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A Peer Reviewed Journal

(Special Issue on Science)

Research Management Cell

Sukuna Multiple Campus

Sundarharaincha, Morang

Koshi Province, Nepal

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Format of Writing Academic Article

Introduction with Literature Review, Methodology, Results and Discussion with Conclusions, (Shortly named as IMRAD).

Title of the Paper (Centered)

Word limit 12 words

Name of the Author/s[1*]

[1]*Affiliation of the Author/s*

**Email of Principal Author:*

Abstract (Left Alignment)

It should contain 250 words

*Keywords:*It should contain 3 to 6 terms.

(Indent and italicized the terms 'key words'.)

Introduction (Left Alignment)

The author should include background, problems, objectives, literature review, and hypothesis (if any). It should contain 800-1800 words.

Methods and Materials/Methodology (Left Alignment)

The author should include brief description of how the research was conducted and the paper (article) prepared. For example: design, population, sample and sources. It should contain 500-800 words.

Result (Left Alignment)

This section should include presentation and analysis through table, picture, graphs, diagrams, images and text. It should contain 600-1100 words. If the section has sub-headings, place the sub-headings accordance with level of heading mentioned by APA 7th edition.

Discussion (Left Alignment)

This section should include the interpretation of results and findings. It should contain 800 - 1900 words.If the section has sub-headings, place the sub-headings accordance with level of heading mentioned by APA 7th edition.

Conclusions (Left Alignment)

The author should conclude his/her result and discussion. This section should contain 300-500 words.

Acknowledgement (If any) (Left Alignment)

References (Left Alignment)

Appendix (If any) (Left Alignment)

Journal Publication Process

The following publication process is adopted by the Research Management Cell (RMC) of Sukuna Multiple Campus:

1. The campus allocates budget for the journal publication.
2. Based on the budget, RMC is given authority to make action plan for publication.
3. Based on the action plan, the RMC announces open call for articles along with the publication guidelines for journal publication.
4. The RMC forms an editorial board from the pool of experts from the country and aboard.
5. The RMC collects the articles as per the guidelines procedures.
6. The RMC hands over the articles to the editorial board.
7. The editorial board provides preliminary feedback to the authors.
8. Incorporating the feedback, the author submits the articles to the editorial board.
9. The board forms a list of experts for review, called team of reviewers.
10. The board also develops an evaluation form for the evaluation of the articles.
11. The board sends the articles to the reviewers without disclosing the author's identity (coded copies) for evaluation.
12. Having received the reviewed articles from the reviewers, the rejected articles will be sent back to the authors along with the reasons of rejection, and they will be excluded from the list but other articles will be sent to the authors along with the feedback without disclosing the identity of the reviewers.
13. The authors should modify the articles based on the feedback and the authors are asked to send the articles again (in the case of modification requirement) to the editorial board.
14. The board meeting makes decision of each individual article for publication even excludingthe rejected articles.
15. The board also makes the design of the journal and the final manuscript is handed over to the RMC authority and the campus.
16. The campus authority, the RMC and the editorial board make decision for publication.
17. After the publication, the authors are asked to disseminate the articles among faculties.

Editorial Notes

It is a matter of great delight to state that Sukuna Multiple Campus, Sundarharaincha, Morang has been successful to set up a milestone in its academic history by publishing a peer-reviewed journal *Academic Journal of Sukuna AJoS* in short. Sukuna Multiple Campus has long been involved in the academic activitiessince it first published its academic journal with the name *Sukuna Sourav* on October/November 1998 AD/Kartik 2055 BS. The secondvolume of the *SuknaSourav* was published on April 2003 AD/Chaitra 2059 BS. Its third volume was published on April 2012 AD/Chaitra 2069 BS under the name JOURNAL OF PUCTA. Likewise, the Journal of PUCTA got published the latest volume of *Sukna Sourav*in 2016/17 AD (2073-74 BS).

With a clear vision of academic writing, Research Management Cell (RMC-Sukuna) of Sukuna Multiple Campus (SMC) initiated publishing multi-disciplinary journal with a newer name and taste that is, *Academic Expedition: A Journal of Sukuna* (AJoS) on March 2015 AD, and its subsequent number was published on April 2017 AD. Unlike these two volumes of AJoS, this current AJoS volume is markedly distinct from the previous ones especially on two counts i.e. the current AJoS is unidisciplinary which means it is related to only science discipline, and it is the first peer-reviewed journal.

In the process of publication, the AJoS has attempted to adhere to all the prescribed norms, rules, or regulations as far as practicable. However, this is the first effort for a serious academic exercise on behalf of editorial team; certain lapses may have crept into the work. The editorial board is firmly committed to improving the scope and qualityof the journal in the days to come. Constructive and positive comments from scholars, academicians and stakeholders are ever welcomed and accepted.

The editorial team fairly anticipates that the AJoS can be of certain help in its related subjects and fields. Last but not least; the team cordially expresses its thankfulness to allthe individuals and institutions-too many unfortunately mention by names-for their inspirations and cooperation.

Thank you!

Editorial Board

RMC-Sukuna

Table of Contents

Distribution records of Hodgson's giant gliding squirrel *Petaurista magnificus* and Black giant squirrel *Ratufa bicolor* in Eastern Nepal

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Abstract

Squirrels are the least studied small mammals due to which their proper distributional records are still unknown. We have presented the local sighting records of two species of squirrel; Hodgson's giant gliding squirrel, *Petaurista magnificus* and Black giant squirrel, *Ratufa bicolor* from Ilam district of eastern Nepal. The survey is based on the opportunistic observation and information obtained from the local community through purposive sampling at Sandakpur and Rong rural municipality and Suryodaya municipality of Ilam. During the study period of one year, 22 March 2021 to 21March 2022, we recorded four evidence of *P. magnificus* in Sandakpur and two in Suryodaya and two evidence of *R. bicolor* in Rong of Ilam district. We also observed an individual of *P. magnificus* feeding on newly emerging sprouts of *Alnus nepalensis* nearby its drey. Purposive sampling method with the local community stated that the population of both species of squirrel is in decreasing trend since last five years due to habitat degradation and hunting for bush meat. The local community also believes that the observation of *P. magnificus* brings bad omen, therefore are knocked off from the trees whenever observed. In particular, more investment on charismatic fauna and limited studies, lack of awareness programs is slowly reducing the number of these small mammals from the ecosystem. As most of the habitat of squirrel lies outside of the Protected Areas (PAs) of Nepal, we recommend stewardship and community awareness as sustainable means to safeguard their future.

Key words: Meat; drey; Ilam; sighting; squirrel

Introduction

Nepal lies in the transitional zone between two bio geographical realms: the Sino-Japanese in the north and Oriental in the south (Holt et al., 2013) and the richness in its biodiversity is a reflection of its unique geographical position, altitudinal and climatic variances (Paudel et. al., 2012). The biodiversity of Nepal is represented by 212 mammalian species (Amin et. al., 2018), among which order Rodentia is the largest mammalian order and is characterized by the presence of ever-growing large incisor teeth, two in the upper arcade and two in the lower (Pachaly et. al., 2001). Squirrels are small-medium sized rodents included in the family Sciuridae which represents 285 species of squirrels in the world having deferent form of adaptations i.e., arboreal, ground-dwelling and gliding squirrels (Thorington et. al., 2012). Nepal is a habitat of eleven species of squirrels (six gliding and five tree) among which eight species are considered as globally Least Concern, two Near Threatened and one Data Deficient (Amin et. al., 2018).

Gliding squirrels are a diverse group of magnificent animals found in the world and believed to be evolved from the tree squirrel (Thorington et. al., 2012).Among six gliding squirrels extant in Nepal, Hodgson's giant gliding squirrel (*Petaurista magnificus*) is categorized globally as Least Concern in the IUCN Red List Assessment (Molur, 2016), Vulnerable in South Asia (Molur et al., 2005) and Data Deficient nationally (Jnawali et al., 2011). The chief distinguishing feature of this species is the wide dark brown or black dorsal stripe that runs from the nose to the base of the tail (Thorington et al., 2012). The diet consists of acorns, chestnuts, other hard fruit and newly emerging sprouts and even insects, chiefly termites (Jackson, 2012).The distribution of this species is restricted to northern south Asia, southern China and western southeast Asia (Molur, 2016) and particularly in Nepal the confirmed distribution records is from Gorkha, Dolakha, Sindhupalchowk, Sankhuwasabha, Kaski, Terhathum, Kanchanpur and Ilam districts and PAs like Annapurna Conservation Area, Makalu Barun National Park, Rara National Park, Sagarmatha National Park, Shivapuri

Nagarjuna National Park, Langtang National Park (Thapa et al., 2016). The habitat of this species comprises evergreen to deciduous forests and in Nepal with an elevation range of 3700m (Jackson, 2012; Thapa et al., 2016).

The Asian giant squirrels, genus *Ratufa* includes four species, among which two are restricted to India and Sri Lanka while two inhabit in dense forests of Nepal and southern China to the islands of Borneo, Java, and Sumatra (Thorington et. al., 2012).The Black giant squirrel (*Ratufa bicolor*) is only one species of giant squirrel extant in Nepal whose distinguishing character is the conspicuous black dorsal body surface with dull buffy white or yellow ventral pelage (Moore & Tate, 1965).The species has been categorized globally as Near Threatened in IUCN Red list and nationally as Endangered species (Duckworth & Molur, 2016; Thapa et al., 2016). The species inhabits in broadleaved and evergreen forests ranging from 200-2000m and has been recorded from Panchthar, Terhathum, Ilam, Morang, Sunsari, Sankhuwasabha, Chitwan districts and PAs like Rara National Park and Makalu Barun National Park (Thapa et al., 2016).Human induced habitat degradation due to shifting agriculture practices, small-scale logging, forest fires, expansion of human settlement, poaching for trade and subsistence and persecution are the major threats to the species (Jnawali et al., 2011; Molur et al., 2005).

In comparison to other faunal species, squirrels are the least studied small mammals and the literature available are scanty. To address this knowledge gap, there is an urgent need to gather timely information on distribution and conservation threat to squirrels. So, an initiative has been taken to document the sighting records of two species of squirrel (*P. magnificus & R. bicolor*) from Ilam district of eastern Nepal.

Methods and Materials

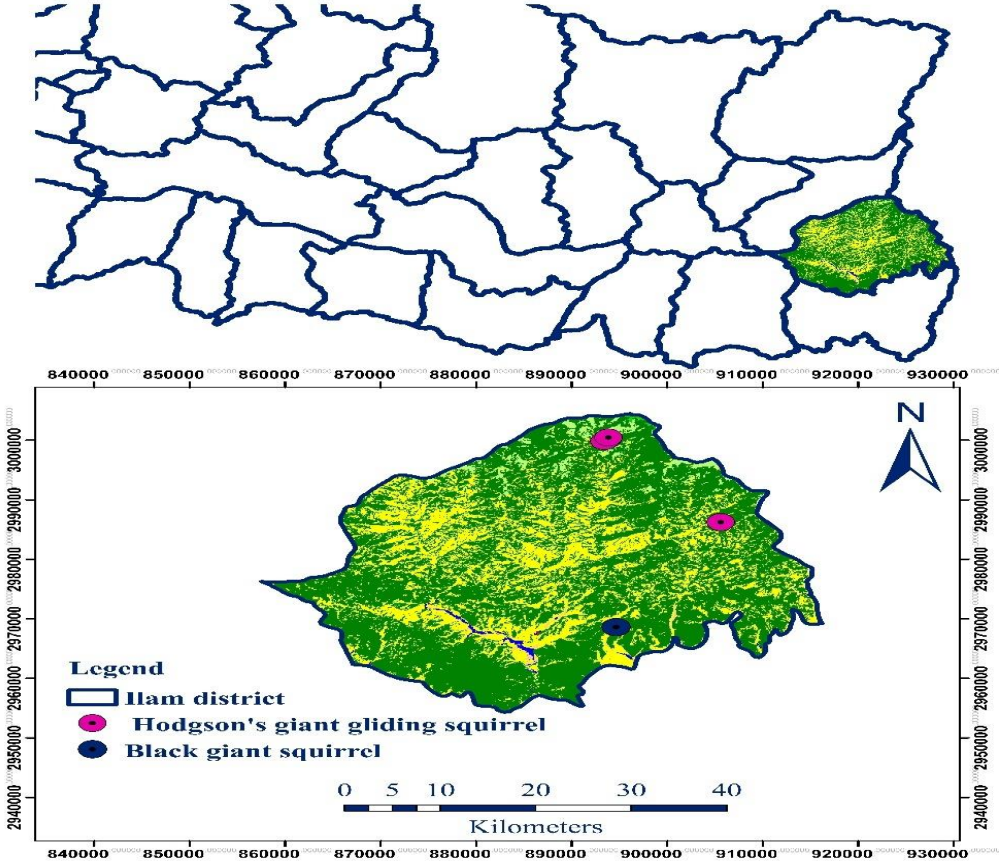
The present study was conducted in Sandakpur Rural Municipality - 2 & 4, Rong Rural Municipality - 2 and Suryodaya Municipality - 3 of Ilam district, Nepal. The area comprises of tropical and sub-tropical forest ranging from elevation of 500-2300 masl. Nepalese alder (*Alnus nepalensis*), Chestnut (*Castanopsis indica*),

Rhododendron, Sikkim fir (*Abies densa*) and Sal (*Shorea robusta*) are the dominant species of plants in the area.

We conducted an opportunistic squirrel survey in between 22 March2021 to 21 March 2022 in Ilam district along with fieldwork of marbled cat and Clouded leopard. Using purposive sampling, we selected and interviewed the local people together information about *P. magnificus* and *R. bicolor*. On the basis of information provided by the local people, we visited the potential sites with local guides from 3-7pm in search of direct and indirect sign of squirrels. Observation was taken on the direct sighting and nests of the species. Number of drey in the tree and its height from the ground was estimated visually (with binocular), Nikon D3000 was used to capture the photographs and Garmin eTrex 10 was used to record GPS coordinate and altitude of the sighting spot. Additional information like preferred areas, any existing social belief regarding the species, and hunting and population change since last five years were gathered from the informal questionnaire taken from the locals who lived within the periphery.

Figure 1

Map of the study area with squirrel sighted locations



Results

In total, six evidences of *P. magnificus*; four nests without squirrel and two nests with squirrel were recorded in Sandakpur - 2 and 4 of Ilam (Appendix plate I & II).

The first observation of squirrel happened on 22 March, 2021 in Mabu, Sandakpur – 4 on a *Pyrus pashia* tree, commonly called Wild Himalayan pear. The GPS location of the point is 27.06713^0 N, 87.9686^0 E and elevation is 1978 meter above the sea level (masl). The drey was composed of twigs and soft mosses which seemed unoccupied for many days and was more or less eight m high from the ground.

On 24 March, 2021 in Mabu, Sandakpur - 4 we did second observation which was also an old drey but without squirrel. The drey seemed even older than previously sighted one. It was on *Saurauia napaulensis*, commonly called as Gogan tree in Nepali and more or less at 12 m high from the ground. The GPS location of the point is 27.06743^0N, 87.96843^0E and elevation is 1952 meter above the sea level.

We observed the squirrel drey on 25March, 2021 on *Abies densa*, commonly known as Sikkim fir. The drey was within 100m south from previously sighted drey and was more or less 14 m high from the ground. We could not identify whether the nest is active or not because of the meshed branches of fir, but it was not occupied by the squirrel during our observation. The GPS location of the point is 27.06743^0N, 87.96843^0E and elevation is 1952 meter above the sea level.

On 27 March 2021, while conducting the mist nest survey for bats near the cave at Yangbillepakha, Mabu, Sandakpur - 4 in the dusk, we observed two individuals of Hodgson's gliding squirrel enjoying their twilight glide. They took a leap from nearby Nepalese alder tree (*Alnus nepalensis*) and glided above us however, the squirrel was not clearly visible because of the dusk. The GPS coordinate is 27.0651^0N, 87.96571^0E and the elevation is 2066 meter above the sea level.

On 31 March 2021 at Sisne, Sandakpur - 2 we observed the live squirrel in its drey (Figure 2). The drey was constructed on *Euria japonica tree* – locally called as Jhingani in Nepali-more or less 10 m high from the ground. The drey was composed of mosses and fur and also had a hole like vertical shaft that led into the inner part. As we approached the drey, our movement alerted the squirrel so, it peeped us from the same vertical shaft of its drey. The larger size, yellow patches on the shoulder and lighter pelage on its sides clearly distinguished the species as Hodgson's giant gliding squirrel. The sun was about to set so we observed the squirrel about 5 minutes after which it glided away from its drey. Within a minute we heard a typical monotonous call "Shree-Shree" from the nearby Chestnut (*A. nepalensis*) tree. Following the call with our headlight, we encountered yellow-colored creature having a black stripe on its body

perching on a branch of *A. nepalensis* (Figure 3). It was foraging on newly emerging sprouts of *A. nepalensis* with its forelimbs. After a while, it rushed towards the top of tree and jumped with its gliding membrane and went out of our sight. The GPS coordinate is 27.07054^0N, 87.97028^0E and the elevation is 1960 meter above the sea level.

Our last sighting in Sandakpur was at a Rhododendron's tree in adjacent to a local villager's house (Figure 4). On 2nd April, 2021 we observed a pile of twigs, leaves, mosses and furs at the top of Rhododendron's tree in Sandakpur - 2, Sisne. The species was the baby of Hodgson's giant gliding squirrel which got alerted by our movement. The GPS coordinates of the point is 27.07054^0N, 87.97028^0E and altitude is 1960 meter above the sea level. We came to know that the house owner, Mohan Rai had recently encountered a gliding squirrel nearby his house injured by an electric shock and lying on the ground. According to him, the individual got shocked by electricity from the nearby electric pole during the glide. The house owner rescued the squirrel and captivated it for around five days then it got dead.

Similarly, on 25 February 2022, while we were on the way to install camera trap for Marbled cat survey in Suryodaya - 3 of Ilam we observed two individuals of Hodgson's giant gliding squirrel; one within the drey and another gliding down from top of Sikkim fir. The GPS coordinate of the spot is 26.93910^0N, 88.08383^0E and altitude is 1511m. The details of sighting of *P. magnificus* are given in Table 1.

We also observed Black giant squirrel taking agile leap from tree to tree in Sal dominated forest of Rong - 2, Ilam (Figure 5). On 12 October 2021, while we were on the way to install camera trap for Marbled cat in Rong - 2 of Ilam we were attracted by two black colored elegant creatures who were emitting a loud and harsh crackle from upper canopy of Sal tree. These creatures were a pair of Black giant squirrel which were resting and within a minute they took agile leap from sal tree and went out of sight. The GPS coordinates of the sighted location is 26.783347 N, 87.968284 E and elevation is 380 m.

Informal questionnaire with the locals revealed that the number of *P. magnificus* and *R. bicolor* is in trend of decreasing order since last five years. They responded that they sight lesser number of individuals of *P. magnificus* nowadays than previous years. Beside these, some locals had evil social belief towards this species. They believe that it will be their misfortune if they sight this creature alive and its nesting around their house is a sign of bad luck. The individuals of *R. bicolor* is threatened due to rampant killing for bush meat and the lack of proper knowledge has led some locals to mistakenly kill the species as pest as its appearance resembles with a more commonly found species i.e. Asian palm civet.

Discussions

The observed dreys of *P. magnificus* was under the dense canopy cover and inside the meshed branches of fir which could help the gliding squirrel in avoiding from detected by predator like jungle cat, civet cat, eagles etc. which is in analogous with finding of Mishra & Raziuddin (2011).The maximum number of unoccupied dreys of *P. magnificus* indicates the decline in the species population as the time passes. The decrease in the population might be due to higher rate of conversion of forested areas into farmlands and settlements (Jnawali et al., 2011) and as discussed by Baral et. al., (2012)there is higher demand of wood for firewood, fodder and timber in eastern Nepal which is threatening the biodiversity including squirrels of this region. Other threats includes rampant killing for subsistence food source by the locals as indicated by Molur et al., (2005)and abdomen as well as electrification as observed. The extent of bad omen associated with the species ranges as misfortune from the sighting near the human settlement. So, locals used to knock off this species with locally made slingshot which significantly contributes to threaten the species population. As reported by Ghimirey et. al., (2012) in Sankhuwasabha, the lack of conservation awareness has led some locals to mistakenly kill the individuals of Black giant squirrel as pest as its appearance resembles with a more commonly found sympatric species i.e. Asian palm civet.

Conclusions

In Nepal, very few studies have been done on squirrel and the literatures available are scanty. The major reason may be due to the cryptic and crepuscular behavior (Smith & Xie, 2013) of gliding squirrel which makes these species difficult to study. Similarly, the lesser interest of general conservationists and lack of resources allocated for the smaller species like squirrels are other reasons behind their low informational records. A checklist on rodents of Nepal published by Thapa et al., (2016) have shown the maximum potential habitat of *P. magnificus* and *R. bicolor* outside of the protected area where the threats are very high. As most of the habitat of these species lies outside of the protected areas, local people can play an integral role to safeguard theses mall mammals via community conservation as discussed by Adom et. al., (2020). We recommend stewardship and community awareness as sustainable means to safeguard the squirrel from the brink of extinction. In the present scenario, an intensive study of squirrels is crucial to formulate conservation strategies and action plan to conserve them.

Acknowledgements

We would like to acknowledge local government and local people of Sandakpur and Rong Rural Municipality and Suryodaya Municipality for their guidance, support and knowledge during the field visit. Special thanks to the local field guide Mr. Birbal Rai, Mr. Man Kumar Rai and Mr. Gopal Khaling for their tremendous support in the field work.

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Appendix plate I

Table 1

Sighting records of Hodgson's giant gliding squirrel

S. N	GPS Location	Elevation (masl)	Tree	Name of a place	Remarks
1.	27.067 N, 87.968 E	1978	Wild Himalayan pear (*Pyrus pashia*)	Mabu, Sandakpur - 4, Ilam	Nest without squirrel
2.	27.067 N, 87.968 E	1952	Gogan (*Saurauia napaulensis*)	Mabu, Sandakpur - 4, Ilam	Old nest without squirrel
3.	27.067 N, 87.968 E	1978	Sikkim fir (*Abiesdensa*)	Mabu, Sandakpur - 4, Ilam	Nest without squirrel
4.	27.065 N, 87.965 E	2066	Nepalese alder (*Alnus nepalensis*)	Mabu, Sandakpur - 4, Ilam	Squirrel glided down from top of Nepalese alder tree
5.	27.070 N, 87.970 E	1960	Jhingani (*Euriata panica*)	Sisne, Sandakpur -2, Ilam	Squirrel nesting on itsdrey
6.	27.070 N, 87.970 E	1960	Nepalese alder (*Alnus nepalensis*)	Sisne, Sandakpur - 2, Ilam	Squirrel foraging on freshly emerging sprouts of*Alnusnepalensis*
7.	27.070 N, 87.970 E	1960	Rhododendron (*Rhododendron* species)	Sisne, Sandakpur - 2, Ilam	Baby squirrel nesting on the drey
8.	26.939 N, 88.083 E	1511	Sikkim fir (*Abies densa*)	Jil, Suryodaya - 3, Ilam	Squirrel glided down from Sikkim fir
9.	26.939 N, 88.083 E	1511	Sikkim fir (*Abies densa*)	Jil, Suryodaya - 3, Ilam	An individual squirrel nesting on the drey

Table 2

Sighting records of Black giant squirrel

S. N	GPS Location	Elevation (m)	Tree	Name of a place	Remarks
1.	26.783 N, 87.968 E	380	Sal (*Shorea robusta*)	Badamtar, Rong - 2, Ilam	Squirrel resting on a branch of Sal tree

Appendix plate II

Figure 2

Hodgson's giant gliding squirrel peeping form vertical shaft of its drey in Sisne, Sandakpur - 2 (Photo: Dibya Raj Dahal)

Figure 3

P. magnificus foraging on newly emerging sprout of A. nepalensis in Sisne, Sandakpur - 2 (Photo: Dibya Raj Dahal)

Figure 4

A baby P. magnificus resembling teddy bear appearance sighted in Sisne, Sandakpur - 2 (Photo: BashuBaral)

Figure 5

Black giant squirrel resting on branch of Sal tree in Rong - 2 of Ilam (Photo: Amir Basnet)

Figure 6

Habitat of Black giant squirrel in Rong - 2 of Ilam (Photo: Bashu Baral)

Study of Biogas Implantation in Nepal (2004-2017)

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Abstract

Nepal has been characterized by very low per capita energy consumption. Due to the easy unavailability and access of other green and eco-friendly sources of energy, the country should depend on conventional fuel source, mostly on firewood. Several technologies regarding renewable and eco-friendly sources of energy have been initiated in their massive production and distribution throughout the country aiming to reduce the energy crisis problem. We have studied the number of biogas implantation from 2004 to 2017. The data of biogas plant installation in different year is provided by Alternative Energy Promotion Center (AEPC). The maximum number of new biogas plant was installed in the year 2014 and 2015. This was due to the stability of peace and public awareness in Nepal. Also maximum percentage of investment was afforded by organization. In this work, we found that the total amount of carbon emission reduction from 2004-2017 after the biogas plant installation in Nepal was 984275 tCo_2.

Keywords: Biogas, Green house gases, Emission reduction, Biomass, Digester

Introduction of Biogas

Methane gas, CH_4 is produced from the biodegradable substance such as animal dunk, vegetable waste, human excreta etc in anaeorbic reactors, which is commonly called biogas. Except oil, coal and gas, biomass is considered as the most contributing factor in terms of traditional energy sources on the basis of their contribution to the world total energy production (Yasar, Nazir, Tabinda, Nazar, Rasheed, & M. Afzaal, 2017). In agricultural country such as Nepal, biogas is

produced in household reactors for lighting and cooking (Gautam, Baral, & S. Heart, 2009). Different studies show that, this technology has promising potential among different possible renewable energy technologies. It helps to increase crop productivity, save time for human and more importantly as it improves our health condition.

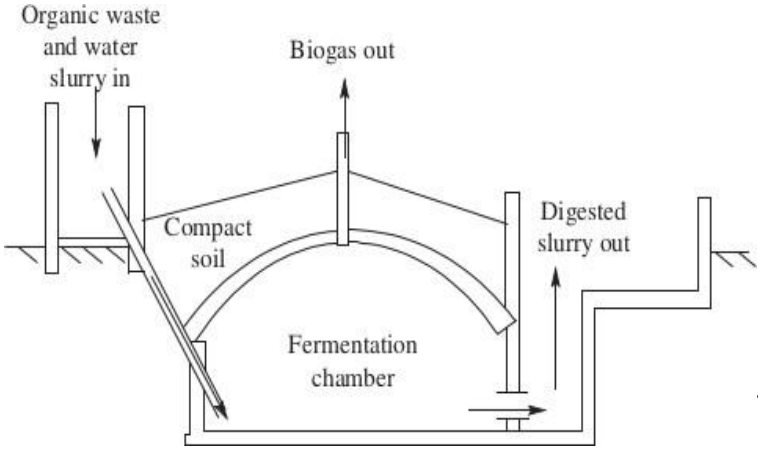
For economic development of country, affordable and reliable energy is needed. Per capita energy consumption of any country can actually reveals the current status of its economic development. Taking reference to world rescue institute (Katuwal & Bohara, 2009) , Nepal's per capita in terms of energy consumption for the year 2005 was 338 kgoe, which is much below as compared to the mean value for other Asian countries (1051.5 kgoe) and worldwide mean (1778 kgoe).

Biogas Digester Design in Nepal

Biogas digesters are used to produce biogas. Among the numerous techniques for the production of biogas, fixed dome below ground biogas plants is most common in Nepal. This model was first developed in 1990. The main reason for this universality of this method is that, it exists in numerous sizes varying from 4 to 20 m^3 and also it can be made by using locally available materials such as clay, bricks, cement, bamboo, wooden supports etc. The model commonly used in Nepal is shown in fig below:

Figure 1

Biogas digester used in Nepal (Katuwal & Bohara, 2009)



A fixed dome plant comprises a digester along with fixed, stationary gas holder on the top of the digester. After the initiation of production of gas, the slurry is moved into compensation tank. The increment on the volume of gas stored in the gas holder automatically increases gas pressure and vice versa (Holder, Kamath & Godbole, 1984).

Animal husbandry is the main inputs for the biogas technology. In such process, methane gas is produced from an underground digester using cattle dunk and the produced gas is used for cooking and lightening. It burns with blue flame without emitting smoke (Katuwal & Bohara, 2009). In regard to the production of different gases, it consists 50-60% methane and 40-50% carbon dioxide and some other gases. The digester size of $6m^3$ can digest 36 kg of dung and almost requires same quantity of water. This quantity can burn stove up to 3.5 hours. On the basis of animal population, 1.9 million family sized biogas plant can be installed in Nepal (Acharya, Bajgain, & Subedi, 2005).

Biogas Development Events in Nepal

Since 1950, Indian farmers have been used biogas technology to produce cheap bio fuel. The potential of huge development and used of biogas sector in Nepal was accounted by development of biogas sector in India, having social and geographical similarities (Gautam, Baral, & S. Heart, 2009). Installation of biogas plant was initiated from 1974 through some demonstrative installation of plants. The department of agriculture of Nepal first installed about 200 biogas plants during 1974 - 1975. In 1977, a Gober Gas Company (GGC) was founded under the Agriculture Development Bank of Nepal (ADBN) aiming at promoting public awareness about biogas plants and installing biogas plants (Pokharel, 2007). After this, for the huge promotion and development of biogas, Biogas Support Program (BSP) was started in the year 1992 (Katuwal & Bohara, 2009). Till 1994, the total number of biogas plants set up were about 12,000 using subsides provided by the government. However, from 1995, all

biogas installations were brought under Biogas Support Program (BSP). Until 2003, the number of biogas plants installed reached to 11,200 under BSP. Therefore, about 110,000 biogas plants were estimated to be installed in 2003 (Pokharel, 2007).

Based on the data of BSP, until 2009, biogas plants were installed in Nepal in four phases which are shown in the table below. During the first phase, the numbers of successfully installed plants were reported to be 6824. Since then, the number of biogas installation has been continuously increasing. In total, 189122 biogas plants had been installed in 66 districts out of the nation's 75 districts.

Table 1

Biogas plant installation on different phases (Gurung, Ghimeray & Hassan, 2012)

Year/phase	Biogas plants installed
First phase (1992–1994)	6824
Second phase (1994–1997 March)	13,375
Third phase (March 1997–June 2003)	91,196
Forth phase (July 2003–June 2009)	63,196
Total	174,591

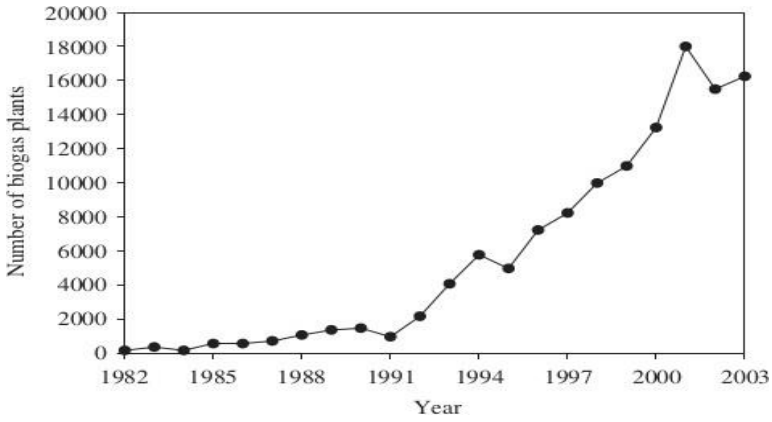
Source: BSP 2009.

Benefits of Biogas in Nepal

The biogas production impacts can be counted locally, nationally as well as globally. It helps to make our kitchen ashless and smokeless and makes our cooking process more comfortable, faster and healthier. Also, it promotes the agricultural productivity by the use of bio slurry. As national benefits, it is proved to be helpful in reducing our dependency on imported petroleum and LPG like non-renewable sources of energy. As global benefits, it helps to protect the world from the adverse effect of climate change and global warming by reducing the production of green house gases (Katuwal & Bohara, 2009). Beside this, there are so many benefits of biogas, which are described in detail below.

Figure 2

Number of biogas plants installed in different years (Katuwal & Bohara, 2009)



(1) Health benefit

Biogas helps in controlling air pollution so that it helps to decrease the suffering rate of different respiratory related diseases, eye infection etc. Also, people can be safe from several diseases such as worms, bacterial diseases and viral infections, as set up of biogas plant motivates people to build toilet. Thus, it plays a vital role to improve sanitation level (Katuwal & Bohara, 2009).

(2) Gender benefit

In the context of developing countries like Nepal, usually Women are being able to save their time up to 3 hrs which they used to spend in collecting firewood especially in rural areas. Thus it also helps to rise up women empowerment getting enough time for social activities (Gautam, Baral, & S. Heart, 2009).

(3) Economic, agricultural benefit

There is no need to buy kerosene, wood or LPG cylinder, inorganic fertilizer because biogas slurry is best organic fertilizer that is high in nitrogen, potassium and phosphorous contents. Thus, it saves the money and rises the economic condition of family as well as country. Also it increases crop productivity (Yasar, et.al, 2017).

(4) Environmental benefit

Depending mostly on firewood as a conventional source of energy for cooking and heating biogas leads to the reduction of uncontrolled deforestation in Nepal. Also, deforestation leads to fuel wood crisis. Moreover, due to the emission of GHG from the use of firewood as fuel results in the environmental degradation locally and globally. Mostly, in Nepal biogas plant has been successful for replacing firewood like non-renewable fuel especially for the purpose of cooking and light. Biogas not only promotes clean and green energy, but it also helps to reduce environmental degradations by conserving forest (Katuwal & Bohara, 2009).

\Carbon Gas Emission

The natural carbon emission is from the exchange of carbon dioxide between the oceans and the atmosphere. The process of respiration of plants and animals and the decomposition of plants and animals in soil is responsible for the production of CO_2 in atmosphere. There are two type of carbon gas emission.

(1) Direct carbon gas emission

Direct carbon emissions in atmosphere occur from sources producing CO_2 as product. These emissions can be grouped as scope 1 and scope 2 emissions. Direct emission of CO_2 from the site of the process or service falls under scope 1 emission. Emission of CO_2 directly from industry and construction sites by burning a fuel is an example of scope 1 emission. Also, gas emission from personal vehicles and by burning stoves using non-renewable source of energy would fall under scope 1. Emission of gas from electricity, heat, or steam used on site falls under scope 2 emission.

(2) Indirect emission of carbon gas

Indirect carbon emissions are emissions from sources upstream or downstream from the process being studied, also known as scope 3 emissions. Examples of upstream, indirect carbon emissions may include:

(1) Emission from the transportation of fuels

(2) Emission from fuel energy used outside of the production site/ facility

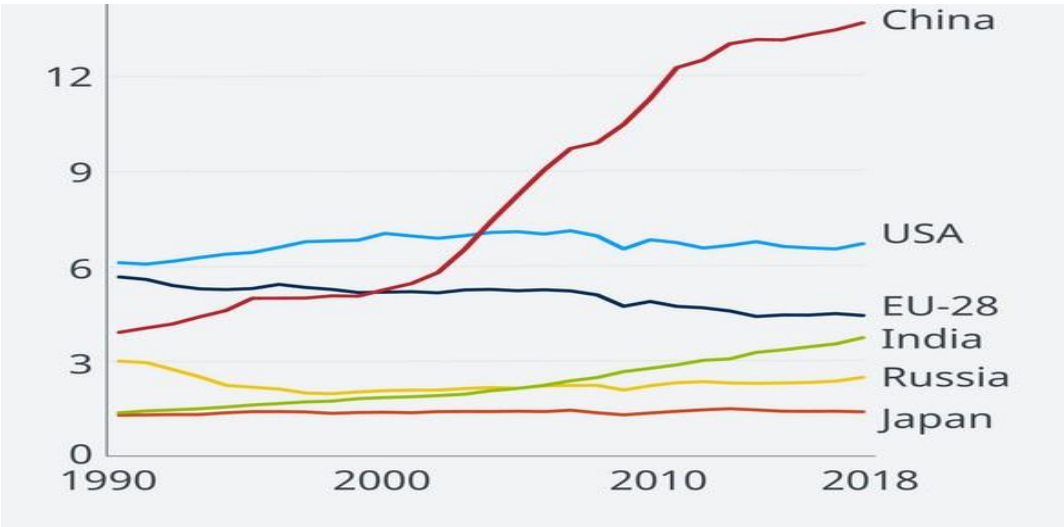
(3) Wastes products and garbage produced from the side of the production site/facility. Examples of downstream, indirect carbon emissions may include:

(4) Any end-of-life process or treatments

(5) Product and waste transportation

Figure 3

Absolute emission of co_2 in Gigatones (Mumma, Stone, Borst & Zipf, 1972).



Objectives

The main objectives of this work are enlisted below.

(1) To estimate the carbon emission reduction by biogas implantation in different year.

(2) To study the biogas implantation in different year.

(3) To study the variation of ER with number of biogas installation.

(4) To study the benefits of biogas implantation in different sectors such as environmental, health, agricultural etc.

Biogas is the promising source of renewable energy. Thus, it has been studied from the past many years by different researchers. Some of them are discussed in this section. Omer and Fadalla (2003) discussed about the potentiality

of biogas energy as a promising optional source of energy and revealed the ecological, social, cultural and economic aspects of biogas technology. Acharya et al. (2005) presents the challenges and opportunities of BSP, benefits of biogas systems, role of BSP stakeholder and reason behind the success of BSP.

Pokharel (2007) disclosed the current status and possible potentiality of biogas production in Nepal. Pokhrel discussed about Nepal's current status in the contribution of Green House Gas (GHG) emission and potential of different Renewable Energy Technology (RETs) for GHG emission reduction.

Gautam et al. (2009) also present the current status of biogas energy in the context of Nepal. According to them, the biogas has helped the nation in several aspects like income generation, life style improvements and cost saving.

Katuwal et al. (2009) proved biogas as viable and emerge as promising technology. According to them, biogas helps to improve health, increase crop productivity, saved times for women and also provides economic advantages to the country through the carbon trading reducing deforestation.

Huisingh, Zhang, Moore, Qiao, and Li (2015) concluded his literature review into the process used for beneficiary management of waste products across Africa. They found that Urban and Periurban waste matters in developing countries comprises a huge percentage of biogenic organic carbon which can be converted into methane using biodegradation process in landfills.

Gurung et al. (2012) reviews and discusses the status, potential and opportunities of RETs in Nepal. According to them, RETs currently provides less than 1% of total energy consumption. They suggested that RET policy should be made in favor of poorer segment of society by considering the socio economic and geographical conditions to make available to all people.

Huisingh, Zhang, Moore, Qiao and Li (2015) found that uncontrolled human activities such as using fossil fuels for domestic purposes and massive deforestation is responsible for adverse climate change and global warming. They

also stated that maximum supply distance of biomass allows cofiring of coal and bio-fuel to be more environmental friendly than the pure coal combustion systems.

Yesar et al. (2017) presented that biogas can be the best alternative to solve the problem of energy crisis. They also showed that installation of biogas plant has significant role in improving the economic, social and health conditions of people by reducing cost for non renewable fuel and fertilizer along with time saving and reducing cases of diseases. They also found that biogas plants were supposed to be installed in those households having higher number of family members ranging from 12 to 15.

Theory

Carbon gas emission reduction (ERy) defined as amount of reduction in carbon gas if the carbon containing source is replaced by the non-carbon containing source. The emission reduction is calculated as:

$$ER_y = BE_y - PE_y - LE_y$$

Where, ER_y = Emission reduction, BEy = Base line emission

PE_y = Project emission and LEy = Leakage emission

Now, base line emission is given by,

$BE_y = B_y * F_{NRB,y} * NCV_{biomass} * EF_{projectedfossilfuel}$ *where,*

B_y = Amount of woody biomass that is replaced in tones

$F_{NRB,y}$ = Fraction of woody biomass used in the absence of the project activity in year y that can be established as non renewable biomass.

$NCV_{biomass}$ = Net calorific value of the non-renewable woody biomass that is substituted $EF_{projectedfossilfuel}$ = Emission factor for substitution of non renewable woody biomass by similar consumers.

Also,

$B_y = N_{HH} * (BC_{BL,HH,y} - BC_{PJ,HH,y})$

where, N_{HH} = Number of households in the project activity number

$BC_{BL,HH,y}$ = Average annual consumption of woddy biomass per household before

the start of project activity, tones/household/year.

$BC_{PJ,HH,y}$ = average annual consumption of the woddy biomass per household in the pre project devices in the project activity.

Methods and Materials

Alternative Energy Promotion Center (AEPC) is one of the potential organizations in Nepal, which works on the various field of alternative energy. Our concern is about biomass plant all over the country and with some simple statistical analysis we have discussed the already existing data of biomass implantation. We use this to predict future consumption, reduction in the emission of carbon gas . For graphical interpretation we put to work with Gnu-plot and Xm-grace.

Here, we are going to estimate carbon gas emission reduction by using biogas plant in Nepal at different year from 2004-2017.While performing this work, we kept all the parameter same as validated by the Ministry of Forest and Environment, Government of Nepal and only vary the number of biogas plant that are installed in different year. Here, we consider cumulative number of biogas plant as total number of biogas plant. In short, we employed the methodology is simply studying the data, calculating emission of carbon gas, reading and understanding them and adding some information -if possible. We have carried out data tabulation and graphical representation by using GNU plot and calculation of Pearson correlation coefficient and p-value using excel.

Result and Discussion

The number of biogas plant installed between 2004 to 2017 is shown in table below. Large number of plants were installed in the year 2014. From the data of 2004, fraction of woody biomass is used in the absence of the project activity in year that can be established as non renewable biomass. The value is found to be 86.1% taking the help of national statistics. The value is for national level and fix for crediting period.
Net calorific value of the non-renewable woody biomass that is substituted (IPCC default for wood fuel $NCV_{biomass}$) is 0.0156 TJ/tone.

Emission factor for substitution of non renewable woody biomass

($EF_{projectedfossilfuel}$) by similar consumers use a value of 63.7 tCO_2/TJ. This value is fixed for the crediting period. Number of households in the project activity, N_{HH} = 9692.

Table 2

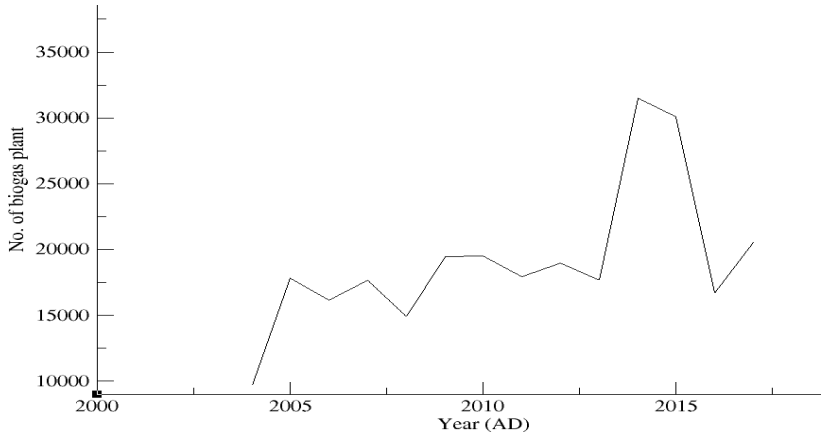
Biogas Plant installation in different year (AEPC, 2020)

SN	Year	No. of installation	Total no of installation
1	2004	9692	9692
2	2005	17803	27495
3	2006	16118	43613
4	2007	17663	61276
5	2008	14884	76160
6	2009	19479	95639
7	2010	19511	115150
8	2011	17907	133057
9	2012	18979	152036
10	2013	17635	169671
11	2014	31512	201183
12	2015	30078	231361
13	2016	16706	247967
14	2017	20536	268503

The survey was done to identify the average annual consumption of woody biomass per household substituted in 2018. The survey has found that the woody biomass consumption is 5.06 tonnes/household/year before the project activity whereas 0.55 tonnes/household/year of the woody biomass consumption is found after the project activity. It means net annual average woody biomass displaced per household is 4.51 tonnes/household/year. By $= 9692 * 100\% * (5.06 - 0.55) =$ 43807.84 tonne/year. Here the operational status of biogas is 100%.

Figure 4

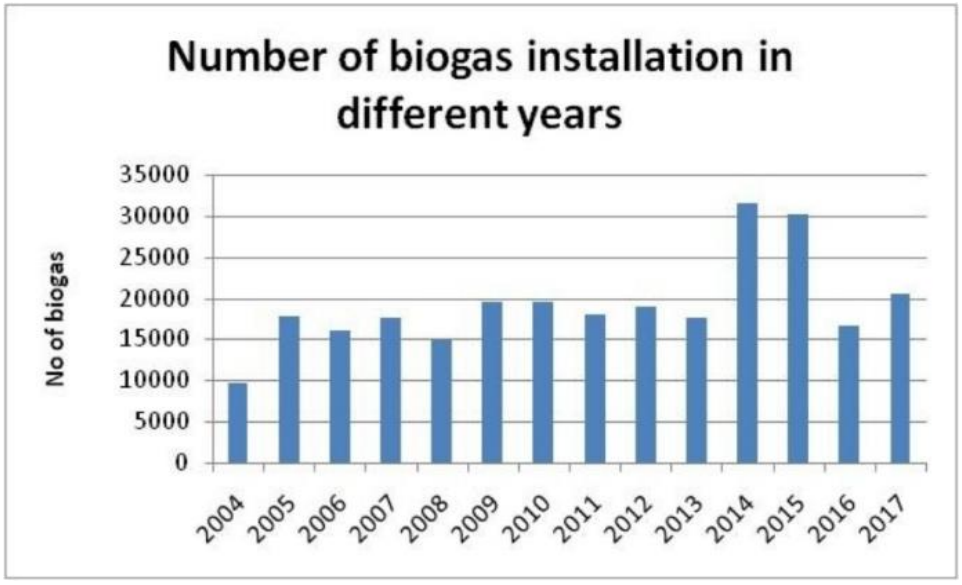
Biogas plant installation in different year (AEPC, 2020)



Now, Baseline emission is; BEy = 43807.84 ∗ 86.1% ∗ 0.0156 ∗ 63.7 = 37481.68 tCo2 considering the leakage of 5%, leakage emission is calculated as LEy = 1874 tCO2 Considering the project emission (PEy) as zero as this is not applicable for this project activity, the emission reduction is calculated as 35,607 tCO2. There is significant positive correlation between cumulative number of biogas plant and BEy, LEy and ERy with pearsion correlation coefficient r (12) = 1 with p value less than 0.001. Thus they are significant.

Figure 5

Variation of biogas plant in different year different year (AEPC, 2020)



From this figure we can say that the carbon gas emission decreases with the increase in number of installation of biogas plant in different year in Nepal.

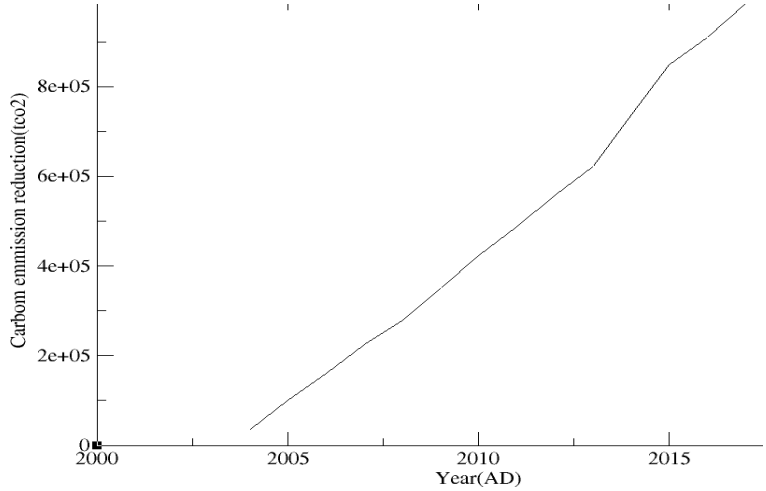
Table 3

Carbon emission reduction

SN	Year	B_y	BE_y	LE_y	ER_y
1	2004	43807	37481	1874	35607
2	2005	12400	106137	5306	100831
3	2006	196694	168290	8414	159876
4	2007	276354	236447	11822	224625
5	2008	343481	293880	14694	279186
6	2009	431331	369044	18452	350592
7	2010	519326	444332	22216	422116
8	2011	600087	513430	25671	487759
9	2012	685682	586664	29333	557331
10	2013	765216	654713	32735	621978
11	2014	907555	776309	38815	737494
12	2015	1042987	892372	44618	847754
13	2016	1118331	956836	47841	908995
14	2017	1210948	1036078	51803	984275

Figure 6

Variation of carbon emission reduction due to the biogas plant



Conclusion

In this research, we have studied the number of biogas power plant from 2004 to 2017. The data of biogas plant installation in different year is provided by Alternative Energy Promotion Centre (AEPC) and BSP. In our result, the maximum number of new biogas plant was installed in the year 2014 and 2015.This was due to the stability of peace and increment in public awareness among people in Nepal.

The carbon emission reduction due to the biogas implantation in different years is plotted in our result. It shows reduction of emission increases from 2004 to 2017. From this work, we found that the carbon emission reduction (ER_y) is calculated as 984275 tCo_2. In this work, p value is less than 0.05 between any two variables. Thus correlation is significant.

Abbreviations

AEPC = Alternative Energy Promotion Centre
BC = Biomass Consumption
BE = Baseline emission
BSP = Biogas Support programme
EF = Emission Factor
ER = Emission Reduction
GHG = Green House Gases
IPCC =Intergovernmental Panel on Climate Change
LE = Leakage Emission
LPG = Liquefied Petroleum Gas
NCV = Net calorific value of the non-renewable woody biomass
PE = Project Emission
RET = Renewable Energy Test Station
TJ = Terajoules

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Review of History and Elevational Distribution Pattern of Bats in Nepal

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Abstract

Hodgson (1835) is first publication of Nepalese bat research. 51 species of bats are distributed in between 64 to 4145 m above sea level. Elevation gradient is a significant factor to influence bat distribution and diversity in mountain environment. Local climatic regime include temperature, precipitation, humidity, cloud cover, productivity are major ecological drivers of elevation. Reviewed Published literatures, organizational research reports and dissertations of different universities and analyzed distributional pattern of bat. In contest of Nepal, elevational distribution patterns of bats show hump shaped distribution as like other studies in globe. Maximum number of species is distributed in High Mountain and in between 1000 to 1500 m asl. *Murina aurata* was highest elevational record that was 4160 m and *Scotophilus heathii* and *Lyroderma lyra* were lowest elevational record that were 64 m asl. Whereas four species of bats had not defined exact locations of distribution. C*ynopterus sphix* is highly dominated species across various elevational gradients that records from 76 to 3656 m asl. Elevational distribution of bats will give the indication of future risk on bat cause by prospective climatic change.

Key words: Elevation, Nepal, Chiroptera, diversity, survey

Introduction

With considerable physiographic and ecological diversity, the Oder Chiroptera is the second-most varied and numerous orders of mammals. It contains 1400 species (Burgin, Collela, Khan & Upham, 2018). Altogether, 128 species of bats are distributed in south Asia (Srinivasulu, Racey & Mistry, 2010). In Nepal, Bats forms the most speciose group of mammals with an account of 51 species (Thapa, 2014). Hodgson collect the collect the seven species of bat in 1843, this was first survey on Nepalese bat species (Bates & Harrison, 1997; Acharya et al., 2010). Than many other foreign researchers like Scully (1887); Hinton and Fry (1923); Fry (1925); Sanborn (1950) ; Worth and Shah (1967); Frick (1969); Agrawal and Chakraborty (1971); Sinha (1973); Johnson et al.(1980); Mitchell (1980); Maeda (1982); Koopman (1983); Corbet and Hill (1992) collected the specimens of bats from Nepal (Bates & Harrison, 1997). Suwal et al. (1995) was reported 38 species of living and breeding species of bats from Nepal (Acharya et al., 2010). Csorba et al. (1999) collected the species of bats and conformed by craniodental measurement (Thapa, 2014). Fifty three species of bats were listed in by Acharya et al. (2010) but Thapa (2014) listed only 51 species of bats in Nepalese species of mammals behind the last checklist of bats, one more bat was added by Sharma et al. (2019). Bats are distributed all over the world except Antarctic and few oceanic islands (Mickleburgh, Hutson & Racey, 2002). Normally three hypothesis of species distribution pattern along elevational gradients are common, they are climatic hypothesis, spatial hypothesis and spatial constants hypothesis (McCain, 2007). Elevational distribution of bats will give the indication of future risk to bats by prospective climatic change (Thomas et al., 2004). In certain cases, patterns of species richness of bats are affected by regional and local climatic regime also. The climatic regime include temperature, precipitation, humidity, cloud cover, productivity etc. all of them are parallel related to altitudinal gradients (McCain & Grytnes, 2010). Bats are known to be distributed only in two patterns in elevational gradients. Either in decreasing elevational pattern or in mid-pick elevational pattern. Low plateau

distribution patterns and low plateau mid-pick distribution patterns are not observed in bats (McCain & Grytnes, 2010).

Elevational gradients are predictable changes of abiotic factors and they are responsible for species richness of bats and other mammals. Variation in overall species diversity and evenness of bats are closely correlated to elevation, highly populated species are distributed in lower elevational range and rare and less populated species are distributed in higher elevational range (Graham, 1983 & McCain, 2007). However, species diversity of bats continuously decline by increasing the elevation (Graham, 1983; Kanuch & Kristin, 2006; Maryanto, Yani, Prijono & Wiantoro, 2011; Patterson, Pacheco & Solari 1996; Linden et al. 2014). Patterson, Pacheco and Solari (1996) suggested that the community compositions of bats are not similar in different elevational ranges and species diversity is continuously decreasing from lower elevations to higher elevations. Whereas, some of the researches suggested that species richness of bats are pick in mid- elevation (Rhabeak, 1995; McCain, 2007; Martins et al., 2015; Mongombe, Falis & Tamesse, 2019). Microclimatic conditions influence factors for distribution pattern of bats (Piksa et al., 2013). Some researches such as; Georgiakakis et al. (2010) and; Raghuram, Jin and Balakrishnan (2014) revealed that elevation does not play significant role in species diversity of bats. Species distribution patterns of bats are only dependent up on the vegetation types and micro climatic variables.

Methods and Materials

Published papers of elevational distribution patterns and species diversity of bats were searched and retrieved from google scholar search engine and web of science data base. The key words for search engine were Bats of Nepal, species diversity, elevational, altitudinal, species richness and distribution patterns. For the analysis of global elevation distribution pattern, 19 available scientific publications in English language published between of 1983 to 2019 were included. In context to species diversity of bats in Nepal, available research publications published in between 1835 to

2021 were included. Scan copy of old research articles, reports and books were provided by Harrison institute, UK, other published journal articles were been search by same search engine and key words. Beside them distribution coordinates of bats in Nepal were collated from afore-mentioned research publications including M. Sc. and B. Sc. dissertations from universities of Nepal as well as authentic projects reports of research organizations and survey reports of bat researchers. We excluded articles published on magazine and documents published on the language except English and Nepali.

Results

Hodgson, (1835), first published an account of seven species of bats from Nepal. For bat research in Nepal, there are now 28 research publications in books and journal articles, 15 M. Sc. dissertations, 9 B. Sc. theses from various Nepali universities, 21 projects report, and 7 survey reports. Most of the bat surveys deployed mist netting, harp trapping, roost survey, morphometric analysis, voucher specimens collection and baculum as well as craniodental analysis. Since, Hodgson, 1835, 18 researches reported 5 species of bats in Nepal (Table 1). Hodgson, 1835 and Bates & Harrison, 1997 each reported maximum species of bats. In between 1835 to 2014, 15 checklists had been developed (Table 2). Thapa (2014) presented the latest checklist of 51 species of bats in Nepal. Bats are distributed in between 64 to 4145 m above sea level in Nepal.

Table 1

Checklists and number of species of in history of Nepal

Author	No of species
Hodgson, 1835	7
Hodgson, 1842	9
Gray & Gray, 1947	11
Scully, 1887	19
Hinton & Fry, 1923	21
Frick, 1969	48
Mitchell, 1980	37
Bates & Harrison, 1997	49
Csorba et al., 1999	51
Molur et al., 2002	51
Baral & Shah, 2008	51
Acharya et al., 2010	53
Janawali et al., 2011	53
Pearch, 2011	50
Thapa, 2014	51

Table 2

*Authors and number of species eported **of** bats in Nepal* .

Authors	No. of species records
Hodgson, 1835	7
Hodgson, 1842	2
Gray & Gray, 1847	2
Scully, 1887	6
Hinton & Fry, 1923	5
Fry, 1925	3
Sanborn, 1950	1
Worth & Shah, 1969	1
Mitchell, 1980	4
Maeda, 1980	1
Maeda, 1982	1
Kock, 1996	1
Bates and Harrison, 1997	7
Topal, 1997	1
Csorba et al., 1999	3
Myers et al., 2000	3
Thapa et al., 2012	1
Dahal et al., 2016	1
Sharma et al., 2019	1

Lyroderma lyara and *Scotophillus heathii* were recorded in Tagandubba, Jhapa they are lowest elevational record of bats in Nepal (Thapa, 2009). *Murina aurata* was recorded in Mukot Himal, Dolapa district at elevation of 4154 m above sea level it is highest elevational record of bat in Nepal as well as highest elevational record of this species in world (Bates & Harrison, 1997; Pearch, 2011).

Table 3

Distribution Pattern of elevational gradient

Elevational Range	Number of Species
Bellow 500 m asl.	21
501- 1000 m asl.	29
1001-1500 m asl.	35
1501-2000 m asl.	17
2001-2500 m asl.	13
2501-3000 m asl.	7
3001-3500 m asl.	5
3501-4000 m asl.	2
4001-4500 m asl	1
Above 4501 m asl.	0

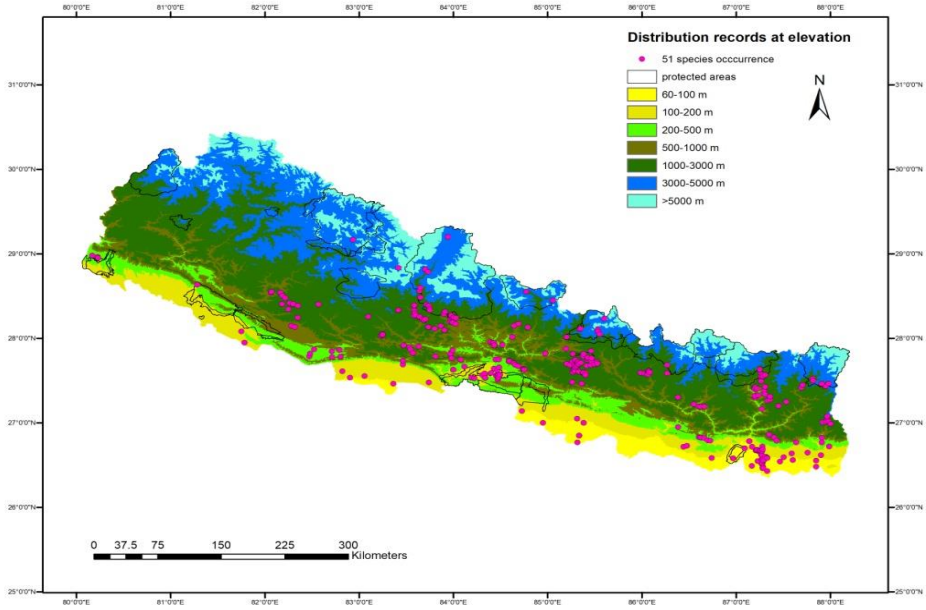
Table 4

Distribution Pattern in Physiography

Physiographic Region	Number of Species
Terai (60-100 m asl.)	8
Chure (101-200 m asl.)	10
Inner Terai (201-500 m asl.)	13
Middle Mountain (501-1000 m asl.)	29
High Mountain (1001-3000 m asl.)	41
High Himalayas (3001-5000 m asl.)	9
Trans Himalaya or Arid land	1

Figure 1

Species Distribution Pattern



In context of bat distribution; 17 species have wide distribution range and has been recorded from several localities throughout the country. They are distributed in between 64 to 3500 m above sea level. Five species of bat have been distributed in a single GPS coordinate. Also, 12 species have been reported from two coordinates, two species from three coordinates. However, 17 species have a few coordinates. Among 51, altogether 35 species are distributed in between 1001 to 1500 m above sea level. Only a single species (*Murina aurata*) of bat was distributed above 4000 m above sea level (Table 3). *Cynopterus sphinx* is highly dominated species in elevational range of Nepal it is distributed in between 76 to 3656 m above sea level. In analysis of distribution of bats in physiographic region of Nepal, 41 species of bats are distributed in High Mountain, and only one species of bats were reported from Trans Himalayan region till now (Figure 1 & Table 4).

Discussion

Altogether, 15 checklists have been published and species diversity of bats is increasing since Hodgson (1835). Frick (1969), included some Indian species and listed 48 species of bats in his checklist (Bates & Harrison, 1997; Csorba, Kruskop & Borissenko, 1999). Mitchell, 1980 corrected the number of species to 37 in his checklist. Bates and Harrison (1997) presented remarkable information on 49 species of Nepalese bat species. They included detailed information of museum specimens and literature. Csorba, Kruskop and Borissenko (1999) published records of Chiroptera from Nepal and listed 51 species in checklist. They included external and craniodental measurements and also added first record of three species in Nepal (Thapa, 2014). Myers et al. (2000) had been visited Eastern, central and Western region of Nepal and collect 14 species of bats and conclude 87 possible Nepalese species. Acharya et al. (2010) and Janawali et al. (2011) had been included 53 species of bats in checklist. These were maximum species of bats in history of Nepal. Thapa (2014) was latest checklist he listed 51 species by including *Scotozous dormeri* and excluding *Sphaerias blanfordi*, *Hipposideros pomona* and *Myotis siligorensis* in Acharya et al., 2010 and

Jnawali et al., 2011. After Thapa, 2014; Dahal, Thapa and Basnet (2016) reported first record of *Scotophilus kuhlii* from Pakali, Sunsari and Sharma et al., 2019 reported bamboo bat (*Trylonictris fluvida*) from Parbat district of western Nepal, so 52 valid Nepalese species bats till now.

Hodgson (1835) to Scully (1887) no conform elevation have been decelerated. They only maintain name of study places in publications. Fry (1925) collected specimens of bats from northern west side of Kathmandu valleys in between 1525 to 2657 m of elevational arrange. Hinton and Fry (1923) collect the specimens in between 90 tom 3250 m elevational ranges of nine different districts of Nepal. Abe (1971) collected and identify the specimens of bats from seven districts of mid Nepal in between 60 to 3000 m of elevational range. Mitchell (1980) also collected specimens of bats from Banke, Dang, Ilam and Sindupalanchokin between 160 to 2700 m of elevational range. Csorba, Kruskop and Borissenko (1999) surveyed the bets by mist netting, harp trapping and morphometric analysis of specimens in 11 districts in between 24 to 3000 m elevation range. Myers et al. (2000) mist netted in Kathmandu and Chitwan in between 200 to 1340 m elevational range. Thapa et al. (2012) reported *Scotozous dormari* from 95 m elevational range. Dahal, Thapa and Basnet (2016) and Sharma et al. (2019) reported *Scotophillus kuhli* and *Trylonictris fluvida* in elevational ranges of 95 m and 908 m elevation respectively. Ruedi et al. (2021) have been collected the specimens of new genus *Submyotodon* from Rashuwa, Tanahun, Kaski, Sangja, Taplejung and Terathum in between elevation range of 670 to 3000 m. It is latest publication for Nepal. Maximum surveys of bats are focusing in eastern to middle Nepal. Only three surveys were conducted in western to far western region of Nepal. As compare in elevational survey pattern maximum surveys were conducted in Middle Mountain.

More population and common species of bats are distributed in lower elevation and less populated rare species are distributed in higher elevational region (McCain, 2007). In contest of Nepal, highly colonized more populated species like *Pteropus*

gigantus, *Rhinolophus* sp., *Lyroderma lyra*, *Rousettus leschenaulti* and *Eonycteris spelaea* have been distributed up to middle mountain and *cynopterus sphinx* has been distributed up to high Himalayas also. As like distribution pattern of bat in Limpopo (Weier et al., 2016), Mount Nimba (Reardon & Schoeman, 2017), Mount Cameroon (Mongombe, Fils & Tamesse, 2019) of Africa and Ispitito (Lopes et al., 2017) in Brazil species diversity of bats in Nepal also more in between 1000 to 1500 m above sea level. Eight species of bats have been distributed only bellow 1000 m of elevational range and 10 species of bats have been distributed only 1500 m above sea level. Above then 1500 m species diversity of bats have been continuously declined up to 4154 m elevational range. No species of bats have been reported in Nepal above 4154 m from sea level.

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Exploration of Freshwater Algae (Excluding Cynobacteria) at Hasina Wetland

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Abstract

Algae are simple, non-flowering, and typically aquatic plants of a large group that includes seaweeds and many single-celled forms. Algae contain chlorophyll but lack true stems, roots, leaves, and vascular tissue. Algal samples were collected randomly by plankton net and squeezing submerged leaves and roots of macrophytes from three localities - Hasina wetland, Khair Khola, and Budhikhola during summer, rainy and winter seasons in 2072.The slides of each sample were prepared by mounting them in glycerin and observed under a compound microscope. A total number of 52 freshwater algae of Hasina wetland and surrounding areas which belong to classes Chlorophyceae, Charophyceae, and euglenophyceae have been identifiedby consulting various literature, and monographsanddescribed in this article. The highest number of 30 taxa under the family chlorophyceae was identified and the largest genus was *Cosmarium* with eight taxa.

Keywords: Hasina wetland, desmids, nemalionopsis, phacus

Introduction

Algae are the simplest photosynthetic organisms accounting for more than half the total primary production in water bodies. They are chlorophyllous thallophytes, i.e., having no true root, stem and leaves or leaf-like organs. They are extremely important ecologically as well as phylogenetically. They are either unicellular or multicellular and completely lack of vascular tissues. Algae reproduce by almost all known methods of reproduction. Basically there exist five types of life cycles i.e., haplontic, diplontic, diplohaplontic, haplobiontic and haplodiplobiontic (Sharma, 1992).

Algae can grow in many diverseaquatic habitats such as damp soil, moist wall, moist wood, tree trunk, and even under or inside porous rocks such as sandstone and limestone. The occurrence of epiphytic, epizoic on molluscs and calcareous rocks, snow, thermal water, and

symbiotic associations has also been reported. Specially, cyanophytes tolerate a wide range of temperatures and can be found growing in hot springs, on snow bands or deep within polar ice.

Algae vary greatly in size, ranging from 0.5 µm unicellular to huge seaweeds (*Macrocystis pyrifera*) which may be of hundred feet or more (Sharma, 1992). They are unicellular, colonial, filamentous or frond-like and bushy plants displaying an endless degree of complexity. Algae also form mutually beneficial partnerships with other organisms. For example, algae live with fungi to form lichens. Algae called *Zooxanthellae* live inside the cells of reef-building coral. In both cases, the algae provide oxygen and complex nutrients to their partner, and in return, they receive protection and simple nutrients (eg, *Azolla* leaf, coralloid root of *Cycas*).

Humansand livestock use different species of algae as food and fodder such as *Porphyra*, *Chlorella*, *Laminaria*, *Sargassum*, *Alaria*, *Nostoc*, *Spirogyra* and *Oedogonium* species. In Nepal, some species of *Spirulina* and *Porphyra* reported from Kathmandu and Pokhara are edible species (Hickel, 1973; Baral et al., 1999). *Spirulina* is protein-rich blue-green algae and is considered a future health food for the world and now can be sold in the market at high price as a protein capsule (Rai, 2011).The nitrogen-fixing capacity of algae can be utilized in agriculture as a bio-fertilizer. About 25% of the total blue-green algae recorded from Nepal are found in paddy fields. They increase the nutrient nitrogen level in paddy fields resulting in higher productivity of the soil. It has been estimated that blue-green algae can add about 40 kg of bound nitrogen to the soil per hectare per year (Van Den Hoek et al., 2009).

Chemical extracts of seaweeds are extensively used in foods, pharmaceuticals, textiles, and emulsions and suspensions. Different species of red algae provide agar and carageenin, which are used for the preparation of various gels in scientific research. Bacteria, fungi and cell cultures are grown commonly on agar. Carageenin is also used as a thickening and stabilizing agent in products such as pudding, syrups and shampoos. Algae have been used in Asian countries to cure or prevent illnesses such as cough, gout, gallstones, goiter, hypertension and diarrhoea. Recently, algae have been surveyed for anti-cancer compounds. Diatoms also have been used in forensic medicine as their presence in the lungs can indicate a person die due to drowning (Rai, 2014).

Numerous taxonomic studies on algae have been carried out around the globe owing to the various beneficial activities of algae. In the context of Nepal, Baral (1995a, b) has listed the

algae of Nepal, based on the literature, reported by other authors hitherto. Most of the exploratory works on algae have been done in and around Kathmandu Valley and in the Eastern and Central mountain regions of Nepal. There are few reports of algae from Eastern Terai region. The phylogeny and morphology of *Nemalionopsis shawaii* collected from the Hasina wetland have been studied by Necchi et al. (2016). However, algae of other families have not been explored from this locality. Hence, an endeavor is made to explore the algal flora (excluding Cynobacteria) of Haseena wetland in this study.

Methods and Materials

Study Area

The present algal exploration was carried out at Haseena Wetland and its periphery areas. It lies in the foothills of Churia range in the tropical zone about 6 km north from Bansbari Chowk (East-west highway, 7 km east from Itahari) in Sundarharaicha Municipality - 5, Morang (Map 1). This wetland is situated between Budhi Khola and KhayerKhola, to the south of Charkhose Jhadi covering an area of about 48 ha including the forest. The water body coverage area is 3.3 ha. The ponds feed from the ground originated 4-5 spring sources. The wetland type is lacustrine (lake/pond), palustrine (marsh/swamp) and riverine.

The climate of this area is tropical or subtropical monsoonal type, experiences three distinct seasons i.e., summer (February to May), rainy (June to September) and winter (October to January). The area has maximum temperature in May and minimum in January. Similarly, it experiences maximum rainfall in July and minimum in December.

Haseena Wetland areas also include the forest almost in degraded condition with the major land vegetation of tropical plants such as *Shorea robusta, Syzygium cumini, Anthocephalus chinensis, Diospyros species, Cassia fistula, Schleichera oleosa, Dalbergia sissoo, Acacia catechu, Bombax ceiba, Aegle marmelos, Trewia nudifloria, Callicarpa arborea, Mallotus phillipensis*, etc. This wetland also provides a good habitat for many rare flora and fauna. This wetland has provided habitat for common floating spices like *Eichhornia crassipes, Pistia stratoites, Monochoria* sp, *Lemna minor, Vallisnaria natans*, etc and emergant species in marshy area like *Schoenopletus mucronata, Alternanthera philoxeroides*, etc.

Algae were collected from four different localities (Fig. 1). The first locality was Khayer Khola (a stream, 26°41′′22.6′N, 87°19′′22.2′E, alt 126m) near Gurung Tol, which lies to the east side from HaseenaWetland. The second locality was Budhi Khola (Lati Khola, a river,

26°42″05.4′N, 087°19″06.3′E, alt 132m) situated to the northwest side from HaseenaWetland.It is larger than Khayer Khola, originated from Mahabharat Range and continues to India.The third to fourth localities of sample collection were the ponds and marshy places in HaseenaWetland.The third locality was an old pond (26°41″33′N, 87°18″48.7′E, alt 118m) situated on the west side of the wetland. The pond (26°41″34′N, 87°19″04.7′E, alt 119) with statue of snakes located at the centre of Haseena wetland was marked as locality no. 4.

Map 1

Hasina wetland showing algae sampling sites

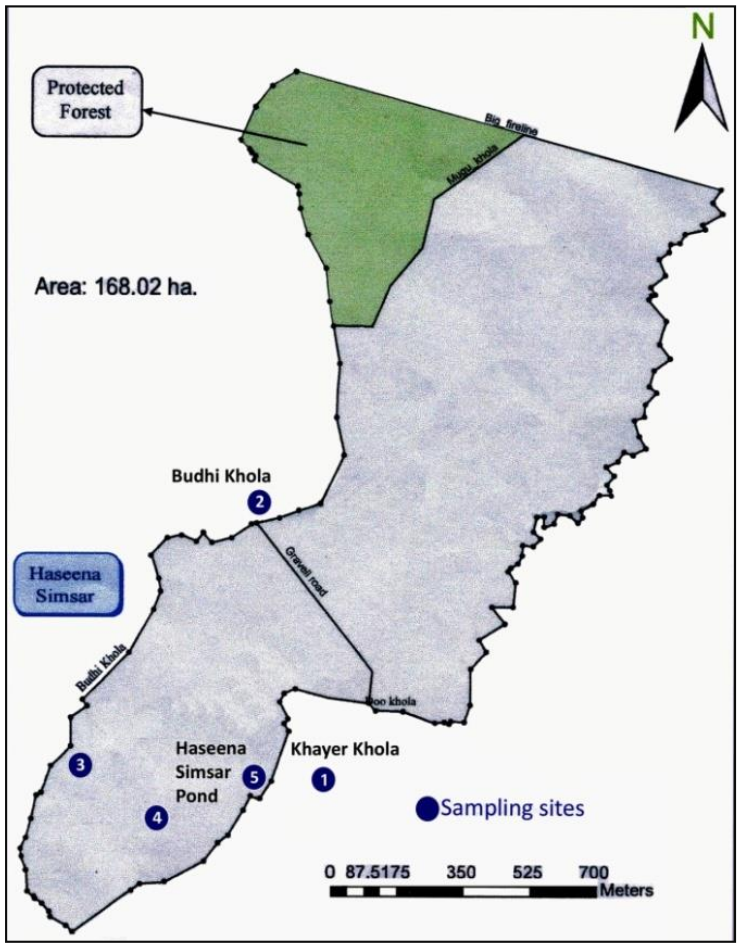


Figure 1

Water resources in Hasina wetland area

(a) Khair Khola (Locality 1), (b) Budhi Khola (Locality 2), (c) Pond of Hasina Wetland (Locality 3), and (d) South-west pond at Hasina Wetland (Locality 4)

Algae Collection and Identification

By random sampling technique, a total of 60 algal samples were collected from four different localities in Haseena Wetland, Khayer Kholaand Budhi Khola (Fig. 1) using plankton net (mesh size 0.5 mm) and by squeezing submerged leaves and roots of aquatic macrophytes during the period of Baishakh to Chaitra, 2072. Samples were filled quarters only because larger the mass of algae gathered the sooner they would die. Enough water was added in the bottle to ensure a saturated atmosphere then it was closed. They were labeled properly with sample number, date of collection, method of collection, locality etc. The latitude, longitude and altitude of four major sites were measured with the help of Geographical Positioning System meter (GPS Garmin etrex). Necessary photographs of the collection sites were taken with the help of Canon Powershoot Camera.Water temperature and pH of each locality were also measured with the help of Mercury thermometer and portable Henna pH meter, respectively. Field note was maintained properly in the field.

The materials were then preserved on FAA solution as well as 4% formaldehyde solution for further detail studies. The slides of each sample were mounted in the glycerin jelly (Sharma, 1992). The prepared slides were examined under compound microscope under different magnification *viz*., 100X, 400X and 1000X. Confused taxa were distinguished by staining with 1% aqueous methylene blue solution and iodine solution for chlorophycean taxa. Microphotographs were taken with the help of microscope model Olympus Ch20i and Canon Digital Power Shot Camera using flash-light off and macro-mode under long exposure period. Algae were measured using stage and ocular micrometers.

Algal taxa were identified by consulting various literatures and monographs such as Prescott (1951), Tiffany and Britton (1952), Desikachary (1959), Randhawa (1959), Scott and Prescott (1961), Philipose (1967), Croasdale and Flint (1986, 1988), Croasdaleet al. (1994), Prasad and Srivastava (1992), Prasad and Mishra (1992), etc. Identification and recent updates of nomenclature were also approved by consulting online algae databases like http://algaebase.org, http://desmids.science4all.nl, http://digicote.info, etc.

Results and Discussion

In this study, a total of 52 freshwater algae (excluding cyanobacteria) have been reported which belong to 4 divisions, 6 classes, 11 orders, 19 families, and 32genera (Tables 1 and 2).

Table 1
Classification table of total algae reported from Haseena Wetland and periphery

Division	Class	Order	Family	Genera	Species
Chlorophyta	Chlorophyceae	Volvocales	Volvocaceae	Eudorina	1. E. elegans
				Pandorina	2. P. morum
		Tetrasporales	Palmellaceae	Sphaerocystis	3. S. schroeteri
		Oedogoniales	Oedogoniaceae	Oedogonium	4. O. sp.
		Chlorococcales	Hydrodictyaceae	Pediastrum	5. P. tetras v. tetraodon
			Oocystaceae	Zoochlorella	6. Z. parasitica
				Glaucocystis	7. G. duplex
				Gloeotaenium	8. G. nostochinearum 9. G. loitlesbergerianum
				Nephrocytium	10.N. agardhianum
				Oocystis	11.O. parva
			Dictyosphaeriaceae	Westella	12.W. botryoides
			Selenastraceae	Ankistrodesmus	13.A. spiralis 14.A. spiralis v. fasciculatus
			Coelastraceae	Coelastrum	15.C. cambricum 16.C. cambricum v. intermedium
			Scenedesmaceae	Crucigenia	17.C. tetrapedia
				Scenedesmus	18.S. acutiformis 19.S. arcuatus 20.S. armatus v.

			boglariensis 21.S. bijugatus 22.S. bijugatus v. gravenitzii
Siphonales	Vaucheriaceae	Dichotomosiphon	23.D. tuberosus
	Zygnemataceae	Mougeotia	24.M. punctata
		Spirogyra	25.S. cf rhizoides 26.S. cf tumida 27.S. cf wangi
	Mesotaeniaceae	Netrium	28.N. digitus v. latum
	Desmidiaceae	Closterium	29.C. dianae 30.C. ehrenbergii 31.C. lineatum 32.C. praelongum v. brevius
Zygnematales		Pleurotaenium	33.P. trabecula
		Actinotaenium	34.A. turgidum
		Cosmarium	35.C. blyttii 36.C. impressulum 37.C. javanicum 38.C. lundellii v. circulare 39.C. lundellii v. ellipticum 40.C. quadrum v. sublatum 41.C. sportella 42.C. sublateriundatum
		Staurastrum	43.S. disputatum v. sinense 44.S. inflexum

				Hyalotheca	45.H. dissiliens
	Charophyceae	Charales	Characeae	Chara	46.C. sp.
Chrysophyta	Xanthophyceae	Heterotrichales	Tribonemataceae	Tribonema	47.T. affine
	Chrysophyceae	Chrysomonadales	Ochromonadaceae	Dinobryon	48.D. tabellariae
Euglenophyta	Euglenophyceae	Euglenales	Euglenaceae	Phacus Trachelomonas	49.P. pseudoswirenkoi 50.T. armata v. longispina
Pyrrhophyta	Dinophyceae	Peridiniales	Glenodiniaceae Peridiniaceae	Glenodinium Peridinium	51.G. borgei 52.P. gatunense

The division Chlorophyta was the largest representative (88. 46%) having 7 orders, 14 families, 26 genera and 46 species followed by other four divisions *viz*. Chrysophyta with 2 order, 2 family, 2 species; Euglenophyta with 1 order, 1 family, 2 genera, 2 species and Pyrrhophyta1 order, 2 family, 2 genera, 2 species (Table 2, Fig. 2).The desmid alga of family Desmidiaceae in Chlorophyta covers the highest position i.e., 32.69%.

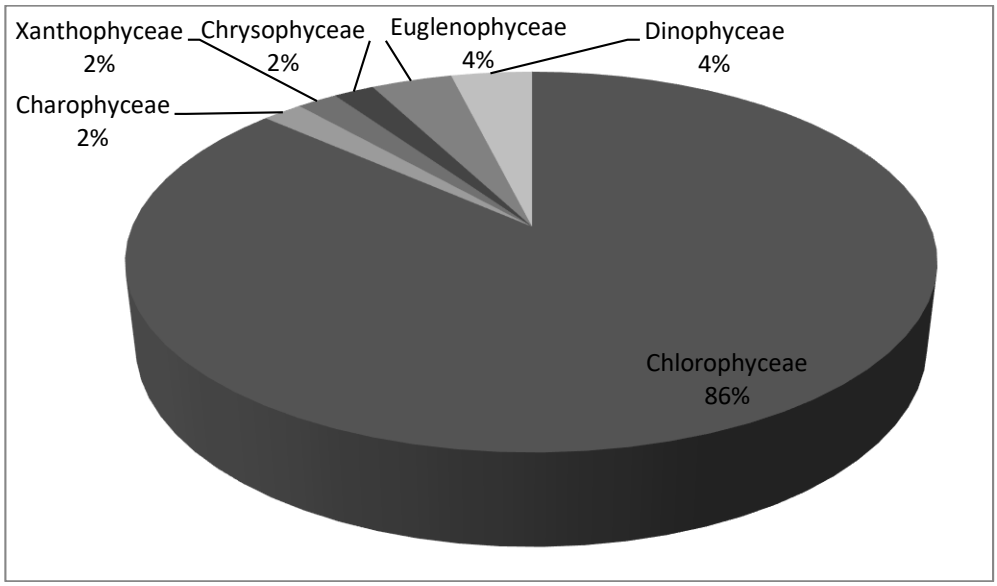
Table 2

Total algae representing under class, family and genera

S.N.	Division	Class	Order	Family	Genera	Algae taxa
1	Chlorophyta	2	7	14	26	46
2	Chrysophyta	2	2	2	2	2
3	Euglenophyta	1	1	1	2	2
4	Pyrrhophyta	1	1	2	2	2

Figure 2

Family-wise occurrence of algae in Haseena Wetland, Morang



Among the genera, *Cosmarium* was found to have maximum species representing 8 taxa (Table 1). Genera *Scenedesmus* is represented by 5 taxa each and *Closterium* is represented by 4 taxa. Species of *Spirogyra* could not be confirmed due to a lack of reproductive structures. Similarly, *Oedogonium* and *Chara* could not be identified up to the species level due to a lack of literature.

Taxonomic Description of Algae

1. *Eudorina elegans* Ehr. [Fig. 3 (2)]

Reference: Prescott 1951, P.76, P l.1, Figs.24-26

Colony spherical or ovate with 16-32 ovoid cells evenly disposed within a gelatinous envelope, or arranged in transverse series; cells usually lying near the periphery of the envelope; colonies up to 200 µm in diameter; cells 10-20 µm in diameter.

2. *Pandorina morum* (Muell.) Bory

Reference: Prsecott 1951, P.75, P. l.1, Fig. 23; Tiffany and Britton 1952, P. 16, Pl. 1, Fig. 13.

Colony motile, sub-spherical to ellipsoid; cells pyriform, usually 16 in number and enclosed in a gelatinous envelope; colony about 220 µm in diameter; cells 12-17 µm long, 10-15 µm in diameter.

3. *Sphaerocystis schroeteri* Chodat

Reference: Prescott 1951,P.83, Pl.3, Figs.6,7; Prasad and Misra 1992, P. 7, Pl. 5, Fig. 12.

Colony spherical with groups of 4-8 cells, arranged towards periphery of hyaline; cells spherical; colonies up to 500 µm in diameter; cells 6-20µm in diameter.

4. *Oedogonium* sp.[Fig. 3 (3)]

Reference: Prescott 1951, P. 156

Filaments unbranched, attached; chloroplast a parietal reticulum with many pyrenoids; nucleus at the periphery of the protoplast.

5. *Pediastrum tetras* var. *tetraodon* (Corda) Hansgirg

Reference: Philipose 1967, P. 129, Fig. 45 d, e, g

Colonies circular to slightly rectangular of 4-8-16 cells without intercellular spaces; inner cells 4-6 sided with a single linear incision; eight-celled colonies 20-33µm and 16 celled colonies up to 50µm in diameter; cells 5-15 µm in diameter.

6. *Zoochlorella parasitica* Brandt

Reference: Prescott 1951, P. 235, Pl. 53, Fig. 9.

Cells ovoid, inhabiting in zooplanktons i.e., *Ophrydium*, fresh-water sponges (*Spongilla*), and *Stentor* spp.; chloroplast 1 (rarely 2); cells 1.5-3 µm in diameter.

7. *Glaucocystis duplex* Prescott

Reference: Prescott 1951, P.474, Pl. 108, Fig. 1.

Colony composed of 8-16 spherical cells enclosed by a much enlarged spherical mother cell wall; cells 40- 44 µm in diameter.

8. *Glaucocystis nostochinearum* Itzigsohn

Reference: Philipose 1967, P. 188, Fig. 101.

A free floating colony of 4-8 elliptical cells enclosed by the old mother cell wall; colony of 4 individuals up to 50 µm long; cells 18-23.4 µm long, 10-18µm in diameter.

9. *Gloeotaenium loitlesbergerianum* Hansg.

Reference: Tiffany and Britton 1952, P. 115, Pl. 32, Fig. 317.

A free floating, spherical or quadrangular ovate colony of 2-8 globose or ellipsoid cells within mother cell wall; 8 celled colonies as much as 80 µm long,70 µm in diameter; cells 18-25µm in diameter.

10. *Nephrocytium agardhianum* Naegeli

Reference: Prescott 1951, P.248, Pl. 54, Figs.15, 16; Tiffany and Britton 1952, P. 116, Pl. 32, Fig. 315.

Colony ovate composed of 2-8 cylindrical or reniform cells, twisting so as to give a spiral arrangement within the old mother cell wall; cells 8-18 µm long, 2-7 µm in diameter.

11. *Oocystis parva* West and West

Reference: Prescott 1951, P.248, Pl. 54, Fig. 3.

One-celled or in families of 2-8 individuals enclosed by mother cell wall; cells ellipsoid or fusiform; chloroplasts 1 to 3 parietal disc, pyrenoids sometimes present; colony up to 43.9 µm in diameter; cells 6-15.6 µm long, 4-7.5µm in diameter.

12. *Westella botryoides* (W. West) de Wildemann

Reference: Prescott 1951, P. 237, Pl.53, Fig.14.

Colony composed of 40-80 spherical cells; cells with 1 parietal, cup- shaped chloroplast; pyrenoid sometimes present; cell 3-9µm in diameter.

13. *Ankistrodesmus spiralis* (Truner) Lemmermann

Reference: Philipose 1967, P. 210, Fig. 119 a.

Cells spindle-shaped, spirally twisted into bundles of 4-16 cells; chloroplast a parietal plate without a pyrenoid; cells 25-35 µm long, 2-3 µm in diameter.

14. *Ankistrodesmus spiralis* (Turn.) G.M. Smith

Reference: Prasad and Misra 1992, P. 27, Pl. 4, Fig. 8.

Cells curved or sigmoid, united in colonies of 34-50 cells; colonies 75-180 µm in diameter; cells 55-110µm long, 3-4.5 µm broad.

15. *Coelastrum cambricum* Archer

Reference: Prescott 1951, P. 229, Pl. 53, Fig. 2; Philipose 1967, P. 230, Fig. 138 a.

Colonies spherical, usually composed of 32 globose cells; outer free wall of the cells with a flattened, truncate projection; cells 10-20 µm in diameter including sheath.

16. *Coelastrum cambricum* var. *intermedium* (Bohlin) G.S. West

Reference: Prasad and Misra 1992, P. 30, Pl. 4, Fig. 5.

Colonies spherical, consisting of 32 cells spherical in middle and sub-spherical at periphery; chloroplast parietal with one pyrenoid; colonies 60-66 µm in diameter; cells 14-21 µm in diameter.

17. *Crucigenia tetrapedia* (Kirchner) W. et G.S. West

Reference: Philipose 1967, P. 240, Fig. 151.

Colony free-floating, 4 triangular cells arranged about central space; a rectangular plate of 16 cells (4 quartets); chloroplast a parietal plate with a single pyrenoid; cells 4.5-9 µm in diameter.

18. *Scenedesmus acutiformis*Schroeder [Current accepted name: *Acutodesmus acutiformis* (Schroder) Tsarenko et John]

Reference: Prescott 1951, P. 275, Pl. 62, Figs. 6-7.

Colony flat; cells arranged in a single series of 4 (2 to 8), fusiform-elliptic, cylindrical with poles sharply pointed; outer cells with 2-4 longitudinal ridges; cells 17-22.5 µm long, 6-8 µm broad.

19. *Scenedesmus arcuatus* (Lem.) Lem. [Fig. 3 (4)]

Reference: Philipose 1967, P. 256, Figs. 166.

Cells arranged to form a curved shape in series of 4-16 oblong ovate individuals; cell wall without spines or teeth; poles of the cell boradly rounded; cells 10-15 µm long, 4-8 µm broad.

20. *Scenedesmus armatus* var. *boglariensis* Hortobagyi

Reference: Philipose 1967, P. 264, Figs. 171 g, j.

Colonies 2-4 celled cells arranged in a linear series; terminal cells with a fairly long spine from each pole; one of the spines somewhat straight and the other slightly curved; cells 8-14 µm long, 2.4-4.2µm broad.

21. *Scenedesmus bijugatus* (Turpin) Kutz.

Reference: Prasad and Misra 1992, P.35, Pl.5, Fig.1.

Colonies flat or slightly curved, of 2-4-8 cells arranged in a single linear series; chloroplast one parietal with single pyrenoid; cells 7-23 µm long, 3.5-7µm broad.

22. *Scenedesmus bijugatus*var. *gravenitzii* (Barnad) Chodat

Reference: Philipose 1967, P. 254, Figs.164 a, b.

Colonies4-8 celled; cells fusiform, ellipsoid, oblong-ellipsoid to ovoid with obtuse poles, without teeth and spines; cells 10-16.7 µm long, 4.5-7.9µmbroad.

23. *Dichotomosiphontuberosus* (A. Braun) Ernst.

Reference: Prescott 1951, P. 290, Pl. 68, Figs. 6-7.

Thallus dichotomously branched tube with constriction at the base of the branches; cushion-like mats in the silt of lake bottoms, sex-organs-bearing branches; vegetative siphons 50-80 µmbroad.

24. *Mougeotia punctata* Wittrock

Reference: Randhawa 1959, P. 167, Fig. 99.

Filaments form sparse, cottony growths; chloroplast a broad plate with 4-6 pyrenoids; vegetative cells 50-135 µm long, 8-10 µm broad.

25. *Spirogyra* cf. *rhizoides* Randhawa

Reference: Randhawa 1959, P. 328, Fig. 316.

Vegetative filaments usually 2 mm to2.5 cmin length; basal part bears rhizoids which are fixed in the mud; cell with thick brown walls and 2-3 clolsely packed chloroplast; vegetative cell 26-28 µm broad.

26. *Spirogyra* cf *tumida* Jao

Reference: Randhawa 1959, P. 355, Fig. 371.

Vegetative cells cylindrical; chloroplast 1, making 2 to 9 turns; conjugation scalariform; cells 85-175 µm long, 16-19 µm broad.

27. *Spirogyra* cf. *wangi* Li

Reference: Randhawa 1959, P. 367, Fig. 397.

Vegetative cells cylindrical; 2 to 3 chloroplasts making 1.5 to 4.5 turns; conjugation scalarifrom; tubes formed by both gametangia; fertile cells inflated toward the middle; cells 150-350 µm long, 30-32 µm broad.

28. *Netrium digitus* var. *latum* Hust.

Reference: Croasdale and Flint 1986, P. 37, Pl. 4, Fig. 2.

Cells of medium size, broadly elliptic, with broadly rounded apices; cell wall smooth; chloroplast with longitudinal plate and deeply serrated margins; cells 64-270 µm long, 32-106 µm broad.

29. *Closterium dianae* Ehrenbergex Ralfs [Fig. 3 (1)]

Reference: Prasad and Misra 1992, P. 105, Pl. 16, Fig. 7.

Cells of medium size, 9-10 times longer than broad; cell wall smooth; chloroplast ridged with 6-8 pyrenoids arranged in a row; cells 105-303 µm long, 16-35 µm broad.

30. *Closterium ehrenbergii* Menegh.ex Ralfs

Reference: Scott and Prescott 1961, P. 11, Pl. 2, Fig. 2.

Cells large, stout, 6-8 times longer than broad, moderately curved; cell wall smooth; chloroplast with 6-8 bands and numerous scattered pyrenoids; cells 450-530 µm long, 65-80 µm broad.

31. *Closterium lineatum*(Ehrenberg) Ralfs

Reference: Croasdale and Flint1986, P.63, Pl. 11, Figs.1-4.

Cells long and narrow, 26-28 time longer than broad, cell wall striated; chloroplast with 4-6 ridges and a median row of 9-12 pyrenoids; cells 400-650 µm long, 19-25 µm broad.

32. *Closterium praelongum* var. *brevius* (Nordst.) Krieg.

Reference: Bando et al. 1989, P. 7, Fig. 1 h.

Cells long, slightly curved, almost straight in the mid-region; wall colourless and smooth; chloroplast with 12-13 axial pyrenoids; cells 250-360 µm long, 17-23 µm broad; isthmus 3-3.5 µm wide.

33. *Pleurotaenium trabecula* (Ehr.) Naeg [Fig. 3 (5)]

Reference: Nurul Islam and Yusuf Haroon 1980, P. 564, Pl. 4, Fig. 56.

Cells of medium size, more or less straight, 11-12 times longer than broad; cell wall smooth; cells 430-510 µm long, 28-40 µm broad.

34. *Actinotaenium turgidum* (Breb. ex Ralfs) Teil.

Reference: Croasdale and Flint 1988, P. 39, Pl. 28, Figs. 9-12.

Cells large, sides convex, tapering to bluntly rounded apex; chloroplast parietal, with 4-6 visible bands, each with a row of pyrenoids; cells 160-230 µm long, 60-105 µm broad.

35. *Cosmarium blyttii* Wille [Fig. 3 (6)]

Reference: Prasad and Misra 1992, P.155, Pl. 24, Figs.2-3.

Cell very small, slightly longer than broad, very deeply constricted; apex truncate and 4 crenate; top view elliptic; cells 14-17.5 µm long, 13-14.5 µm broad.

36. *Cosmarium impressulum* Elfv.

Reference: Nurul Islam 1970, P. 924, Pl. 11, Figs. 6-8.

Cells small, slightly longer than broad, deeply constricted; cell wall smooth; top view broadly elliptic; chloroplast parietal with one pyrenoid in each semicell; cells 20.5 µm long, 15 µm broad.

37. *Cosmarium javanicum* Nordst

Reference: Croasdale and Flint 1988, P. 71, Pl. 35, Figs. 13-14.

Cells oblong-elliptic, the sides convex; chloroplast parietal with 4 longitudinal bands, each with a row of pyrenoids; cells 90-188 µm long, 45-89 µm broad; isthmus 35-52 µm wide.

38. *Cosmarium lundellii* var. *circulare* (Reinsch) Krieg.

Reference: Bharati and Hegde 1982, P. 744, Pl. 1, Fig. 2.

Cells medium size, circular in front view and elliptic in top view; cell-wall minutely punctate; cell46µm long, 37.8µm broad; isthmus 13.5µm wide.

39. *Cosmarium lundellii* var. *ellipticum*West & West

Reference: Scott and Prescott 1961, P. 61, Pl. 25, Fig. 8.

Cells more or less broadly ellipsoid in front view, elliptical in top view; cell apex is somewhat flat; wall punctate; cell57-73µm long, 40-58 µm broad; isthmus 15-23 µm wide.

40. *Cosmarium quadrum*var. *Sublatum* (Nordst.) West & West

Reference: Croasdale and Flint 1988, P. 95, Pl. 54, Figs. 4-7.

Cells small, sinus deep and linear, only slightly dilated in interior; apical angles broadly rounded, sides slightly convex, apex broad; cells 60-90 µm long, 54-85 µm broad; isthmus 18-30 µm wide.

41. *Cosmarium sportella* Breb. in Kutz.

Reference: Croasdale and Flint 1988, P. 102, Pl. 45, Figs. 6, 7.

Cells small as long as broad; sinus deep and narrow; chloroplast central with 2 pyrenoids; cells 45-51 µm long, 42-47 µm broad; isthmus 11-14.5 µm wide.

42. *Cosmarium sublateriundatum* West et West

Reference: Bando et al. 1989, P. 21, Fig. 7 e.

Cells medium-sized, slightly longer than broad, deeply constricted, lateral margins evenly convex, with 6 or 7 delicate undulations, the apex truncate; each semicell with 2 pyrenoids; cells 41-46 µm long, 36-40 µm broad; isthmus 12.5-13.5 µm wide.

43. *Staurastrum disputatum* var. *sinense* (Lutk.) West et West

Reference: Croasdale et al. 1994, P. 95, Pl. 81, Figs. 10-14.

Cells small as long as broad; lower margins slightly concave; apex straight, lateral angles broadly rounded; granules limited to 4 or 5 circles on the angles; cells 17-24 µm long, 19-25 µm broad; isthmus 5.5-9 µm wide.

44. *Staurastrum inflexum* Breb.

Reference: Croasdale et al. 1994, P. 102, Pl. 126, Figs. 5-6.

Cells small, longer than broad, usually broadly cup-shaped; apex slightly raised and convex; cells often twisted at the isthmus; cells without process 19-28 µm wide, with process 27-42 µm wide; isthmus 6-11 µm wide.

45. *Hyalotheca dissiliens* (J.E. Smith) ex Bréb in Ralfs [Fig. 3 (7)]

Reference: Tiffany and Britton 1952, P.204, Pl. 56, Fig.631.

Filaments long, straight, cylindrical with wide sheath; mostly broader than long; cells cylindric-discoidal, lateral margins slightly convex; chromatophore axial, 1 in each semicell; pyrenoid single, central; cells 10-39 µm long, 10-33 µm broad.

46. *Chara*sp. [Fig. 3 (8)]

Reference: Prescott 1951, P. 336.

Stem and branchlets corticated or ecorticate; antheridium produced below the oogonium, both from periphery of branchlet nodes; coronula composed of 5 cells arranged in a single tier; oospore terete.

47. *Tribonema affine* (Kutz.) G.S. West [Fig. 3 (11)]

Reference: Prescott 1951, P. 367, Pl.96, Figs. 7-9.

Filaments straight and slender; cells long, cylindrical with thin wall; chromatophores 4 pale, yellow-green parietal plates with smooth margins; cells 35-40 µm long, 5-5.6 µm broad.

48. *Dinobryon tabellariae* (Lemm.) Pascher

Reference: Prescott 1951, P.379, Pl.98, Figs.3-5.

Solitary or epiphytic; loricas broadly fusiform, extended posteriorly into a short tapering stipe; cells 18-22 µm long, 7-10µm in diameter.

49. *Phacus pseudoswirenkoi* Prescott [Fig. 3 (9)]

Reference: Prescott 1951, P.402, Pl.85, Fig.26; Pl.87, Fig.2; Pl.88, Fig.14.

Cells orbicular, sharp and curved, anterior end broadly rounded; periplast longitudinally striated; paramylon body single, large circular disc; cells 41 µm long, 30 µm broad.

50. *Trachelomonas armata* var. *longispina* (Playf.) Deflandre [Fig. 3 (10)]

Reference: Prescott 1951, P. 411, Pl. 83, Fig. 27.

Flagellum aperture without collar but with a circle of erect spines at the margin; spines short in anterior region but stout, both short and long in posterior region; cells µm 40-43 long, 30 µm broad.

51. *Glenodinium borgei* (Lemm) Schiller

Reference: Prescott 1951, P.428, Pl.90, Fig.8,9.

Cells broadly ovoid to subglobose; epitheca with 1 apical, 2 intercalary; hypotheca with 5 postcingular and 2 antapical plates; cells 40-46 µm long, 36-40 µm broad.

52. *Peridinium gatunense* Nygaard [Fig. 3 (12)]

Reference: Prescott 1951, P.433, Pl.90, Figs.25,26.

Cells globose to elliptic; the longitudinal furrow extending from high in the epicone to near the posterior pole; epitheca with 13 plates; hypotheca with 2 large antapicals and 5 postcingular plates; cells 45-80 µm long, 55-80 µm broad.

Figure 3

Different Species of Algae in Hasina Wetland

(1) *Closterium dianae* (2) *Eudorina elegans* (3) *Oedogoniumsp.* (4) *Scenedesmus arcuatus* (5) *Pleurotaenium trabecula* (6) *Cosmarium blyttii* (7) *Hyalotheca dissiliens* (8) *Chara sp.* (9) *Phacus pseudoswirenkoi* (10) *Trachelomonas armata var. longispina* (11) *Tribonema affine* (12) *Peridinium gatunense*

The water parameters such as temperature and pH of different localities of Hasina Wetland have been described in table 3. The temperature of pond water in locality 3 was recorded maximum (32°C) in rainy season and minimum (15°C) in winter. The pH of water was more or less similar in all localities in both seasons.

Table 3

Water parameters of different localities in Hasina Wetland

Locality No.	Habitat	Water temp. (°C)		Water pH	
		rainy	winter	rainy	winter
1	Stream	26	21	7.0	7.0
2	River	28	22	6.5	7.0
3	Pond	32	15	6.5	6.5
4	Pond	28	22	7.0	7.0

Conclusion

A total of 52 freshwater algae, excluding cynobacteria, have been reported from Haseen Wetland and its surrounding areas. Thus, this study revealed that the Hasina Wetland area is rich in algal flora. Many new and interesting algae have been reported from this area. So, further extensive exploration in different seasons is recommended.

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Formation and Function of Traditional Wooden Plough in Nepal: A Mathematical Observation

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Abstract

Plough is incarnated by the poor-rural people and used for sustainable agriculture. The ploughing process is considerably more efficient while oxen powered ploughs took place than the initial introduction of human-powered ploughs. This study excavated the plough making process with mathematical interpretation, the use of the plow in ploughing hilly terraces and disseminates the knowledge of plough construction and ploughing system to the concerned public. All the respondents were familiar about the components of the plough and their indigenous measurements however, they have only little knowledge for making a perfect plough and it's functioning. It is found that if the height of the oxen increases then the inclination of beam with fore-share of the ploughs is also increases or if the height of the oxen decreases then the inclination of beam with fore-share of the plough is also decreases. It is also opined that there are no such training and workshops regarding the plough making and using in a proper and scientific way. A recommendation for making the strategic objective is that those people who have not the complete mathematical knowledge about plough cutting and ploughing should be made fully aware of the application of mathematical knowledge. Thus, the Government must have to make budgetary provisions and NGOs, civil societies & media must prepare the videos of training imparted and literacy sessions held and present them.

Keywords: Agriculture, indigenous, oxen, plough, terrace, inclination

Introduction

Plough is a machine applied in farming all over the world for preparing soil to plant any kind of crops. Basically plough is used for initial cultivation of the upper layer of the soil. In other word, ploughs are known as the implements applied for opening and loosening of the soil. It creates moisture better through burying weeds and dried soil down and allows fresh nutrient in the surface. In history, ploughs were incarnated by the poor-rural people and used for sustainable agriculture. Undoubtedly the process was considerably more efficient while oxen powered ploughs took place than the initial introduction of human-powered ploughs. Various other animals such as horses, mules, buffalos etc. have also been used as plough puller for the purpose of agriculture in the poor countries. However, steam-engines gradually suppressed the use of traditional ploughs and the steam-engines similarly were taken over by the powered tractors. Since 2000, Tillage of world is transformed to the modern system of soil preparation but it is significantly causing the soil damage and erosion and so lessening the productivity of the grains. The competition is taking place for using the modern ploughs or tractors thus the relevance of the traditional ploughs and its construction process is almost being disappeared.

Development of Different Ploughs

The different types of ploughs have been developed which are classified as human-power, animal-power, mechanical-power and electrical-power ploughs. Human-power ploughs are used for stationary manual work by every farmer. It was fully existed until the time of *Malla* regime and partially of *Rana* regime. Animal-power ploughs are developed for ploughing the fields in the hilly and the plain region by an average power of pair of oxen or buffalos which has been remained in existence for 6 decades. In the hilly terraces, the animal-power ploughs cannot replace any other advance modernized ploughs. However, in the *Terai* region, it has been seen a wide application of those modernized ploughs as mechanical-power like tractors and mini-tractors. The efficiency of diesel engines are more than the petrol engines so that the tractors nowadays are

much demanded in the plain regions. In Nepal, the animal-power and mechanical-power ploughs are treated as the best and easily accessible ploughs for ploughing different topographic fields. The electrical-power ploughs are used mostly in the form of electrical motors and partly while ploughing the fields. It is most useful as it cleans, quests and smoothes the fields and needs less attention as well as care so that the operation cost remain almost constant throughout it life. The electrical-power ploughs are not much in existence in Nepal but it is commonly used in the developed countries. Therefore, out of 4 stages, we are in the 2nd and 3rd stage in the development of the ploughs as we have been practicing farming of hilly regions by animal-power ploughs and most of the *Terai* regions by mechanical-power plough.

Types of Ploughs

In the world, there are two main tillage implements such as primary tillage implements and secondary tillage implements. Wooden plough, soil-turning plough, moldboard plough, disc plough, reversible plough, subsoil plough, chisel plough, ridge plough, rotary plough and basin-lister plough are found under the category of first type of tillage implements. Similarly, different types of implements like cultivator, harrow, plank and roller are fallen in the secondary tillage implements. However, in Nepal, wooden ploughs in the hilly lands, tractor drawn cultivators in the *Terai* lands and harrows in some of the developed part of the hill and some of the congested area of the *Terai* region found their existence in the farming.

Ploughs Used in Nepalese Tillage

Ploughs are used in hillside and rural *Terai* region of Nepal for primary tillage. The main three different ploughs are wooden or indigenous ploughs, iron or inversion ploughs and special purpose ploughs. The wooden plough is a kind of implement that is made up of wood with an iron stripe as a share point. The plough consists of body, beam, fore share and handle. It is drawn with a pair of oxen in hill and either oxen or he-buffalos in the *Terai*. With V-shaped furrow-cutting, it opens the soil which is not perfect ploughing as it is left the un-ploughed strip between furrows.

Fussell (1966) in his article entitled "Ploughs and Ploughing before 1800" has claimed that the factory for plough designs was established in the middle of the eighteen century. Gradually, the plough making process took a course from Norway, Germany, and France to other part of the continent as a progress of primitive ploughs to the finely finished factory produced ploughs. It took several decade of the nineteenth century to produce all-purpose ploughs however the knowledge behind the production of such type of plough was taken from the ancient ploughs. In the ploughs, the wooden parts were revised to the iron for maintaining interchangeability as per the necessity whenever the accidental damage occurred, immediate replacement of damage part of beam, fore-share would be repaired. This research article has been arrived to the good conclusion regarding ploughs development in reference to eighteen century however; it could not explore the formation and function of ploughs of the ancient time.

Salar, Karparvarfard and Kargarpour (2021) has authored a research article on "Forces and Loosening Characteristics of a New Winged Chisel Plough (WCP)" in which they have found that the workability of a winged chisel plough examining its three wing depths, three bend angles and three rake angles. The findings revealed that the draught and vertical forces were largely augmented by increasing the wing depth, bend and rake angles whereas the soil raising was declined by increasing the wing depth and bend angle, the effect of the rake angle was not raising significantly. Although they have suggested that the winged chisel plough should be adopted for farming but they did not link up the function of the WCP with the traditional tillage plough.

Sharma, Bajracharya and Sitaula (2009) in their research article: "Indigenous Technology Knowledge in Nepal – A Review" has examined profound knowledge is generated through use of natural resources from the indigenous practices. However, nowadays the knowledge is less prioritized or forgotten because of systematic and scientific basis of knowledge is neglected. This article recommended that collection of indigenous technical knowledge (ITK) should be incorporated in the curriculum of environment and sustainable development. The pros and cons of ITK will help for

further strengthening the knowledge of professionals in respective field. It has been observed that ITK has seen a huge demand for sustainable development of five district of Nepal but it has not been observed the ITK application in the field of agro-engineering.

Nuralin at al. (2020) has authored a research article on "The Working Part of Reversible Plough: Design and Experiments" in which they claimed that cost-effectiveness is obtained through minimization of turbulence and maximization of the plough floor composition. Applying mathematical modeling to improve the quality of the soil by designing the ploughs and their physical parameters ensures the performance of the plough. A plough with a rectangular and trapezoidal ploughshare proved to be the most efficient solution investigated which are slightly similar to reversible ploughs. Based on empirical findings, the lower side of the trapezoidal plough is 9.9% lower than the standard. It also discovered that the use of trapezoidal plowshare was able to increase the speed of the plough from 2.13 to 2.25 meter per second by 5.4% instead of rectangular plowshare. Thus the effect reduces the tractor slip and that enables 11.09% of fuel savings. But still it has not been explored the plough-making and its functionality processes.

Abbaspour-Gilandeh et al. (2020) in their article entitled "Measuring and Comparing Forces Acting on Moldboard Plow and Para-plow with Wing to Replace Moldboard Plow with Para-plough for Tillage and Modeling It Using Adaptive Neuro-Fuzzy Interface System (ANFIS)" have evaluated that the draft, vertical and lateral forces which are acting on the both ploughs are basically in three working depths such as the Para-plough without wing, Para-plough with forward-bend wing and Para-plough with backward-bend. It also claimed that the presence of the three forward speeds which are to investigate the application of suitable Para-plough instead of moldboard-plough. They found that the draft force required by the increment of implements with the increment of the forward speed and working depth. And the root mean square error for the above models draft = 0.121, vertical forces = 0.014 and the lateral forces = 0.016.

However, it has not been found what mathematical modeling is appropriate for the function of traditional plough and also it has not been shaded the light on how do the forces applied work in ploughing system.

Gebregziabher et al. (2007) have authored a research article entitled "Design of the Eghiopian Ard Plough Using Structural Analysis Validated with Finite Element Analysis" in which they have found that the sensitivity is essential for the visualizing the effect of the dimensional parameters and forces acting on the structure of the ard plough. They claimed that the production of the wooden structure is based on experience, culture and trial & error methods. The traditional force analyses are based on static analysis at equilibrium of the structure. It has concluded that the mathematical descriptions based on traditional calculations were developed considering the static analysis of the implement structure of the ard plough at equilibrium condition. The traditional calculations were then verified by means of finite element analysis and ABAQUS software with error less than 3% in draught capacity and 5% in vertical capacity. This is the good article for analyzing the draught and vertical capacities however it has not been uprooted the formation process of traditional wooden ploughs.

Mathematics involved in traditional wooden plough-cutting has not been explored although the necessity of the ploughs has been fulfilled by rare plough-cutters in the village. They have gathered huge experiences of measuring all dimensions of ploughs while reducing a cylindrical log into mixed-prismic-ploughs. However, it was not possible to disseminate the idea of engineering of the ploughs to the general agriculturalist in the village. The ploughmen also could not be able to work well by understanding the ploughing system according to the nature, shape and size of the ploughs. Therefore, the hidden mathematics behind the formation of ploughs and its working system must have to explore to make all harvesters easy for farming in the hilly terraces. The present paper has been devoted to explore the formation and function of traditional plows in 3 of the hilly local levels of Morang district of Nepal.

Hypotheses

The hypotheses framed for the present study are as follows:

i) It seems that the traditional wooden ploughs are not made proper due to lack of mathematical concepts; and
ii) There is lack knowledge about the functioning of the components of the ploughs.

Scope and Limitation

The study excavates the plow making process with mathematical interpretation, the use of the ploughs in ploughing the hilly terraces and disseminates the knowledge of ploughs construction and ploughing system to the concerned public. The research has been conducted on different stakeholders of agricultural system it includes ploughmen, plough cutters, harvesters, senior citizens and agriculture students hailing from the 3 of the local levels of the Morang district of Nepal. The study is confined only to the small area; therefore, its findings may not be universally accepted or applied.

Methods and Materials

The present study has been conducted in purposively selected rural municipality of *Kerabari*, municipality of *Miklajung* and municipality of *Letang* according to the convenient sampling technique. The primary data has been collected with the help of a well structured interview schedule administered to 3 ploughmen, 3 plough cutters, 3 harvesters, 3 senior citizens and 3 agriculture students. In all, 15 respondents constituted the sample. Chi-square test, correlation and percentage analysis has been used to test the hypothesis by quantifying the data.

Result

The data collected have been presented in the tables and the interpretation thereof is given.

Category of Selected Respondents

Data pertaining to category-wise distribution of respondents presented in Table 1 show

Table 1

Category-wise Distribution of Respondents

Category	Number	Percent
Ploughmen	3	20
Plough Cutter	3	20
Harvester	3	20
Senior Citizen	3	20
Agriculture Students	3	20
Total	15	100

that out of 15 respondents, 3 (20%) each are ploughmen, plough cutters, harvesters, senior citizens and agriculture students.

Knowledge about Plough Cutting Process

The data in table 2 is related to the views of respondents about the Knowledge about Plough Cutting Processes. A close examination of the figures depicts that 11 (73.30%) respondents are of the views that they have not had the knowledge about plough formation.

Table 2

Distribution of Respondents According to Their Views on Knowledge about Plough Cutting Process

Category	Number (Yes)	Number (No)
Ploughmen	1	2
Plough Cutter	0	3
Harvester	1	2
Senior Citizen	2	1
Agriculture Students	0	3
Total	4	11

However, the remaining 4 (26.70%) respondents reported that they know how to cut the ploughs. To infer, we can say that the respondents in an overwhelming majority who reported lacking of plough making process.

Formation Process of Traditional Wooden Ploughs

The following two diagrams show the processes of making ploughs that the double ploughs can be made from the single log as shown in the diagram (i) and the single plough can be made from the same log as shown in the diagram (ii). An eight *Bittas* long cylindrical wooden log with the circumference of the base 25 inches is required for making *Banje Halo* however it requires 5.5 to 6 *Bittas* of log for making a *Hile* or *Dalle Halo*. After removing the skin of the cylindrical log, cut diagonally the log to make two ploughs at once from a single log as shown in the diagram (i) above and then chisel it triangularly towards the fore share and trapezoidal towards the head from the neck of the plough.

Figure 1

Pair of Ploughs from a Single Log

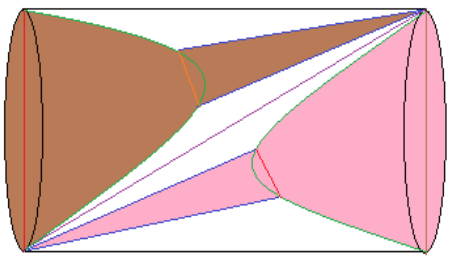
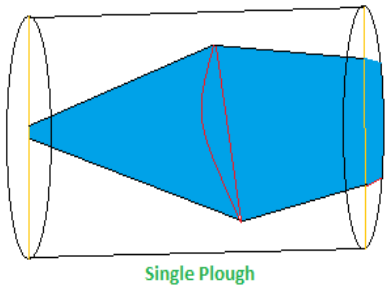


Figure 2

Single Plough from a Single Log



In this way two ploughs can be made from a bit bigger log. And, in the diagram (ii), a single plow is made from either a big or a small log. Shaping logs into ploughs by chiseling two symmetries of the log for obtaining two ploughs as shown in diagram (i). In the similar manner, an unbroken log for obtaining a single plough as shown in diagram (ii) and converting them as a triangular prism to the front and a parallelepiped to the head. A hollow *Haris* pass is required to adjust the *Haris* that should be quite bigger than the size of the Haris from 5 inches above the neck at front and 4 inches above the base at back. For adjusting *Anau*, make a *Bitta* of vertical pass from the head of the plough to meet the *Haris* pass any where inside *Haris* pass. The *Haris* and *Anau* must meet together inside to make both of them tight and so it can be easily pulled up

the *Anau* by striking from the *Haris* pass to the *Anau* pass in case it is broken inside. *Thedi* must be tightened 1 *Bitta* back from the tip of the *Haris* vertically and 2 inches back from the opposite tip of the *Haris* horizontally. Leaving 4 inches from the top of the *Anau*, the *Hatta* should be adjusted to control ploughing and centralize the force. The component '*Pati*' is tightened above the *Haris* at the neck to decrease the inclination of the *Haris* and sometimes it is tightened below the *Haris* at the neck adjoining to *Nak* to increase the inclination of the *Haris* according to the height of the oxen. Measuring 2 *Bittas* at the *Nak* from the tip of the share of the plough, make a drain of width 3 inches to place the iron strip and tie it tight with iron clip at the middle. In case the plough seemed having the cracks around the head as soon possible manage it by binding a suitable *Pheta* of steel or iron plate around it.

Diagrammatic Nomenclature of Plowing Components

According to the data given by the ploughmen, ploughs cutters, harvesters & senior citizens the traditional wooden ploughs and yokes with completely leveled components have been formed (which are shown in diagram (iii) and diagram (iv) above). *Juwa* is made of with length of 5 feet, breadth of 6 inches and height of 2.5 inches in the cuboidal shape. There are four *Jotaras* spiral tying with *shaila* on the upper part of the *Juwa*.

Table 3

Nomenclature of Ploughing Components of Traditional Wooden Plough and Yoke

Nepali Name	English Name
Tundo	*Fore-share*
Karuwa	*Iron-clip*
Phali	*Iron-strip*
Pati	*Wage*
Haris	*Beam*
Anau	*Plough Controller*
Juwa	*Yoke*
Hallund	*Leather Stripe*
Shailo	*Lever*

Thedi	*Wooden Pin*
Jotaro	*Yoke-rope*
Tauko	*Head*
Hatta	*Handel*
Nak	*Nose*
Pheta	*Head Band*
Total	15

Figure 3

Components of a Plough (Halo)

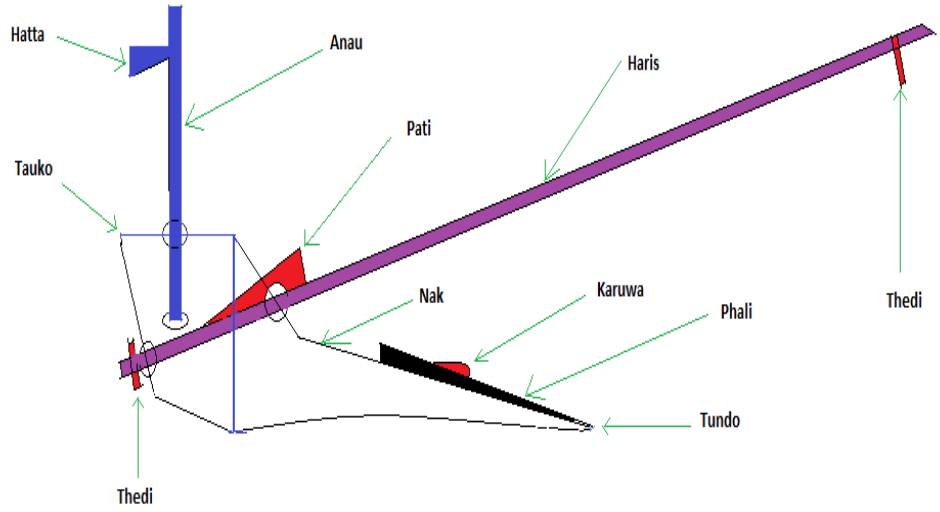
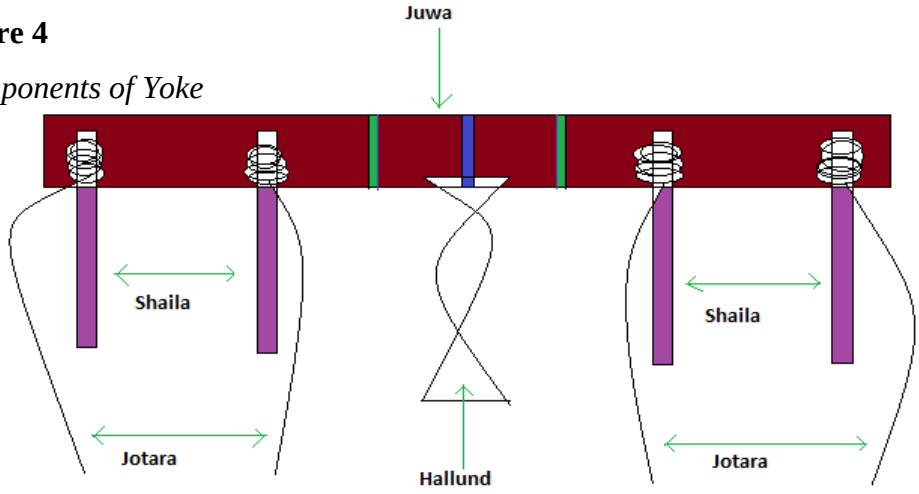


Figure 4

Components of Yoke



Respondents consistently responded the length of one of the four *Jotaro* is 3 meters long which must tie with the neck of the oxen while ploughing the field. *Hallund*

is of length 1 foot to 2 feet must place at the midpoint of the extremities of the *Juwa* which helps to balance the power of the oxen with respect to the load. Longer the length of the leather stripe the smaller the inclination of *Haris* appears so that the plough-share remains '*Thado*' and oppositely shorter the length of the leather stripe the bigger the inclination of *Haris* appears which results the plough-share remains '*Ghose*'.

Indigenous Mathematical Knowledge about Ploughs

A question i.e. 'Do you know about the indigenous measurement of the different components of plough?' was put to the respondents. In response to this question, all of them responded 'yes' and have provided the similar information about the measurement of the components of the ploughs as shown in the table 4 below.

Table 4

Indigenous Measurement of the Different Components of Ploughs as per the Views of the Respondents

Type of Traditional Wooden Ploughs	Indigenous Measurement (in inch/*amal*)										
	Length of *Tundo*	Length of *Haris*	Width of *Haris*	Slope of *Haris* for Tall Oxen	Slope of *Haris* for Short Oxen	Length of *Anau*	Slope of *Anau*	*Anau* Hollow Pass	*Haris* Hollow Pass	Length of *Phali*	Slope of *Pati*
Banje (Chimte) Halo	30	84	48	6	4	4	8	4	9	16	5
Dhule (Balaute) Halo	36	90	48	8	5	4	6	3	10	18	6

Hile (Dalle) Halo	24	96	42	6	4	3	10	5	8	14	5

As they had practiced, they have provided the measurement of the components in inches (*Ainchi or Amal*) and feet (*Bitta or Kuret*). As comparing the data pertaining in the table 4, it is clear that longer the length of *Haris*, the longer the length of *Tundo* of the plough and the shorter the length of the *Haris* demands the shorter the length of the *Tundo*. And the same result is seen for the slope of *Haris* for tall oxen and slope of *Haris* for the short oxen.

Cutting and Chiseling the Ploughs Using the Measuring Instruments

A question 'are wooden ploughs constructed with mathematical measurement?' is put to the respondents, in response to this question; 4 of them responded strongly agree, 4 of them agree, 7 of them were in undecided and none of them were fell on disagree and strongly disagree category.

Respondents' views on cutting and chiseling the ploughs using the measuring instruments and analysis thereof through Likert scale and the chi-Square calculations are given below:

Table 5

Observed Values

Respondents	Likert Scale					Total
	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	
Ploughmen	1	1	1	0	0	3
Plough Cutters	2	1	0	0	0	3

Harvesters	0	1	2	0	0	3
Senior Citizens	1	1	1	0	0	3
Agriculture Students	0	0	3	0	0	3
Total	4	4	7	0	0	15

Table 6

$$\textit{Expected Values } (E_i) = e_{ij} = \frac{\sum R_i \times \sum C_j}{\sum total}$$

Respondents	**Likert Scale**				
	Strongly Agree	**Agree**	**Undecided**	**Disagree**	**Strongly Disagree**
Ploughmen	0.8	0.8	1.4	0	0
Plough Cutters	0.8	0.8	1.4	0	0
Harvesters	0.8	0.8	1.4	0	0
Senior Citizens	0.8	0.8	1.4	0	0
Agriculture Students	0.8	0.8	1.4	0	0

Table 7

Chi-Square Value $(\chi^2) = \sum \frac{(O_i - E_i)^2}{E_i}$

Respondents	Likert Scale					Total of all $\frac{(O_i - E_i)^2}{E_i}$
	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	
Ploughmen	0.05	0.05	0.11	0	0	0.21
Plough Cutters	1.8	0.05	1.4	0	0	3.25
Harvesters	0.8	0.05	0.26	0	0	1.11
Senior Citizens	0.05	0.05	0.11	0	0	0.21
Agriculture Students	0.8	0.8	0.83	0	0	2.43
$(\chi^2) = \sum \frac{(O_i - E_i)^2}{E_i}$						7.21

The table 5, 6 and 7 depicted that the Chi-Square value is 7.21 in accordance with the degree of freedom = (r - 1) (c – 1) = (5-1) (5-1) = 16 and the level of significance = 5% = 0.05, where, O_i is the observed frequency and E_i is the expected frequency. And, thus the table value (critical value) at 5% level of significance at 16 degree of freedom observed is 26.30. Since, our Chi-square calculated value is less than the Chi-square critical value (i.e. 7.21 < 26.30) then, the hypothesis (i) is accepted and it is established that the traditional wooden plows are not made proper due to lack of mathematical concepts.

Ploughing Depths According to the Types of Soil in both Dry and Rainy Seasons

In response to this question "Do you know in how much depth a plough ploughs the different types of soil, *Chimte, Balaute and Hile* in different seasons? The respondents have presented their data as shown in the table 8. There are three different types of ploughs which plough different fields in different depths for different seasons.

Table 8

Ploughing Three Types of Soil at Different Depths in Different Seasons

Types of Soil	Depth (in inch)					
	Dry Season			Rainy Season		
	Surficial	Medium	Deep	Surficial	Medium	Deep
Chimte	4	6	8	5	7	9
Balaute	5	7	9	6	8	10
Hile	6	9	11	8	10	12

In the winter, a *Chimte halo* (which is quite longer in size) can plough 4 inches surficial depth, 6 inches medium depth and 8 inches maximum depth but 5 inches surficial depth, 7 inches medium depth and 9 inches maximum depth in the summer season. As far as the winter season is dry so that the soil does not remain flexible. Similarly, *Balaute halo* ploughs 4 inches surficial, 7 inches medium and 8 inches maximum in the winter season however 6 inches, 8 inches and 10 inches are the surficial, the medium and the deep depths in summer season. Finally, the above data depicted that *Hile halo* (which is quite shorter in size) can plough 6 inches, 9 inches and 11 inches surficial, medium and maximum depths in ploughing respectively in the

winter season but 8 inches surficial, 10 inches medium and 12 inches maximum depths since the soil of the summer season is looser than that of winter season.

Comparison between Angle Made by Beam and Height of Oxen

Using LD = WCS × sinα, where LD is the linear deflection (inches), WCS is the width of the control surface (inches) and α is the angle, the respondents' *Amal* between beam and the plough-share is converted to the angle.

Table 9

Respondents' Views on the Angles Made by the Beam & the Heights of the Pair of Oxen

Inclination of Beam (in degree)	Height of Oxen (in feet)
30	2
35	2.5
40	3
45	3.5
50	4
55	4.5
60	5
65	5.5
70	6
75	6.5

The heights of the oxen are measured by toes-to-head principle of the man which are converted to obtain the data in feet corresponding the indigenous measurement to the nowadays mathematics.

Relationship between the Inclination of Beam and Height of Oxen

The following table 9 depicts the correlation between the inclination of beam and the height of oxen.

Table 10

Computation of Correlation Coefficient between the Inclination of Beam and Height of Oxen

X	Y	XY	X^2	Y^2	Correlation Coefficient
30	2	60	900	4	
35	2.5	87.5	1225	6.25	
40	3	120	1600	9	
45	3.5	157.5	2025	12.25	
50	4	200	2500	16	
55	4.5	247.5	3025	20.25	Perfect Positive Correlation
60	5	300	3600	25	
65	5.5	357.5	4225	30.25	
70	6	420	4900	36	

75	6.5	487.5	5625	42.25	
$\Sigma X = 525$	$\Sigma Y = 42.5$	$\Sigma XY=2437.5$	$\Sigma X^2 = 29625$	$\Sigma Y^2= 201.25$	r = 1

The correlation coefficient between the inclinations of beam with height of the oxen,

$$r = \frac{n\sum XY - \sum X \sum Y}{\sqrt{n\sum X^2 - (\sum X)^2}\sqrt{n\sum Y^2 - (\sum Y)^2}}$$

$$= \frac{10 \times 2437.5 - 525 \times 42.5}{\sqrt{10 \times 29625 - (525)^2}\sqrt{10 \times 201.25 - (42.5)^2}}$$

$$= \frac{24375 - 22312.5}{\sqrt{296250 - 275625}\sqrt{2012.5 - 1806.25}}$$

$$= \frac{2062.5}{\sqrt{20625}\sqrt{206.25}}$$

$$= \frac{2062.5}{143.61 \times 14.36}$$

$$= \frac{2062.5}{2062.24}$$

= 1.00 which is perfect positive correlation.

Since, it is the perfect positive correlation so it has a linear relationship between inclination of beam and height of oxen that if the height of the oxen increases then the inclination of beam with fore-share of the ploughs is also increases or if the height of the oxen decreases then the inclination of beam with fore-share of the ploughs is also decreases.

Discussions

The study has led to the recommendations as follows:

Formation and Function of Traditional Wooden Ploughs

The indigenous knowledge of layman about the measurement of making ploughs and its functioning demands that those people who have not the complete mathematical knowledge about plough cutting and ploughing should be made fully aware of the application of mathematical knowledge.

Strategic Objectives

Provide short duration training and workshops to the ploughmen, plough cutters and harvesters, manage literacy sessions as well as field trips to the hilly agricultural sites for senior citizens and enroll the agriculture students for the research work as a mandatory hour of their college study related to the area of plough and ploughing system of (especially of hilly region) Nepal.

Actions to be Taken

By Government

- Make budgetary provisions for training institutes, NGOs and civil societies for launching the training and literacy sessions as well as the research and field visits programs to the agriculturists;
- Ensure regular monitoring, evaluation and feedback of the training and the literacy sessions arranged;
- Organize the frequent field visits and strengthen the research wing to have access about the reliable research findings;
- Get regular requisite feedback to make the programs more effective and result oriented; and
- Develop a school curriculum incorporating the formation process and functioning of all types of ploughs. Since, school mathematics is a powerful tool to invent a plough when its theory and practice works were provisioned in the textbooks.

By NGOs, Civil Society and Media

- Select the area and people for conducting need based training and literacy sessions/programs;
- Inform the selected people about the venue, date and time of programs and sessions;
- Organize specific programs for making the people aware of the need, relevance and uses of traditional wooden plough;
- Arrange and invite agriculture experts to address the quality training programs;
- Provide handouts and manage platform for presentation of contents; and
- Prepare the videos of training imparted and literacy sessions held and show them through T.V. and social media.

If the above recommendations are sincerely accepted by the Ministry of Agriculture, Government of Nepal as well as all the stakeholders it is hoped that we can get success in cutting and applying the traditional wooden ploughs for prolific production of grains in rural hilly regions of Nepal.

Conclusion

The following are the conclusions of the study:

- The traditional wooden ploughs and yokes are not made proper due to lack of mathematical concepts.
- All the respondents knew about the components of the ploughs and their indigenous measurements however, they have only a little knowledge for making a perfect ploughs and its functioning.
- Since the length of the beam is longer than that of the height of the oxen so that the angle between directions of applied forces (in beam) and the plough-share in a wooden plough must always less than one right angle.
- The length of the beam is directly proportional to the length of the share of the plough i.e. it is resulted that the longer the length of the beam the longer the

length of the plough-share and similarly the shorter the length of the beam the shorter the length of the plough-share.

- If the height of the oxen increases then the inclination of beam with fore-share of the ploughs is also increases or if the height of the oxen decreases then the inclination of beam with fore-share of the ploughs is also decreases.
- The shorter the leather stripe is tied with beam the easier to plough the field is possible and the longer the leather stripe is made the harder to plough the field because the shorter leather stripe raises the beam so that the plough remains '*Ghose*' and the longer leather stripe lowers the beam so that the plough remains '*Thado*'. Similarly, the taller the height of the oxen the more the plough remains '*Ghose*' and the shorter the height of the oxen the more the plough remains '*Thado*'.
- Lack of knowledge about the cutting and using the traditional wooden ploughs, people cannot make a perfectly straight ploughs and they also don't care about all the aspects of ploughing which results number of unbroken rows (*Ranta*) left inside the soil so that the grain production is always remains inadequate.
- Majority of the respondents were of the views that there are no such training and workshops regarding the plough making and using it in a proper and scientific way.

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Altitudinal Butterfly Diversity in the Southern Part of Sankhuwasabha, Nepal

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Abstract

The present work was the result of a survey on butterfly fauna of the southern part of Sankhuwasabha. The study's observational period ran from October 4 to October 25 in the year 2020 with the aim of examining the diversity of altitude-dependent butterflies. A total of 31 species of butterfly belonging to 27 genera under nine families were documented, where Nymphalidae and Satyridae were the most dominant families, contributing high species richness, 25.81% and 19.35% respectively, where, the families Acraeidae and Hesperiidae were least observed contributing 3.23%, each. Elevations from 1000 m to 1100 m had the highest butterfly diversity (H=2.17), higher Piulou's evenness (J'=0.94) and 1700 to 1800 m.a.s.l. had the least diversity (H=0.56). The Jaccard's Similarity Index indicated that the butterfly communities' similarity was highest between altitudes of 1600-1700 m.a.s.l. and 1700-1800 m.a.s.l.

Key words: abundance, altitudinal, butterfly, diversity, species richness

Introduction

Butterflies are a taxonomically studied group of insects and are good indicators of habitat deterioration and quality (Kocher and Williams, 2000) having great aesthetic values (Ahsan and Javaid, 1975) and their richness is influenced by climatic factors, which decide reproduction and survival conditions. Nepal has 663 listed butterfly species under 11 families (Smith, 2010) and 29 species and subspecies have been found to be endemic (Khanal, 2008) which are restricted to a particular area.

According to BPN (1996), Bhusal and Khanal (2008), 18% of the species in the mid-hill zones are vulnerable, and many species of butterflies in Nepal are rapidly going extinct. Global warming changes the distribution pattern of butterfly species throughout the Earth (Walther et al., 2002) which are highly sensitive to light, humidity and

temperature (Owen, 1971) and are correlated with movement, development and distribution of butterflies. Butterfly richness increases with increase in habitat size and vegetation composition (Price, 1975) which provide important ecological services for crops and their conservation (Davis, Hendrix, Debinski and Hemsley, 2008) which is essential to sustaining the productivity of natural and agricultural landscapes.

Butterfly diversity reflects overall plant diversity and various research has concluded that a decrease in species richness with altitude is a typical feature of many organisms, including insects, with the exception of bees (Gauld, 1987), indicating that species richness peaks at middle elevations, rather than at lower ones.

There were several studies related to butterfly diversity in eastern parts of Nepal. However, altitudinal variation of butterflies was lacking. The purpose of this study was to document the response of butterfly richness and abundance across the altitudinal gradient and expected that results to provide baseline data for future study about the relation of butterfly communities with altitude.

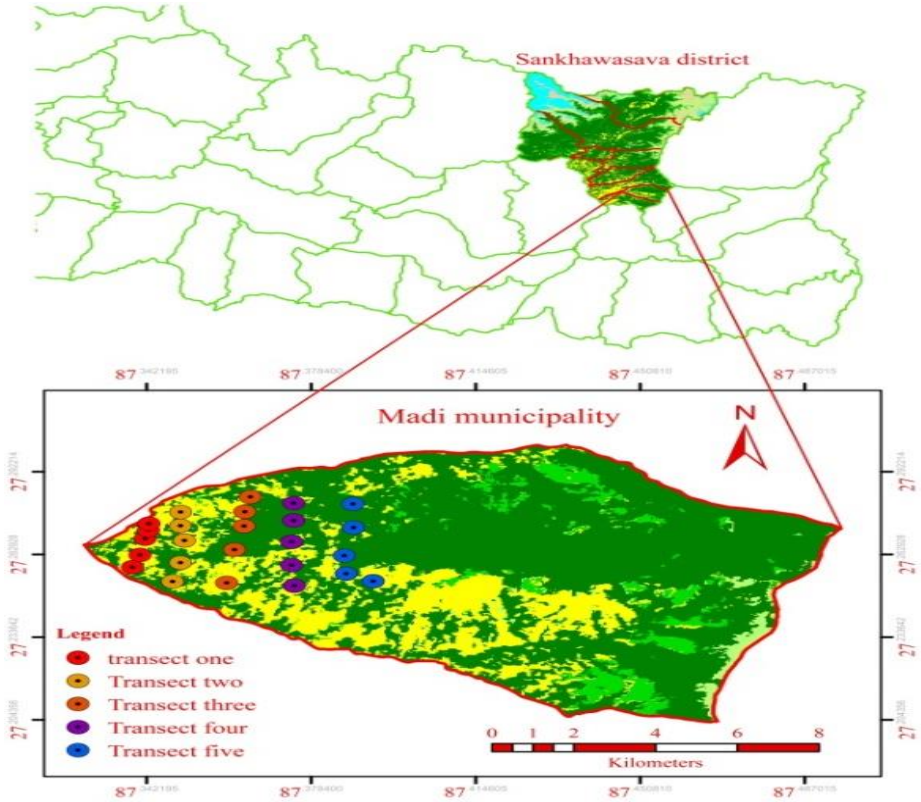
Methods and Materials

The Study Area

The study area was Madi, the southern part of Sankhuwasabha district of Koshi Province, which is located 87°37’10.84’’ E to 87°39’01.78’’ E and 27°26’67.39’’ N to 27°28’74.04’’ N in the Mid-Hill zone of Nepal. The temperature ranges between 18.6°C to 29.2°C during the study period. The annual rainfall varies from minimum 5.40 mm in the winter to maximum 302.6 mm in summer (DHM, 2015). The altitude of the study area varies from 1000 m.a.s.l. to 1800 m.a.s.l.

Figure 1

Map of Study Area



Sampling Methods

Butterfly observations were carried out from 2nd to 25th October of the year 2020. Species richness and abundance of butterflies were studied using transect counts, modified from (Pollard, 1977). Five transect routes were established and butterflies were observed within a five-meter band on both sides of each transect, while walking at a slow and steady pace. Each Pollard transect was walked for at least three days in the middle of the day, from 10 am to 3 pm, on a sunny day. The data of butterflies was collected by a sweeping net. Each captured butterfly species was photographed from different angles as often as possible to obtain sufficient photographs to enable correct identification of the species and was released unharmed. Using a GPS device (Gramin etrex 10), the altitudes of different butterfly species were measured.

Butterfly Identification

Photos of butterflies collected from the study area were identified using literature (Evans, 1932; Wynter-Blyth, 1957; Haribal, 1992; Kehimkar, 2008; Smith, 2011a; Kunte, Roy, Kalesh and Kodandaramaiah, 2016).

Data Processing and Statistical Analysis

The collected data was analyzed by using MS - Excel and various statistical tests, such as Shannon-Wiener diversity index, Pielou's Evenness and Jaccard's similarity index.

Shannon-Wiener Diversity Index (H): It represents the species diversity of any geographical landscape (Shannon and Wiener, 1948).

Shannon-Wiener Diversity Index (H) = - Σ pi ln pi

Where,

P = the proportion (n/N) where n is the particular species abundance and N is the total species abundance

ln = the natural log

Σ = the sum of the calculations

Pielou's Evenness (J′): It is an index that measures diversity along with species richness (Pielou, 1969).

J′= H / ln(S)

Where,

H = Shannon diversity index

ln = the natural log

S = total number of species

The Jaccard Similarity Index: It is a measure of the similarity between two sets of data (Jaccard, 1908).

Jaccard Similarity Index J (A, B) = $\frac{|A \cap B|}{|A \cup B|}$ Where,

J = Jaccard Similarity Index

A = Species richness in area A

B = Species richness in area B

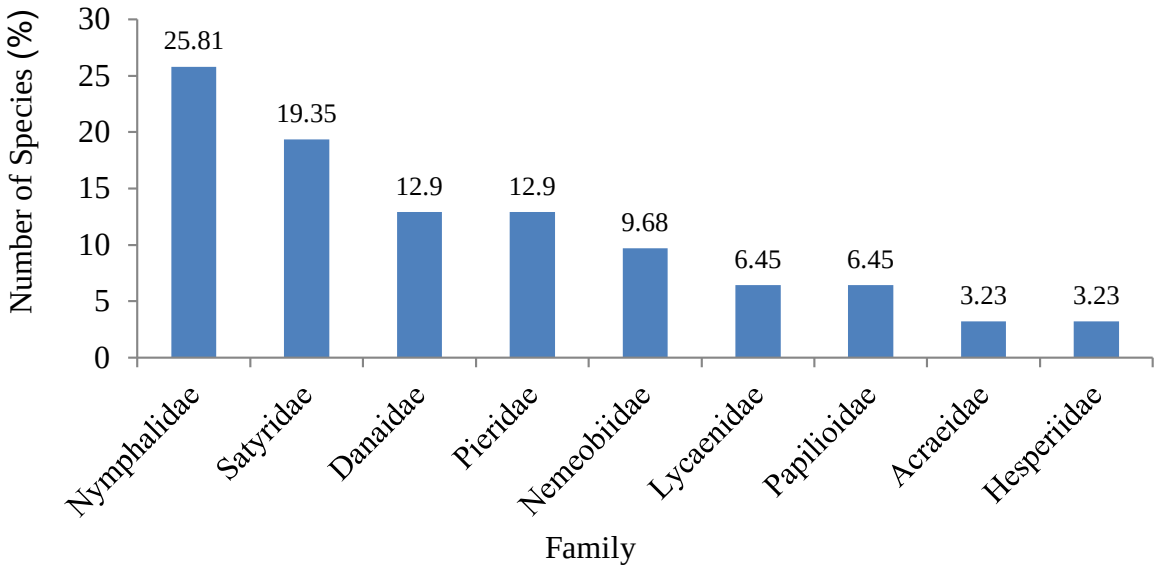
Results

Diversity and Distribution

A total 31 butterfly species belonging to 27 genera under nine families were recorded during the entire study period in which family Nymphalidae contributed eight species (25.81%) followed by Satyridae, six species (19.35%), Danaidae and Pieridae each with four species (12.90%), Nemeobiidae three species (9.68%), Lycaenidae and Papilionidae each two species (6.45%), Acraeidae and Hesperiidae each with one species (3.23%) (Figure 2).

Figure 2

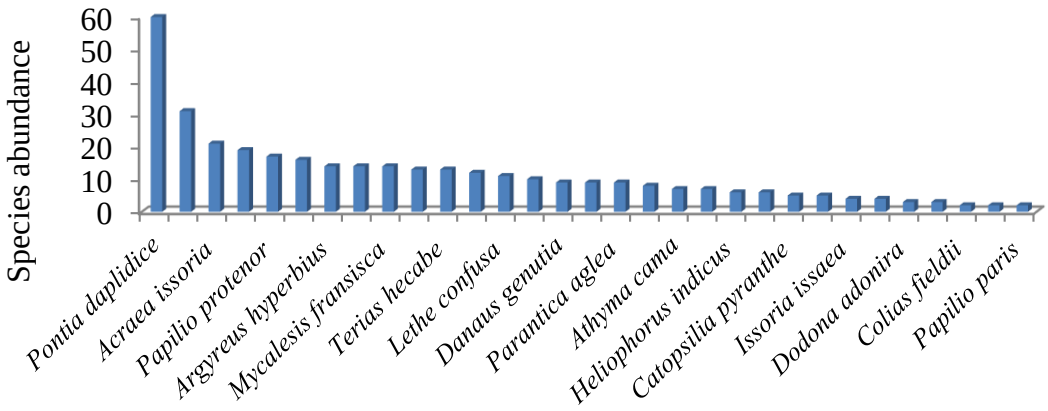
Family Wise Distribution of Butterfly Species



Pontia daplidice was the most dominant species recorded with 60 individuals, whereas *Papilio paris, Neptis hylas, Colias fieldi* were observed with the least number. Likewise, with family distribution concerns, the family Nymphalidae contributed highest with 96 individuals whereas the family Lycaenidae contributed least with 12 individuals.

Figure 3

Species Wise Butterfly Distribution

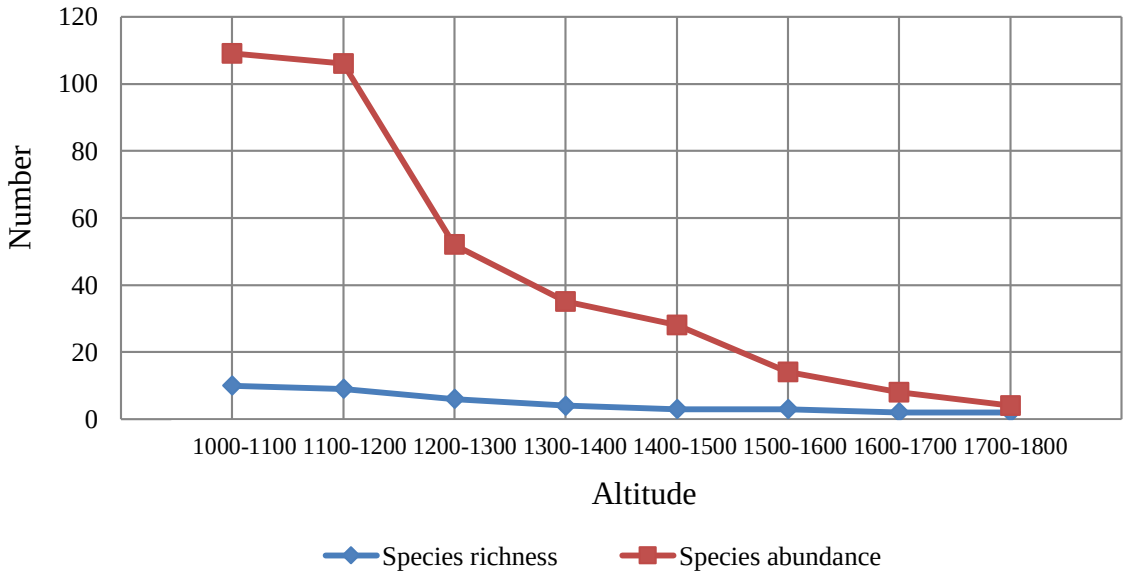


Altitudinal Butterfly Diversity

The highest butterfly richness and abundance were recorded in 1000-1100 m.a.s.l. and the lowest at 1700-1800 m.a.s.l. The correlation coefficient of altitude with species richness and abundance was found to be of high negative significance (-0.938) and (-0.937) respectively (Figure 4).

Figure 4

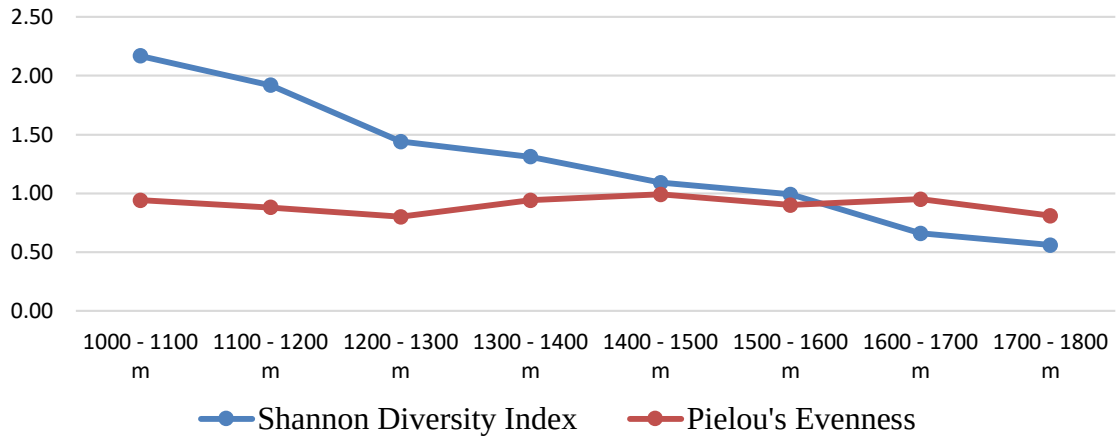
Butterfly Species Richness and Abundance



Altitude 1000-1100 m maximum and 1700-1800 m least Shannon Diversity Index (H=2.17) and (H=0.56) respectively. Pielou's Evenness was highest (J'=0.99) at altitude 1400-1500 m.a.s.l. and least (J'=0.80) at 1200-1300 m.a.s.l. (Figure 5).

Figure 5

Shannon Diversity Index and Pielou's Evenness



Species Similarity

The Jaccard similarity index obtained the highest (J=0.333) between altitudes of 1600-1700m.a.s.l. and 1700-1800 m.a.s.l. and the lowest (J=0.067) between 1000-1100m.a.s.l. and 1100-1200m.a.s.l. (Table 1).

Table 1

Jaccard's Similarity Index

Altitude (m.a.s.l.)	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800
1000-1100	*	0.118	0.067	0	0	0	0	0
1100-1200	0.118	*	0.154	0	0	0	0	0
1200-1300	0.067	0.154	*	0.111	0.125	0	0	0
1300-1400	0	0	0.111	*	0.167	0	0	0
1400-1500	0	0	0.125	0.167	*	0.200	0	0
1500-1600	0	0	0	0	0.200	*	0	0
1600-1700	0	0	0	0	0	0	*	0.333

1700-1800	0	0	0	0	0	0	0.333	*

Discussion

Diversity and Distribution

In a total, 31 butterfly species were recorded. Family Nymphalidae contributed the highest species richness (25.81%) whereas families Acraeidae and Hesperiidae had the least (3.23% each). Thapa (2008) also obtained the similar result that Nymphalidae and Acraeidae contributed the highest and least species numbers respectively at Thankot and Syuchatar, Kathmandu.

Bhusal and Khanal (2008) documented that the family Nymphalidae contributed the highest species richness and Hesperidae contributed least in the eastern Siwalik hill of Nepal. Similar results were obtained by Khanal (1982, 1984) at Thankot and Syuchatar, Kathmandu, where 54 butterfly species were recorded in which Nymphalidae and Satyridae were dominant families.

Shrestha (2016) documented in Manang district, Nymphalidae and Satyridae were the most prevalent families, but Acraeidae and Hespiridae were least prevalent. This finding supports the current study, which may have been influenced by the area's relatively similar height and temperature.

Similarly, Kumar, Devi and Mattu (2016), Gajbe (2016), Narasimmarajan, Vasava, Mahato, Parida andMathai (2014), Trivedi, Bhadja and Vaghela (2013), Tiple and Khurad (2009), Kunte (1997), Kunte, Joglekar, Utkarsh, and Pramod (1999), Eswaran and Pramod (2005), Soubadra and Priya(2001), Padhye, Dahanukar, Paingankar, Deshpande and Deshpande (2008) and Pang, Sayok and Jenang (2016) documented Nymphalidae as the most dominant family because of availability of their specific larval host plants (Saikia, 2014), their ecological adaptation (Jiggins, McMillan, Neukirchen and Mallet, 1996) and high dispersal ability (Adler and Dudley, 1994). Sundarraj, Banupriya and Jeyabalan (2016) recorded Nymphalidae contributed the

highest diversity whereas Hespiridae contributed lowest in the Gudalur forest area, Nilgiri hills, India. This result supports the present study might be of similar elevation.

Datta and Kalwani (2014) revealed that the highest butterfly diversity was shown by families Nymphalidae and Hespiridae, but family Pieridae had the highest abundance at Kambalakonda eco-tourism park, Andra Pradesh, India, which is a bit similar to this study. However, Mukherjee, Banerjee, Basu and Gautam (2015) documented the highest butterfly diversity of family Lycaenidae, followed by Nymphalidae and least contributed by Papilionidae at Kolkata, India, which contradicts with this study.

Altitudinal Butterfly Diversity

The number of species found at the lower elevation is much higher compared to higher elevation, indicating that the correlation coefficient of altitude with species richness and abundance with high negative significance because of hot & wet environmental conditions (monsoon) favorable for butterfly diversity (Ashish, Tiple and Khurad, 2009).

Climatic conditions like low temperatures, higher incidence of cloudy sky and the presence of a lesser number of flowering plant species at higher altitude (1600 to 1700 m.a.s.l and 1700 to 1800 m.a.s.l.) might be the reasons for lower values of richness and abundance. Elevation 1000 to 1100 m.a.s.l. had the highest butterfly diversity (H=2.17) and higher Piulou's evenness (J'=0.94) and 1700 to 1800 m.a.s.l. had the lowest butterfly diversity (H=0.56), which is parallel to (Sparrow, Sisk, Ehrlich and Murphy, 1994), Lien and Yuan (2003) who documented significant differences in the butterfly diversity between low and high elevation sites. Being fond of sunshine and basking, low altitude had greater butterfly diversity and abundance as compared to high altitudes, which corresponds that the diversity of insects or butterflies decreases with increasing altitudes (Price, 1991).

Species similarity

The highest levels of species similarity were found between 1600-1700 m.a.s.l. and 1700-1800 m.a.s.l. (0.333), 1400-1500 m.a.s.l. and 1500-1600 m.a.s.l (0.200).Between the two closest altitudinal sites, there was a significant species resemblance. As the altitudes diverge, the similarities get less and less until they are completely different. The uniformity of this butterfly species across altitudes may be driven by similar temperatures and plant diversity.

Conclusion

The presence of 31 species of butterflies (4.6 % of the total recorded species of Nepal) in just a small surveyed site suggests that Madi, Sankhuwasabha of Koshi Province is likely to be a very important habitat. Further studies are also required to examine the relation of butterflies' species and abundance with different environmental parameters such as altitude, habitat, floral diversity in Madi, Sankhuwasabha.

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Appendix 1

S.N.	Family	Scientific Name	Common Name
1	Nymphalidae	*Aglais cashmirensis* Kollar 1844	Indian Tortoiseshell
2		*Argyreus hyperbius* Linnaeus 1763	Indian Fritillary
3		*Precis iphita* Crammer 1779	Chocolate Pansy
4		*Cethosia biblis* Drury 1770	Red Lacewing
5		*Athyma cama* Moore 1857	Orange Staff Sergeant
6		*Issoriaissaea*Doubleday 1846	Queen of Spain Fritillary
7		*Neptis hylas* Linnaeus 1758	Common Sailer
8		*Vanessa cardui* Linnaeus 1758	Painted Lady
9	Satyridae	*Lethe confuse* Aurivillius 1898	Banded Tree-Brown
10		*Ypthima baldus* Fabricius 1775	Common Five-Ring
11		*Melanitis leda* Linnaeus 1758	Common Evening Brown
12		*Mycalesisperseus*Fabricius 1775	Common Bush-Brown
13		*Mycalesis fransisca* Stoll 1780	Lilacine Bush-Brown
14		*Ypthima huebneri* Hubner 1818	Common Four-Ring
15	Danaidae	*Danaus genutia* Crammer 1979	Common Tiger
16		*Danaus chrysippus* Linnaeus 1758	Plain Tiger
17		*Parantica aglea* Stoll 1781	Glassy Tiger
18		*Euploea mulciber* Crammer 1777	Striped Blue Crow
19	Pieridae	*Catopsilia pyranthe* Linnaeus 1758	Mottled Emigrant
20		*Terias hecabe* Linnaeus 1758	Common Grass Yellow
21		*Colias fieldii* Menetries 1855	Dark Clouded Yellow
22		*Pontia daplidice* Linnaeus 1758	Bath White
23	Nemeobiidae	*Zemeros flegyas* Crammer 1780	Punchinello
24		*Abisara fylla* Doubleday 1847	Dark Judy
25		*Dodona adonira* Hewitson 1865	Striped Punch
26	Lycaenidae	*Heliophorusindicus*Frushtorfer 1908	Eastern Blue Sapphire
27		*Lampides boetics* Linnaeus 1767	Pea Blue
28	Papilionidae	*Papilio paris* Linnaeus 1758	Paris peacock
29		*Papilio protenor* Crammer 1775	Spangle
30	Acraeidae	*Acraea issoria* Hubner 1818	Yellow Coaster
31	Hesperiidae	*Parnara guttata* Stoll 1781	Straight Swift

Biocomposites and their Application

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Abstract

Biocomposites are gaining popularity quickly on the industrial level due to their high versatility, biodegradable nature, and excellent performance. This paper reviews the application of bio-composite based on polysaccharides in immobilized enzymes, drug delivery systems, and packaging. Various bio-composites such as clay minerals, Metal-organic frameworks with biomacromolecules, hectorite, saponite, etc. have been proved to be excellent bio-composite in various fields of science.

Keywords: Biocomposite, biofibres, drug delivery, packaging, immobilized enzymes

Introduction

Biocomposites are biomaterials made of reinforcing natural fibers and matrices (resins). Researchers are motivated by a concern for the environment to study natural fiber cost of reinforced polymer composites -effective synthetic fiber choices composites with reinforcement (Bhambure, 2019). Similar to this, the need for novel composites that are environmentally friendly has been prompted by an increase in global environmental and social concern, a high percentage of petroleum resources being decreases and new environmental legislation (Bharath & Basavarajappa, 2016). Thus, bio fibers are the primary components of bio composites, which are created from biological sources like recycled wood, wastepaper, agricultural processing byproducts, or regenerated cellulose fiber. Natural polysaccharides like chitosan, alginate, starch,

gelatine, and carrageenan are also examples of biological sources. Due to their unique qualities, benefits in terms of health issue and capacity to be recycled, natural fibers offer an alternative resource to artificial fibers such as carbon and glass fiber as reinforcement for polymeric materials to create low-cost, renewable, as well as eco-friendly composites (Fiore et al., 2011).

Natural fibers' accessibility and ease of manufacture have persuaded researchers to experiment with readily available, reasonably priced fibers. By using better structural arrangements and positioning the fibers in strategic places, bio composites' strength and stiffness limits can be solved. They are useful in a variety of high-performance engineering applications, industrial applications, and other industries by combining the beneficial features of two different materials (Bhambure, 2019), and the medical field for the human implant (Manikandan et al., 2021). Over the past ten years, the utilization of biocomposites in residential applications, building materials, aerospace, circuit boards, as well as automotive applications has increased significantly (Bharath & Basavarajappa, 2016). Similarly, other examples of applications of bio-composites are in the area of tissue engineering, drug delivery systems (Mishra et al., 2016) restorative applications, storage devices, photocatalysts, biosensors, encapsulation of enzymes and cells, construction, energy, and packaging (Jawaid & Swain, 2017). In this review, we will discuss some of the applications of biocomposite materials.

Result and Discussion

Biomedical Applications

In areas including drug delivery, immunization, wound dressings, human implants, as well as tissue engineering, clay-based biohybrids are being employed more and more. The acknowledged biocompatibility and inherent nontoxicity of these materials are the cause of this trend. Another crucial aspect is how simple it is to alter clays and precisely control their relevant properties, including surface charge, adsorbed biomolecule density, or hydrophilicity (Ruiz-Hitzky et al., 2013). Some of the biomedical applications are described below:

Biocomposite as Drug Delivery System

Metal-organic frameworks (MOFs) have developed into innovative biocomposites for use in drug administration, biosensing, the preservation of biological specimens, and the manipulation of cells and viruses (Velasquez-Hernandez et al., 2021). Protein-based therapies can be effectively protected and released under regulated conditions using MOFs. MOFs are newer delivery systems for pharmaceuticals based on nucleic acids and carbohydrates. Strong azolate-based MOFs (such ZIF-8, ZIF-90, and MAF-7) provide excellent drug delivery platforms thanks to their high encapsulation efficiency, adjustable release profile, and favorable biocompatibility (DDS) (Velasquez-Hernandez et al., 2021).

Biocomposites in the Field of Human Implants

Different elements are combined to create composite materials, which have superior properties over traditional materials. Depending on the needs, material qualities including physical, chemical, as well as mechanical properties can be modified in composite materials. This benefit broadens the uses of composite materials in the area of human implants. Because of their inherent characteristics with living tissue, conventional metals or ceramics have significant limits after being implanted in the human body. The composite material, which enables composites to create implants for biomedical applications, can eliminate these restrictions. The composite materials are improved by the most recent research to more closely resemble genuine bone, biological processes, and tissue properties. Implants made of functionally graded materials (FGM) get beyond the drawbacks of composite materials (Manikandan et al., 2021).

a. Functionally graded material in dental applications
b. In the field of the joint implant
c. In hip joint replacement

Biocomposite Based on Polysaccharides in Immobilized Enzymes

Clay minerals (biocomposite) have recently been exploited as attractive inorganic supports for enzyme immobilization due to their inexpensive cost, chemical

inertia, thermal stability, properly defined layered structure, as well as ion-exchange ability (An et al., 2015), (Sedaghat et al., 2009). Clay minerals and dealing in particular, show a high affinity for binding as a result of exchangeable cations (like Na+ or Ca2+) inside the interlayer region (Cacciotti et al., 2019). Through a cation exchange procedure, these cations might be swapped out for positively-charged enzyme molecules. For this reason, a number of writers have utilized Na-montmorillonite (Na-MMT) as well as Ca-montmorillonite (Ca-MMT) to covalently and physically immobilize enzyme molecules, such as catalase (Kaushal et al., 2018), glucoamylase (Gopinath & Sugunan, 2007), amylase (Mardani et al., 2018), lipase (Tu et al., 2017), laccase (Aydemir & Guler, 2015) and invertase (Andjelkovic et al., 2015).

OPT (Optigel, an activated food-grade MMT) composite materials appeared to be sufficient carriers for the covalent immobilization of bromelain, similar to SMP, and the addition of various micro clay amounts had no impact on the enzyme's capacity to bind proteins or catalyze processes (Cacciotti et al., 2019). Although SMP composite systems seemed to have a better apparent affinity, protease immobilized on OPT carriers had the maximum product release velocity. Moreover, clay/CS composite membranes have been studied for usage as packaging materials for controlled drugs delivery systems in the food and pharmaceutical industries (Rhim et al., 2013).

Additionally, a lipid coating can improve the colloidal stability and biocompatibility of MOF-based DDS, prolong circulation time, and facilitate cellular uptake. 2015 saw the publication of groundbreaking findings on lipid-on-MOFs from Wuttke et al. and Wang et al. (Wang et al., 2015),(Wuttke et al., 2015). Wang et al. created a variety of hydrophilic Zr-based MOFs with various particle sizes, including UiO-66, UiO-67, and BUT-30 (e.g., particles in the range of 20- 30 nm, and 200-500 nm range)(Wang et al., 2015), and higher affinity for polar solvents (e.g., water). The authors demonstrated that the use of lipids might be used to modify the stability of MOF colloids in less polar solvents (e.g., CHCl3). Lipid-on-MOF systems were the subject of

a study by Wuttke et al. that showed their potential for application as drug delivery systems (Wuttke et al., 2015).

Biocomposites as Packaging

Concerns over the environmental consequences of using plastics in packaging are growing. As a result, interest in biopolymers and biodegradable packaging materials made from renewable sources has grown. However, biopolymers often have low mechanical and barrier properties as well as poor processability, which place restrictions on their industrial application and scalable manufacturing. Bionanocomposites with improved packing qualities, including as mechanical toughness, gases and water resistant characters, as well as optical clarity, have been created to get around these restrictions. Additionally, bioactive substances can be included to give the ensuing packaging material the desired functional qualities. Foods are typically packaged in materials like paper, paperboard, plastic, glass, or metal (Turan et al., 2017).

Despite a number of nanoparticles that may be used as fillers in nanocomposite materials to improve the behavior of polymers, silicate-based layered clays like montmorillonite (MMT), hectorite, as well as saponite have received the most attention due to their availability, low cost, significant improvements, and ease of processing (Duncan, 2011), (Silvestre et al., 2011). Similarly, the edible films could be applied to goods using a variety of methods, such as dipping, spraying, as well as brushing. By acting as a physical resistant against flavor loss, moisture absorption, as well as the gaseous exchange such as O_2 and CO_2, edible films have the potential to extend the shelf life and maintain food quality. Therefore, food packaging that is edible can also include edible films. To improve their barrier and mechanical qualities, edible films combine lipid, polysaccharides, and protein (Moldao-Martins et al., 2003), (Togrul & Arslan, 2004),(Abugoch et al., 2016), (Ayranci & Tunc, 2004), (Lee et al., 2003), (McHugh & Senesi, 2000), (Pedro Javier et al., 2008).

Environmental Application of Biocomposites

Since Antiquity, clay-organic compounds have been used in environmental applications. For example, in Ancient Rome, dirt and decomposing urine were mixed with clays to increase the effectiveness of laundry procedures. Clays are a plentiful, inexpensive, and non-toxic natural resource, making them particularly appealing for environmental protection measures aimed at reducing dangerous species. As a result, research towards more efficient and environmentally friendly clay modifications, particularly for the treatment of drinking water, is expanding. In this situation, biopolymer-modified clays offer a desirable alternative for pollutant removal. For instance, the recuperation of azo dyes as well as heavy metal ions has benefited from the combination of adsorbent characteristics with ion-exchange ability with chitosan-clay bio nanocomposites (Ruiz-Hissy et al., 2013).

Biocomposites in the Automotive Industry

The Molded Fiber Glass Company in Ashtabula, Ohio, produced a total of 46 different glass fiber-reinforced items in open moulds by hand rolling polyester resins into glass fiber mats (Williams, 2007).Hundreds of these were produced after they were originally employed in the building of a prototype car. This historic conversion from conventional steel as well as aluminum parts to glass composites was made in order to reduce weight, improve mechanical qualities, and increase manufacturing efficiency. Since then, glass fibers have been able to coexist with steel in the production of car bodies, which now consumes up to 15% of the world's steel, 25% of its glass, as well as 40% of its annual global oil output. These benefits include their great abundance, low cost, excellent mechanical properties, and consistently reliable performance (Bielefeldt et al., 2013). Vehicle polymers are environmentally friendly in automotive engineering. Vehicles are responsible for 23% of all carbon emissions worldwide, and 80% of all emissions from a vehicle's lifetime occur while it is in motion (Wad, 2005).The ecology is heavily burdened by the greenhouse gas pollution caused by automobiles. Utilizing biocomposite materials would have two advantages: it would reduce the weight of the

vehicle overall, increasing fuel economy by around 7% for every 10% reduction in weight, and it would reduce carbon dioxide emissions by roughly 20 kg for every kilogram of weight lost(Akampumuza et al., 2017a).

Thermoplastic aliphatic polyester (PLA) is made mostly from sugar generated from sweet potatoes, sugarcane, maize, and biomass resources such waste paper, food scraps, leftover timber, straws, and chaff. Studies have shown that PLA (poly lactic acid) bonded with natural fibers significantly reduces carbon dioxide with up to 85% less than PP while also having enhanced thermal and impact characteristics. PLA is already utilized in composites for vehicle interiors (Akampumuza et al., 2017a).

A research of the mechanical properties of sisal, abaca, hemp, coir, kenaf, and jute fiber reinforced polypropylene (PP) composites found that the tensile strength and modulus rose with increasing fiber volume fraction (Wambua et al., 2003). Soy oil is an additional intriguing component for automotive bio composites. As a result, if the program were to be implemented commercially, Cargill estimated that "for every million pounds of petroleum-based polyols replaced with BiOH polyols, approximately 2,200 barrels of crude oil may be saved." In 2005, Cargill created the BiOH brand of soy-based polyols (Meier et al., 2007).

Conclusion

This review presents information about the application of biocomposites based on polysaccharides in immobilized enzymes, drug delivery, packaging, biomedical, environmental and automotive sectors. It has been shown that various bio-composites act as an effective method to replace plastic and other harmful substances. Particularly clay/CS composite membranes have been investigated and shown to be efficient for application in the pharmaceutical business as controlled drug delivery vehicles, largely in the food industry for packaging materials, and also in the covalent immobilization of food enzymes.

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