNPWC (2000). "Count Rhino-2000" in Royal Chitwan National Park,Wildlife Nepal.HMG.

Edds, D. R. (1989). Multivariate analysis is Fish Assemblage Composition and Environmental Correlates in a Himalayan River-Nepal's Kali Gandaki/Narayani. Ph.D. Dissertation, Oklahoma State University, Stillwater. 137 PP.

FRSR (1980). Standard Method of Analysis, Soil Plant Tissue, Water and Fertilizer. Farm Resources and System Research Division. Los Bonus.

Gaur,R.(1987). Environment and ecology of early man in north west India. B.R. Publishing Corporation,New Delhi.

Gyawali, S. R. (1986). Park People Conflict: Assessment of Crop Damage and Human Harassment by Rhinoceros (*Rhinoceros Unicorn's)* in Sauraha areas adjacent to the Royal Chitwan National Park. M.sc. Thesis, Noragric Agricultural University of Norway.

Hales,D. (1989). "Changing Concepts of National Parks".D.Western and M. C.Pearl (eds).Conservation in the twenty-first Century.New York: Oxford University Press.

HMG (1968). Soil Survey of Chitwan Division. Kathmandu: Forest Resources Survey Publication No.5. Ministry of Forests, HMG-Nepal.

HMG (2003). Climatic Data of Rampur Station-2002. Department of Hydrology and Meteorology.HNG,Nepal.

Ikeda, H., K. Okamoto and M. Kukuhara (1997). Estimation of Above Ground Grassland Phytomass With a Growth Model Using Landsat TM and Climate Data. Biological Abstract 106(20):Ab.501 .International Journal of Remote Sensing July 20 : 2283-2294.

IUCN (1990). IUCN Red list of Threatened Animals. IUCN, Gland Switzerland and Cambridge, U.K.

Jha, P.K. (1992). Man and Environment in Nepal. Craftman Press, Bangkok.

Jha, P.K. and S.N. Jha (1995). Seasonal Changes in Importance Value Index (IVI) and Bio-mass in a Lowland Nepalese Grassland Community. Geobios 27(1)25-30 PP.

Jha,P.K. (1972). Above Ground Primary Production in Grassland at T.U.,Kirtipur,M.Sc. Dissertation ,Central Department of Botany.

Brady, N. C . (1960). The Nature and Properties of Soil. Prentice-Hall of India, Pvt. Ltd. New Delhi.

Briggs, M.J. and A.K. Knapp (1995). Interannual Variability in Primary Production in Tallgrass Prairie: Climate, Soil Moisture, Topographic Position and Fir as Determinants of Aboveground Bio-mass. American Journal of Botany 82(8): 1024-1030.

Carson, B., P. B. Shah and P. L. Maharjan (1986). Land Systems Report: The Soil Landscapes of Nepal. HMG, Topological Survey Branch, Kathmandu, Nepal. Bear, F. E. I (1964). Chemistry of the Soil. Reinhold, New York. 233-245 PP.

CBS, (2001). Statistical Year Book of Nepal, Central. Bureau of Statistics, Kathmandu.

Chew, R.M. (1974). Consumers as Regulators of Ecosystems: An Alternations to Enrgetics, Ohio Journal Science, 74:359-371.

Chidumayo,E.N.(1997).Annual and spatial variation in herbaceous biomass productin in Zambian dry mimbo woodland.S.Afr. Jour.Botany.

Clement, B.and E. Maltby (1996). Plant Diversity and Ecological Variables in Moist and Wet Grasslands of Riverine Wetlands. Acta. Botanica 143(4-5): 309-316.

Coupland, R.T. (1974). Grasslands. The Encyclopaedia Britannica 8:280-294 pp.

Dabadghao, P.M. and K.A. Shankarnarayan (1973). The Grass Cover of India. Indian Council of Agricultural Research, New Delhi.

Dagar, J.C. (1987). Species Composition and Plant Biomass of an Ungrazed and a Grazed at Ujjain, India. Tropical Ecology 28:208-215.

Dhar, N.R. and G.N. Bhatt (1970). Effect of Organic matter and Phosphate on the Yield of Paddy and wheat in the field. National Academy of science, India. Indian Physical Science 40 (1): 9-19.

Dhungel, S.K.(1985). Ecology and Habitat Study of Hog Deer in RCNP, Ph.D. Thesis, University of California, USA.

Diaz, E., A. Roldan, V. Castillo and J. Albaladego (1997). Land Production In a xeric, Torriorthent Amended With Urban Solid Refuse. Biol. Abs. 104(11): Ab 1264.

Dinerstein, E. (1991). Sexual Dimorphism in the Greater One horned Rhinoceros (*Rhinoceros Unicornis)*. J. Mammalogy, 72(3): 450-457.

Dinerstein, E. and C. M. Wemmer (1988). Fruits Rhinoceros eat: Dispersal of *Trewia nudiflora* (Euphorbiaceae) in Lowland Nepal. Ecology, 69(6): 1768-1774.

Joshi, S.R and P.K. Jha (1995). Biomass Production in the Grasslands of the Royal Chitwan National Park, Nepal. Ecoprint: An International Journal of Ecology 2(1): 40-45p.

Joshi, S.R (1995). Grassland Biomass in Royal Chitwan National Park, Nepal. M.Sc. Thesis, Central Department of Botany, T.U., Kathmandu.

Karki, J.B(1997). Effects of Grazing, Utilization and Management on the Grassland of RBNP, Nepal. M.Sc Thesis, Wildlife Institute of India.

Keya, G. A. (1998). Herbaceous Layer Production and Utilization by Herbivorous Under Different Ecological Condition in an Arid Savannah of Kenya. Biol. Abs. 105(14): Ab. 706 July 30.

Knystautas, A. (1987). The Natural History of the USSR,century. London.

Lamsal, P.(1995). Biomass Production of Grassland of Royal Chitwan National Park and Consumption pattern of the Park Resources by Local Villagers. M.Sc. Thesis Central Department of Zoolgy, T.U., Kathmandu.

Laurie, A. (1978). The Ecology and Behavior of the Greater One-Horned Rhinoceros. Ph. D. Thesis, University of Cambridge. 450 PP.

Lee, J.J., and D.L. Inman (1975). The Ecological Role of Consumers- An Aggregated System View. Ecology 56: 1455-1458.

Lehmkuhl, J.F. (1989). The Ecology of South Asian Tallgrass Community, Ph.D. Thesis, University of Washington, U.S.A.

Lehmkuhl, J.F., R.K Upreti and U.K Sharma (1988). National Park and Local Development. Grass and People in RCNP, Nepal. Environment Conservation 15: 143-148.

Leith, L. (1975). Primary Production of the Major Vegetation Units of the world. Pp. 203-215. In H. Leith and R.H. Ambasht (1975). Biotic stress and Variability in Structure and Organic (Net Primary) Production of Grassland communities at Varanasi, India, Tropical Ecology. 16 : 86-95.

Lekhak,H.D. and B.Lekhak (2003). Natural Resource Conservation and Sustainable Development in Nepal.Kshitiz Publication,Kathmandu,Nepal.

Mac Mohan, J.A. (1981). Successional Processes, Comparisions Between Biomass with Special Reference to Probable Roles of and Influences on Animals. PP 277-304 in West, D.C, H.H Shugart and D.B. Botk in (eds). Forest Succession Concepts and Application. Springer-Verlag, New York.

Maskey, T. M. (1989). Movement and Survival of Captive-reared Gharial (*Gavialis gangeticus)* in the Narayani River, Nepal. Ph.D. Dissertation, University of Florida, Janesville. 203 PP.

Mathur,Y.K.(1984). Cenozoic palyniofossils,vegetation,ecology and climate of the North and Northwestern sub-Himalayan region,pp. 504-552 in whyte R.O. (ed.),Evolution of the Easst Asian Environment. Vol.II, Paleobotany, Paleozoology and Paleoanthropology, Universiity of Hong Kong, Hong Kong.

Mc Náughton, S. J., M. B. Coughenour and L. L. Wallace (1982). Interactive Process in Grassland Ecosystems. PP 167-194 in Stes, J.R. et. Al. (eds).

McDougal,C.(1980). The Face of Tiger, Andre Deutsch, London.

McNeely, J.A.(1990). "The Future of National Parks". Environment.Vol.32(1).

Milton, J. P and G. A Binney (1980). Ecological Planning in the Nepalese Terai: A Repot on Resolving Resource Conflicts Between Wildlife Conservation and Agriculture Land Use in Padampur Panchayat. Washington D. C. Threshold. International Center for Environment Renewal. PP 240.

Mishra, H.R and M. Jefferies (1991). Royal Chitwan National Park, Wildlife Heritage of Nepal. The Mountaineers, U.S.A.

Mishra, H.R(1982 a) . Balancing Human Needs and Conservation in Nepal's Royal Chitwan National Park. Ambio 11 (5): 246-257.

Mishra, H.R. (1982b). The Ecology and Behavior of Chital (*Axis axis*) in RCNP, Ph.D. Thesis, University of Edinburg U.K.

Mishra, M.K and B.N. Mishra (1984). Biomass and Primary Production in an Indian Grassland. Tropical Ecology. 25(2):239-247.

Mishra, M.K.and B.N.Mishra (1979). Turnover rates of a grassland community. Comp.Physiol.Ecol.3,150-153.

Moe. S.R. and P. Wegge (1997). The effects of Cutting and Burning on Grass Quality and Axis Deer (*Axis axis)* use of Grassland in Lowland Nepal. Journal of Tropical Ecology 13, 279-292.

Moore, C.W.E. (1964). Grass and Grasslands (ed by C. Barnard) Melburne, Mac. Millan and Co.Ltd. P_P 182-205.

Murphy.P.G. (1975). Net Primary Productivity in Tropical Terrestrial Ecosystem.pp 217-231. In H.Lieth and R.H. Whittaker (eds) Primary Productivity of the Biosphere .ASpringer,New York

Nepal, S.K.,and K.E. Weber (1993). Struggle for Existence: Park- People Conflict in the Royal Chitwan National Park, Nepal. Bangkok, AIT/ Division of Human Settlements Development.

Nye, P.H. and D.J. Greenland (1960). The Soil Under Shifting Cultivation: Technical Communication No. 51, CAB: England 156 pp.

Pandey, R.K. A.K. Kandya and P.C. Kotwal. (1987). A Ecological Studies of Kanha Wildlife National Park, India. IV. Forage Consumption by Sustained Wild Ungulates. J. Trop. For. 3: 48-66.

Pandit, S.N. (1995). Vegetation Composition, Biomass Production of the Grassland and Park Resources Consumption Pattern by Ethnic Group of Adjoining Villages of Royal Chitwan National Park. M.Sc. Thesis, Central Department of Botany, T.U., Kathmandu.

PCARR (1980). Methods of Analysis for Soil, Plant tissue, Water and Fertilizer, Philippenes, 1980. A Practical Manual.

Peet, N.B., A.R. Watkinson, D.J. Bell and K. Brown(1997). The Management of Tall Grasslands For the Conservation of Biodiversity and Sustainable Utilization. Scientific and Management Report. University of East Anglia/DNPWC, Norwich, U.K.

Peet, N.B., A.R. Watkinson, D.J. Bell and B.J. Kattel (1998). Plant Diversity in the Threatened Sub-Tropical Grasslands of Nepal. Biological Conservation 88: 193-206.

Pokharel, S.K. (1993). Floristic Composition, Biomass Production and Biomass Harvest in the Grassland of Royal Bardia National Park, Nepal. M.Sc.Thesis, Norway.

Raison, R.J. (1979). Modification of Soil Environment by Fire with Particular Reference to Nitrogen Transformations. A Review, Plant and Soil. 51: 73-108.

Ramakrishna, P.S. (1992). Shifting Agricultural and Sustainable Development. MAB Parthenon and UNESCO Biosphere Series (Jefferes, J.N.R. ed.)

Richard , C., J.P Sah, K. Basnet , J.B. Karki, B. Subba and Y. Raut. (2000). Grassland Ecology and Management in Protected Areas of Nepal, Proceedings of a Workshop. RBNP, Bardia. Vol.1 ICIMOD, Kathmandu, Nepal.

Rijal, A., S. Rayamajhi, S. Upadhayay and N. Pradhan (2001). Royal Chitwan National Park and its buffer zone management plan 2002-2007. Ministry of Forests and Soil Conservation ,Department of National Parks and Wildlife Conservation, Kathmandu,Nepal.

Rusch, G.M. and M. Oesterheld (1997). Relationship Between Productivity and Species and Functional Group Diversity in Grazed and Non-Grazed Pampas Grassland. Oikos 78(3): 519-526. Biological Abs . 103(12): 506.

Sah, J.P. (1993). Wetland Vegetation and its Management: A Case Study in KTWR, Nepal. M.S. Thesis, Natural Resoureces Programme, Asian Institute of Technology, Bangkok, Thailand.

Sah, J.P. (1997). Koshi Tappu Wetlands: Nepal's Ramsar Site, IUCN Wetland Program, Bangkok.

Sah, V.K., A.K Saxena and V. Singh (1994). Seasonal Variation in Plant Biomass and Net Primary Productivity of Grazing lands in the Forest zone of Garhwal Himalaya. Tropical Ecology 35(1): 115-131.

Scheaf, C.D. (1978). Population size and Structure and Habitat Relations of the Barasingha *Cervus Duvauceli* in RSWR, Nepal. Ph.D. Thesis. Michigan State University.

Seidensticker, J. (1976). Ungulate Populations in Chitwan Valley, Nepal. Biological Conservation, 10:183-210.

Sharma, B (2000). Aboveground Biomass and Primary Productivity in the Grassland of Royal Shuklaphanta Wildlife Reserve, Nepal. M.Sc. Thesis, Central Department of Botany, Kathmandu.

Sharma, U.R (1986). A Study of Park-People Interaction in RCNP. Report Submitted to WWF-US.

Sharma, U. R. (1991). Park-People Interactions in Royal Chitwan National Park, Nepal. Ph.D. Thesis, University of Arizona, 275 PP.

Sigdel, E.R.(1994). Physico-Chemical Properties of Soil in Royal Chitwan National Park, Nepal. M.Sc. Thesis, Central Department of Botany, Kathmandu.

Singh, J.S. and P.S. Yadava (1972). Biomass structure and Net Primary Productivity in the Grassland Ecosystem at Kurukhetra. pp. 59-79. In P.M. Golley and F.B. Golley (eds) Tropical Ecology with an emphasis on organic production. University of Georgia, Athens.

Singh, J.S. and L. Krishnamurthy (1981). Analysis of Structure and Function of Tropical Grassland Vegetation of India. Indian Review of Life Sciences 1: 225-270.

Singh, U.N. and R.S. Ambasht (1975). Biotic Stress and Variability in Structure and Organic (Net Primary) Production of Grassland Communities at Varanasi, India,Tropical Ecology. 16: 86-95.

Sinha, A., R.S. Rana and S.R Gupta (1991). Growth Patterns, Net Primary Production and Energy Transfers in two Grassland Communities of Sodic Soils. Tropical Ecology 32(1): 105-116.

Smith, J. L. D. (1994). Dispersal, Communication & Conservation Strategies for the Tiger (*Panthera* Tigris) in Royal Chitwan National Park, Nepal. Ph. D Dissertation, University of Minnesota, Minneapolis, 155 PP.

Stainton,J.D.A. (1972). Forests of Nepal. London: John Murray.

Sunquist, M.E. (1981). The Social Organization of Tigers (*Panthera Tigris)* in Royal Chitwan National Park, Nepal. Smithsonian Contributions to Zoology, No. 3.

Tamang, K.M. (1982). The Status of the Tiger and its Impact on Principal Prey Population in RCNP, Nepal. Zoology, Michigan State University.

Tamot, B. (1998). Variation in the Surface Soil and Vegetation Distribution. An Ecological Study of Shivapuri Hill. M.Sc. Thesis, Central Department of Botany, T.U. Kathmandu.

Tansley, A.G. (1939). The British Islands and their Vegetation. Cambridge University Press.

Thomas, A.S. (1960). Proc. IXth Int. Grassland Congr., Reading P_p. 405-407.

Tiwari, S.C. (1986). Variation in Net Primary Production of Garhwal Himalayan Grassland. Tropical Ecology 27: 166-173.

t'mannetze, L. (1978). An Introduction to Grassland Vegetation and its Measurement. In: Measurement of Grassland Vegetation and Animal Production. Common Wealth Agrc. Bureaus-Bull 52:1-7.

Tripathi, G.R. (1996). The Ecology of Royal Chitwan National Park, Nepal. M.Sc. Central Department of Botany, T.U., Kathmandu.

Trivedy, R.K., P.K. Goel and C.L. Trisal (1987). Practical Method in Ecology and Environmental sciences, Enviro Media Publications, Karad India.

Tsuchida, K. (1983) . Grassland Vegetation and Succession in Eastern Nepal. In : Numata, M. (ed), Structure and Dynamics of Vegetation of Eastern Nepal. Chiba University, Japan.

Turk, E. E. (1943). Soil Fertility Management in Agriculture. Field Soil Science. 55: 94-98.

Turner, C., L. John, B. Blair, R. J. Schartz and J. C Neel (1997). Response to fire, Topography and Supplemental N in all Tall Grass Prairie. Biol. Abs.104(9)Ab-444.

Wilson, E.O. (1992). The diversity of life.W.W. Niorton and Comp., New York, London.

Young, V. A. (1934). Plant Distribution as Influence of Soil Heterogeneity in Cranberry Lake Region of Adrondack Mountains. Ecology 15(2):154:195.

Zobel, D.B., M.J. Behan, U.K.R. Yadav and P.K. Jha (1987). A Practical Mannual For Ecology. Ratna Pustak Bhandar, Bagbazar, Kathmandu, Nepal.

Zobel, Kristjan and Jaaan Liira (1997). A Scale Independent Approach to the Richness Vs Bio-mass Relationship in Ground-layer Plant Communities. Biological Abstract 104(12) Ab. 379-Oikos 80(2): 325-332.

ANNEX -1

Aboveground biomass production (g/m^2) contributed by each Quadrate in all seasons.

Phase-1 Monsoon Season

Grassland plots	Q_1	Q_2	Q_3	Average (g/m^2)
Plot 1	748.8	468.68	573	596.82±115.59
Plot 2	797.6	604.0	594.4	665.33±93.6
Plot 3	872.0	745.4	1134.8	917.4±162.18
Plot 4	1263.6	1615.8	922.0	1267.53±283.25
Plot 5	2292.8	956.0	1869.2	1706.0±557.8

Phase -2 Winter Season

Grassland plots	Q_1	Q_2	Q_3	Average (g/m^2)
Plot 1	844.8	463.6	540.8	616.4±164.54
Plot 2	498.0	614.0	555.2	555.73±124.81
Plot 3	754.4	667.2	1157.2	859.6±213.42
Plot 4	787.2	1384.0	1005.6	1058.93±246.54
Plot 5	690.8	820.0	886.0	798.93±81.07

Phase - 3 Spring Season

Grassland plots	Q_1	Q_2	Q_3	Average (g/m^2)
Plot 1	284.0	200.8	249.2	244.66±34.12
Plot 2	432.0	336.0	331.2	366.4±46.42
Plot 3	230.0	304.0	474.0	336.0±102.15
Plot 4	568.0	350.0	488.0	468.67±90.04
Plot 5	392.0	298.0	208.0	299.33±75.12

ANNEX-2

Belowground biomass (g/m^2) contributed by each Quadrate in all seasons.

Phase -1 Monsoon Season.

Grassland plots	Q_1	Q_2	Q_3	Average (g/m^2)
Plot 1	528.0	330.8	960.0	606.26±262.76
Plot 2	791.6	546.8	827.84	722.08±124.82
Plot 3	669.6	750.8	1033.24	817.88±155.84
Plot 4	784.0	776.0	632.0	697.33±59.53
Plot 5	1013.6	728.0	880.0	873.86±116.67

Phase - 2, Winter Season

Grassland plots	Q_1	Q_2	Q_3	Average (g/m^2)
Plot 1	772.0	368.0	700.8	613.6±176.08
Plot 2	612.0	495.2	545.6	550.93±47.83
Plot 3	660.0	596.0	1057.6	771.2±204.19
Plot 4	384.0	628.0	702.0	571.33±135.86
Plot 5	386.4	498.0	651.6	512±108.71

Phase - 3, Spring Season

Grassland plots	Q_1	Q_2	Q_3	Average (g/m^2)
Plot 1	700.0	622.0	673.6	665.2±32.39
Plot 2	728.0	569.6	621.2	639.6±65.96
Plot 3	808.0	797.2	860.0	821.73±27.41
Plot 4	897.2	488.0	448.0	611.06±202.98
Plot 5	564.8	425.2	634.8	541.6±87.12

Annex 3
Plant Species Enumerated in the Study Area

Grasses :	
Scientific Name	Family
Vetiveria zizenioides (L.) Kuntze	Gramineae
Chrysopogon aciculatus (Retz.) Trin	Gramineae
Eleusin indica (L.) Gaertn	Gramineae
Fimbristylis dichotoma (L.) Vahl	Cyperaceae
Digitaria cillaris (Retz.) Koeler	Gramineae
Cyrtococcum accrescens (Trin.) Stapf	Gramineae
Kyllinga brevifolia Rottb.	Cyperaceae
Fimbristylis falcata (Vahl) Kunth	Cyperaceae
Oplismenus compositus (L.) P. Beauv	Gramineae
Desmostachys bipinnata (L.) Stapf	Gramineae
Echinochloa colona (L.) Link	Gramineae
Cyperus distans L.f.	Cyperaceae
Cyperus iria L.	Cyperaceae
Apluda mutica L.	Gramineae
Bothriochloa bladnii (Roxb.) A. camus	Gramineae
Chloris dolichostachya Lag.	Gramineae
Imperata cylindrica (L.) P. Beauv	Gramineae
Saccharum spontaneum L.	Gramineae
Saccharum bengalensis L.	Gramineae
Phragmites karka (Retz.) Trin	Gramineae
Saccharum munja Roxb	Gramineae
Narega porphyrocoma (Hance ex Trin.) Bor	Gramineae
Themeda villosa (Poir) A. Camus	Gramineae
Hemarthria compressa (L.F.) R. Br.	Gramineae
Cynodon dactylon (L.) Pers	Gramineae
Setaria glauca (L.) P. Beauv	Gramineae
Fimbristylis schoenoides (Retz.) Vahl Enum	Cyperaceae
Paspalum conjugatum Bergius	Gramineae

TREES, SHRUBS AND HERBS:

Trees:	
Plant Name	Family
Dalbergia sissoo O. Roxb.	Leguminosae
Acacia catechu (L.F.) Wild	Leguminosae
Bombax ceiba L.	Bombacaceae
Trewia nudiflora L.	Euphorbiaceae
Bauhinia malabarica Roxb.	Leguminosae
Butea monosperma (Lam.) Kuntze	Leguminosae
Aegle marmelos (L.) Corr.	Rutaceae
Syzygium cumini (L.) Skeels	Myrtaceae
Ficus religiosa L.	Moraceae
Ficus bengalensis L.	Moraceae
Ficus semecordata Buch.-Hum ex Sm.	Moraceae

Ficus lacor Buch-Ham.	Moraceae
Ficus hispida L.	Moraceae
Citrus medica L.	Rutaceae
Unidentified A (Tharu name : Sohari)	
Shrubs:	
Murraya koenigii (L.) Spreng	Rutaceae
Murraya pinnata (Roxb.) Maxim	Rutaceae
Colebrookea oppositifolia Sm.	Labiatae
Clerodendron viscosum Vent.	Verbenaceae
Pogostemon bengalensis (Burm. f.) Kuntze	Labiateae
Caryopteris odorata (D.Don) B.L. Rabinson	Verbenaceae
Mallotus philippensis Muell.-Arg.	Euphorbiaceae
Callicarpa macrophylla Vahl.	Verbenaceae
Cassai sp.	Leguminosae
Cassia tora L.	Leguminosae
Mimosa pudica L.	Leguminosae
Mimosa rubicaulis Lam.	Leguminosae
Caesalpinia bonduc (L.) Roxb.	Leguminosae
Caesalpinia cuculata Roxb.	Leguminosae
Coffea benghalensis Heyne ex Roem. & Shult.	Rubiaceae
Phyllanthus emblica L.	Euphorbiaceae
Ziziphus mauritiana Lam.	Rhamnaceae
Bridelia retusa (L.) Spreng	Euphorbiaceae
Sida acuta Burm. f.	Malvaceae
Grewia sp.	Tiliaceae
Thespesia lampas (Cav.) Dalzell & Gibson	Malvaceae
Pouzolzia zeylanica (L.) Benn and Brown	Urticaceae
Herbs:	
Cissumpelos pariera (L.) J.R. Forst	Menispermanceae
Dioscorea bulbifera L.	Dioscoreaceae
Oxalis corniculata L.	Oxalidaceae
Phyllanthus amarus Schumacher & Thonn	Euphorbiaceae
Euphorbia hirta L.	Euphorbiaceae
Euphorbia sp.	Euphorbiaceae
Centella asiatica (L.) Urb.	Umbelliferae
Hydrocotyle sp.	Umbelliferae
Desmodium triflorum (L.) DC.	Leguminosae
Lindernia crustacea (L.) F. Mell	Scrophulariaceae
Unidentified B (Tharu Name : Majhlat)	
Unidentified C (Tharu Name : Jhinpatia)	
Pteridophytes:	
Equisetum debile Roxb.	Equisetaceae
Pteris sp.	Pteridaceae
Dryopteris cochlata L.	Pteridaceae
Orchids:	
Nervilia sp.	Orchidaceae

ANNEX 4

Physico-Chemical Properties of soil from Five Different Plots.

Monsoon Season

Plot	P^H	O.M %	N%	P (kg/ha)	K (kg/ha)	WHC%
P_1	7.15	1.6395	0.06825	20.17	49.5984	78.8
P_2	7.1	2.666	0.13325	29.42	59.1504	88.0
P_3	7.3	2.2955	0.11475	20.17	73.8064	92.0
P_4	7.55	0.7985	0.0399	27.57	54.3744	64.8
P_5	7.5	1.882	0.09405	25.72	87.8062	80.0
Mean	7.32	1.8563	0.09004	24.61	64.94716	80.72

Winter Season

Plot	P^H	O.M %	N%	P (kg/ha)	K (kg/ha)	WHC%
P_1	7.7	1.7105	0.08555	20.17	73.4784	80.3
P_2	7.5	3.293	0.16465	12.77	197.6542	90.3
P_3	7.7	2.851	0.14255	16.47	92.5824	85.65
P_4	7.65	1.1405	0.057	16.47	54.3744	68.65
P_5	7.6	2.4235	0.1212	14.62	87.8062	84.5
Mean	7.63	2.2837	0.11419	16.1	101.17912	81.88

Spring Season

Plot	P^H	O.M %	N%	P (kg/ha)	K (kg/ha)	WHC%
P_1	7.85	1.1835	0.05915	10.365	49.5984	77.65
P_2	7.8	3.036	0.15185	9.81	121.2382	86.0
P_3	7.75	2.181	0.05905	11.845	83.0302	83.0
P_4	8.0	1.326	0.06625	14.065	97.3582	69.3
P_5	8.0	1.839	0.09195	11.845	145.118	80.65
Mean	7.88	1.9131	0.08565	11.586	99.2686	79.32

QUESTIONNAIRE

Questionnaire to be used to evaluate the consumption of park resources by local people during grass cutting period and attitudes towards the park.

Name : Age :

Ethnicity :

Village Development Committee : Village :

Education :

1. Distance to National Park ..... km

2. How many people are in your family ?

   a. 1-3 [ ] b. 4-7 [ ] c. 8-12 [ ] d. 13 and above [ ]

3. How many people purchase permit to collect forest resources during grass cutting period from your family ?

   a. 1 [ ] b. 2 [ ] c. 3 [ ] d. 4 [ ] e. 5 and above [ ]

4. Which one is the prime importance of the Park resources ?

   a. Khar [ ] b. Khadai [ ] c. Firewood [ ] d. Others [ ]

5. How many days you have collected khar in the grass cutting period ?

   a. 1-5 days [ ] b. 6-10 days [ ] c. 11-15 days [ ]

6. What do you have on your house wall ?

   a. Bricks [ ] b. Khadai [ ] c. wood [ ]

7. What do they have on their roof ?

   a. Tiles [ ] b. Thatch [ ] c. Tin [ ]

8. Can a collect Khar according to your need ?

   a. Yes [ ] b. No [ ]

9. If your can't collect, what is the cause ?

   a. Due to great competition [ ]
   b. Due to low production of Khar in the Park [ ]
   c. Due to other factor [ ]
   d. Limited time [ ]

10. What is the alternative source of Khar if Park does not allow local people to enter the park for two weeks ?

a. No alternative source [ ]
b. May be use straw, leaves of tree etc. [ ]
c. May be use tile of metal sheet [ ]

11. How many days you have collected Khadai in grass cutting period ?

a. 1-5 days [ ] b. 6-10 days [ ] c. 11-15 days [ ]

12. Can you collect Khadai according to your need ?

a. yes [ ] b. no [ ]

13. What is the use of Khadai in your house ?

a. building walls of house and stockyard [ ]
b. to make fences [ ]
c. making fish traps and others [ ]

14. How many days you have collected firewood during grass cutting period ?

a. 1-5 days [ ] b. 6-10 days [ ] c. 11-15 days [ ]

15. Can you collect firewood according to your needs ?

a. yes [ ] b. no [ ]

16. Do you use other fuel instead of firewood carried from Park ?

a. yes [ ] b. no [ ]

17. If yes, which type of fuel you have used ?

a. firewood by other source [ ]
b. kerosene or other petroleum products [ ]
c. electricity [ ]
d. gas stove [ ]
e. dung or crop residues [ ]
f. bio-gas [ ]

18. What is your attitude towards Bio-gas ?

+ ve [ ] - ve [ ]

19. Do you have Bio-gas ?

Yes [ ] No [ ]

20. Do you know that Bio-gas helps in conserving forests ?

Yes [ ] No [ ]

21. How much did you harvest the park resources during the grass-cutting season (2003) ?

Park resources	Load (Bhari)	kg./load
Firewood		
Khar (Thatch grass)		
Khadai (reed)		

22. What do you use this park resources?

Park resources	Purposes
Wood	
Khar	
Khadai	

23. Did your's members of the household participate to collect the park resources illegally during the rest of the months of the year (2003) ?

If no, why? .....

If yes, how many members participated ? ..... and which types of park resources collected and why ? ....
.....

24. Which types of park resources are more important ? Rank

Fire wood	Babiyo
Khar	Simthi
Khadai	Other

25. How much did you sell or buy the park resources ?

Park resources	Sell/buy	Load
Fire Wood		
Khar		
Khadai		

26. Do you satisfy with the establishment of Royal Chitwan National Park ?

a. yes [ ] b. no [ ]

27. What other resources would you like to be permitted to collect during the grass cutting season ?

Fire wood	Medicinal plants and herbs
Wild edible plants	Fish
Others	

28. Do you want to say about the grass cutting seasons and the Royal Chitwan National Park ?

.....

29. What are the prices of per load khar, Khadai and firewood ?

a. Khar [ ] b. Khadai [ ] c. Firewood [ ]

30. Do you know bio-diversity ?

Yes/No. .....

31. Do you satisfy with the establishment of Royal Chitwan National Park ?

a. Yes [ ] b. No [ ]

If yes, why ? .....

If no, why ? .....

32. Do you have any problem from Park animals ?

a. Yes [ ] b. No [ ]

33. What is the extent of crop damage caused by wildlife?

a. 25% [ ] b. 50% [ ] c. 75% [ ] d. 100% [ ]

34. Do you have any compensation scheme on crop damage ?

.....

35. Do you have any suggestions to improve the situation ?

.....

36. Do you satisfy with the establishment of community forest ?

a. Yes [ ] b. No [ ]

If yes, why ? .....

37. Does Community forest need extension? your opinion

a. Yes [ ] b. No [ ] ....

38. Importance of Grassland ?

.....

Plate 1: Researcher in the Research Field during phase 1 in the Community Grassland

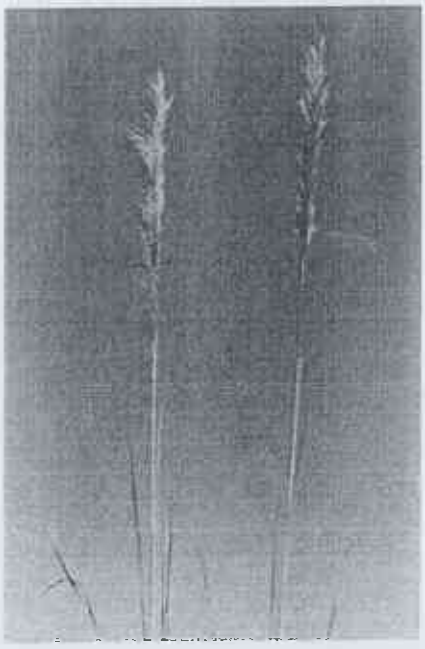


Plate 2: Booming *Succharum munja* attaining its maximum height in plot 1

Plate 3: Three-days grass cutting period-2003 in the National Park

Plate 4: A Tharu man with loads of *Imperata cylindrica*, a thatch grass for roofing

Plate 5: A Tharu woman carrying *Saccharum spontaneum*, from the National Park, of multi purpose use.

Plate 6: A type of fish-trap made up of reeds of *Saccharum spontaneum*.

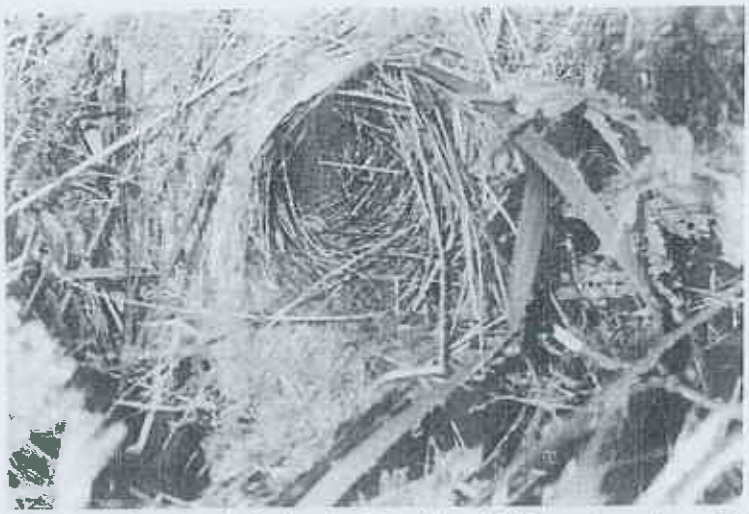


Plate 7: Grassland – A Prime habitat for different species of birds

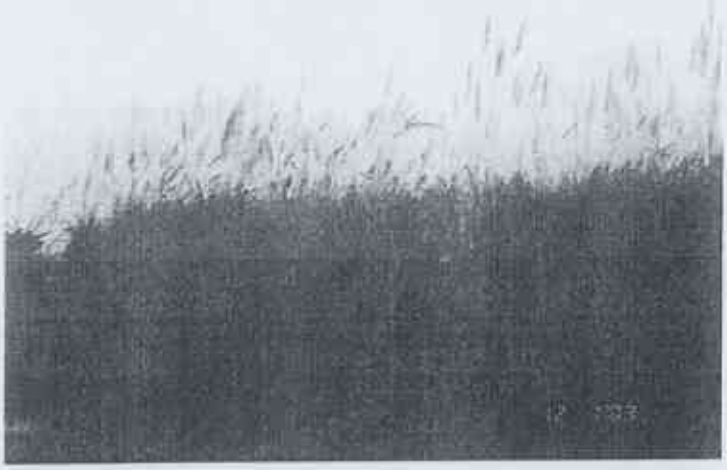


Plate 8: Succession – Short grasses being succeeded by tall grasses

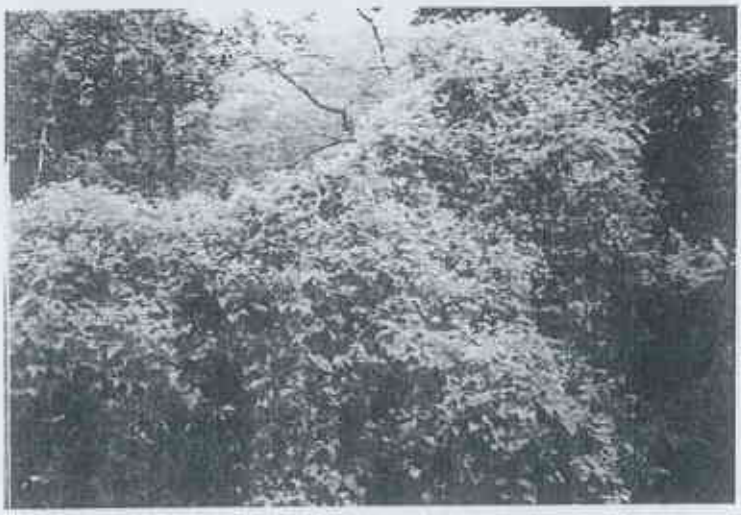


Plate 9: Succession - *Mikania micrantha* forming a thick complete mat covering grasslands, swamps, shrubs and forest lands.

Plate 10: Flooding – A rescued rhino baby at Tiger Tops – Chitwan during the monsoon - 2001

Plate 11: Poaching: A rhino killed by electric shock in the buffer zone area

Plate 12: Human casualty – A man-eater tiger shot by the Park authority, which had killed several local people in Madi area.