Herpetological Inventory of Sirdibas, Bihi and Prok VDCs of Manaslu Conservation Area, Gorkha District, Nepal

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DECLARATION

I hereby declare that the work presented in the thesis entitled **"Herpetological Inventory of Sirdibas, Bihi and Prok VDCs of Manaslu Conservation Area, Gorkha District, Nepal"** has been done by me. All sources of information have been specifically acknowledged by reference to the authors or institutions.

Biraj Shrestha

Date: October 2, 2013

An Undertaking of Bhaktapur Municipality

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LETTER OF APPROVAL

This dissertation entitled "**HERPETOLOGICAL INVENTORY OF SIRDIBAS, BIHI AND PROK VDCS OF MANASALU CONSERVATION AREA, GORKHA DISTRICT, NEPAL**" submitted by **Mr. Biraj Shrestha** has been carried out under our supervision. The entire work is based on the results of his research work and has not been submitted for any other degree and organization to the best of our knowledge. We recommend this dissertation work to be accepted for the partial fulfillment of Master of Science degree in Environmental Science.

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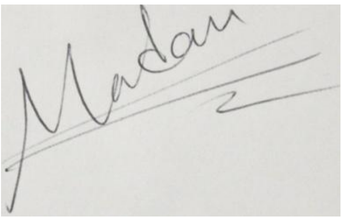
CONFIRMATION

This is to certify that the thesis entitled "**Herpetological Inventory of Sirdibas, Bihi and Prok VDCs of Manaslu Conservation Area, Gorkha District, Nepal**" has been carried out by Mr Biraj Shrestha for the partial fulfillment of Master's Degree in Environmental Science with special paper Biodiversity Conservation and Wildlife Management. This is his original work and I am pleased to assist him as joint supervisor.



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ABSTRACT

The Manaslu Conservation Area (MCA) is a biodiversity rich spot that harbors a wide variety of local flora and fauna, thus herpetofauna fall no apart to this diversity. A field study was carried out at the tail end of April 2012 for 15 days with the purposes of conducting an inventory of local herpetofauna in three Village Development Committees (VDCs) of MCA, recording their composition and abundance, studying their distribution pattern, relationship between species' abundance, elevation and ambient temperature, and ethnoherpetology of the area.

Rapid Rural Appraisal (RRA) was carried to figure out the potential areas of local herpetofauna. Species composition and abundance were recorded by adopting field survey methods like Visual Encounter Surveys, Patch Sampling, Dip netting and Opportunistic sampling. The checklist of species found in the area was prepared by triangulating data generated from all methods like Field survey, Photo-elicitation, Questionnaire survey, Key Person Interviews, Group Discussion and published literature. For spatial analysis, Global Positioning System (GPS) data acquired from the field were mapped in Arc GIS 9.3. Scatter plot, Regression analysis, one way ANOVA, Correlation analysis, Runs Test and Coefficient of variation were applied to analyze the relationship between abundance of herpetofauna with elevation and temperature. Likewise, ethnoherpetological information was garnered from local people using standard questionnaire sheets.

A checklist of 33 herpetofaunal elements has been created from this study, including 5 species of amphibian and reptile observed during the field survey. The total number of individuals encountered was 65 within an altitude range of 1438-2665 m. Of them, *Laudakia tuberculata* was detected mostly in all three VDCs of MCA. *Calotes versicolor* has been recorded at higher elevation (2512 m) in this study than adjacent Annapurna region mentioned in other literature and *Elaphe hodgsonii* is documented first time from the region.

There was moderate relationship (R=0.543) between abundance, elevation and temperature. Abundance decreased with increasing elevation (C=-0.532) while increased with rise in surrounding temperature (C=0.499). A regression equation $Y = 1.6404+0.0006X_1+0.0503X_2$ was developed from the taken data. Local people favor 'Paha' frogs due to their food and medicinal value and opine their decline at present. They strongly support for 'Paha' conservation before the species face extinction.

Key words: Herpetofauna, Manaslu Conservation Area, Ethnoherpetology, Inventory, Abundance, Elevation, Temperature, Regression

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Finally, I offer my sincerest gratitude deep down to my parents for the personality I've become and dedicate this piece of work to them.

Biraj Shrestha

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ACRONYMS & ABBREVIATIONS

ANOVA	Analysis of Variance
asl	above sea level
CARON	Companions for Amphibians and Reptiles of Nepal
CBO	Community Based Organization
CEPF	Critical Ecosystem Partnership Fund
CV	Coefficient of Variation
DDT	Dichloro Diphenyl Trichloroethane
Df	Degree of freedom
GIS	Geographic Information System
GO	Government Organization
GPS	Global Positioning System
ICRA	International Centre for development oriented Research in Agriculture
INGO	International Non-Governmental Organization
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KMTNC	King Mahendra Trust for Nature Conservation
MCA	Manaslu Conservation Area
MCAP	Manaslu Conservation Area Project
NGO	Non-Governmental Organization
NPWC	National Parks and Wildlife Conservation
NTNC	National Trust for Nature Conservation
p-value	Probability value
PVC	Poly Vinyl Chloride
RRA	Rapid Rural Appraisal
SPSS	Statistical Package for Social Sciences
VDC	Village Development Committee
VES	Visual Encounter Surveys

CHAPTER I

INTRODUCTION

1.1 Background of the Study

Herpetology is the science dealing with the life history of amphibians and reptiles. It encompasses a wide array of species falling under the classes of *Amphibia* and *Reptilia* viz. newts, salamanders, toads, frogs, crocodiles, turtles, lizards, skinks, snakes etc. All these animals are collectively known as herpetofauna that exhibit wide diversity and important components of any ecosystem. They are ectothermic or cold-blooded animals whose body temperature depends upon the ambient temperature (Shah & Tiwari, 2004). According to Schleich & Rai (2012a), Amphibians are divided into three orders; Gymnophiona (Caecilians), Caudata (tailed amphibians) and Anura (tailless amphibians) while reptiles have three orders; Crocodylia, Chelonians and Squamata. The order Squamata further categorized into two sub-orders; Sauria and Serpentes (Schleich & Rai, 2012a, 2012b).

Herpetofauna have colonized a variety of habitats ranging from hot lowland to the cold mountain summits, forests, swamps, trees, deserts etc, but their enigmatic nature & elusive character have resulted in limited study (Chettri, Acharya, & Bhupathy, 2011). Amphibians and reptiles hold special position on food web even regulating the number of other animals. According to Gibbons and Buhlmann (2001), salamanders specifically contribute more energy to the food chain than either birds or mammals. Herpetofauna have significant ecological roles like seed dispersal, forest litter decomposition and control of rodent population. They are even the indicators of environmental quality since amphibians are sensitive to moisture conditions because of their permeable skin while reptiles are influenced with external temperature fluctuations (Wang & Chan, 2008). Hence, their elaborated studies will shed the importance of herpetofauna and their commendable inputs in functioning of an ecosystem (Ahl & Hampton, 2010).

Till today, a total of 9,084 species of reptiles have been described (Uetz, 2010), yet they are poorly represented on the International Union for Conservation of Nature (IUCN)'s Red List of Threatened Species. There are about 6,300 species of amphibians world wide of which one-third (32%) species are threatened with extinction and 168 already gone extinct (Halliday, 2009). Among vertebrates, amphibians are most threatened and are declining rapidly while lack of conservation measures for these poorly understood creatures suggest more amphibian species will face extinction (Stuart et al., 2004). Reptiles are even facing the similar declines as amphibians in relation to taxonomic breadth, geographic scope and severity while the threat level is high in amphibians (42%) and low (20%) in reptiles (Bohm et al., 2013).

South Asian region harbors exceptionally rich diversity of herpetofauna including several unique and endemic species as the region shares two biogeographic realms – Palaearctic and Oriental (Shah & Tiwari, 2004). There are variations in total diversity of herpetofauna found in Nepal. Shah (1995) listed 43 species of amphibian and 100 species of reptile making a total of 143 species while Shrestha (2001) documented 59 amphibian species and 147 reptiles. The publication of Schleich and Kastle (2002) claimed 50 amphibian species and 123 reptiles. Likewise, Shah and Tiwari (2004) mentioned the occurrence of 190 species of herpetofauna in the country. The latest figure from Schleich and Rai (2012c) reported a total of 127 species of reptiles while 50 amphibian species from Nepal (Schleich & Rai, 2012a). Since the research and inventories regarding herpetofauna in the country is always underrated so their actual status is poorly known. Bhuju et al. (2007) in "Nepal Biodiversity Resource Book' stated one-third of the total number of herpeto species (65) are found outside the protected areas and claimed Central Terai-Siwaliks to harbor the highest number (45%). Further, the book indicated sixty-four species of herpetofauna (34% of total herpeto species) listed in the IUCN Red List, while fourteen endemic to Nepal. Under the National Parks and Wildlife Conservation (NPWC) Act 1973, three species of herpetofauna, viz. Gharial, Golden monitor and Asiatic rock python have been listed as protected species of Nepal (http://www.dnpwc.gov.np/protected-species.html).

1.2 Statement of the Problem

Nepal is biologically rich country often favored with high level of endemism and herpetofauna don't fall apart to this diversity. But in Nepal, herpetology remains the least studied subject in science while merely the Arun Valley, the Annapurna-Dhaulagiri region, and the Chitwan National Park have been extensively studied (Shah & Tiwari, 2004). As herpetofauna is the poorly studied group in the country, their present status is also poorly known (CEPF, 2005). There are scanty literature, information and research works regarding amphibians and reptiles compared to other species, besides only a limited knowledge exists on the importance of herpetofauna in Nepal. It is thus important to bridge the existing research gap and disseminate widely about these overlooked creatures for the unparalleled diversity they display and ecological roles they are designated for.

Bhuju et al. (2007) mentioned non availability of herpetofauna related information in Manaslu Conservation Area (MCA) however, the ‘Project Proposal for Mansalu Conservation Area’ (KMTNC, 1998) provided a checklist of 5 herpetofauna from an altitude of 1600-3700 m. These differences in figure can only find a consensus until and unless meticulous researches are carried out. In Nepal, amphibians and reptiles are distributed across a wide range of altitude from 80 m to 5,490 m (Shah & Tiwari, 2004). Mountains because of inaccessibility, isolated valleys, microclimatic variation and vegetation act as faunal barrier that provide niches to numerous life forms but restricts into limited study (Nanhoe & Ouboter, 1987). Scanty literature are available so far the high altitudinal herpetofauna are concerned, specifically from the eastern and western Himalayan region (Dutta, 1999). The spatial distribution studies of herpetofauna are necessary which even tell about altitudinal range of species and ecological niches. As amphibians and reptiles are ectotherms, their activity will be very much influenced by surrounding temperature. In this regard, the hypotheses set in this study were;

i. To determine whether the abundance of herpetofauna depended upon abiotic factors like elevation and ambient temperature?
ii. Were the sampled data (abundance, elevation & temperature) generated from a random process?

Since available space for all living beings are limited and with burgeoning human population many herpetofaunal elements interact with human communities. Hence, studies regarding variety of interaction between human cultures and herpetofauna, often called ethnoherpetology is necessary to understand threats caused by anthropogenic factors and even conservation issues (Alves et al., 2012).

1.3 Objectives

The general objective of this study is mainly to conduct an inventory of herpetofauna in three Village Development Committees (VDCs) of MCA.

The specific objectives of the study include;

- To document species composition and abundance of herpetofauna in the study area.
- To study their distribution in the area.
- To study herpetofauna and environmental (abiotic) factors such as elevation and temperature relationship.
- To conduct ethnoherpetology study of the area.

1.4 Limitations of the Study

Ioannidis (2007) affirmed that all research works have some limitations and it is important to acknowledge the limitations for they help in understanding the findings, making improvements further and ascribing credibility level. There were a few limitations in carrying out this research work. Firstly, I surveyed the study site from tail end of April to mid of May 2012, which is pre-monsoon season in Nepal, only 15% of the total rainfall occurs (Pradhan, 2007). Mostly amphibians are connected with water bodies and their predator reptiles even influenced by favorable summer temperature so the pre-monsoon survey might be the major limiting factor. Primary data collection was limited to trail survey only, due to rugged cliffs on either side of the trail. There were limitations on full coverage of the data like habitat analysis, soil and moisture conditions. Nubri is the first/much-spoken language of the local people so it was not easy to generate ethnoherpetology data from the respondents.

CHAPTER II

LITERATURE REVIEW

2.1 Herpetology – In course of Nepal's History

Nepal acts as an intervening zone between varying eastern and western Himalayan fauna while lies at the junction of four prime faunal units – Mediterranean and West Chinese sub regions of the Paleartic Region, Indian and Indo Chinese sub regions of the Oriental region (Swan & Leviton, 1962). Nepal thus harbors greater variety of life forms and favor high level of endemism and because of the isolated mountains with differing microclimates. This have always enthralled zoogeographers as stated by Nanhoe and Ouboter (1987) while claiming Nepalese herpetofauna comprised of Tibetan, Himalayan, Western Himalayan, Eastern Himalayan, Indo-Chinese & PanOriental & Indian species.

According to Shah & Tiwari (2004), the history of herpetological studies were first taken in Nepal during Hodgson's period of collection (1826-1854). Then came avid amphibian and reptile collectors like Hodgart (Boulenger, Annandale, Wall, & Regan, 1907) and Stevens (Boulenger, 1913), Smith and Battersby (1953), Swan and Leviton (1962) and others. Swan and Leviton (1962) had carried out detailed zoogeographical analysis and provided a good checklist of Nepal's herpetofauna that served useful reference for further studies. Other important contributions mentioned by Shah and Tiwari (2004) included works of Fleming and Fleming (1974), Kramer (1977), Nanhoe and Ouboter (1987), Shah (1995), Darevsky et al. (1997), Shrestha (2001), Schleich and Kastle (2002). Recent works include that of Shah & Tiwari (2004), Schleich and Rai (2012a, b, & c), and Sharma et al. (2013).

The earlier studies were of little use because locality data of amphibians and reptiles were inaccurate and incomplete (Nanhoe & Ouboter, 1987). Many open questions still linger although herpetological studies took place almost 200 years ago in Nepal (Schleich & Kastle, 2002). Likewise, Shah and Tiwari (2004) stressed much work need to be done in context of Nepal's herpetofauna despite having significant researches on herpetofauna's taxonomy, biology, ecology and distribution since Hodgson's collection. All the available literature have one thing in common, zoogeography of amphibians and reptiles while there are hardly any studies relating climate change and herpetofauna, their relation with abiotic factors and very few ethnoherpetological studies. Since South Asia harbor wide variety of herpetofauna, information regarding several taxonomic groups are lacking in accessible form thus limiting the conservation efforts (Pokhrel & Thakuri, 2010).

2.2 Distribution

Nepal is sandwiched between Palearctic region in the north and Oriental region in south, hence herpetofauna of Nepal make up majority of PanOriental-Indian species following Indo-Chinese, Himalayan, West Chinese and Mediterranean species. Altitudinal distribution by Swan and Leviton (1962) disclosed species occurrence from <1,000–14,000 ft while Mediterranean and West-Chinese species reaching to an altitude of 18,000 ft. Species richness is high in central Nepal, then in Eastern and Western Nepal according to Swan and Leviton (1962), further highlighted high diversity in eastern belts than western Nepal. Owing to favorable niches for a number of living forms including herpetofauna, in Nepal amphibians and reptiles are distributed from 80-5,490 m and embrace Palearctic, Oriental, Indo-Chinese and Himalayan elements (Shah and Tiwari, 2004). Likewise, Shrestha (2003) commented on the distribution of reptiles from lowland zone (sea level) to the trans-Himalayan Zone (3,636-5,455 m) but affirmed richness of species in forests of Terai, Chure, Bhabar and Siwalik. Bhuju et al. (2007) categorized species distribution from confinement and richness perspectives and claimed central Terai Siwalik region having highest number of herpetofauna. In almost the same way, Shah, Kharel, and Thapa (2011) asserted on the distribution of snakes from an altitude <100 m (lower Terai zone) to the high mountains of Himalayan zone (> 4,800 m) with highest diversity in Terai and Siwalik zone.

2.3 Thermal Ecology

Herpetofauna are cold-blooded animals since they don’t have heat insulating layer like in aves and mammals. They generate less heat to sustain themselves while in high external temperatures they are unable to control their body temperature as they don’t possess sweat glands. Thus, these ectothermic animals are largely controlled by the surrounding temperatures. On the other hand, reptiles (snakes) have a definite thermal range (4-38^{0}C) viable for survival and growth, temperatures < 2^{0}C makes them torpid while > 38^{0}C causes irreversible chemical change in proteins and may lead to death. However, the optimum temperature range for full/peak activity is from 21-37^{0}C (Parker & Grandison, 1977). Bickford et al. (2010) likewise, stated that for most lowland tropical herpetofauna, 38-42^{0}C is the lethal temperature range. The thermal tolerance for high land species is even narrower and most ectotherms functioning well at lower temperatures called thermal optimum.

2.4 Survey Techniques

Transect survey is much appropriate than quadrate survey when one tends to survey a variety of habitats in a patchy environment or along riverbanks. Bennett (1999) in his book 'Expedition Field Techniques' have opined that the encounter rate for diurnal species are comparatively high in transect surveys as of less disturbance while walking on a single direction. In a similar way, Hill et al. (2005) acclaimed transect survey to be effective for all reptile species except slow-worms. A transect of specified distance could simply be walked and species encountered are recorded or could involve intensive searching among the covers to increase the encounter rate however, amphibians transect are even set in the similar way as reptile transects.

Visual Encounter Surveys (VES) are most popular techniques for herpetofaunal surveys and documents species presence that involves walking along a designated area (transects, quadrats etc.) for prescribed time and visually searching the concerned species (Crump & Scott, 1994). Nevertheless, there are certain assumptions and limitations of visual encounter surveys that need to be addressed while opting for VES. Gillespie (1997) recommended the appropriate transect length as 500 m along the potential habitats.

There are particular species (amphibians and fossorial reptiles) restricted to specific microhabitats like bushes, logs, rocks, litter etc. these represent individual patches, and in whole represent quadrats. Thus for species limited to specific microhabitats, randomized patch sampling is appropriate (Lambert, 2008).

Fellers and Freel (1995) discussed about 'Dip netting' method suitable for larval and egg mass sampling in amphibians but finds equally applicable for frogs, fish, snakes and other aquatic invertebrates. The general rule is to sweep the dip net under the water on a regular basis and record the species if encountered accordingly. Australian Government's (2009) guideline advised dip nets to be effective in shallow water sampling of amphibians both for diurnal and nocturnal searches.

Opportunistic observation is a method which ensures inclusion of species found besides other standardized methodologies (Durkin, Steer, & Belle, 2011). This method is applicable for all kinds of survey while the basic notion is to record the subject visually when normal survey activities are not carried out.

2.5 Threats

Gibbons et al. (2000) highlighted six contributing factors; habitat destruction, disease and parasitism, pollution, global climate change, invasive species and overexploitation for the decline of amphibians and reptiles as outlined by the organization Partners in Amphibian and Reptile Conservation. In Nepal and adjoining nations apart from climate change/natural calamities, other main threats involve habitat destruction, habitat modification, land use change, over collection of species (mainly amphibians) for food and medicine. Shah and Tiwari (2004) reported clearance of well known '*charkose jhadi'* - Nepal's Terai forest and destruction of many pristine water bodies have led to the extinction of some unique herpetofauna. They also pinpointed the indiscriminate use of Dichloro Diphenyl Trichloroethane (DDT) in the 60s to eradicate malaria, hydropower dam construction, land use changes as local extinction of these species. Shah, Kharel, and Thapa (2011) specified about the threats to snakes as wanton killing (prime), illegal capture by snake charmers & illegal collection for hides, medicines, food etc.

2.6 Ethnoherpetology

Ethnoherpetology is a subdivision of ethnozoology that deals with variety of interactions between human cultures and herpetofauna (Alves et al., 2012). These traditional knowledge and folklore are storehouse of valuable information about the natural world and ideas, perceptions developed by human communities regarding communal species enable gathering new discoveries while may address the conservation problems (Ceríaco et al., 2011).

According to Shah and Tiwari (2004), herpetofauna has been considered and consumed by many ethnic communities as a source of food & medicine since early times in Nepal. They make up good supplement of protein while also serve for therapeutic purpose as medicines. On the other hand, most of the amphibians and reptiles reflect religious and cultural values in Hinduism and Buddhism. In mountains, mostly frogs from the genus Paa, are often consumed as important source of protein and presumed health benefits. They are eaten fresh or often smoke-dried for future use and remarkably supposed to cure human ailments (Shah, 2001). Certain ethnic groups like Musahar, some Tharus, Barahpanthe magar, Chamarmattha etc. consume non-poisonous snakes (python, boa, rat snakes etc.) and even their eggs as well (Shah et al., 2011).

2.7 Herpetofaunal studies in MCA

In 1998, then King Mahendra Trust for Nature Conservation (KMTNC) submitted a 'Project Proposal for Manaslu Conservation Area' which included a checklist of 5 herpetofauna in MCA. While the webpage of National Trust for Nature Conservation (www.ntnc.org.np) report the presence of three reptiles in MCA. A study conducted by Pokhrel and Thakuri (2010) claimed the presence of 16 species of amphibian and reptile, 12 from primary observations, while 4 from secondary sources. The authors however, did not infer about the altitudinal range of the recorded species.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Study Area

3.1.1 Location

Manaslu Conservation Area lies in Gorkha district – Western Nepal (Figure 1) with co-ordinates $28^0 20'24''$N - $28^0 45'00''$N and $84^0 28'48''$E - $85^0 11'24''$E. It has an area of 1,663km^2 with seven VDCs namely; Sirdibas, Chumchet, Chhekampar, Bihi, Prok, Lho and Samagaun. The whole region is solely managed by NTNC (Bhuju et al., 2007). Sirdibas is the lower VDC, south of MCA having an area of 330 sq. km and an altitude of 1420 m asl. On the other hand, Bihi and Prok VDCs are adjacent to Sirdibas with respective areas of 122 and 146 sq kms. Mean elevation of Prok VDC (2440m asl) is comparatively high than Bihi VDC i.e. 2110 m asl. Major settlements of Sirdibas include Jagat (entry point of MCA), Sirdibas, Philim, Eklebhati, Nyak etc. Likewise, human settlements in Prok VDC are found in Prok, Ghap and Namrung (Keshav Khanal pers. comm.). The MCA comprise of mountain peaks, high altitude lakes, rivers, pastures, forests, glaciers and cultivated lands. A total of 19 types of diverse ecosystem and 11 types of vegetation have been documented from the site (Bhuju et al., 2007).

3.1.2 Climate and Vegetation

There is wide variation in climate (temperature and precipitation) as the southernmost part offer tropical climate while the northern part is freezing cold throughout the year. According to Ranjitkar (2013), there are six different climatic zones; Tropical (< 1000 m), Sub-Tropical (1000-2000 m), Temperate (2000-3000 m), Sub-Alpine (3000-4000 m), Alpine (4000-5000 m) and Arctic climatic zone (>5000 m) in the region. However, Bhuju et al. (2007) mentioned occurrence of about 8 bioclimatic zones from Lower Sub-Tropical (1001-1500 m) to Nival (>5000 m) zone. The southern belt has an average temperature of 30^0C in summer and 10^0C in winter; on the other hand northern fringes remain below freezing point. Precipitation usually last from June to September as the summer monsoon (KMTNC, 1998) and the average rainfall in Southern Manaslu varies between 2,000-3,000 mm per year. Some of the phenomenal aspects of this region include; mountain peaks, high altitude lakes, rivers, pastures, forests, glaciers and cultivated lands. There are 19 types of diverse ecosystem and 11 types of vegetation in MCA (Bhuju et al., 2007). KMTNC (1998) documented the presence of 1500-2000 species of flowering plants, 19 types of forests and divided the vegetation of Manaslu into three categories based on altitude; Low hill, Middle mountain and High mountain vegetation.

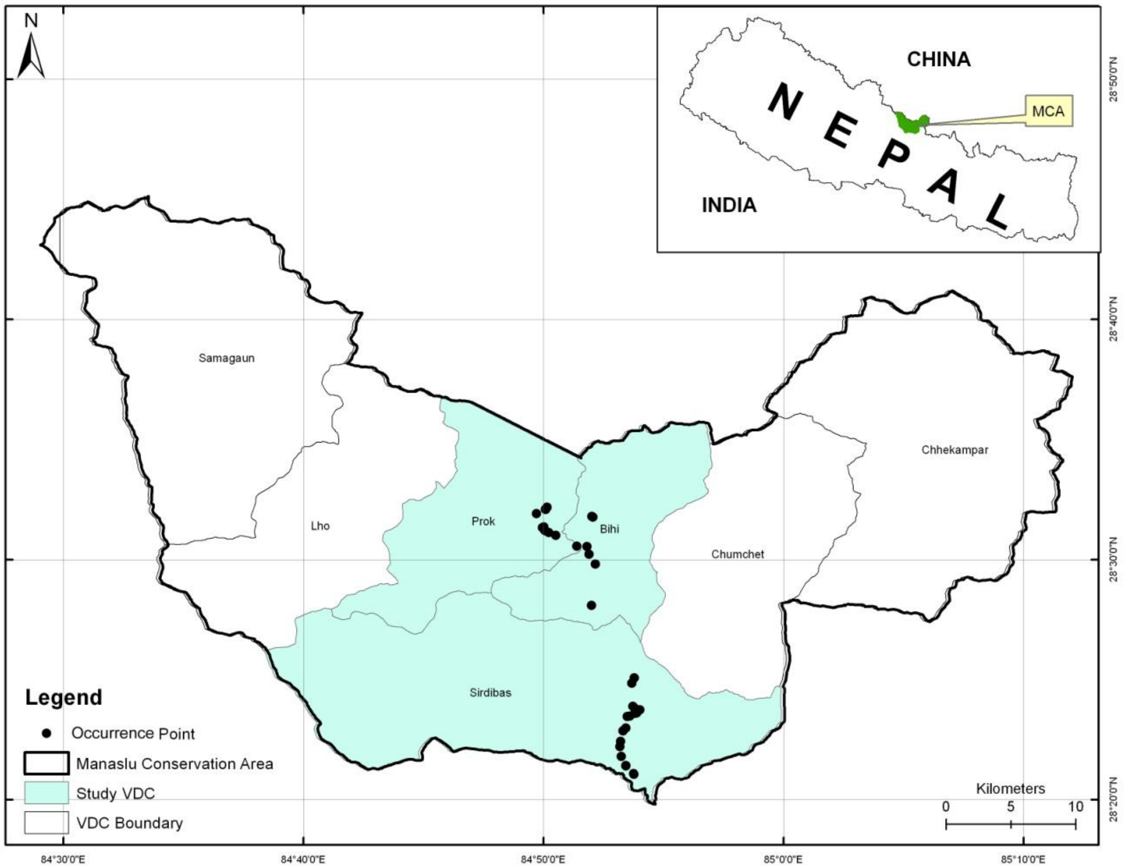

Figure 1: Location of the Study Area

3.1.3 Population and Household characteristics

The population density of Manaslu Conservation Area is 4 people/km^2. According to National Population and Housing Census 2011 Report, Sirdibas VDC has the highest households (572) following Bihi (208) and Prok (187). Total population of Sirdibas is 2510 (1171 male, 1339 female), Bihi and Prok have comparatively lower population; 612 (288 male, 324 female) and 575 (273 male, 302 female). The average family size in MCA is 3.5 person per household (CBS, 2012). KMTNC (1998) reported Bhotias (people of Tibetan origin) as the major ethnic group in MCA, apart from Sirdibas where Gurung and Karki are the major inhabitants. However, the Tibetans used 'Lamas' and 'Thakuris' as their caste. Languages spoken in Sirdibas are mainly Nepali and Gurung while in Bihi and Prok, Kutang and Tibetan are widely used. Agriculture and livestock rearing is the main occupation in all three VDCs, except Sirdibas where people are focused on hotel enterprise as the major income source (Keshav Khanal pers. comm..).

3.2 Research Design

Table 1: Overview of the research model

Broad objective	Specific objectives	Methods	Equipments/Materials
Inventory of herpetofauna in 3 VDCs of MCA.	To document species composition and abundance of herpetofauna in the study area.	➢ Transect Visual Encounter Survey (Crump & Scott, 1994) ➢ Patch Sampling – 25x25m^2 (Lambert, 2008) ➢ Dip netting (Fellers & Freel, 1995) ➢ Opportunistic Sampling (Durkin et al., 2011)	• GPS (Garmin) • Snake hook • Topographical Map • Metric tape • Gloves • Dip-net (20x20cm^2)
	To study herpetofauna distribution in the area.	➢ Mapping technique (Arc GIS 9.3)	• Camera (Sony Cybershot – DSC, W200)
	To study herpetofauna and environmental (abiotic) factors such as elevation and temperature relationship.	➢ Statistical analysis in SPSS 16.0	• Field Identification guide (Shah & Tiwari, 2004)
	To conduct ethnoherpetology study of the area.	➢ Questionnaire survey	• Questionnaire sheets

3.3 Sampling Procedure

Rapid Rural Appraisal (RRA) was opted to help the researcher understand rural life in a fairy limited time. RRA comprise of wide range of tools like Questionnaire surveys, Key Informant Interviews, Group Interviews, Direct Observations etc. (ICRA, 2007). Snowball sampling was carried out to identify relevant individuals for this research and they were asked to recommend like-minded people. Snowball sampling is a non-probability sampling technique where respondents who display a similar interest are selected (Hagai, 2006). Besides, convenience sampling was conducted along with snowball method in questionnaire survey to minimize time consumed for social survey. Convenience sampling collects information from respondents accessible and available to the researcher.

3.4 Sources and Types of Data

3.4.1 Primary Source

Primary data comprised of two integral parts of the research;

i. Intensive field survey
ii. Social survey

Field based methods involved in the research were determined after careful literature reviews suitable for the region. Transect VES, Patch Sampling, Dip netting, Opportunistic Sampling were the source for species account in the surveyed sites. On the other hand, social survey data were in the form of Questionnaire, Key Informant Interview and Group Discussion. However, direct observation was even included as primary data to help the researcher to validate the information from the respondents of the social survey.

3.4.2 Secondary Source

Almost every research is backed up by secondary data due to the limitations, and this research is no exception. Information regarding herpetofauna’s presence, diversity, richness, MCA location, Climate and Vegetation, Population and Household characteristics documented in literature formed the basis for secondary data.

3.5 Data Collection Techniques

3.5.1 Primary Data Collection

Reconnaissance (Literature Review)

Literature review was done with great attention in detail before the field visit to acquaint species assemblage of the area and also to deduce potential distribution of species in the study sites. The relevant publications helped to know about local climate, topography, ethnic composition and so forth.

Field Survey

After literature review, field survey was carried out at the tail end of April 2012 and continued for 15 days. Potential areas and habitats for herpetofauna were garnered using RRA tools like key person interviews, group interviews and direct observation. Jagat of Sirdibas VDC to Ghap of Prok VDC was surveyed for ocular observation of amphibians and reptiles. Transect VES was the main applied method among all four other surveying techniques in the field. A 500 m transect walk was conducted at the main trail of MCA in the selected VDCs. Species encountered during the transect walk were noted down in the field data sheet along with other requisite information like the GPS coordinates, elevation and also the ambient air temperature was recorded. In case of non-detection, probable refuges like under logs, rocks, branches and litters were searched to increase the possibility of detection.

Patch sampling was carried out in the Ghap region of Prok VDC because of its plateau like terrain. A 25x25 m^2 quadrat was laid in the preselected sites and the patches (particular microhabitats) were searched carefully for presence of the species. In case of species observation, necessary information were taken and the overturned rocks, logs etc were placed back to normal. Dip netting was conducted in a brook near the entry point of Prok village as strong currents of Budigandaki river throughout all the places, however it was unfavorable for amphibian detection. In addition to this, species that were encountered besides normal survey activities were also recorded opportunistically, often called opportunistic sampling.

Photo-elicitation

Bignante (2010) advocates Photo-elicitation as widely known technique of data gathering in sociology that involves showing images and other types of visual interpretation in an interview. The respondents were asked to comment upon them however, the images used could be taken by the researcher or have collected from secondary sources. Photo-elicitation method stimulates respondents to share their association with the subject in image displayed, often acts as guides and facilitates research (Petersen & Østergaard, 2003). Nevertheless, they are useful adjuncts to questionnaire and interviews that further help to validate the research findings.

Questionnaire survey

Ethnoherpetological information have been gathered mainly using open-ended, few close-ended and dichotomous questions. Standard questionnaires were developed to generate people's perception on the local herpetofauna, their significance and use, hunting, underlying threats, status etc. All the questions in English language were translated into Nepali before the survey began while in Prok a translator/local expert was hired as interpreter due to language barrier. Both snowball and convenience samplings were applied for questionnaire survey in the study sites.

Key Person Interview

Key Person in this survey involved local 'Amchi' – traditional healer of Prok Village and youths who had prior experience of fish and 'Paha' hunting in the region. Likewise, informal interview was made with Manaslu Conservation Area Project (MCAP)'s office staff in order to infer the probable location of herpetofauna, their significance, threats and exploitation trends.

Group Discussion

This was carried out in Prok village with family members of a local 'Amchi' – Mr Dorje Thakuri as to garner much information about local herpetofauna and their significance to humans as food and medicines prepared according to Tibetan scriptures.

Direct Observation

Wandering around at the site was carried out to recognize anthropogenic pressure on natural resources (forests, water bodies). Paha collection was not observed throughout the trip while evidence regarding humans' hostility with herpetofauna became clear as a dead snake crushed completely its head was found in the main trail of Sirdibas. This method helped to cross-check and verifies the results obtained from respondents via ocular observation.

3.5.2 Secondary Data Collection

I collected secondary data from various sources like available published literature found in NTNC library, MCAP Office (Philim), research papers on the internet, reports from Natural History Museum, Swayambhu, Kathmandu and other similar publications.

3.6 Data Analysis Tools

According to the prime purpose of this research – herpetological inventory, priority was given on the preparation of a checklist regarding Manaslu's herpetofauna. Hence, 'Triangulation Method' was adopted to increase the validity of research findings and combines both qualitative and quantitative approach (Yeasmin & Rahman, 2012).

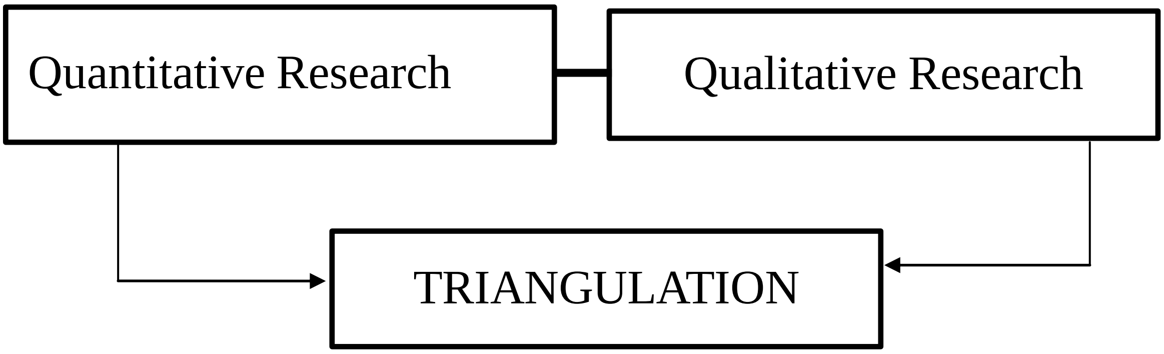

Figure 2: Concept of Triangulation Model

In this research, Data Triangulation technique among other triangulation methods was used for validation purpose. Its basic principle is to collect data from multiple sources in the same study for greater validation of the findings (Hussein, 2009). Triangulation technique is widely used in social science but even finding application in other fields.

For spatial distribution of the amphibians and reptiles, species encounter maps were created using Arc GIS 9.3. Regarding environmental variables, species relation was examined using statistical tool – Statistical Package for Social Sciences (SPSS) 16.0 along with other calculations. Data of ethnoherpetology were calculated and interpreted using Microsoft Office Word 2007.

CHAPTER IV

RESULTS AND ANALYSIS

4.1 Species Diversity

4.1.1 Field Survey

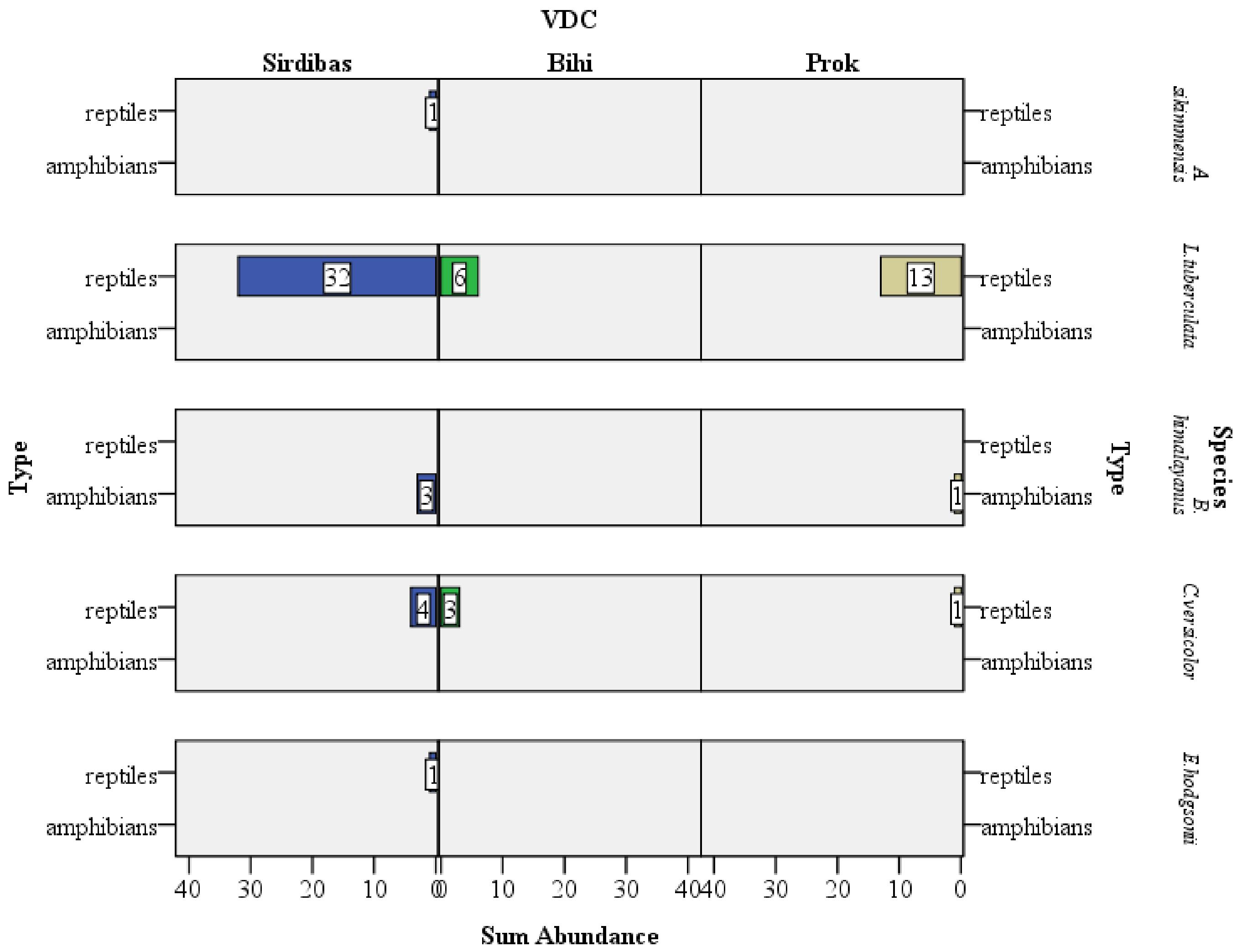

Figure 3: Population pyramid of herpetofauna observed in three VDCs of MCA

The above figure depicts population pyramid of herpetofauna encountered during survey throughout the three VDCs, viz. Sirdibas, Bihi and Prok of Manaslu Conservation Area. Altogether 5 species (*Asymblepharus sikimmensis, Laudakia tuberculata, Bufo himalayanus, Calotes versicolor versicolor* & *Elaphe hodgsonii)* were recorded and their individuals totaled 65. High abundance of herpetofauna was observed in Sirdibas VDC i.e. 41 and all 5 different species of amphibian and reptile were encountered there. Among them, the highest number (32) was of *Laudakia tuberculata* and then of *Calotes versicolor* (4). 3 individuals of Himalayan toad – *Bufo himalayanus* were found in Philim and Chisapani of Sirdibas VDC. One skink - *Asymblepharus sikimmensis* was recorded from the farmland while a non-venomous snake, *Elaphe hodgsonii* was observed dead along the trail of Manaslu Conservation Area in Sirdibas VDC.

In Bihi VDC, 9 individuals of reptile were recorded out of which 6 individuals were *Laudakia tuberculata* and the rest (3) were individuals of *Calotes versicolor*. However, no live sightings of amphibians, skinks and serpents were observed in Bihi VDC.

The abundance of herpetofauna in Prok VDC was 15, a bit high than Bihi VDC (9) in reference to the methodology opted in that region. The highest abundance was of *Laudakia tuberculata* (13) while *Calotes versicolor* with just a single observation. In addition, *Bufo himalayanus* had been observed near a cascade in Prok village.

Table 2: Checklist of herpetofauna encountered in MCA throughout the field survey

S. No.	**Scientific Name**	**Common Name**	**Nepali/Vernacular name**	**No. of Individuals recorded**	**Encountered Elevation (in m)**
AMPHIBIAN (TOAD)					
1	*Bufo himalayanus* (Gunther, 1894)	Himalayan Toad	Khasre bhyaguto	4	1601-2250
REPTILES (LIZARDS, SKINK & SNAKE)					
2	*Calotes versicolor versicolor* (Daudin, 1802)	Common garden lizard	Chheparo, Girgit	8	1484-2512
3	*Laudakia tuberculata* (Hardwicke & Gray, 1827)	Himalayan rock lizard	Chheparo, Patharchatuwa	51	1438-2665
4	*Asymblepharus sikimmensis* (Blyth, 1853)	Sikkim skink	Bhanemungro	1	1682
5	*Elaphe hodgsonii* (Gunther, 1860)	Himalayan trinket snake	Sarpa, Wayana	1	1470

4.1.2 Photo-elicitation Survey

Colorful pictures of herpetofauna published in ‘Herpetofauna of Nepal’ and some old photographic plates were shown to the respondents during the questionnaire survey. The purpose was to elicit information on presence of potential herpetofauna in the region. As many as 30 respondents, admitted to have seen following amphibians and reptiles in their region.

Table 3: Checklist of herpetofauna recorded through the photo-elicitation survey

S. No.	Species Scientific Name	Common Name	Nepali/Vernacular Name
1	*Bufo himalayanus* (Gunther, 1894)	Himalayan toad	Khasre Bhyaguto
2	*Bufo melanostictus* (Schneider, 1799)	Black-spined toad	Khasre Bhyaguto
3	*Bufo microtympanum* (Boulenger, 1882)	Small-eared toad	Khasre Bhyaguto
4	*Bufo stomaticus* (Lutken, 1862)	Marbled toad	Khasre Bhyaguto
5	*Megophrys parva* (Boulenger, 1893)	Myanmar pelobatid toad	Dyang paha
6	*Amolops formosus* (Gunther, 1875)	Beautiful stream frog	Hariyo paha
7	*Amolops monticola* (Anderson, 1871)	Montane stream frog	Kalo paha
8	*Chaparana sikimensis* (Jerdon, 1870)	Sikkimese frog	Rato paha
9	*Euphlyctis cyanophlyctis* (Schneider, 1799)	Skittering frog	Dholbaje paha
10	*Limnonectes nepalensis* (Dubois, 1975)	Nepalese cricket frog	Tyang Tyang paha
11	*Paa annandalii* (Boulenger, 1920)	Annandale's frog	Bhyaguto
12	*Paa blanfordii* (Boulenger, 1882)	Blandford's paa frog	Paha
13	*Paa liebigii* (Gunther, 1860)	Liebig's frog	Man paha
14	*Paa polunini* (Smith, 1951)	Langtang frog	Sano paha
15	*Polypedates maculates* (Gray, 1834)	Common Indian tree frog	Rukh bhyaguto
16	*Calotes versicolor versicolor* (Daudin, 1802)	Common garden lizard	Chheparo
17	*Laudakia tuberculata* (Hardwicke & Gray, 1827)	Himalayan rock lizard	Chheparo
18	*Oriotiaris tricarinatus* (Blyth, 1854)	Three-keeled mountain lizard	Hariyo chheparo
19	*Asymblepharus himalayanus* (Gunther, 1864)	Himalayan ground skink	Bhanemungro
20	*Asymblepharus sikimmensis* (Blyth, 1853)	Sikkim skink	Bhanemungro
21	*Mabuya carinata* (Schneider, 1801)	Brahminy skink	Bhanemungro
22	*Amphiesma platyceps* (Blyth, 1854)	Mountain keelback	Chankhe sarpa
23	*Boiga multifasciata* (Blyth, 1861)	Himalayan cat snake	Sarpa
24	*Oligodon erythrogaster* (Boulenger, 1907)	Red-bellied kukri snake	Sarpa
25	*Xenochrophis sanctijohannis* (Boulenger, 1890)	St. John's keelback water snake	Panisanp
26	*Gloydius himalayanus* (Gunther, 1864)	Himalayan pit viper	Andho sarpa
27	*Ovophis monticola monticola* (Gunther, 1864)	Mountain pit viper	Andho sarpa
28	*Trimeresurus albolabris* (Gray, 1842)	White-lipped pit viper	Haryousarpa

4.1.3 Key Person Interview

Snowball sampling method helped to identify key informants of this research. One of them was an ‘Amchi’ – the traditional local healer of Prok village named Dorje Thakuri while the other was a local expert in fish and Paha hunting, named Chimik Namgyal of the same village. Herpetofauna recognized by them during the interview are as follows;

Table 4: Checklist of herpetofauna according to KPI (Mr Dorje Thakuri)

S. No.	Species Scientific Name	Common Name	Nepali/Vernacular Name
1	*Bufo himalayanus* (Gunther, 1894)	Himalayan toad	Khasre Bhyaguto
2	*Bufo melanostictus* (Schneider, 1799)	Black-spined toad	Khasre Bhyaguto
3	*Bufo microtympanum* (Boulenger, 1882)	Small-eared toad	Khasre Bhyaguto
4	*Chaparana sikimensis*(Jerdon, 1870)	Sikkimese frog	Rato paha
5	*Limnonectes nepalensis*(Dubois, 1975)	Nepalese cricket frog	Tyang Tyang paha
6	*Paa blanfordii*(Boulenger, 1882)	Blandford's paa frog	Paha
7	*Paa liebigii* (Gunther, 1860)	Liebig's frog	Man paha
8	*Polypedates maculates*(Gray, 1834)	Common Indian tree frog	Rukh bhyaguto
9	*Laudakia tuberculata* (Hardwicke & Gray, 1827)	Himalayan rock lizard	Chheparo
10	*Oriotiaris tricarinatus* (Blyth, 1854)	Three-keeled mountain lizard	Hariyo chheparo
11	*Asymblepharus himalayanus* (Gunther, 1864)	Himalayan ground skink	Bhanemungro
12	*Asymblepharus sikimmensis* (Blyth, 1853)	Sikkim skink	Bhanemungro
13	*Mabuya carinata* (Schneider, 1801)	Brahminy skink	Bhanemungro
14	*Amphiesma platyceps* (Blyth, 1854)	Mountain keelback	Chankhe sarpa
15	*Boiga multifasciata* (Blyth, 1861)	Himalayan cat snake	Sarpa
16	*Elaphe hodgsonii* (Gunther, 1860)	Himalayan trinket snake	Sarpa
17	*Oligodon erythrogaster* (Boulenger, 1907)	Red-bellied kukri snake	Sarpa
18	*Gloydius himalayanus* (Gunther, 1864)	Himalayan pit viper	Andho sarpa
19	*Ovophis monticola monticola* (Gunther, 1864)	Mountain pit viper	Andho sarpa
20	*Trimeresurus albolabris* (Gray, 1842)	White-lipped pit viper	Haryousarpa

Table 5: Checklist of herpetofauna according to KPI (Mr Chimik Namgyal)

S. No.	Species Scientific Name	Common Name	Nepali/Vernacular Name
1	*Bufo himalayanus* (Gunther, 1894)	Himalayan toad	Khasre Bhyaguto
2	*Bufo melanostictus* (Schneider, 1799)	Black-spined toad	Khasre Bhyaguto
3	*Bufo stomaticus*(Lutken, 1862)	Marbled toad	Khasre Bhyaguto
4	*Megophrys parva* (Boulenger, 1893)	Myanmar pelobatid toad	Dyang paha
5	*Amolops monticola*(Anderson, 1871)	Montane stream frog	Kalo paha
6	*Euphlyctis cyanophlyctis*(Schneider, 1799)	Skittering frog	Dholbaje paha
7	*Paa annandalii*(Boulenger, 1920)	Annandale's frog	Bhyaguto
8	*Paa blanfordii*(Boulenger, 1882)	Blandford's paa frog	Paha
9	*Paa liebigii* (Gunther, 1860)	Liebig's frog	Man paha
10	*Polypedates maculates*(Gray, 1834)	Common Indian tree frog	Rukh bhyaguto

11	*Calotes versicolor versicolor* (Daudin, 1802)	Common garden lizard	Chheparo
12	*Laudakia tuberculata* (Hardwicke & Gray, 1827)	Himalayan rock lizard	Chheparo
13	*Oriotiaris tricarinatus* (Blyth, 1854)	Three-keeled mountain lizard	Hariyo chheparo
14	*Asymblepharus himalayanus* (Gunther, 1864)	Himalayan ground skink	Bhanemungro
15	*Asymblepharus sikimmensis* (Blyth, 1853)	Sikkim skink	Bhanemungro
16	*Amphiesma platyceps* (Blyth, 1854)	Mountain keelback	Chankhe sarpa
17	*Boiga multifasciata* (Blyth, 1861)	Himalayan cat snake	Sarpa
18	*Elaphe hodgsonii (Gunther, 1860)*	Himalayan trinket snake	Sarpa
19	*Oligodon erythrogaster* (Boulenger, 1907)	Red-bellied kukri snake	Sarpa

4.1.4 Group Interview

Family members of Dorje Thakuri in Prok village were interviewed to get the possible checklist of local herpetofauna in their region. The group was targeted for interview owing to their higher knowledge comparing to other village dwellers. Since, photo-elicitation technique was major for species documentation, six family members provided their best knowledge/experience to identify species in their vicinity. The checklist thus prepared is comprised of only 12 species of herpetofauna.

Table 6: Checklist of herpetofauna according to Group Interview

S. No.	**Species Scientific Name**	**Common Name**	**Nepali/Vernacular Name**
1	*Bufo himalayanus* (Gunther, 1894)	Himalayan toad	Khasre Bhyaguto
2	*Bufo melanostictus* (Schneider, 1799)	Black-spined toad	Khasre Bhyaguto
3	*Paa liebigii* (Gunther, 1860)	Liebig's frog	Man paha
4	*Calotes versicolor versicolor* (Daudin, 1802)	Common garden lizard	Chheparo
5	*Laudakia tuberculata* (Hardwicke & Gray, 1827)	Himalayan rock lizard	Chheparo
6	*Asymblepharus himalayanus* (Gunther, 1864)	Himalayan ground skink	Bhanemungro
7	*Asymblepharus sikimmensis* (Blyth, 1853)	Sikkim skink	Bhanemungro
8	*Mabuya carinata (Schneider, 1801)*	Brahminy skink	Bhanemungro
9	*Amphiesma platyceps* (Blyth, 1854)	Mountain keelback	Chankhe sarpa
10	*Elaphe hodgsonii (Gunther, 1860)*	Himalayan trinket snake	Sarpa
11	*Oligodon erythrogaster* (Boulenger, 1907)	Red-bellied kukri snake	Sarpa
12	*Ovophis monticola monticola* (Gunther, 1864)	Mountain pit viper	Andho sarpa

4.1.5 Secondary Data

There are three publications related to MCA herpetofauna, all the species documented in those literature have been incorporated as secondary data. The presence of 28 amphibians and reptiles have been recorded from three documents i.e. MCAP Proposal (KMTNC, 1998), Herpetofauna of Nepal (Shah & Tiwari, 2004) and Quick survey of herpetofauna – Companion for Amphibians and Reptiles of Nepal (CARON)'s report (Pokhrel & Thakuri, 2010).

Table 7: Checklist of herpetofauna according to secondary sources

S. No.	Species Scientific Name	Common Name	Nepali/Vernacular Name	Source
1	*Bufo himalayanus* (Gunther, 1894)	Himalayan toad	Khasre Bhyaguto	K,H,C
2	*Bufo melanostictus* (Schneider, 1799)	Black-spined toad	Khasre Bhyaguto	H
3	*Bufo microtympanum* (Boulenger, 1882)	Small-eared toad	Khasre Bhyaguto	H,C
4	*Bufo stomaticus*(Lutken, 1862)	Marbled toad	Khasre Bhyaguto	H,C
5	*Amolops formosus*(Gunther, 1875)	Beautiful stream frog	Hariyo paha	C
6	*Chaparana sikimensis*(Jerdon, 1870)	Sikkimese frog	Rato paha	H,C
7	*Euphlyctis cyanophlyctis*(Schneider, 1799)	Skittering frog	Dholbaje paha	H
8	*Limnonectes nepalensis*(Dubois, 1975)	Nepalese cricket frog	Tyang Tyang paha	H
9	*Paa blanfordii*(Boulenger, 1882)	Blandford's paa frog	Paha	C
10	*Paa liebigii* (Gunther, 1860)	Liebig's frog	Man paha	K,H,C
11	*Paa polunini* (Smith, 1951)	Langtang frog	Sano paha	H
12	*Paa rostandi (Dubois, 1974)*	Mostanh frog	Sindhure paha	H
13	*Calotes versicolor versicolor* (Daudin, 1802)	Common garden lizard	Chheparo	H,C
14	*Laudakia tuberculata* (Hardwicke & Gray, 1827)	Himalayan rock lizard	Chheparo	K,H,C
15	*Oriotiaris tricarinatus* (Blyth, 1854)	Three-keeled mountain lizard	Hariyo chheparo	C
16	*Asymblepharus sikimmensis* (Blyth, 1853)	Sikkim skink	Bhanemungro	H,C
17	*Mabuya carinata* (Schneider, 1801)	Brahminy skink	Bhanemungro	H
18	*Varanusbengalensis (Daudin, 1802)*	Bengal Monitor	Bhainse gohoro	H
19	*Pythonmolurus bivittatus (Kuhl, 1820)*	Burmese rock python	Ajingar	H
20	*Amphiesma platyceps* (Blyth, 1854)	Mountain keelback	Chankhe sarpa	H,C
21	*Amphiesma stolatum* (Linnaues, 1758)	Buff-striped keelback	Harara	H

22	*Boiga multifasciata* (Blyth, 1861)	Himalayan cat snake	Sarpa	C
23	*Elaphe hodgsonii* (Gunther, 1860)	Himalayan trinket snake	Sarpa	H,C
24	*Oligodon erythrogaster* (Boulenger, 1907)	Red-bellied kukri snake	Sarpa	K,H,C
25	*Xenochrophis sanctijohannis* (Boulenger, 1890)	St. John's keelback water snake	Panisanp	H
26	*Gloydius himalayanus* (Gunther, 1864)	Himalayan pit viper	Andho sarpa	H
27	*Ovophis monticola monticola* (Gunther, 1864)	Mountain pit viper	Andho sarpa	H
28	*Trimeresurus albolabris* (Gray, 1842)	White-lipped pit viper	Haryousarpa	H,C

Legend: K = KMTNC (1998), H = Herpetofauna of Nepal, C = CARON

4.1.6 Data Triangulation

The amphibians and reptiles related data have been collected from different sources; field survey, photo-elicitation, key person interview, group interview and publications. They were categorized from the viewpoint of nature of data as; quantitative and qualitative. Quantitative data were those obtained from field survey and publications which were empirical in nature while qualitative data comprised of information garnered from key person interviews, group interview and photo-elicitation technique. Quantitative data make up 43% of the total data gathered throughout the study and they are a bit less than the qualitative data (57%).

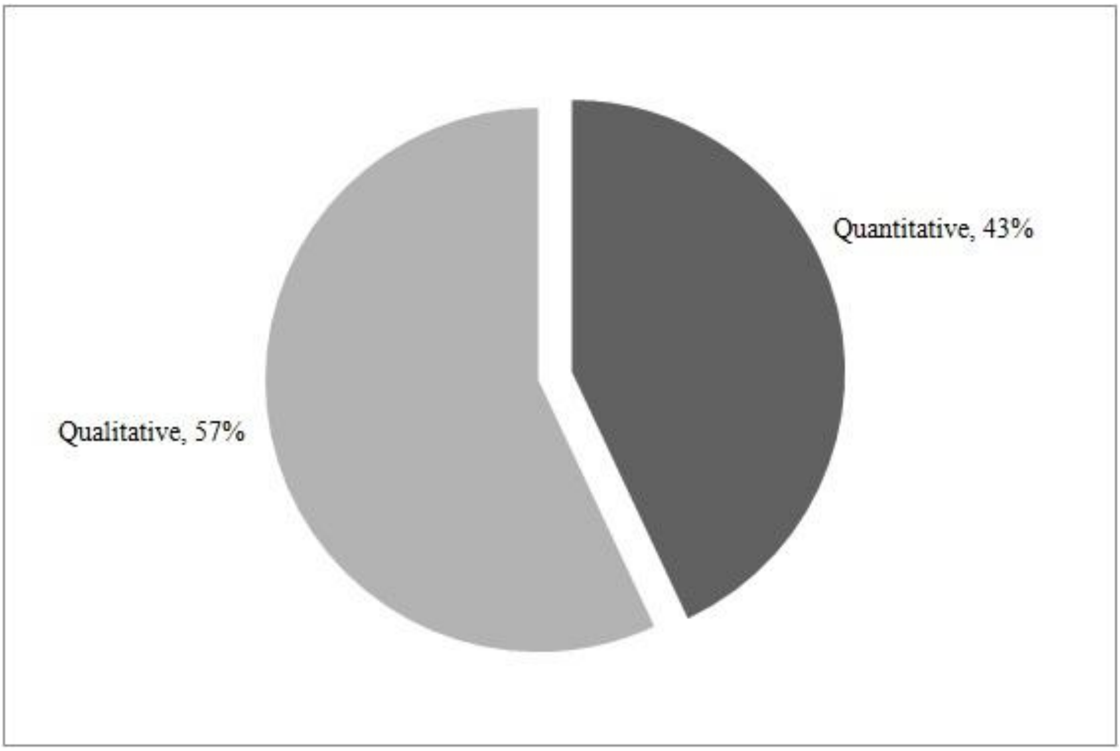

Figure 4: Nature of the data

Data triangulation is the technique of gathering data from various sources and converge them in order to increase the validity of results. Based on this and the expert's verification, a checklist of 33 species of amphibian and reptile was prepared. Thus occurrence 33 species of herpetofauna (16 amphibian species and 17 reptile species) is confirmed in the MCA.

Table 8: Checklist of herpetofauna of MCA obtained from the data triangulation.

S. No.	**Species**	**FS**	**PE**	**KPI**		**GI**	**K**	**HoN**	**C**	**E**
				Dorje	*Chimik*					
	Amphibians									
	Family: Bufonidae									
1	*Bufo himalayanus*	X	X	X	X	X	X	X	X	X
2	*Bufo melanostictus*		X	X	X	X		X		X
3	*Bufo microtympanum*		X	X				X	X	X
4	*Bufo stomaticus*		X		X			X	X	X
	Family: Megophryidae									
5	*Megophrys parva*		X		X					X
	Family: Ranidae									
6	*Amolops formosus*		X						X	X
7	*Amolops monticola*		X		X					X
8	*Chaparana sikimensis*		X	X				X	X	X
9	*Euphlyctis cyanophlyctis*		X		X			X		X
10	*Limnonectes nepalensis*		X	X				X		X
11	*Paa annandalii*		X		X					X
12	*Paa blanfordii*		X	X	X				X	X
13	*Paa liebigii*		X	X	X	X	X	X	X	X
14	*Paa polunini*		X					X		X
15	*Paa rostandi*							X		X
	Family: Rhacophoridae									
16	*Polypedates maculates*		X	X	X					X
	Reptiles									
	Family: Agamidae									
17	*Calotes versicolor versicolor*	X	X		X	X		X	X	X
18	*Laudakia tuberculata*	X	X	X	X	X	X	X	X	X
19	*Oriotiaris tricarinatus*		X	X	X				X	X
	Family: Scincidae									
20	*Asymblepharus himalayanus*		X	X	X	X				X
21	*Asymblepharus sikimmensis*	X	X	X	X	X		X	X	X
22	*Mabuya carinata*		X	X		X		X		X
	Family: Varanidae									
23	*Varanus bengalensis*							X		X
	Family: Boidae									
24	*Python molurus bivittatus*							X		X
	Family: Colubridae									
25	*Amphiesma platyceps*		X	X	X	X		X	X	X
26	*Amphiesma stolatum*							X		X
27	*Boiga multifasciata*		X	X	X				X	X

28	*Elaphe hodgsonii*	X		X	X	X		X	X	X
29	*Oligodon erythrogaster*		X	X	X	X	X	X	X	X
30	*Xenochrophis sanctijohannis*		X					X		X
	Family: Viperidae									
31	*Gloydius himalayanus*		X	X				X		X
32	*Ovophis monticola monticola*		X	X		X		X		X
33	*Trimeresurus albolabris*		X	X				X	X	X

Legend: FS = Field Survey, PE = Photo-elicitation, KPI = Key Person Interview, GI = Group Interview, K = KMTNC, HoN = Herpetofauna of Nepal, C = CARON, E = Expert (Prof Karan Bahadur Shah)

4.2 Distribution of herpetofauna in the area

Species occurrence points noted via GPS (Garmin) were plotted in GIS (Arc 9.3) to produce species distribution maps of the surveyed region. Ocular observations of amphibians and reptiles have been successful from the entry point of MCA – Jagat, Sirdibas VDC to Ghap of Prok VDC. Altitudinal ranges of encountered species were from 1438 m to 2665 m and species detection was possible due to adoption of various herpetofaunal surveying techniques. Since trail survey was carried out, species occurrence points (Figure 6) can be seen adjacent to rivers of the region. Species distribution is a bit of clumped in Sirdibas, from Jagat to Philim. Often, human settlements having crevices were found to be dwelt by species *Laudakia tuberculata* with good abundance. In Prok, this species was found to be uniformly distributed across different locations like settlements, farmlands, forests, outcrops etc.

No publication has yet provided species distribution maps of herpetofauna in MCA hence, there is wide scope of the areas to be explored for this purpose. Maps plotted for this study are of three types regarding the distribution of herpetofauna and delineates actual encounter spots during the field survey.

The VDC wise map (Figure 5) gives comparative information on the distribution of species among Sirdibas, Bihi and Prok VDCs. Herpetofauna recorded in the entire study area is provided on Figure 6. Field methods used for herpetofauna detection of the study area have also been delineated on Figure 7.

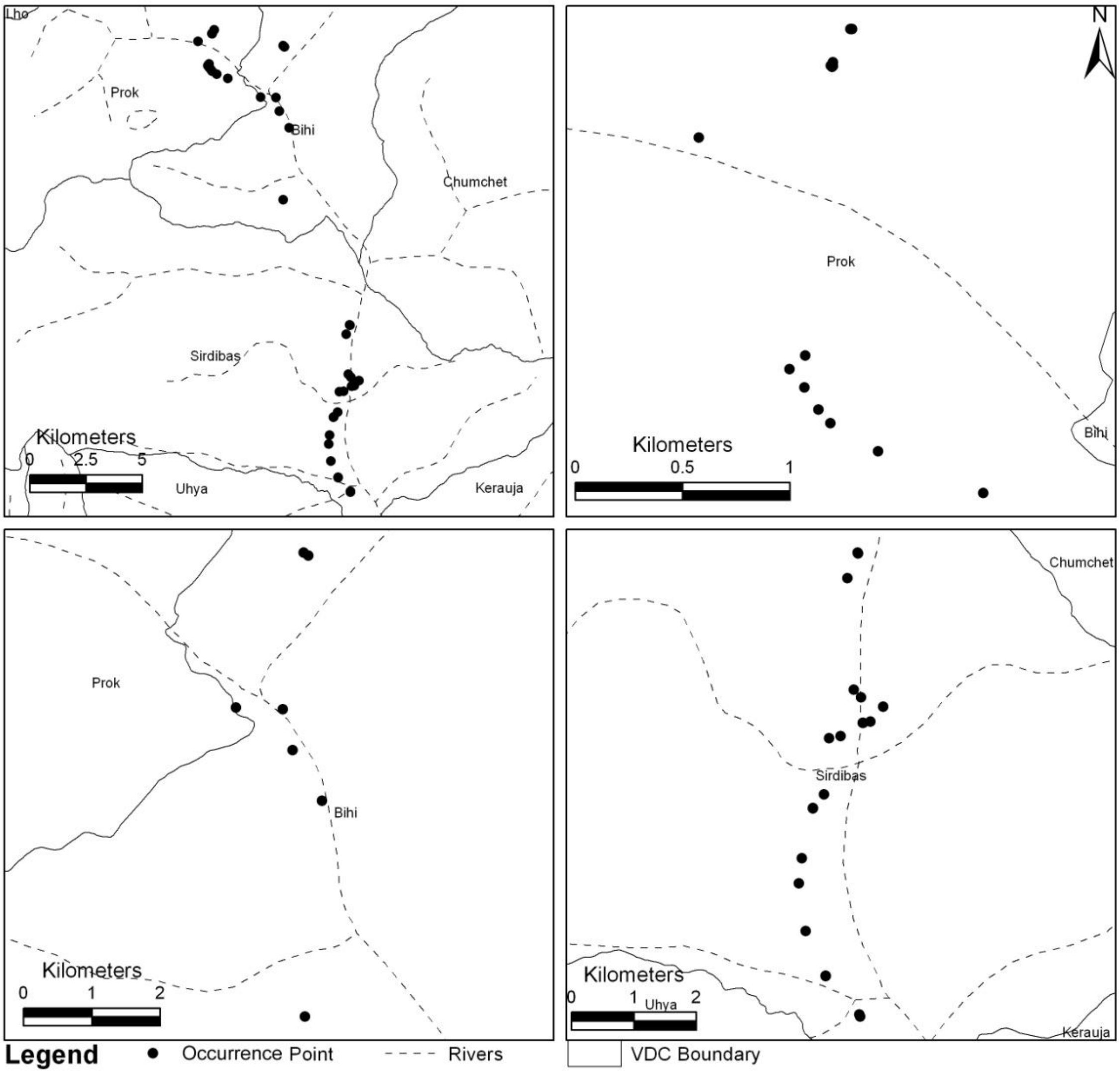

Figure 5: Distribution of herpetofauna according to the VDCs

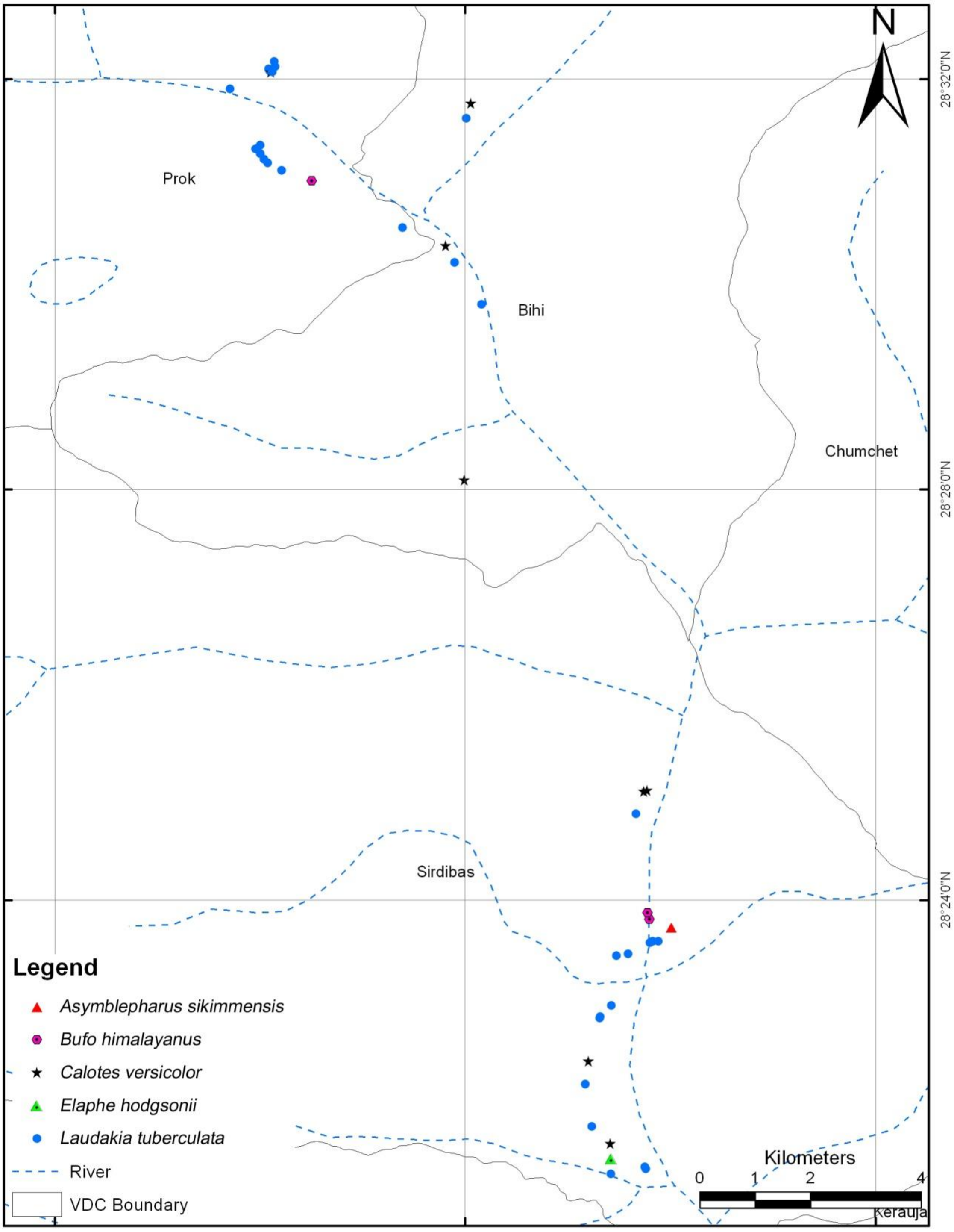

Figure 6: Herpetofauna recorded in the whole study area

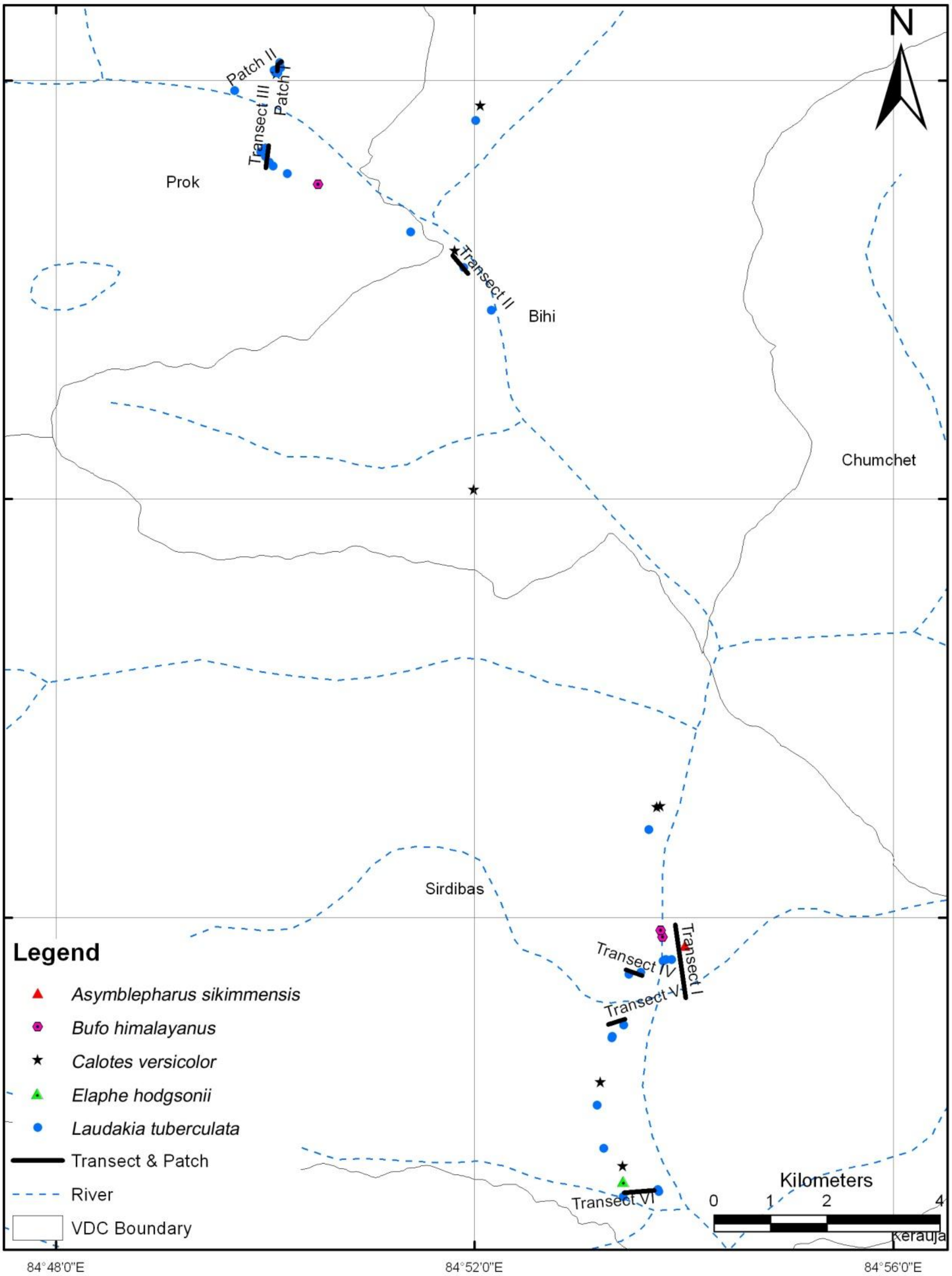

Figure 7: Transects and quadrats laid in the study area for recording herpetofauna

Table 9: Frequency of detected species

Statistical measures		Abundance
N	Valid	45
	Missing	0
Mean		1.44
Median		1.00
Mode		1
Std. Deviation		.693
Skewness		1.711
Std. Error of Skewness		.354
Kurtosis		3.204
Std. Error of Kurtosis		.695

From the above table, the value of skewness for abundance is 1.711 which means the distribution is asymmetrical and therefore positively skewed being elongated to the right side of the frequency curve as in Figure 8. It shows species with lesser abundance is frequently distributed thus not giving a clear picture of abundance in that sampled or encountered region as the sampled season (prior to monsoon) was not much viable for cold-blooded species study. While, the flatness of the curve was determined by the kurtosis value i.e. $3.204 \approx 3$, mesokurtic in nature which follows the normal distribution code.

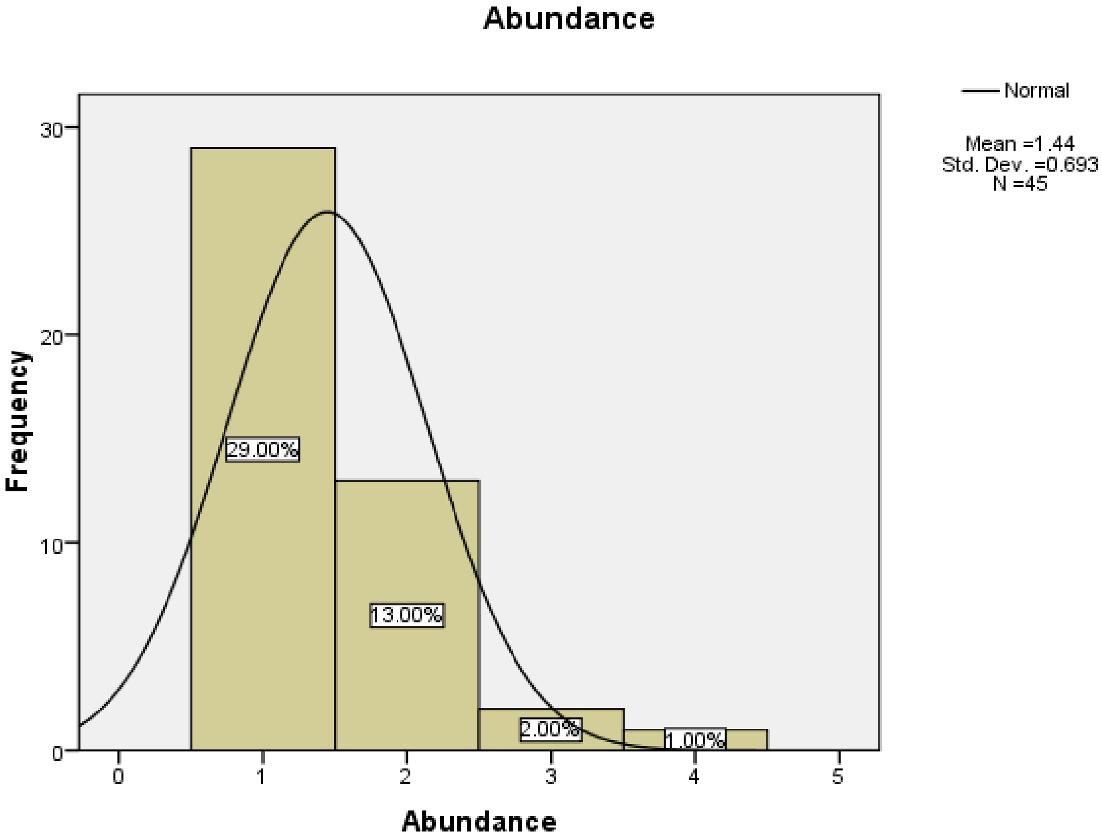

Figure 8: Frequency of low abundant species in the whole study area

4.2 Environmental (Abiotic) factors and their relation with the herpetofauna

From the collected data, linear regression analysis was opted to determine whether the abundance of herpetofauna can be predicted or not by other variables like elevation and temperature. But first it was necessary to examine a scatter plot of abundance by elevation and again abundance with temperature just as to determine whether a linear model is reasonable for these variables or not.

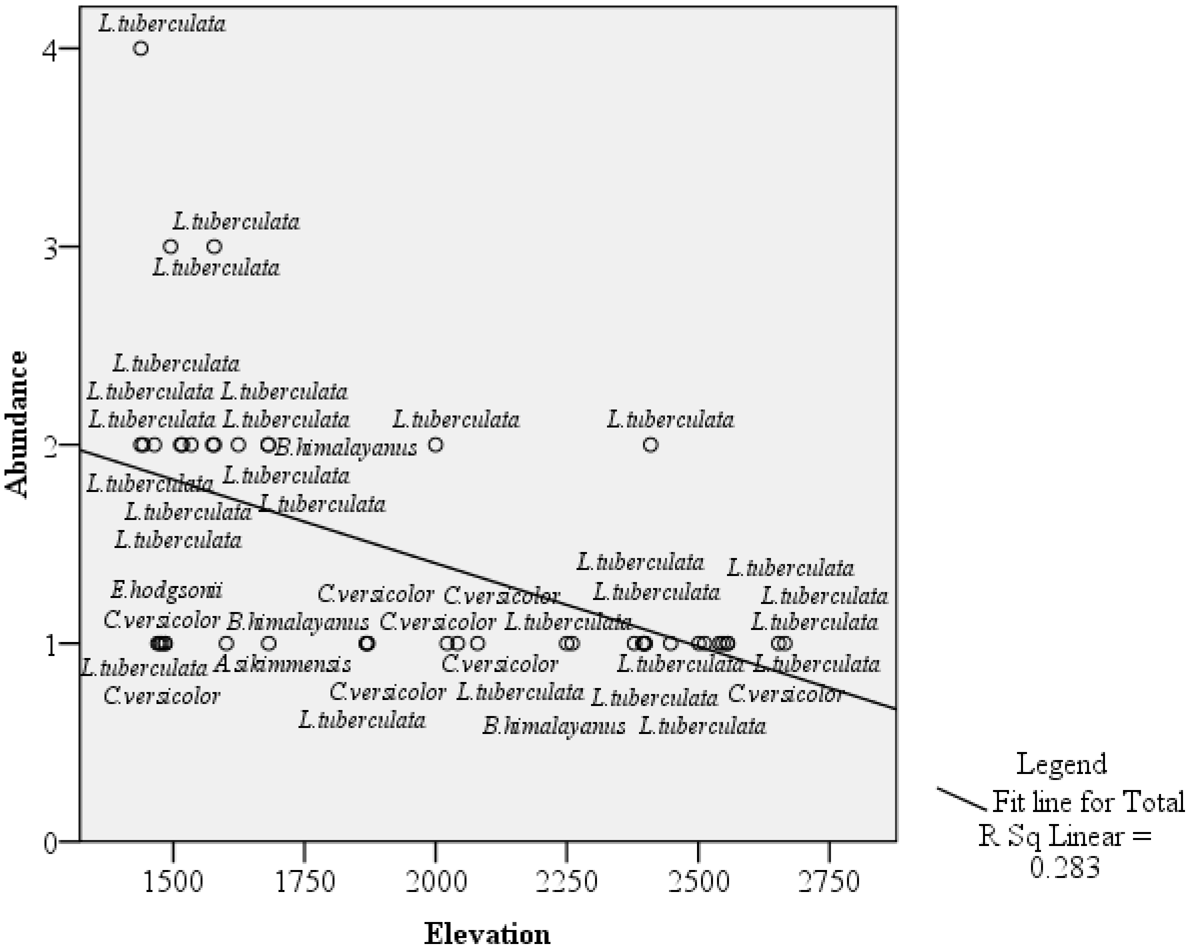

Figure 9: Scatter plot between species abundance and elevation encountered

The resulting scatter plot appeared to be suitable for linear regression with the possible cause that variability of abundance decreased with increasing elevation as the cold-blooded animals would not prefer to reside in rising elevations with lesser temperatures. The value R square, which is coefficient of determination, tells us that 28% of the variation in abundance due to elevation is explained by the above model.

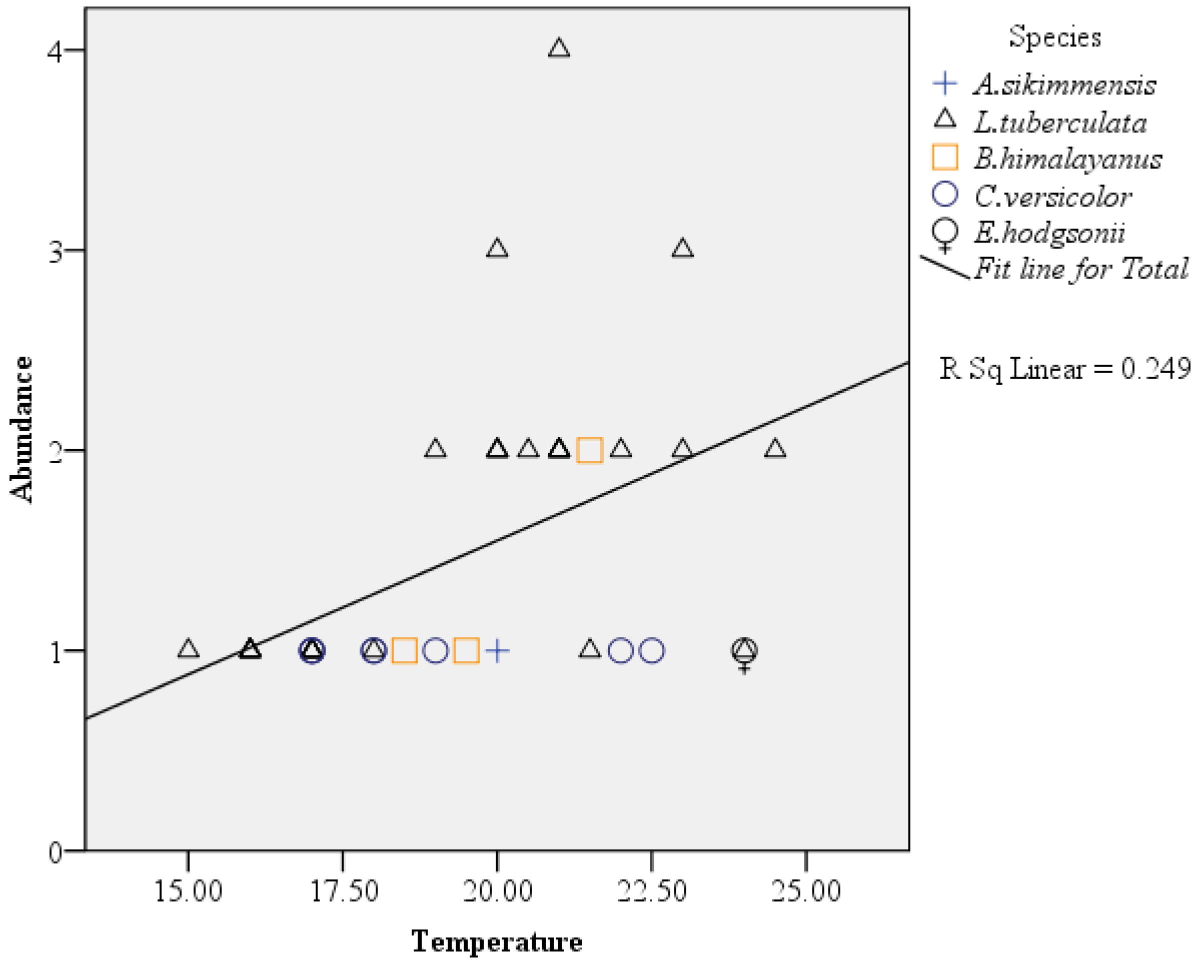

Figure 10: Scatter plot between species abundance and ambient temperatures

The resulting scatter plot between abundance of herpetofauna and ambient temperature appeared to be suitable for linear regression with the possible cause that variability of abundance increased with increasing elevation as the cold-blooded animals in general prefer to reside in warm temperatures. The value R square, which is coefficient of determination, tells us that almost 25% of the variation in abundance due to temperature is explained by the above model.

From the scatter plot it was suitable to analyze the data via linear regression analysis hence; a regression equation was formulated;

$Y = a+b_1X_1+b_2X_2$, where Y = Abundance of herpetofaunal species (Dependant variable)

X_1 = Elevation aspect,

X_2 = Ambient temp.

(Independent variables)

a, b_1 & b_2 = regression parameters, constants.

Table 10: Regression Coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	1.6404	1.808		.907	.369
	Elevation	.0006	.000	-.377	-1.648	.107
	Temperature	.0503	.061	.188	.819	.417

a. Dependent Variable: Abundance

From the table, we could see the coefficients of the regression line $Y= a+b_1X_1+b_2X_2$ as $a=1.6404$, $b_1=0.0006$ and $b_2=0.0503$ which transforms the regression line into

$Y = 1.6404+0.0006X_1+0.0503X_2$. Now with this equation we could predict the abundance of herpetofauna in that region with the known values of elevation and ambient temperature.

Table 11: ANOVA Table

ANOVA[b]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	6.215	2	3.108	8.762	.001[a]
	Residual	14.896	42	.355		
	Total	21.111	44			

a. Predictors: (Constant), Temperature, Elevation

b. Dependent Variable: Abundance

ANOVA test was carried out to check to determine the acceptability of the model from statistical perspective. Since the significance value of the F statistic (0.001) is less than 0.05, that means there exists a relationship between Y on X. Therefore, the regression line Y on X is significant. Also it could be interpreted as that the variation in abundance explained by the model is not due to chance.

Table 12: Model summary showing Multiple Correlation Coefficient (R) and R square

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.543[a]	.294	.261	.596

a. Predictors: (Constant), Temperature, Elevation

This model summary table gives an idea of the relationship between the model and the dependant variable. Here the value of R (0.543), which is the multiple correlation coefficient between the joint effect of elevation and ambient temperature with abundance of species. Its moderate value, R=0.543 indicates a moderate kind of relationship between the variables. R square value (0.294) is the coefficient of determination which explains that 29% of the variation in abundance is by the model.

For Correlation analysis,

Table 13: Correlation analysis between the variables (Abundance, Elevation and Temperature)

	Statistical measures	Abundance	Elevation	Temperature
Abundance	Pearson Correlation	1	-.532**	.499**
	Sig. (2-tailed)		.000	.000
	N	45	45	45
Elevation	Pearson Correlation	-.532**	1	-.824**
	Sig. (2-tailed)	.000		.000
	N	45	45	45
Temperature	Pearson Correlation	.499**	-.824**	1
	Sig. (2-tailed)	.000	.000	
	N	45	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

There's a negative correlation between abundance and elevation as Pearson Correlation coefficient between them is -0.532 which is a moderate negative correlation. This suggests that abundance of herpetofauna will be low with rising elevations and also p-value is less i.e. 0 means statistically significant.

On the other hand, there's a moderate positive correlation between abundance and temperature i.e. 0.499 which explains increment in abundance of herpetofauna with increase in temperature as is true with the case of cold-blooded animals who need external source of heat to regulate their body mechanisms. Also p-value being less than 0.001 suggests statistically significant.

For Partial Correlations,

Table 14: Partial Correlation analysis keeping elevation as the control variable

Control Variables			Abundance	Temperature	Elevation
-none-[a]	Abundance	Correlation	1.000	.499	-.532
		Significance (2-tailed)	.	.000	.000
		Df	0	43	43
	Temperature	Correlation	.499	1.000	-.824
		Significance (2-tailed)	.000	.	.000
		Df	43	0	43
	Elevation	Correlation	-.532	-.824	1.000
		Significance (2-tailed)	.000	.000	.
		Df	43	43	0
Elevation	Abundance	Correlation	1.000	.125	
		Significance (2-tailed)	.	.417	
		Df	0	42	
	Temperature	Correlation	.125	1.000	
		Significance (2-tailed)	.417	.	
		Df	42	0	

a. Cells contain zero-order (Pearson) correlations.

In this table, partial correlations between variables keeping elevation as the control variable are analyzed. With zero-order correlations (correlations without any control variables), there's a significant positive relation between abundance and temperature and statistically significant ($p<0.001$) but when effect of elevation is controlled, the association between abundance and temperature is a bit low (0.125) yet positive and p-value (0.417) being greater than 0.01, hence suggesting statistically insignificant.

The possible interpretation of this finding could be that the observed positive relationship between abundance and temperature is due to underlying relationships between each of those variables and the elevation range to where the species reside.

Table 15: Partial Correlation analysis keeping temperature as the control variable

Control Variables			Abundance	Elevation
Temperature	Abundance	Correlation	1.000	-.246
		Significance (2-tailed)	.	.107
		Df	0	42
	Elevation	Correlation	-.246	1.000
		Significance (2-tailed)	.107	.
		Df	42	0

Likewise, when temperature is chosen for the control variable, there exists a bit low negative correlation (-0.246) between abundance and elevation nearly equal to zero and p-value being greater than 0.001 implying statistically insignificant.

The possible interpretation of this finding could be that the observed negative relationship between abundance and elevation is due to underlying relationships between each of those variables and the ambient temperature range to where the species reside.

Runs Test

The hypothesis that abundance, elevation and temperature are correlated with each other or not

Or

The abundance, elevation and temperature measures are randomly ordered.

Table 16: Runs Test calculation

	Abundance	Elevation	Temperature
Test Value[a]	1[b]	1868	19.00
Cases < Test Value	0	21	21
Cases >= Test Value	45	24	24
Total Cases	45	45	45
Number of Runs	1[c]	4	10
Z		-5.726	-3.908
Asymp. Sig. (2-tailed)		.000	.000

a. Median

b. All values are greater than or less than the cutoff. Runs Test cannot be performed.

c. Only one run occurs. Runs Test cannot be performed.

For abundance, since all the values are greater than or equal to the cut point so Runs Test couldn’t be performed.

While for elevation, the cut point being 1868 – the sample median. Of 45 sampling sites, 21 were below the median so they are considered as the negative cases. The remaining 24 sites were at or above the median, they are considered as positive cases. The next statistic is a count of the observed runs in the test variable. A run is defined as a sequence of cases on the same side of the cut point. The observed runs is only 4, so Z test is negative and the 2-tailed significance value is 0, which is the probability of obtaining a Z statistic as or more extreme (in absolute value) than the obtained value, if the elevation range values above and below the median is purely random. Hence, the elevation range values are not random or co-related with abundance and temperature.

Descriptive Statistics

	N	Mean	Std. Deviation
Abundance	45	1.44	.693
Valid N (list wise)	45		

From the table, we have the values of mean (1.44) and standard deviation (0.693) of the variable abundance and using these one could check the consistency/variability of the data from a measure called the coefficient of variation.

$$\text{Coefficient of Variation (C.V.)} = \frac{\sigma}{\bar{x}} \times 100$$

$$= \frac{0.693}{1.44} \times 100$$

$$= 48.13\%$$

This represents that there is a moderate variability in the abundance of herpetofaunal species in all three VDCs of Manaslu Conservation Area. However, one could check the variability of species abundance according to VDC wise and for that mean and standard deviations of all three VDCs were calculated.

Sirdibas VDC (X_1)	Bihi VDC (X_2)	Prok VDC (X_3)
Mean = 1.78	Mean = 1.29	Mean = 1
S.D. = 0.78	S.D. = 0.45	S.D. = 0
C.V. (X_1) = 0.78/1.78 x 100	C.V. (X_2) = 0.45/1.29 x 100	C.V (X_3) = 0/1 x 100
= 43.82%	=34.88%	= 0

The above calculated values of Coefficient of Variation (C.V.) of all three VDCs give an idea that C.V. (X1) > C.V. (X2) > C.V. (X3) , which means there's homogeneity of abundance in Prok VDC and then consistency in Bihi VDC with higher variability in Sirdibas VDC – possibly due to lesser elevation and favorable temperature for ectotherm activities.

4.3 Ethnoherpetology of MCA

4.4.1 Overall characteristics of the Respondents

Information regarding respondents' general characteristics like age-structure, sex, caste, occupation and their location has been briefed in Table 17. The number of males was double (20) than the females (10) and the selected respondents were those available nearby the researcher hence gender biasness was unintentional. People of different age-structure participated in the survey however, major respondents (53.3%) fall into the age category between greater than 30 to less than or equals to 60 years.

There were mainly two conspicuous group of ethnicities in the study region; Lama and Gurung. Lamas, originally from Tibet make up most percent share of the surveyed population while Gurungs are found in the lower regions of Manaslu, mainly Sirdibas. Agriculture is the key occupation found in survey result as 76.7% respondents are engaged with farming activities while few respondents are entrepreneurs and students.

The sampled population was mostly belonging to Prok (63.3%), followed by Sirdibas (23.3%) and Bihi (13.3%).

Table 17: Overall characteristics of the Respondents in MCA during study

Category		**Number of Respondents**	**%**
By Sex			
	Male	20	66.7
	Female	10	33.3
By Age-structure			
	≤ 30 years	12	40
	> 30 to ≤ 60 years	16	53.3
	> 60 years	2	6.7
By Caste			
	Gurung	9	30
	Lama	19	63.3
	Thakuri	2	6.7
By Occupation			
	Agriculture	23	76.7
	Business	4	13.3
	Student	3	10
By VDC			
	Sirdibas	7	23.3
	Bihi	4	13.3
	Prok	19	63.3

4.4.2 Perception towards the herpetofauna

The local people have varied opinions regarding morphology of snakes, lizards and frogs of their region. Of the total responses obtained in favor of snakes, 90% indicate fear upon seeing them. Respondents neither find serpents ordinary looking nor beautiful in appearance. The remaining 10% response considers snakes as very unpleasant things.

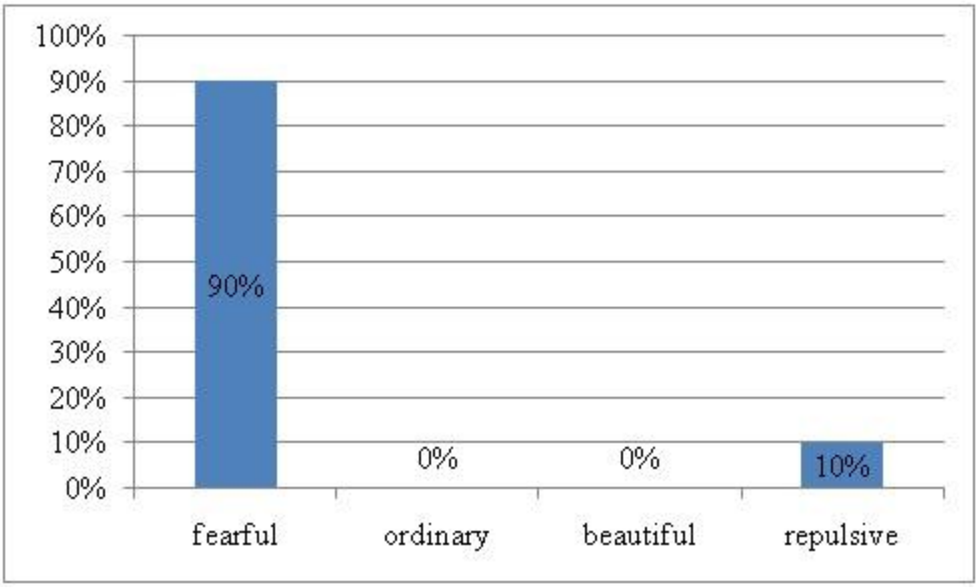

Figure 11: Percentage of respondents' perception towards the snakes

The feeling of animosity is bit low in case of lizards where, 77% response is made as ordinary looking species. However, 23% respondents take lizards as beautiful in appearance.

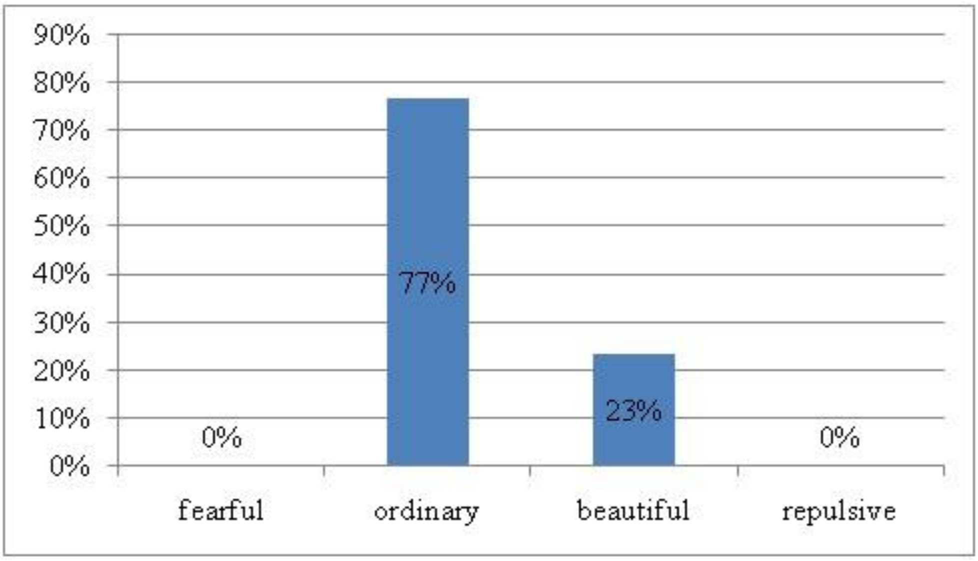

Figure 12: Percentage of respondents' perception towards the lizards

In case of frogs (mainly Pahas), the scenarios is totally different as major percentage (87%) of response favor Paha frogs as beautiful creatures while 13% find them as ordinary.

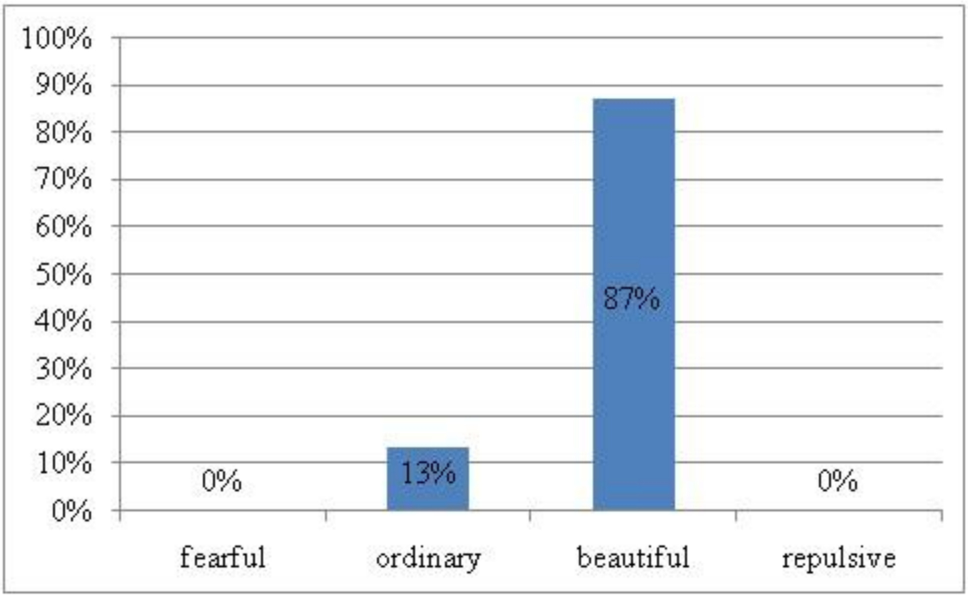

Figure 13: Percentage of respondents' perception towards the frogs (Pahas)

4.4.3 Significance

Responses have been gathered regarding herpetofauna’s relative importance in the region. People have opined 4% significance religiously and consider sacred to snakes as they reflect godlike character in mythology. Nevertheless, equal percentage of response (48%) were assembled for medicinal and food purpose. But these significances have been derived from Paha species of frogs of their locality.

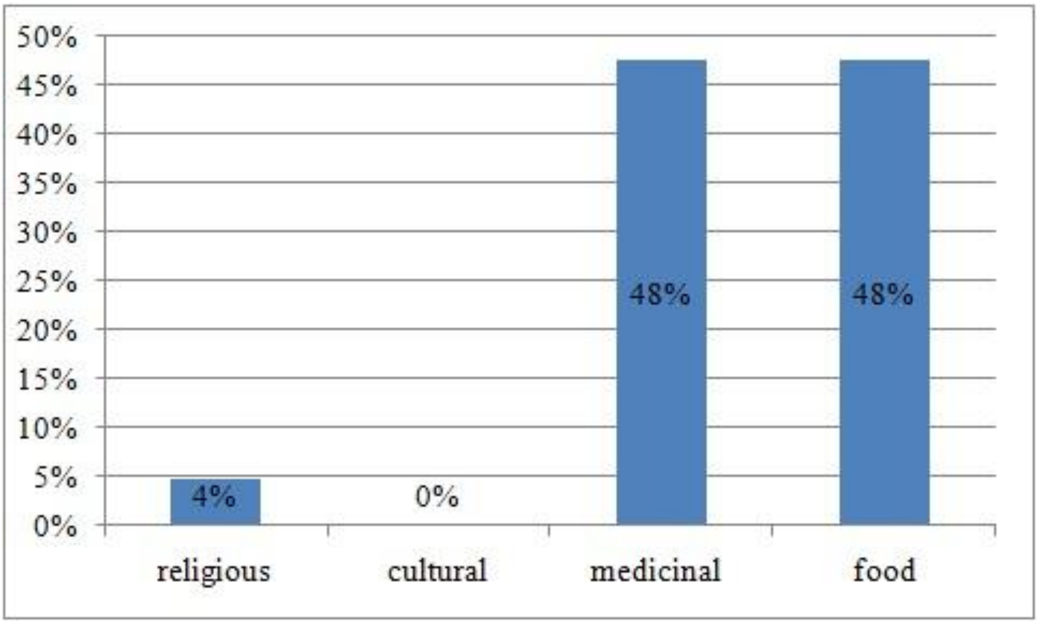

Figure 14: Percentage share of responses according to significance of herpetofauna

Respondents expressed that Paha frogs are protein rich diet and a delicacy to savor. The key informants during the survey and group interview even admitted the food value of Paha frogs. However, Dorje Thakuri recommended rubbing salt all over the body in the skinned 'Paha' before consumption. During interviews, people's views on Paha frogs' taste were also gathered. As many as 38% of the respondents admitted Paha's meat to be extremely good, another 30% took it as good while 18% considered it as ordinary. The interviewees opined multiple methods of processing Paha's meat like sun-baked, smoked, shade dry and deep oil fry before consumption.

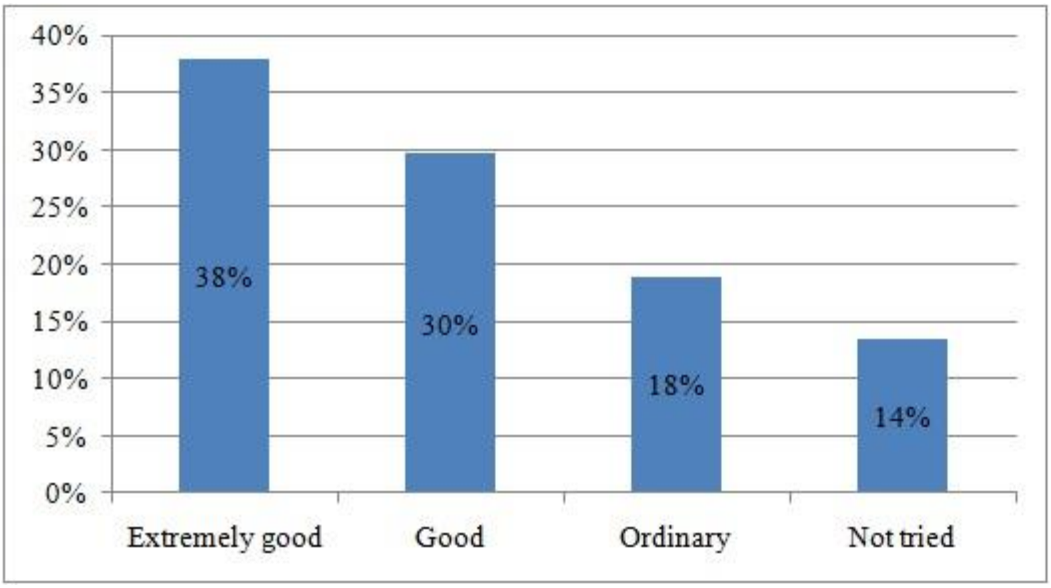

Figure 15: Percentage share of taste by the respondents who have consumed Pahas' meat

Talking about medicinal significance, the respondents believed that Paha frogs possess medicinal attributes. Consumption of Paha's meat or soup prepared from dried form cures common ailments (27%) like diarrhea, dysentery, vomiting etc. The meat is a panacea for stomach-ache (23%) and provides vigor after prolonged illness (20%). The respondents consider to have had relieved the problems of cold and fever (14%), headache (10%) and urine problem (6%) using frogs' meat as medication.

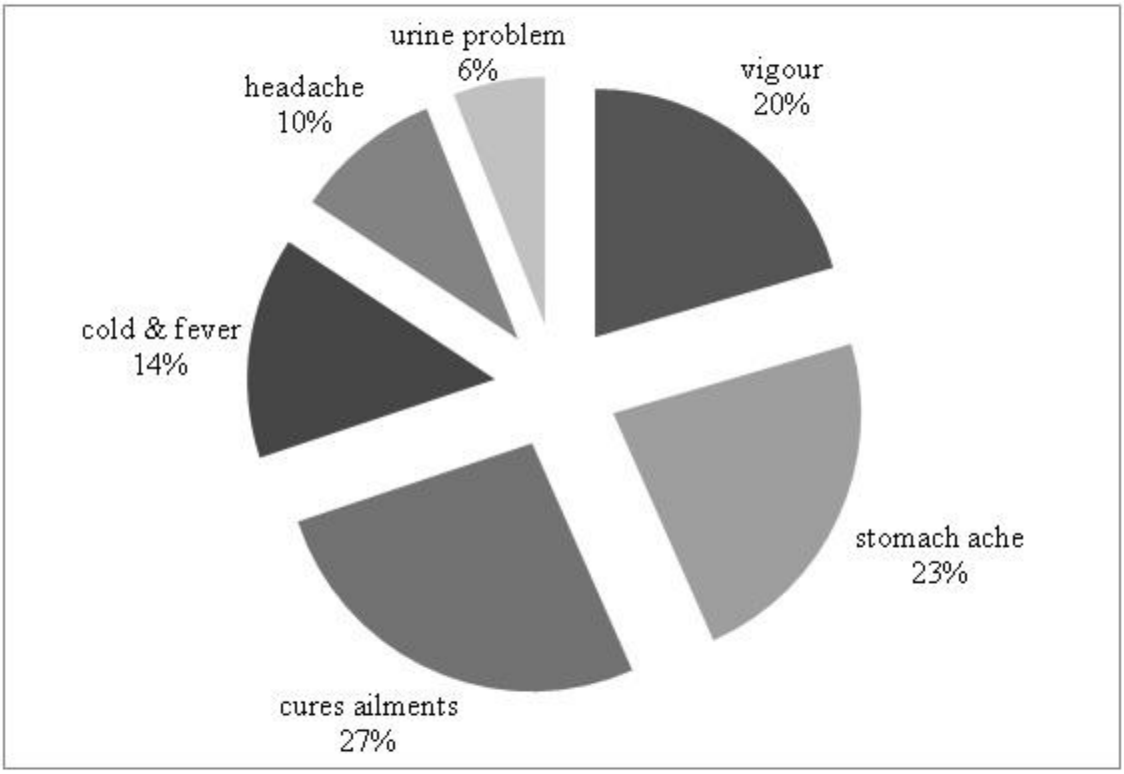

Figure 16: Percentage share of medicinal significance of Paha frogs

Dorje Thakuri, a key informant of Prok village expressed certain procedural rules as mentioned in Tibetan orthodox medicine. Pahas should be sun dried and then mixed with other herbs to make a paste and used as disinfectants, while some needs to be shade-dried. Soups made from Paha without spice are of great importance and believed to cure fever, stomach ache, diarrhea, cough and cold. Even frogs' eggs and tadpoles possess medicinal values and are consumed according to the nature of the ailments involved.

4.4.4 Hunting and Population Decline

Since Pahas are widely used as food and medicine by MCA inhabitants, the question of Paha hunting is worth to mention here. All the respondents have heard of Paha hunting that is carried out in rainy/summer season and specially when the water level is low in the pool and streams. But here, opinions have been collected regarding hunting by interviewed people. Among the respondents, 60% of them have hunted Paha in the area.

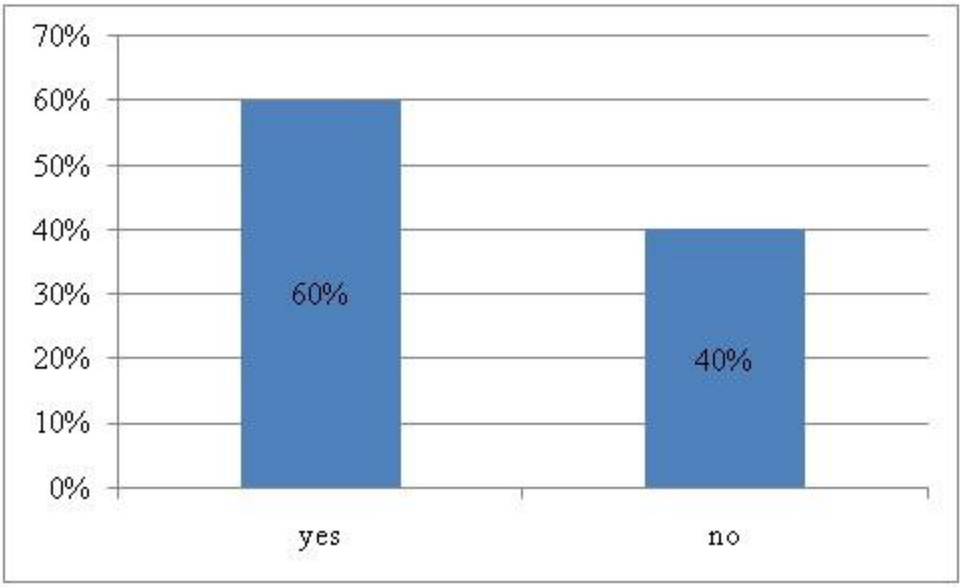

Figure 17: Percentage share of the respondents who have hunted Pahas

The experienced ones informed that Paha hunting in season takes place as a great time to relish. Often men form groups and visit brooks at night carrying torch which facilitates detection of the targeted frogs. Pahas are collected by removing rocks in water bodies, some wear spiky made waist belts and frogs caught are pinned there. During seasonal collection, there's neither any limitation nor any sort of restrictions placed for Paha hunting. This haphazard collection has the possibility of Paha's population decline in the region.

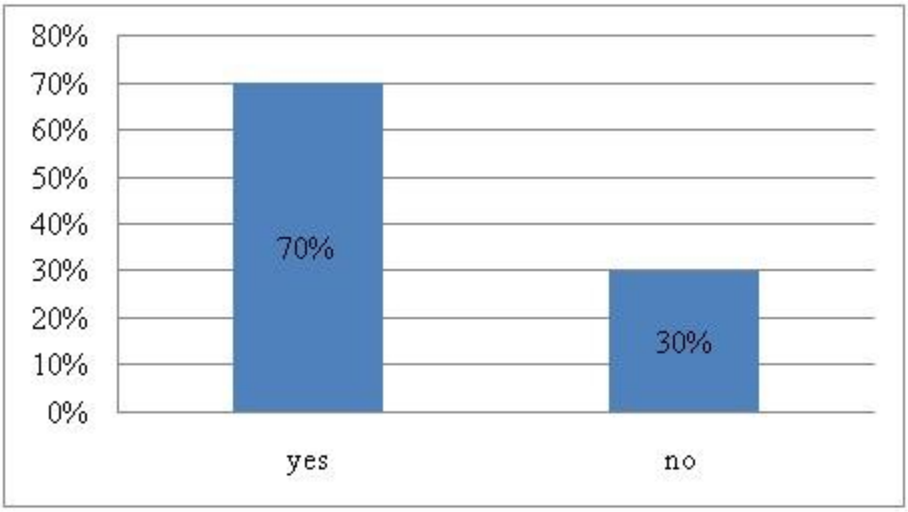

Figure 18: Percentage share of responses on herpetofauna decline

People have responded collectively for all the herpetofauna in the region and their decline. 70% of the reply suggests that amphibians and reptiles are dropping down in number while 30% feel the situation is still uniform. People have various opinions regarding the local decline of species; forest degradation (40%) forms the major share, followed by over-collection (33%), climate change (20%) and piping system (7%).

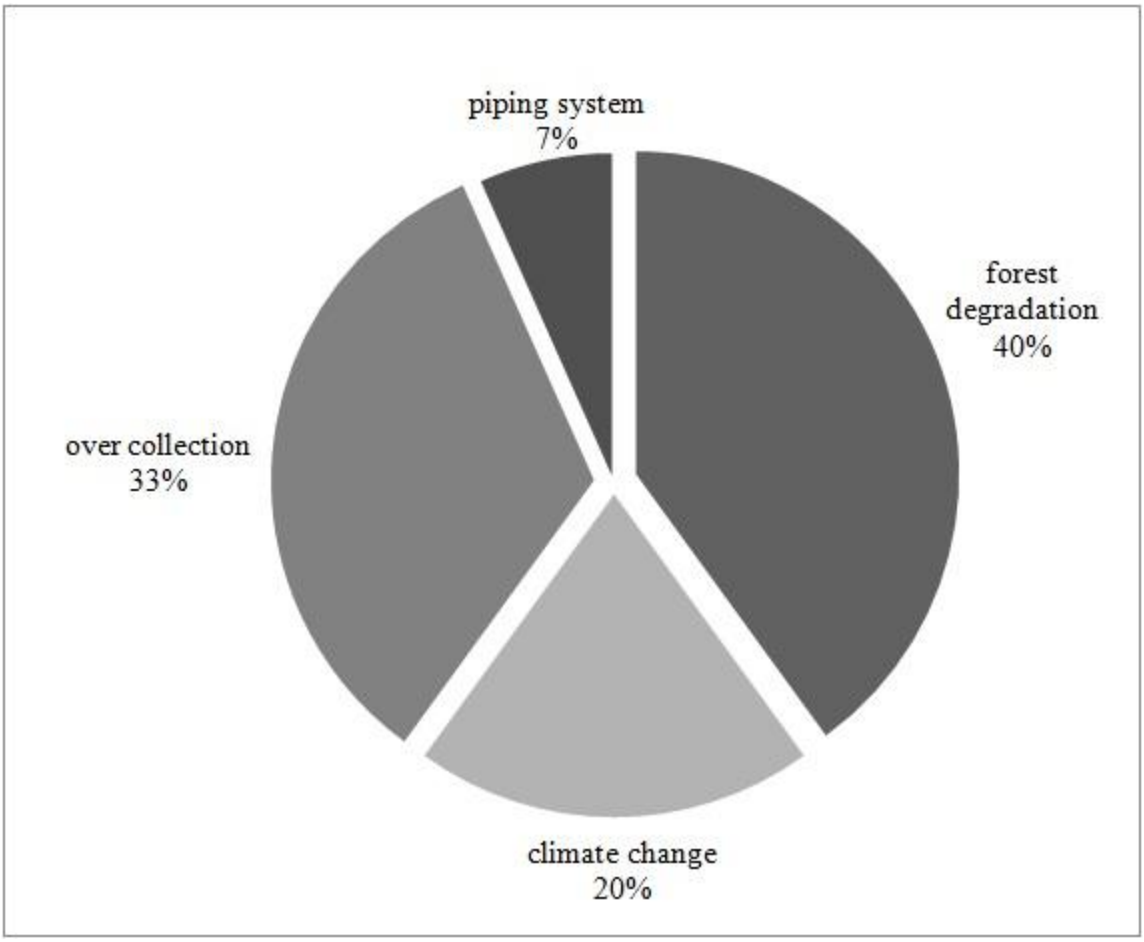

Figure 19: Percentage share of factors behind herpetofauna's decline

Piping system refers to supply of water from local spring, brooks, and ponds to villages for daily use. This led less water in the source which was confirmed via direct observation by the researcher while on the other hand, creating challenges for amphibians breeding.

4.4.5 Response towards Conservation

Because of the significances herpetofauna typically possess and gradual decline, respondents feel that herpetofauna should be conserved. Here, percentage share of responses were gathered on amphibians and reptiles conservation.

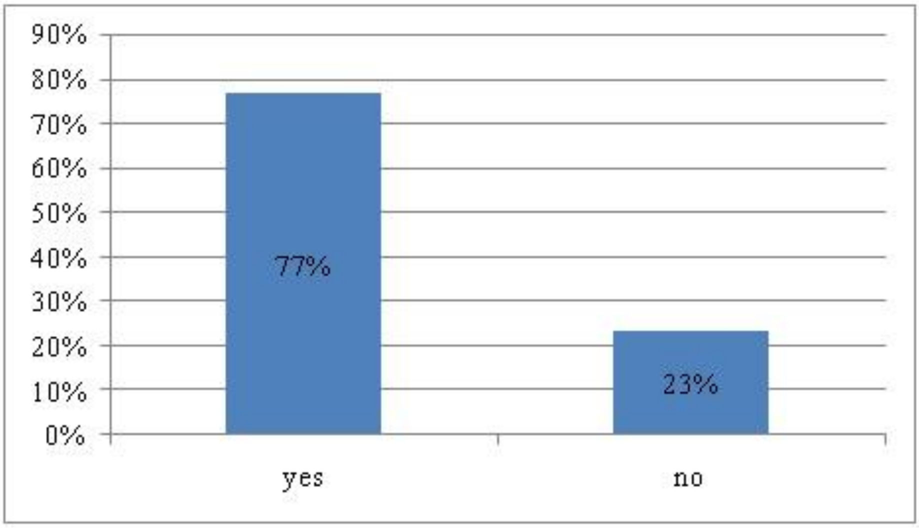

Figure 20: Percentage share of responses on the importance of herpetofauna's conservation

Majority of the reply (77%) assert yes to their conservation while 23% disagree with the thought of conserving herpetofauna. The respondents even expressed their purpose behind conserving herpetofauna of the region as Pahas are good source of food (45%) and medicine (45%). Few opined about ecological role and importance in food web (8%) hence realize the need to conserve them. 2% of the response is under the impression that herpetofauna filter out impure oxygen in the air.

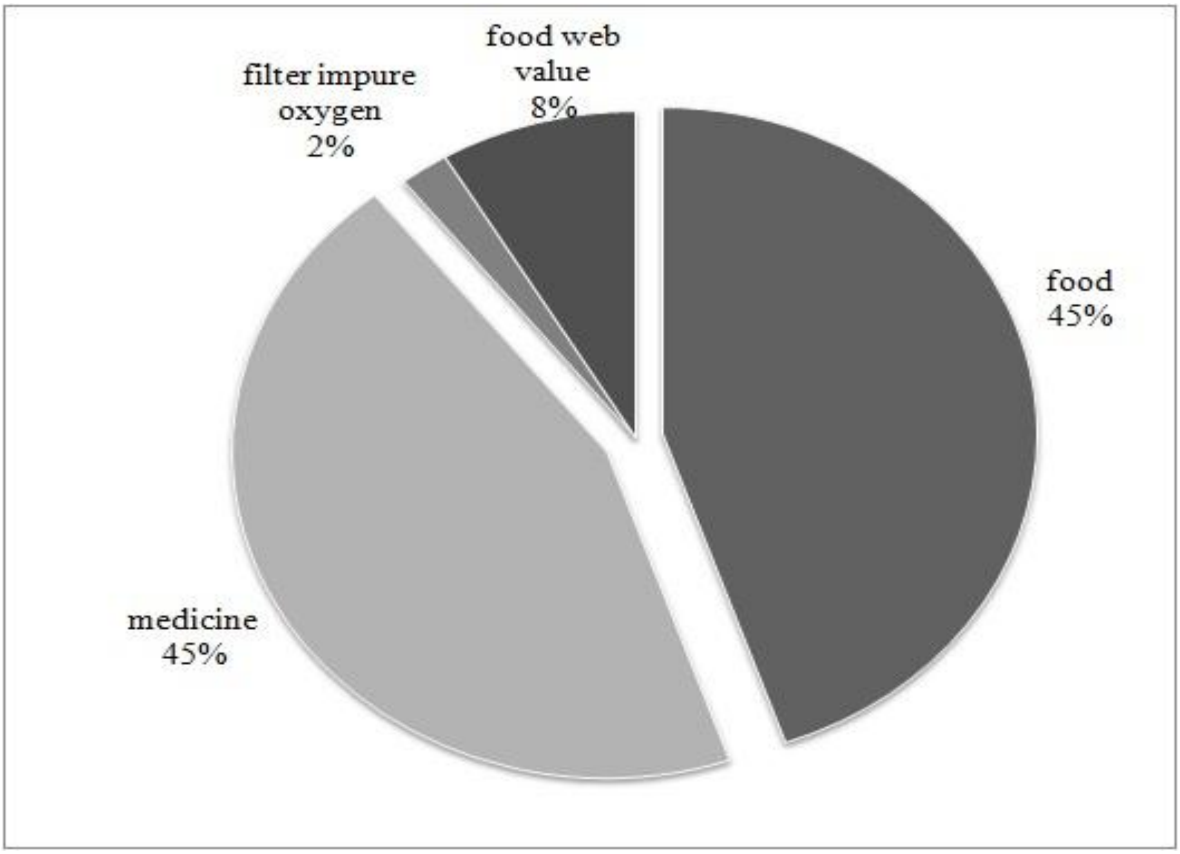

Figure 21: Percentage share of factors behind herpetofauna's conservation

CHAPTER V

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Herpetological Inventory

The Manaslu Conservation Area is a biodiversity rich spot mainly because of its inaccessible mountains, rugged terrain and isolation, micro-climatic variation with altitude, diverse ecosystems, rivers, high altitude lakes and so forth. All these abiotic factors have shaped life (flora and fauna) in diverse forms and herpetofauna are no apart to this rich variety. A checklist of 33 species of amphibians and reptiles have been developed from three VDCs of MCA; Sirdibas, Bihi and Prok. The present documentation of herpetofauna is greater in diversity than previous studies. KMTNC (1998) had first reported the presence of 5 herpetofauna in MCA while NTNC's official webpage of MCAP displayed the presence of merely 3 reptiles from the region. The diversity of herpetofauna further increased to 16 species in the study conducted by Pokhrel and Thakuri (2010). However, all these previous literature have not successfully portrayed the true picture of herpetofauna's presence in MCA.

Detection probability of species varies significantly across spatial and temporal scale. The observed diversity of herpetofauna during intensive field survey was minimal (5 species). This is attributed to a one-time survey and specifically the pre-monsoon season which limits onto species activity and probable sighting. The main trail of MCA where most of the field survey was carried out had steep slopes on either side. This limiting factor has influenced the detection rate of species from the study area. Similarly, the strong currents of Budigandaki river imposed difficulties to collect information regarding local herpetofauna in the region. Behavioral response of some herpetofauna like those having burrowing mode of existence also restricted equal probability of being sighted.

Among all the observed species in MCA, *Laudakia tuberculata* – Himalayan Rock Lizard was ubiquitous and seen on human settlements, outcrops, farmlands, trail etc. There were previous records of this species in all the available literature from the region. However, the number of individuals observed was found to be lower (51) in my study than Pokhrel & Thakuri's (2010) study i.e. >100. This is because of the not-so-favorable surveying season for herpetofauna as the study took place in pre-monsoon season when 15% of the total rainfall occurs (Pradhan, 2007). Likewise, very low detection of *Asymblepharus sikimmensis* (1) than Pokhrel & Thakuri's (2010) study i.e. 9 could be attributed to the same aforementioned reason.

The observed individuals of *Calotes versicolor* were higher (8) than previous study (2) in 2010. This could be because of adoption of standard field surveying techniques like Transect VES, Patch sampling and Opportunistic sampling. Our efforts to capture a live Paha frog went unsuccessful throughout the whole survey period. This suggested to carry out the amphibians' survey during monsoon season when 80% of the total rainfall occurs (Pradhan, 2007). However, *Bufo himalayanus* reported earlier in KMTNC (1998) and Pokhrel & Thakuri's (2010) study have also been successfully recorded in my study. I observed 3 individuals in the main trekking trail of MCA and 1 individual caught by Dip netting. The low encounter of the Himalayan toad could be due to drying off the freshwater pools witnessed at various sites in MCA. I even observed existing pressure on freshwater pools, brooks as because of Poly Vinyl Chloride (PVC) piping system to human settlements during the survey. This could have hindered the detection of amphibian species to an extent. Interestingly, the available relevant publications indicate that *Elaphe hodgsonii* has been confirmed for the first time from MCA in this study.

Since data gathered from intensive field survey couldn't reflect the actual assemblage of herpetofauna in MCA, other methods like photo-elicitation, key person interviews and group interview were found to be worthwhile. Shah (2001) had recorded 9 herpetofauna from southern Annapurna region through interviews with local residents. In a similar way, Pokhrel & Thakuri (2010) had used colorful pictorial guides to elicit information on local herpetofauna of MCA and found out 3 species. However, I used the term 'Photo-elicitation' technique to garner information after showing color plates of herpetofauna from field guide. This technique widely adopted in social science (Bignante, 2010) and even used in my study resulted an assemblage of 28 herpetofauna from the region.

In previous studies (Nanhoe & Ouboter 1987, Shah 2001, Pokhrel & Thakuri 2010), data gathered from personal observations, interviews and literature were found to have merged to produce a complete checklist of herpetofauna. The term for this technique is known as 'Data Triangulation Method' which none of the researchers had mentioned earlier. I have used the same technique to validate my findings and gain credibility in the final result. Ultimately, my study provided a checklist of 33 herpetofauna in three VDCs of MCA which is higher than all available previous literature.

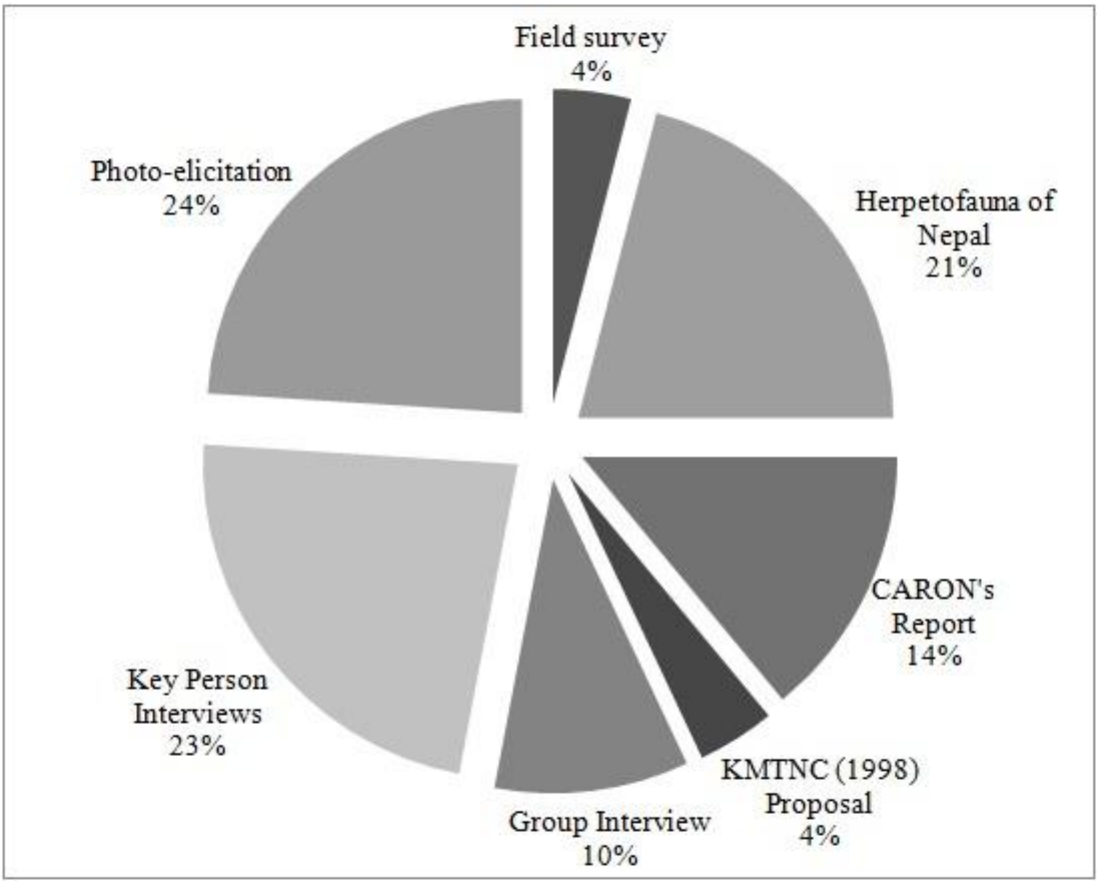

Figure 22: Percentage share of data collected from various sources

5.1.2 Spatial Distribution in Three VDCs

Herpetofauna were detected from Jagat, entry point of MCA to Ghap region of Prok VDC, within an altitudinal range of 1438-2665 m. The recorded elevation data of 5 herpetofauna in my study were found to be fluctuating when compared to findings by other researchers in the same region and elsewhere of the country. The altitudinal gradient of Himalayan rock lizard, *Laudakia tuberculata* was recorded in MCA from an altitude of 1438 m to 2665 m in 2012 which was between 1600-3510 m in previous study (KMTNC, 1998). But then again study conducted by Pokhrel & Thakuri (2010) agrees with my findings of spatial distribution of *Laudakia tuberculata* from Jagat to Prok. On a slightly different note, Nanhoe & Ouboter (1987) reported the altitudinal distribution of *Laudakia tuberculata* from 790 m to 2250 m at the southern side and upto 3400 m in the northern side of the Annapurna Himal. The elevation range was narrower in Shah's (2001) study of the southern Annapurna region, i.e. 1320-2170 m.

The highest recorded locality for *Calotes versicolor* is 2512 m in this study, which is higher than Nanhoe & Ouboter's (1987) record, i.e. 1660 m and Shah's (2001) study (up to 1950 m). Thus, the population of *Calotes versicolor* is stable even at higher altitudes in MCA than adjacent Annapurna Conservation Area. I had observed *Bufo himalayanus* up to an altitude of 2250 m in Prok village which was previously observed up to 2330 m (KMTNC, 1998), while Pokhrel & Thakuri (2010) sighted them only in lower regions of MCA, i.e. upto Sirdibas VDC. In Annapurna region, it was observed not more than an altitude of 2700 m (Nanhoe & Ouboter, 1987) but Shah (2001) recorded it at the highest of 2200 m from southern Annapurna region. The maximum elevation range for *Bufo himalayanus* was moreover similar in all previous studies. One species each of *Asymblepharus sikimmensis* and *Elaphe hodgsonii* had been encountered in my study with elevation of 1682 m and 1470 m. This couldn't infer the highest altitudinal range of both herpetofauna, however Shah (2001) recorded *Asymblepharus sikimmensis* up to an altitude of 2400 m and Nanhoe & Ouboter (1987) have reported *Elaphe hodgsonii* not more than 2740 m.

5.1.3 Abiotic factors and Species detection

The scatter plot (Figure 9) has explained relationship between species abundance and recorded elevation in my study which is similar to findings in other literature. The falling scatter plot fits quite true with the notion that cold-blooded species occur mostly at lower altitudes. I have observed the decreasing pattern of species abundance with increasing elevation. This is because rising elevation is inversely related with temperature and herpetofauna prefer to reside in regions with optimum temperature. KMTNC (1998) had even reported that lower region of MCA support more herpetofauna due to available habitat conditions. Further, Pokhrel & Thakuri (2010) didn't find any herpetofauna after Lihi (2927 m) up to Larke (5106 m) of MCA which indicates less detection of species at higher elevation. Interestingly, the scatter plot in Figure 10 also support herpetofauna's presence in lower Manaslu as the graph continue increasing with rising ambient temperature. Abundance has increased from basically 1 to the maximum of 4, because activity and detection of ectotherms are associated with optimal temperature. From the gathered data of abundance, elevation and temperature, a regression line is existent between them. The value of multiple correlation coefficient (R) in Table 12 further advocates, moderate kind of relation between the associated variables and R^2 indicated the established model is not due to chance. Correlation tables validate the findings of respective scatter plots and establish a significant relationship between the variables. Nevertheless, the partial correlation tables suggest that when control variable is chosen and correlation is studied between two variables, the relation becomes insignificant. Thus, the whole relationship is existent only when all variables like abundance, elevation and temperature are considered.

Over the last century, global temperature has increased significantly by 0.7^0C and pretty double between the period of 1980-2005 than during 1905 to 2005 (Blaustein et al., 2010). The IPCC report further imply as the climate will project more dramatically by 2100 rising between 1.1 and 6.4^0C. Amphibians and reptiles have a very narrow thermal range for their activity and survival conditions. Despite they rely on external temperatures to gain energy, they suffer irreversible chemical changes in their proteins under maximum temperature. Reptiles have certain thermal range like 4-38^0C for most species while the optimal temperature is narrowed between 21-37^0C for peak activity. Beneath 2^0C, they become completely torpid and die out so temperature rise as we say climate change is detrimental for reptile's survival. On the other hand, amphibians are even influenced by external thermal gradient despite their actual thermal range is unknown. But with rise in temperature of 1-6^0C than the current level will alter the sex ratio, desiccate eggs, increase tadpole mortality, decrease population, single sex dominance, susceptibility to disease etc (Bickford et al. 2010).

Figure 23 and 24, reports about the temperature trend in the month of April and May of Gorkha based meteorological station within a span of 30 years (1982-2011). There is fluctuation in mean temperature from 22^0C in 1982 to 24^0C in 2011 for the month of April. However, after couple of ups and downs in the trend line temperature graph again rise after 1999 till 2011. Mean temperature rise implies of climate change as temperature is an integral part of climate.

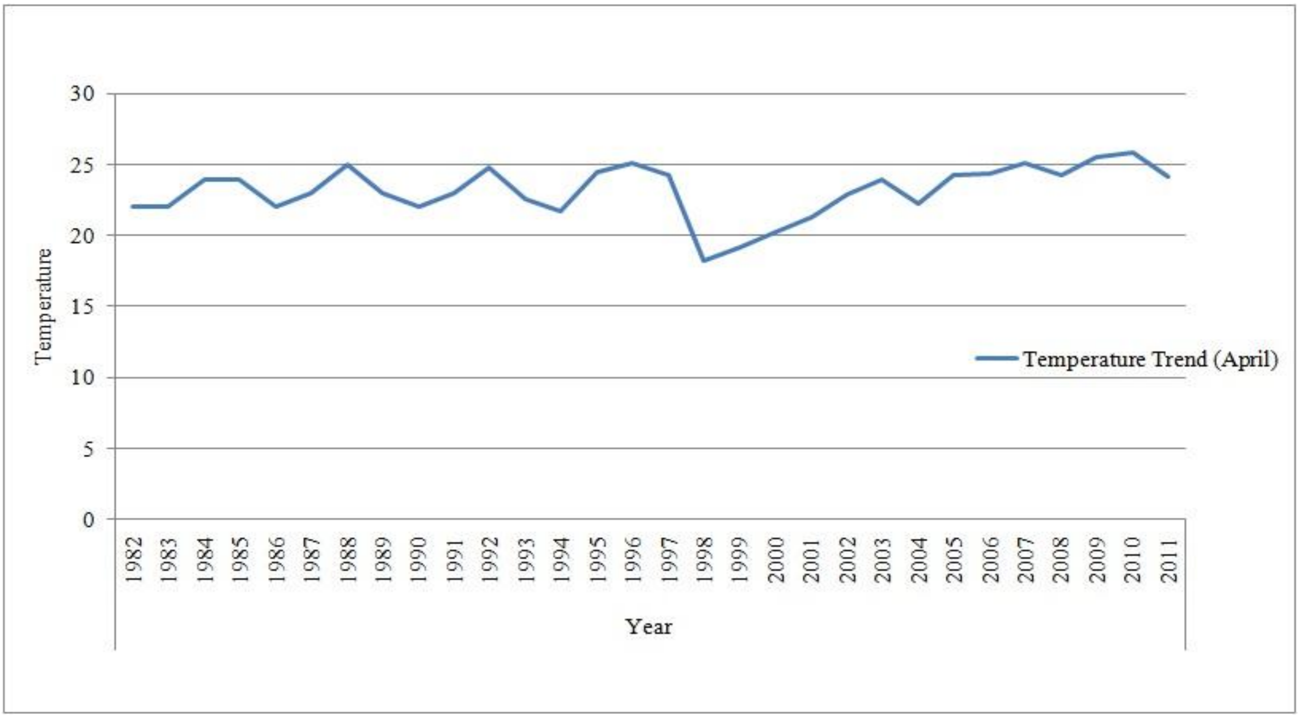

Figure 23: Mean Temperature (^{0}C) Trend in April (1982-2011) based on meteorological station of Gorkha

As the survey took between April - May 2012, mean temperature trend data for May in 30 years were even considered. We could observe fluctuation in mean temperature from 1982-2011 while the latter part show increase in mean temperatures. Both of these line graphs for April and May states rise in temperature in the latter decade (after 2000).

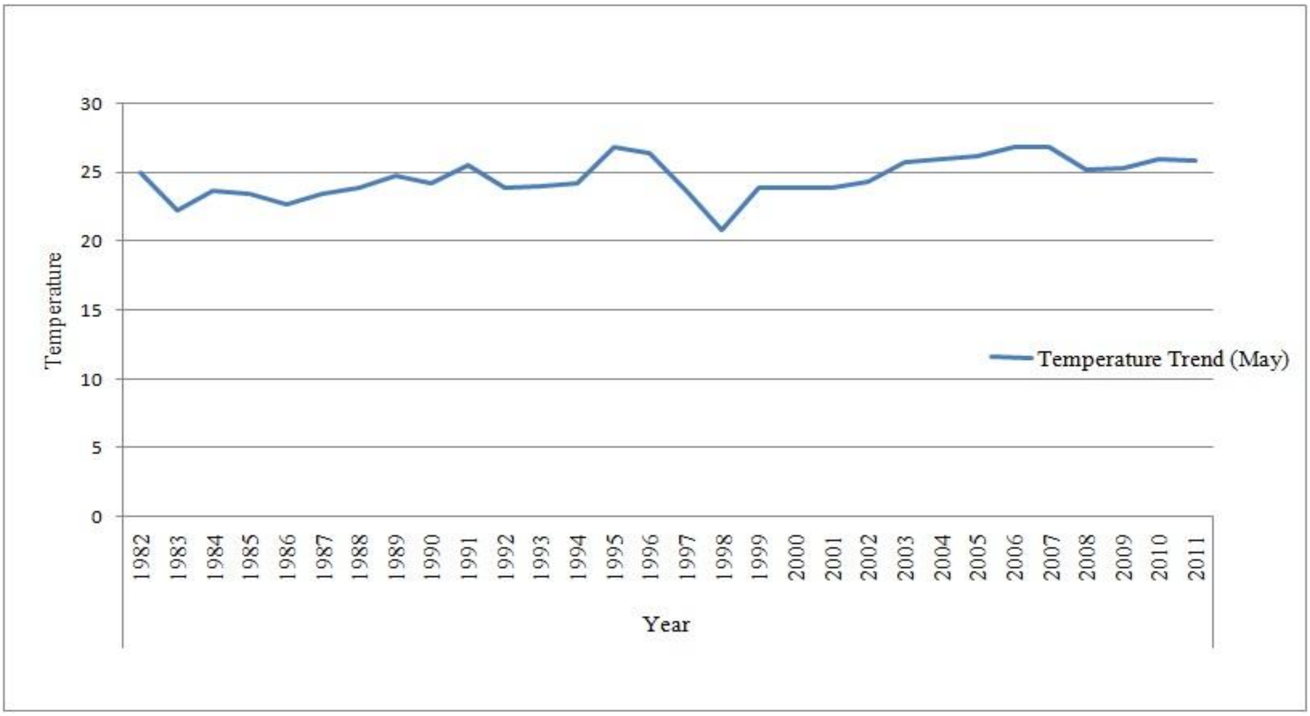

Figure 24: Mean Temperature (^{0}C) Trend in May (1982-2011) on meteorological station of Gorkha

5.1.4 Ethnoherpetological Study

Human societies have been shaped by culture, tradition, resource use, beliefs, norms, religion since ages. All of them have one thing associated - natural resources and in the past societies have best utilized all sorts of resources in their vicinity, even herpetofauna (Shah and Tiwari, 2004). In my study, I found frogs locally called ‘Paha’ are considered important by local people as good source of food and medicine. Pahas are good supplement of proteins and believed to cure common human diseases (KMTNC, 1998). Pokhrel and Thakuri’s (2010) study have assigned specifically ‘Paa’ genus frogs of the area to have the food value. The meat of Paha is excellent in taste and consumed fresh, smoke-dried and semi-dried, though meat/soup prepared from the frog is used as medication in case of several diseases (Shah, 2001). These benefits they derive from Pahas have led to haphazard collection and their decline in the region. Local people are concerned about conservation issues of ‘Paha’ frogs regarding their food value and presumed health benefits while belittle other herpetofauna found in MCA. This clearly indicates the lack of ecological education amid local residents about amphibians and reptiles in the area.

5.2 Conclusion

A checklist of 33 herpetofaunal elements from MCA area has been provided by incorporating data gathered from various sources. There were 16 species of amphibian representing 4 families and 17 species of reptile belonging to 6 families. The species assemblage list I had prepared were the results of different methods like; Field survey, Photo-elicitation, Questionnaire survey, Key Person Interview, Group Discussion and from literature. However, I was able to observe directly 5 herpetofauna in three VDCs of MCA in a 15 days survey. They were one species of amphibian representing single family and 4 species of reptile belonging to 3 families. The total number of individuals recorded was 65. Opportunistic sampling method was equally important as Transect VES, although both require careful attention in sighting.

Of the 5 recorded herpetofauna, *Laudakia tuberculata* was very common and sighted all the way from Jagat of Sirdibas VDC to Ghap of Prok VDC. Its population is more stable than other herpetofauna of MCA. *Elaphe hodgsonii*, Himalayan trinket snake has been recorded for the first time from MCA. Amphibians and reptiles were distributed from an altitude of 1438 to 2665 m. *Calotes versicolor* had the highest recorded locality (2512 m) in MCA than adjacent Annapurna region.

The abundance of herpetofauna in MCA was related to other variables; elevation recorded and surrounding temperature. Species presence decreased with increasing altitude while the observation kept increasing with rising ambient temperature. Herpetofauna are vulnerable to climate change and data (30 years) of temperature indicate that latter years have witnessed rise in temperature.

The villagers were largely aware of 'Paha' frogs in all three VDCs because of the food value and medicinal significance of the species. They are often hunted in season and only local experts have the knowledge to capture it alive. Even, there are procedures to process Paha's meat for future use while different recipes for utilizing as food and medicine. Local people seem amiable merely for Pahas and other mountain frogs but this situation is pretty different for other herpetofauna. Snakes and lizards are not considered as important as the Pahas, however they are considered obnoxious and people intentionally cause damage to them. Locals believe there have been gradual decline in overall herpetofauna's population compared to past decades due to factors like forest degradation, climate change, over exploitation and the water piping system in villages. They urge for conserving useful species like Paha frogs before they face local extinction.

5.3 Recommendations

- Herpetofauna related survey should be carried out in peak season (June-September) and should cover entire MCA.
- Varied surveying techniques should be used for increasing spotting probability.
- Over exploitation of Paha frogs by the local people should be regulated.
- The existing brooks and cascades are important for mountain frogs along with bushes, vegetation and forests for the reptiles. These invaluable resources must be protected to ensure survival of herpetofauna.
- Conservation awareness programs, related workshops are crucial to educate local people, especially to teach the importance of herpetofauna. This will also help to curb wanton killings of these neglected creatures.
- The nation based GOs/NGOs/INGOs/CBOs should come forth and prioritize amphibians and reptiles conservation as one of their regular activities.

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APPENDICES

Appendix 1 – Photo Plates

Difficult trail on the way to Manaslu Conservation Area

Entry point of MCA at Jagat

Searching for herpetofauna

The researcher with a local paha hunter

Photo plates (contd.)

Bufo himalayanus photographed in Philim

Laudakia tuberculata photographed in Jagat

A dead *Elaphe hodgsonii* observed in Jagat

Photo plates (contd.)

A field guide used during the survey

MCAP Official briefing on biodiversity of the area

Participants of group interview at Prok village

Local people of Sirdibas VDC, who provided information on local herpetofauna

Photo plates (contd.)

Mr Dorje Thakuri, key informant and local traditional healer (Amchi) of Prok village

Mr Chhimik Namgyal, key informant and local paha hunter of Prok village

Appendix 2 – Field data sheet for herpetofaunal documentation (Manaslu Conservation Area, 2012)

S. no.	Date	Time	Name of the species	No. of species	GPS location		Altitude	Habitat Type	Methodology	Weather		Remarks
					Easting	Northing					Temperature (^{0}C)	

Start GPS location	End GPS location
E:	E:
N:	N:

Transects: ....…, # Patches: …………………. Dip net: …………………………………

No. of patches……………

Location name: ……………………….

<u>Note</u>

Habitat type: Tree, Hole, River/streams/pool, Beneath rock/boulder, Swamps/ditches, Dry land, Agricultural land, Human settlement, Fallen logs, Litters, Bushes

Method: Transect (T1, T2, T3…..), Patch sampling, Opportunistic sampling and Dip-net

Weather: sunny, cold, partly cloudy, windy, wet, fine

Appendix 3 - Questionnaire format for Ethnoherpetology in MCA

1. Introduction about Respondents

Name:	Sex:
Caste:	Age:
Occupation:	Religion:
Address:	Education:

2. Have you ever seen any herps? (i)Yes (ii)No
   - If yes, please tell us

Herpetofauna (herps)		Common Name	Nepali Name	Activity Pattern		Status *
				Day/Night	Season	
Reptiles	# Snakes					
	# Lizards					
	# Skinks					
	# Geckoes					
Amphibians						
	# Frogs					
	# Toads					

*= common (C), rare (R), extinct (E)

3. What's your perception towards herptiles anatomy?

Repulsive	Fearful	Ordinary	Beautiful	Splendid

4. Have you heard any mythology/story about any herps? (i)Yes (ii)No
   - If yes, what have you heard?

5. Do you know about values of any herps in following aspect?

Name of herps	Religious	Cultural	Medicinal	Food

6. Have you heard about hunting of herps? (i)Yes (ii)No
   - If yes, how they hunted the herps?

Name of herps	Date of Hunting	Method of Hunting

7. Have you ever hunted herps yourself? (i)Yes (ii)No
   - If yes, when, where & how?

8. Have you tasted the meat of any kind of herps? (i) Yes (ii) No
   - If yes, what kind of herps and what is the taste like?

9. Do you know about uses of any herps? (i)Yes (ii)No
   - If yes, which body parts for what purpose?

Name of herps	Body Parts	Purposes	Process of Use	Effectiveness

10. What's the probability of snake bite, injury and treatment therewith in your region?

Snake bite	Injury	Treatment

11. Do you know the importance of herps in our community? (i)Yes (ii)No
    - If yes, what is its importance in which sector?

12. Do you know the importance and role of herps in agriculture? (i)Yes (ii)No
    - If yes, mention

13. Do you think herps have declined in the last decade? (i)Yes (ii)No
    - If yes, what is the main reason of their declination?

14. Do you think herps need to be conserved? (i)Yes (ii)No
    - If yes, why?

15. Do you know any organizations or individuals working for the conservation of herps in Nepal?
    i. Yes ii. No

    If yes, mention

Appendix 4 – Species documentation with GPS location during the detailed field survey

Location	Species	Number	Longitude	Latitude	Elevation (m)
Philim	*Asymblepharus sikimmensis*	1	84.9001667	28.3954722	1682
Philim	*Laudakia tuberculata*	2	84.8980556	28.3933333	1681
Philim	*Laudakia tuberculata*	3	84.8971389	28.3933056	1578
Philim	*Laudakia tuberculata*	2	84.8969167	28.3932222	1578
Philim	*Laudakia tuberculata*	2	84.8967222	28.3931111	1575
Philim	*Bufo himalayanus*	1	84.8966389	28.3968333	1601
Chisapani	*Bufo himalayanus*	2	84.8963333	28.3979444	1681
Eklebhaati	*Calotes versicolor*	1	84.8962500	28.4177222	1871
Eklebhaati	*Calotes versicolor*	1	84.8957222	28.4175833	1868
Chisapani	*Laudakia tuberculata*	2	84.8944722	28.4140000	1624
Philim	*Laudakia tuberculata*	2	84.8931667	28.3912500	1443
Philim	*Laudakia tuberculata*	2	84.8913056	28.3909722	1438
Salleri	*Laudakia tuberculata*	4	84.8904167	28.3828889	1438
Salleri	*Laudakia tuberculata*	1	84.8886111	28.3810833	1474
Salleri	*Laudakia tuberculata*	2	84.8885833	28.3808611	1464
Salleri	*Calotes versicolor*	1	84.8867500	28.3737222	1484
Salleri	*Laudakia tuberculata*	3	84.8861944	28.3700833	1495
Jagat	*Laudakia tuberculata*	2	84.8872500	28.3632222	1534
Jagat	*Calotes versicolor*	1	84.8902778	28.3603611	1485
Jagat	*E. hodgsonii*	1	84.8903056	28.3579444	1470
Jagat	*Laudakia tuberculata*	1	84.8903306	28.3555556	1478
Jagat	*Laudakia tuberculata*	2	84.8959167	28.3566972	1517
Jagat	*Laudakia tuberculata*	2	84.8960278	28.3563611	1514
Bihi	*Laudakia tuberculata*	2	84.8649722	28.5035556	2000
Bihi	*Calotes versicolor*	1	84.8635278	28.5061944	2022
Bihi	*Laudakia tuberculata*	2	84.8565000	28.5092222	2409
Bihi	*Laudakia tuberculata*	1	84.8693611	28.4967778	2447
Bihi	*Calotes versicolor*	1	84.8665278	28.4681389	2042
Deng	*Calotes versicolor*	1	84.8675833	28.5293056	2080

Deng	*Laudakia tuberculata*	1	84.8668889	28.5269722	1868
Prok	*Bufo himalayanus*	1	84.8418056	28.5167778	2250
Prok	*Laudakia tuberculata*	1	84.8368333	28.5185556	2378
Ghap	*Laudakia tuberculata*	1	84.8284444	28.5317500	2260
Kwak, Prok	*Laudakia tuberculata*	1	84.8347500	28.5350000	2555
Kwak, Prok	*Laudakia tuberculata*	1	84.8348611	28.5347778	2556
Kwak, Prok	*Laudakia tuberculata*	1	84.8349444	28.5346667	2547
Kwak, Prok	*Calotes versicolor*	1	84.8351111	28.5344167	2512
Kwak, Prok	*Laudakia tuberculata*	1	84.8353611	28.5345833	2540
Kwak, Prok	*Laudakia tuberculata*	1	84.8356667	28.5362500	2653
Kwak, Prok	*Laudakia tuberculata*	1	84.8358056	28.5354167	2665
Prok	*Laudakia tuberculata*	1	84.8334167	28.5225833	2501
Prok	*Laudakia tuberculata*	1	84.8326667	28.5220278	2398
Prok	*Laudakia tuberculata*	1	84.8333611	28.5212500	2397
Prok	*Laudakia tuberculata*	1	84.8340278	28.5203333	2398
Prok	*Laudakia tuberculata*	1	84.8345833	28.5197500	2394