Journal of Environment Sciences

(JoEnvSc)

Year 4 **2018A.D.** **Volume 4**

Published by:

Government of Nepal
Ministry of Forests and Environment
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Printing : Swetkali Chhapakhana
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Published Year : 2018

Views expressed in the articles are those of authors

Editorial

About the Journal of Environment Sciences (JoEnvSc)

It is our great pleasure to bring out the current issue of Journal of Environment Sciences, Volume 4;a continuation of research publication by Department of Environment. In the present issue, 28 reviewed articles based on original research have been incorporated. The articles have been categorized under the thematic areas like Forestry, Chemistry, Pollution, Agriculture and Climate Change.

This issue intends to cover the research activities of the department and researcher who got research grants from this organizations as well as other research organizations and academic institutions too. We highly encourage the young researcher to pursue quality research and contribute to build scientific knowledge on management of environmental issues, solving environmental problems, sustainable development, environmental resources conservation and equitable benefit sharing.

The link between the result of the scientific research and societies is dissemination of knowledge, data and information through publication. We believe and trust that the research finding will be very helpful to the scientific community as well as general public to enrich their knowledge and information on wise use of environmental resources, implementation of concept of industrial ecosystem, waste minimization, integrated waste management, increase the adaptive capacity in climate change and so on. This help to pile of scattered knowledge, information, techniques, technologies that have been generated in different paradigm of environment. The journal aims to share environmental information and establish relationship among professionals, researchers, academicians and policy makers in the broad arena.

Editorial Board would like to thank professionals, experts, academicians, advisors and reviewers whose critical comments and feedback help to improve the quality of the journal. We acknowledge the contribution of the researchers for their interest in publishing their valued work in this publication. We look forward for further cooperation, co- collaboration and help in days to come for the habitable planet management through publication of applicable research.

Editorial Board

Journal of Envorinment Sciences - Volume -4

Demand and Supply of Forest Resources from Community Forest in Nepal

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Abstract

Community forestry enhances environmental resources, forest cover, biodiversity, carbon stock, soil fertility and forest resources, and promotes sustainable use of forest resource by conserving new trees of forest. To analyze the status of demand and supply of forest products, five different community forests of Jyamrung VDC of Dhading District, Nepal were selected purposively. It was observed that family size, gender, livestock and landholding of CFUG have significant effects in community forest management. Demand of timber, firewood and fodder was higher than supply. For the management of CF, meetings of CFUG committee was conducted in regular interval while general meeting was conducted once in a year. CFUG were involved in plantation, branch cutting, bush clearing, thinning; and removal of over mature trees, pest and disease affected trees and malformed trees. It is recommended to develop REDD$^+$ strategy and supportive policies, and provide assistance for community-based enterprises and private sector.

Keywords:*Community Forest Management; Socioeconomic Factors; Forest Products; Demand and Supply Status*

Introduction

Community forest management (CFM) has helped in enhancement of forest cover, conservation of biodiversity and production of forest goods to support subsistence livelihoods (Karky and Skutsch, 2010, Zenteno et al., 2013, K.C., 2017, K.C. et al., 2014). They are promoting sustainable use of forest resource by conserving new trees of forest and providing easier access to firewood, timber, fodder, litter and grass through conservation and management of forest (Banskota et al., 2007, K. C. et al., 2013, K. C., 2016). A total of 1,798,733 hectare of forest is handed over to 18,960 CFUGs (DoF, 2015). Due to the heavy dependence on fodder, fuel wood and construction timber, forests have been under threat of depletion throughout the country (Dev et al., 2003). Harvest rate depends on tree species, climatic conditions, forest site, level of forest degradation, deforestation and management practices (MoEWNR, 2013). Socio-economic variables like age, gender, ethnicity and wealth influence participation in CFM (K. C. et al., 2017). Demand and supply of forest products depends on the bio-physical context, economic status of the people and policies of government (NFA, 2012). Supply of fuel wood from CF depends on availability of per capita forest area, growing stock and nature of tree species while demand is directly related to fuel wood consumption activities and pattern among the CFUGs member (Dev et al., 2003).

Forecasts of the future supply and demand for forest products is important for planning and decision making in the forestry sector as demand and supply changes with time (MoEWNR, 2013). Harvest of fuel wood and timber affects growing stock, area and carbon storage in the forests, so analysis of demand and supply of forest products is necessary to project the forest carbon removal/storage in the forest (NFA, 2012). But, there is limited study in Nepal focusing on demand and supply status of forest products in CF so, research questions, what is the status of demand and supply of forest products in community forest of Nepal? needs empirical answers.

Materials and Methods

Study Area

The study was undertaken in Jyamrung VDC of Dhading District, Nepal. Inside Jyamrung, five community forests were there namely, Patela Community Forest User Group (PCFUG), Chandrakali Community Forest User Group (CFUG), Salghari Chyandanda Community Forest User Group (SCCFUG), Mahadev Community Forest User Group (MCFUG) and Sattale Tapu Community Forest User Group (SCFUG). Brief information about each CFUG is shown in following table-1.

Table 1: Brief Information about the CFUG

CFUG Name	Patela CFUG	Chandrakali CFUG	Salghari Chyandanda CFUG	Mahadev CFUG	Sattale CFUG
Handover Year	2059 BS	2065 BS	2068 BS	2066 BS	2058 BS
Renewed Year	2068 BS	2065 BS	2068 BS	2066 BS	2069 BS
Forest Area (ha)	47.62	42.5	33.82	65.4	66
Major Plant Species	*Shorea robusta, Terminalia alata, Schima wallichi, Pinus wallichiana and Castanopsis indica*				
Major Animal Species	*Panthera paradus, Muntiacus muntjak, Lepus nigricolis, Canis aureus, Histrix indica, Macaca mulatta*				
Total CFUG Member	191	86	77	83	121
Altitude	700-1200	400-700	700-900	600-800	600-1000
Forest Type	Natural forest	Natural mixed	Natural broad leaved	Natural forest	Natural broad leaved and coniferous forest

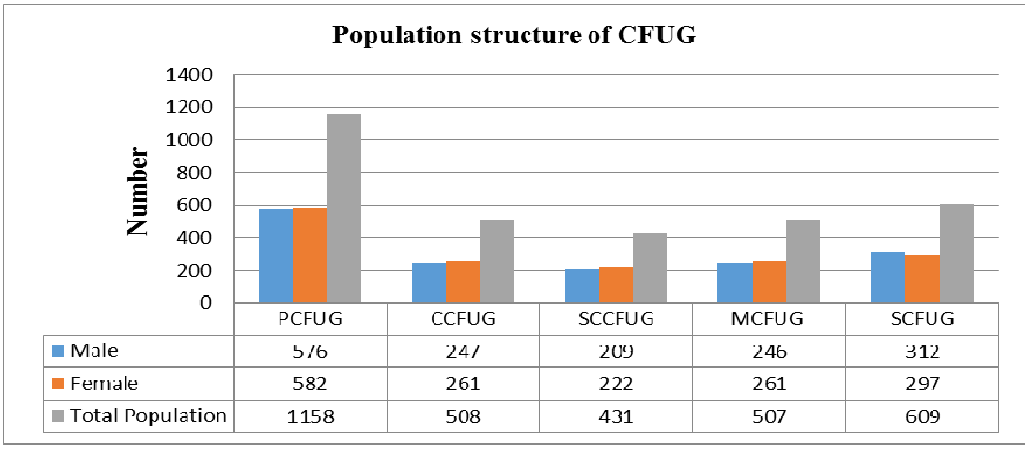
The study was based on secondary data taken from Community Forestry Operational Plan of the given forest. The data is both qualitative and quantitative in nature. Purposive sampling was done to select the Jyamrung VDC of Dhading district, Nepal consisting of 5 CFUGs in the VDC for data collection. After collection of data, collected data and information was analyzed and interpreted efficiently in the systematic manner. Statistical and mathematical tools like average and percentage were used to analyze the data and presented in the simple and clear tables and figures. Qualitative data and information was also interpreted in descriptive way.

Results and Discussion

Socioeconomic Status of CF

Age, gender, caste and landholding have significant effects on participation of CFUGs in community forest management (K. C. et al., 2017, Dev et al., 2003). So, population structure, livestock and landholding status of CFUG were analyzed in this study. Population of female was more as compared to the population of male in most of the studied CFUG as shown in Figure-1.

The male and female population of Nepal was 48.51 percent and 51.49 percent, respectively (CBS, 2012). There was more involvement of female in conservation and management of forest as adult males were out of their home for their education and work as supported by the study of K.C. et al, (2015), Aryal et al, (2017) and Dev et al., (2017). Also, older individuals from higher caste and richer households are more likely to participate in high levels of forest management (Dev et al., 2003, Adhikari and Lovett, 2006). Richer families and higher caste people influence more in decision making in CFUG committee as compared to Janajatis, Newars and Dalits (MFSC, 2013b).



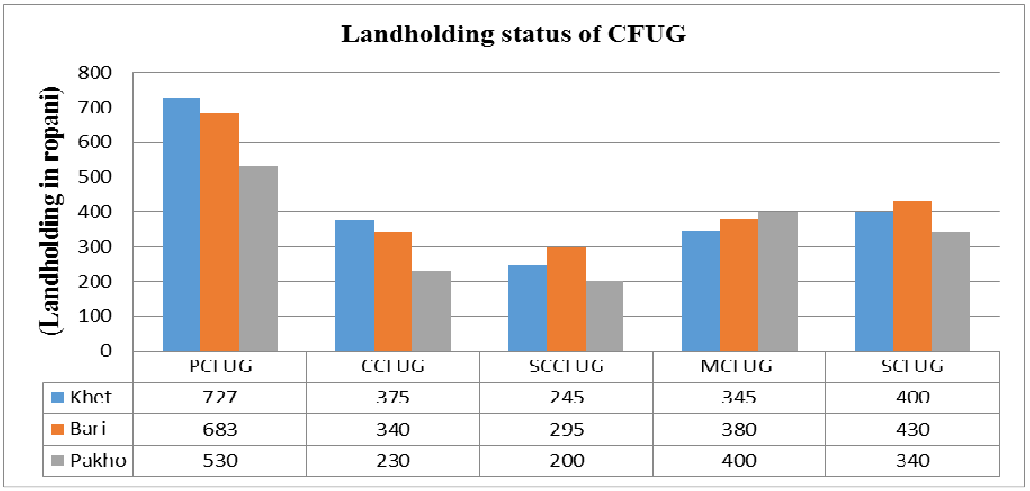
	PCFUG	CCFUG	SCCFUG	MCFUG	SCFUG
Male	576	247	209	246	312
Female	582	261	222	261	297
Total Population	1158	508	431	507	609

Figure 1: Population Structure of Studied CFUG

Women are sensitive to economically sustainable goals as they are dependent on forest for their subsistence and participate in forest conservation projects (Aryal et al., 2009). Men from poorer households benefits more from employment opportunities while women benefits more from mobilization of CFUG funds (MFSC, 2013b). A female with a large family benefit the most from CF (Jana et al., 2014), while small family of 5–8 people benefit the least (Adhikari et al., 2007).

Land Holding Status of CFUG

Three major types of agricultural land owned by CFUG (khet, bari and pakho) is shown in Figure-2. Khet is the irrigated cropland, bari is the unirrigated cropland and pakho is the grassland.



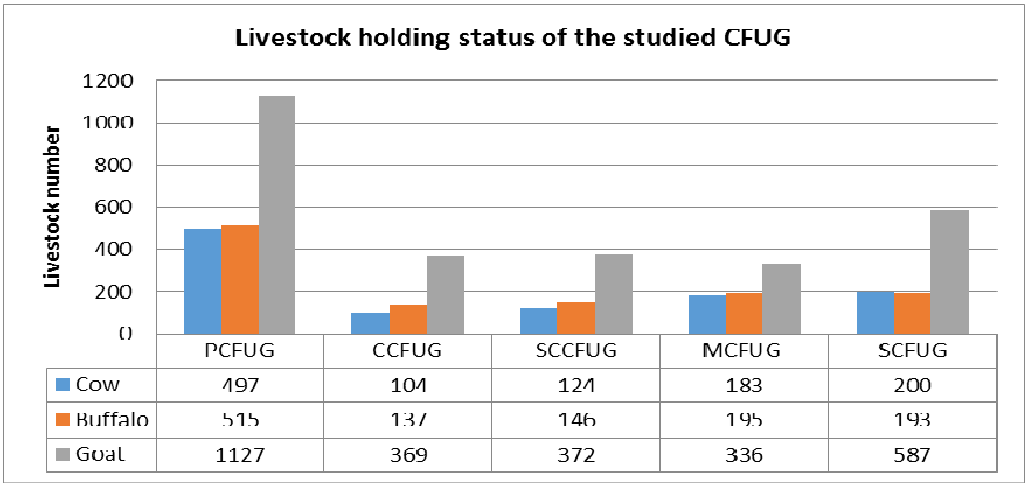
	PCFUG	CCFUG	SCCFUG	MCFUG	SCFUG
Khet	727	375	245	345	400
Bari	683	340	295	380	430
Pakho	530	230	200	400	340

Figure 2: Landholding Status of Studied CFUG

Richer families own more land in all categories as compared to poorer families (Neupane, 2003). CFUG with less landholding status have higher level of participation in conservation and management of forest (Aryal et al., 2009), while CFUG with large landholdings participate more in suggestion and decision-making (Dev et al., 2003).

Livestock Holding Status in CFUG

The major livestock domesticated by the CFUGs were buffalo, cow and goat as shown in figure-3. People were keeping goat for meat and buffalo and cow for milk and milk products. Most of the CFUGs were involved in agriculture and they were keeping domestic animals for utilizing waste from agriculture. The livestock were also used as the source of dung for making compost to use in agricultural field as supported by the study of Neupane, (2003). CFUGs were getting fodder and litter for their livestock from CF and their Pakho. Fodder from CF was harvested during monsoon season in the month of July and September for livestock.



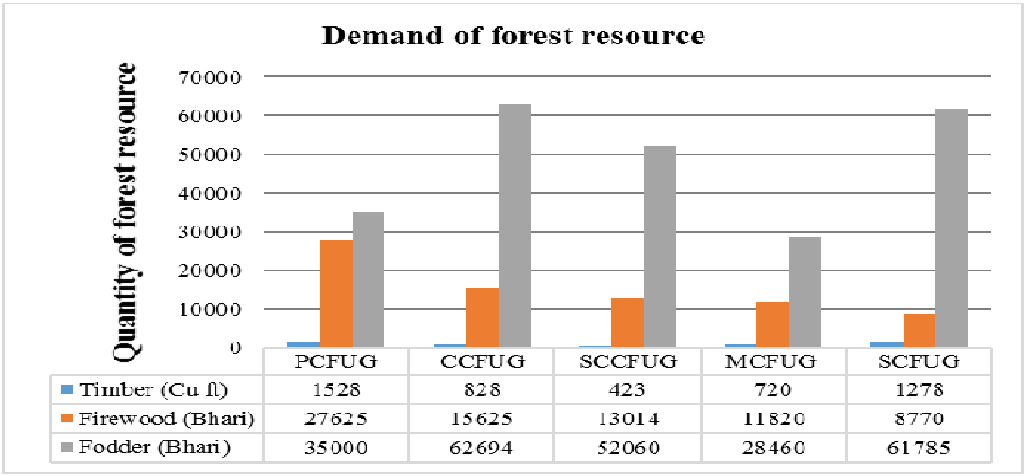
	PCFUG	CCFUG	SCCFUG	MCFUG	SCFUG
Cow	497	104	124	183	200
Buffalo	515	137	146	195	193
Goat	1127	369	372	336	587

Figure 3: Livestock Status in Studied CFUG

Participation of resource-poor groups in CFUG can result in an increased benefit to improve their socio-economic condition (Dev et al., 2003). Services and funds of forest, skill development training and educational support are taken by the poor and extreme poor households while institutional training on leadership development is taken by middle class (MFSC, 2013b). Rural poor women living near the forest largely depend on forest resource to meet their daily livelihood needs for generating income to the family or meeting households' consumption requirements (Aryal et al., 2009). Rich Hindu people with good education, high capital, low levels of land ownership and low per capita consumption benefits more from the forests (Jana et al., 2014). Livelihood of nearly 80 percent of Nepalese rural households depends on forest sector as it provides important household products, inputs to agriculture, income and environmental services (MFSC, 2013b).

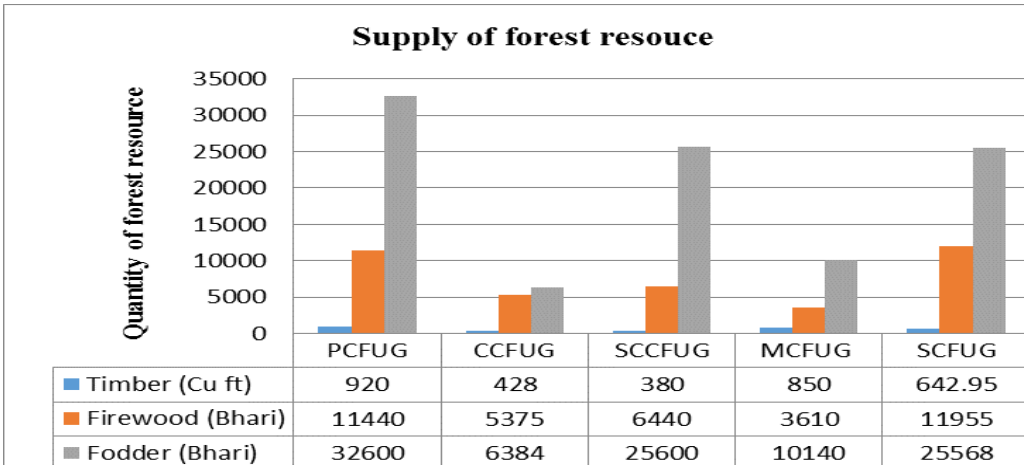
Demand and Supply of Forest Resources

The demand and supply status of timber, firewood and fodder in all 5 CFUGs is shown in Figure-4, 5 and 6. Demand of all forest products is higher than supply in all the studied CFUGs similar to the study of Aryal et al., (2009).



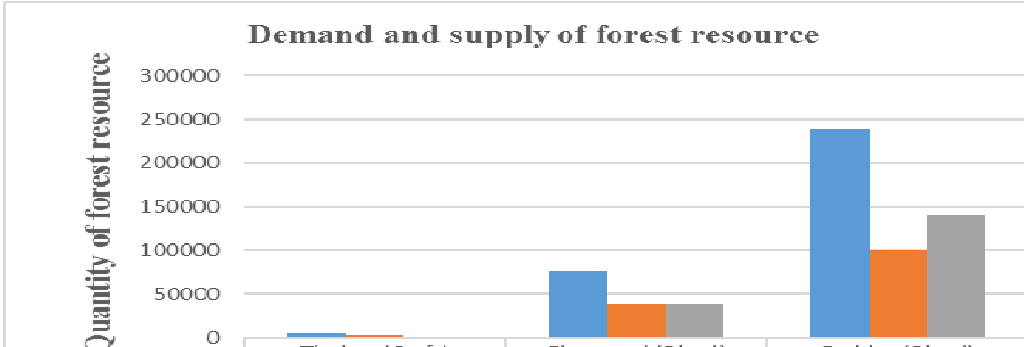
	PCFUG	CCFUG	SCCFUG	MCFUG	SCFUG
Timber (Cu fl)	1528	828	423	720	1278
Firewood (Bhari)	27625	15625	13014	11820	8770
Fodder (Bhari)	35000	62694	52060	28460	61785

Figure 4: Demand of Forest Resources



	PCFUG	CCFUG	SCCFUG	MCFUG	SCFUG
Timber (Cu ft)	920	428	380	850	642.95
Firewood (Bhari)	11440	5375	6440	3610	11955
Fodder (Bhari)	32600	6384	25600	10140	25568

Figure 5: Supply of Forest Resources



	Timber (Cu ft)	Firewood (Bhari)	Fodder (Bhari)
Total Demand	4777	76854	239999
Total Supply	3220.95	38820	100292
Deficit	1556.05	38034	139707

Figure 6: Demand and Supply of Forest Resources

There is a large gap between demand and supply for all forest products in Nepal (MFSC, 2013b, Thoms, 2008). The demand and supply status for different years shows that there is a shortage of timber and fuel wood in the Terai (MFSC, 2013a, NFA, 2012), but surplus in the hills and mountains. Transport of surplus wood from hills to the Terai is difficult due to terrain and high cost of transportation (NFA, 2012). Supply reaches 75 percent of demand in the mountains, 49 percent in the hills and 40 percent in the Terai. Access to forest products across wellbeing classes shows that middle and upper classes meets their demand for timber than the poor and extreme poor (MFSC, 2013b). Deficit of timber and fuel wood will be at a decreasing rate in 2011 and 2015 and surplus in the year 2020, 2025 and 2030. Pressure on Terai forest is high to meet the needs of Terai people and urban areas of hills due to migration of people from hill to Terai (NFA, 2012). Many community forests do not have enough forestland to fulfill forest products need of majority of CFUGs (Thoms, 2008).

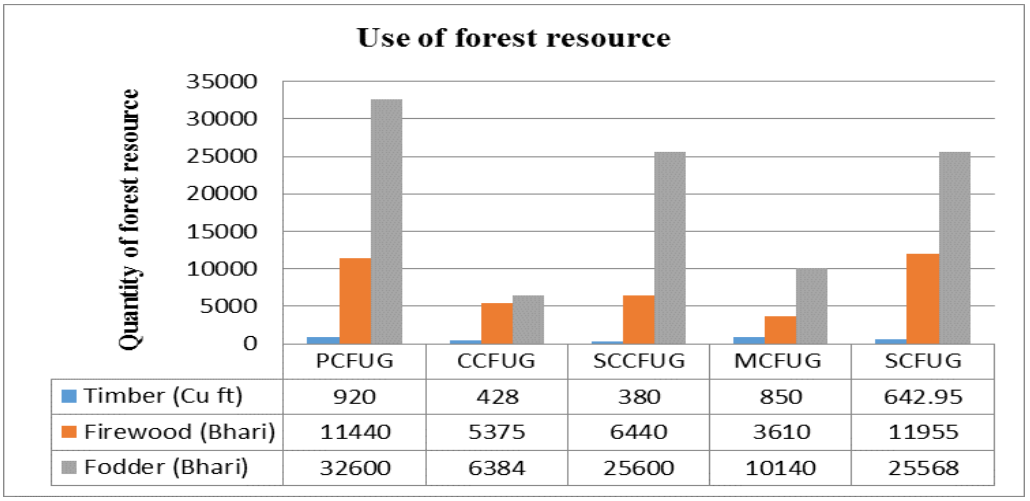
The demand and supply of forest products depends on biophysical factors of different ecological regions and policy regimes of government (MFSC, 2013a). It also depends partly on HHs size and installation of efficient ICS and biogas (Aryal et al., 2009). Changes in supply, demand, and governance provide opportunity to earn more from their forest assets for the low-income forest communities (Scherr et al., 2003). In some CFUGs, deficit in supply to meet subsistence needs is a management problem due to limited access to vital forest products (Thoms, 2008).

Use of Forest Resource

People harvest timber, firewood and fodder from the forest as shown in Figure-7. Timber was allowed to the CFUG during construction of a private and community building similar to the study of K.C. et al, (2015). Dry firewood and fodder was harvested throughout the year while green wood was harvested once in a year during winter season.

Food, fuel, timber, fodder, construction material, medicines, bedding for animals and leaves for composting are forest products important for livelihoods and well-being (Thoms, 2008). Out of 86 percent of Nepal's households using fuel wood, more than 75% of them collect their fuel wood from forest. Timber is used in the construction of residential houses, commercial and industrial buildings, livestock sheds and furniture (NFA, 2012). Equal amount of forest products is allowed to harvest for each CFUG regardless of household size or income by collecting dues but those who do not need the product sell their surplus to other users or other people (Thoms, 2008). Forests provide source of local rural employment and income from forest product activities (Scherr et al., 2003). Natural, financial, social and institutional capital generated by larger CFUG provides more household benefits and private capital gains (MFSC, 2013b). Firewood, small branches, twig, maize stalks, cobs and crop residues are energy source used for domestic cooking and heating purposes (Neupane, 2003). Fuel wood is also used for cooking food and preparation of animal feed and alcohol (Aryal et al., 2009). Use of forest resources prevent intensification of poverty (Sreedharan and Matta, 2010).

Community forests provide indirect livelihood benefits through ecological services such as watershed protection, erosion control, enhanced soil fertility and windbreaks for farmland (Thoms, 2008, Acharya, 2003). It prohibits hunting and forest fire, and controls grazing and forest encroachment (Acharya, 2003). CFUG also provide opportunity for social networking and skill development through user group formation, income generation, home improvement, improved trails, in-village drinking water sources, support to schools, construction of community buildings, community roads and village electrification (Thoms, 2008). Demand of fuel wood and timber for subsistence and commercial use has been one of the main drivers of deforestation and degradation in Nepal (MFSC, 2013a).



	PCFUG	CCFUG	SCCFUG	MCFUG	SCFUG
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Firewood (Bhari)	11440	5375	6440	3610	11955
Fodder (Bhari)	32600	6384	25600	10140	25568

Figure 7: Use of Forest Resource from the Studied CFUG

Deepening poverty and increased livelihood vulnerability may also lead to degradation of forest resource (Sreedharan and Matta, 2010). Increase in income of family and lack of youths for collection and gathering of forest products has led towards substitution of fuel wood by kerosene and LPG in Nepal (NFA, 2012).

Regulatory Management in CFM

Forest resource can be improved through development of human capital, women's awareness, social role, confidence and empowerment; protection from forest fire, illegal tree felling, unregulated extraction of forest products; plantations on barren land; and resolving land disputes with individuals and neighboring FUGs (Dev et al., 2003). For conservation of forest, CFUG conducts weeding, singling, thinning, pruning, cleaning, selective felling, fire control, grazing control, plantations, soil conservation work and leaf litter collection (Acharya, 2003).

For the regulatory management in studied CF, meetings of CFUG committee were conducted in regular interval and general meeting was conducted on annual basis. People used to be involved in plantation from June-July; branch cutting, bush clearing and thinning from December-February; and removal of over mature trees, pest and disease affected trees and malformed tree from December-April. Also, monetary fine was charged as a punishment for restriction from the illegal use of forest products. Equal benefit distribution with equal participation and collective decision-making is necessary to create effective and equitable forest management (Dev et al., 2003). Participation of women in annual general meeting, decision-making, monitoring and patrolling reduces violation of rule (Aryal et al., 2009). Restriction of traditional timber production and scientific forestry by government lead CFUG decision-makers towards passive management and less production oriented management (Thoms, 2008).

REDD^{+} strategy should be implemented to support tree planting through incentives, sustainable harvesting and effective distribution of wood products (MoEWNR, 2013). Also, assistance for community-based enterprises, supportive policies, active engagement of the private sector and sales of wood products and NTFPs can improve livelihood of CFUG (Scherr et al., 2003).

Conclusion

From the above findings, it can be concluded that family size, gender, livestock and landholding of CFUG have significant effects in community forest management. Demand of all the forest products is higher than supply. People harvest timber occasionally, dry firewood and fodder throughout the year and green wood once in a year during winter season. For the management of CF, meetings of CFUG committee and general members was conducted. People used to be involved in plantation, branch cutting, bush clearing, thinning, removal of over mature trees, pest and disease affected trees and malformed tree. For sustainable conservation and management of CF, $REDD^{+}$ strategy, assistance for community-based enterprises, supportive policies, active engagement of the private sector and sales of wood products and NTFPs should be implemented. Also, similar studies are recommended in other community forests of the country.

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Shift Assessment of Upper Tree Species Limit and Tree Line Recruitments in Manaslu Area, Nepal

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Abstract

The upper species limit shift and treeline dynamics of Abies spectabilis (D. Don) Mirb was investigated around Lho village in Manaslu Conservation Area, Central Nepal. A census was carried in a belt transect. Forest mensuration parameters, tree-age. Ambient climate change data of the precipitation and temperature and NDVI was analyzed. The results indicate that the vertical distance between the oldest tree (106yr) and youngest seedling (5yr) was 110m; similarly, there was an increase of mean annual temperature by 0. 05oC (R^2=0.10, P>0.05) per year and decrease in precipitation by 1.78mm (R^2=0.15, P < 0.01) per year. Results of NDVI analysis of satellite imageries suggested an increase of 78% area for the between 1976 to 2016. The correlation between five-year interval recruitment from seedling to tree form and the mean annual temperature change was positive (r = 0.35, P = 0.04); similarly, correlation with mean annual precipitation was negative (r = -0.36, P<0.5).

Keywords : *Abies spectabilis, Treeline, Climate Change, NDVI.*

Introduction

Climate, in general temperature is the most influencing predictor variable of treeline formation and maintenance (Harsch et al. 2009) as well as the species line determination (Korner 2003). Plants response to warmer climatic conditions by either adapting their life cycles or shifting their ranges to suitable habitats (Walther et al. 2005). The effect is distinct in high alpine ecosystem and is sensitive bio-monitors of past and recent climate change and variability (Kullman 1998).

In recent decades, remotely sensed satellite imageries are being widely enabling firmer conclusions about changes to treeline forests (Zhang et al. 2009) provided that they are of good resolution. Normalized Difference Vegetation Index (NDVI), helpful in distinguishing bare ground areas and partially forested areas, or densely forested areas (Harsch et al. 2009; Singh et al. 2011). It has also been applied in detecting the altitudinal treeline shift as in Changbai mountain between period 1977 to 1999 (Zhang et al. 2009) and Uttarakhand from 1970 to 2006 (Singh et al. 2012).

Materials and Methods

Study Area

The study was conducted in Lho village of Manaslu Conservation Area (MCA) which lies in Gorkha district of central Nepal, about 200km from capital city Kathmandu. The study area experiences the sub-alpine zone. *A. spectabilis* (D. Don) Mirb is found throughout the Himalayan from Afghanistan to Bhutan (Stainton 1972). In Nepal it is widespread between 3050m and the treeline and sometimes descends as low as 2745m. The forest is most extensive in central midlands of Nepal. The regeneration period of the *A. spectabilis* is 30 years (Prakash and Khanna 1979).

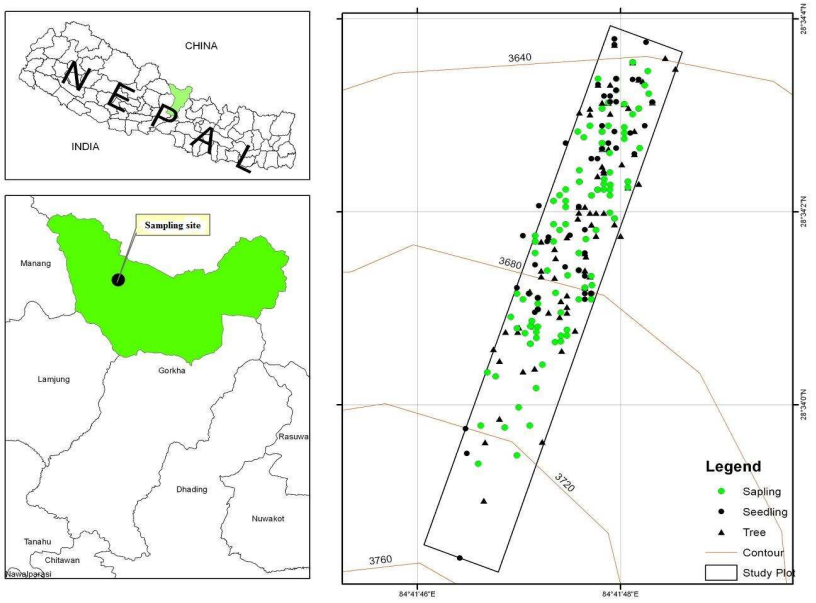

Figure 1: Map Showing Study Site with Enumeration of Seedling, Sapling and Tree

Sampling

The transect walk was carried out at alpine region (upslope) toward treeline (downslope) which was located at 3701m asl, above which no seedling or sapling of *A. spectabilis* (D.Don) Mirb was observed. Taking this point as a reference, the vertical walk was carried out till the first individual was observed, which was the upper species limit of *A. spectabilis* in that slope. Census of transect from the upper limit along down slope toward the treeline and further down to the forest of *A. spectabilis* of dimension 245m×20m was carried out. For the study, growth stages of *A. spectabilis* were categorized as; trees (>2m) (Wang et al., 2006), saplings (0.2-2m) (Baier et al. 2007; Brang et al. 2004) and other as seedlings (<0.2m).

Age of Trees, Saplings and Seedlings

Tree cores of *A. spectabilis* were collected from transect by using the increment borer (Haglof, Sweden). The increment borer was directed in such a way to retrieve exact pith. Occasionally, when the borer went out of the center, the coring procedure was repeated in order to get the pith. Fifty-eight cores out of 76 trees encountered (due to the greater possibility of breaking down of small sized DBH of tree) were bored at the basal height from the ground. Collected cores were air dried at room temperature and glued into grooved sticks with the transverse surface facing up and polished until optimal surface resolution allowed annual rings to be visible under the microscope. Each ring of the cores was counted and cross dated using skeleton method (Fritts 1976) and age of a tree was estimated. In addition, the age of seedlings and saplings was determined by counting the number of branch whorls and bud scars on the main stem (Gaire et al. 2011; Wang et al. 2006).

Stand Structure and Establishment Analysis

To define the stand structure DBH, height and crown diameter of live *A. spectabilis* at the site were measured. DBH was measured with the help of diameter tape at 1.3m above the ground and height was measured by the Sunto clinometer and for the seeding and sapling directly with the help of measuring tape. Crown diameter was calculated by measuring and adding the radii of the crown projection areas in four directions and then by dividing into 2 the value obtained (Avsar 2004). For the relationship between establishment and climate change, recruitment from 1971 to 2010 were summed across 5-year intervals and compared with seasonal climate records compiled into 5-year averages over the same time period (Camarero and Gutierrez 1999). The climate parameters used in the analyses include monthly mean temperatures and total precipitation.

Methods to Estimate the Rate of Upward Shift of Vegetation

The species limit advance of *Abies spectabilis* within study area was evaluated by subtraction using the equation given by (Gamache and Payette 2005; Suwal 2010). The total shift was divided by the number of years taken to reach the recent position from oldest position by the species and expressed in per decade shift.

$$\text{Rate of Shift} = \frac{\text{Recent position of species - Oldest position of species}}{\text{Number of years taken to reach the recent position}} \times 10 \text{ (m/decade)}$$

(Gamache and Payette 2005; Suwal 2010)

NDVI Analysis

The study involves data selection, pre-processing, treeline ecotone delineation, vegetation index calculation; and change analysis. Orthorectified and cloud free (<10%) Landsat imagery of 1976, 1988 and 2016 (UTM/WSG84 projection) was used to delineate the current vegetated area. Landsat imageries were downloaded from the Earth Explorer web site (http:// earthexplorer.usgs.gov).

Three images were acquired for four decades as other images for the '90s were not applicable to this study owing to their low quality caused by more percentage of cloud coverage. The NDVI capture the contrast between the visible-red and near-infrared reflectance of vegetation canopies. It is defined as,

$$NDVI = (NIR - RED) / (NIR + RED)$$

Where, RED and NIR are the visible-red (0.58-0.68um) and near-infrared (0.725-1.1um) reflectance, respectively. The NDVI is scaled between -1 to +1. For this study NDVI value between -0.2 to 0.1 is considered to be non-vegetated snow-covered area, between 0.1 to 0.4 as sparse vegetation and between 0.4 to 1.0 as dense vegetated area.

Results and Discussion

Local Climatic Trends

Weather data from the Jagat meteorological station (elevation = 1270m asl, distance=34km, aspect = East) showed that the trends of summer (June–September) and winter (December–February) temperatures between 1971 and 2010 were different (Figure 2). The average winter mean temperature showed an average increase at a rate of 0.04°C per year (R^2=0.15, P<0.05), and average summer mean temperature showed an increase of 0.07°C per year (R^2=0.45, P<0.0001). The mean temperature also showed the increasing trend of temperature with an average increase of 0.05°C per year (R^2=0.10, P>0.05). The result is in conformity with the studies done all over the Nepal by

analyzing the temperature data during the period from 1971-1994 which showed a warming trend (Shrestha et al. 1999).

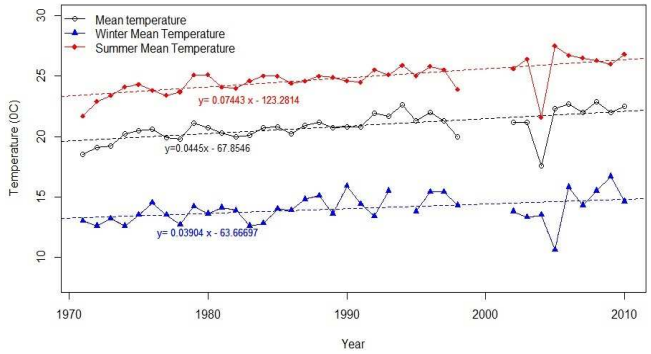

Figure 2: Variation in Mean Temperature, Winter Mean Temperatures (Dec–Feb) and Summer Mean Temperatures (Jun–Sept) for the Period 1971–2010 [data from the Jagat Meteorological Station]

Similarly, the total annual precipitation during the period from 1971 to 2010 showed that there is fluctuation in the rainfall pattern. In the span of 39 years there is slight decrease in average precipitation at a rate of 1.78mm per year (R^2=0.15, P < 0.01) (Figure 3). According to Shrestha (2008), all Nepal annual precipitation is decreasing at a rate of 9.8mm per decade.

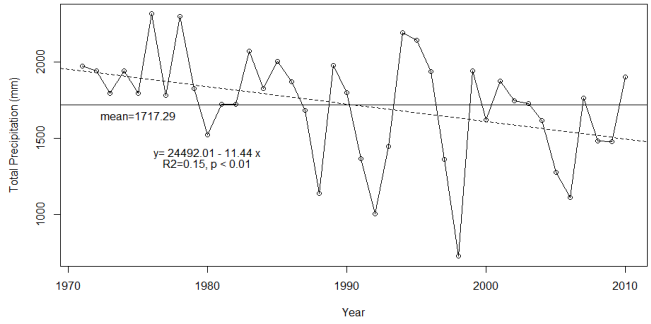

Figure 3: Trend in Precipitation of Jagat Meteorological Station, Gorkha

Stand Characteristics

In the relationship between crown diameter, DBH and height of *Abies spectabilis*, crown diameter is taken as the response variable and DBH and height both as the predictor variables. In both the cases of crown diameter and DBH (F=209.2, P<0.001) and logarithm of crown diameter and logarithm of height (F=66.76, P<0.001)) the relationship is statistically significant. In the relationship between height and DBH, former taken as response and later as predictor the relation is statistically significant (F=90.74, P<0.001) (Figure 4). When the K/d ratio is plotted (Figure 5) the variation is apparent, particularly at smaller stem diameters. As the stem diameters approaches to 30–40 cm the ratios begin to stabilize, with the decline becoming less rapid, which is helpful for estimating basal area from crown diameters measured from aerial photographs or other methods of remote sensing (Hemery et al. 2005).

At the initial phase of establishment, the DBH of *A. spectabilis* increases with increase in age and as the species tends to mature, the increase in DBH is likely to slow down. The relation between

age and DBH of *A. spectabilis* was statistically significant (n= 76, F= 37.73, P< 0.001) (Figure 6).

The age–frequency of *A. spectabilis* displayed inverse J-shaped distribution (10-year intervals). The 21-32 year-old age class (trees that established in the 1980s) accounted for the largest age class (25 stems). The majority of trees (65 stems) were between 42 and 12 years established between 1970s and the 2000s. Before 1970s, establishment has been very poor with mature individuals (>50 years) accounting for only 5 stems of the total population (Figure 7).

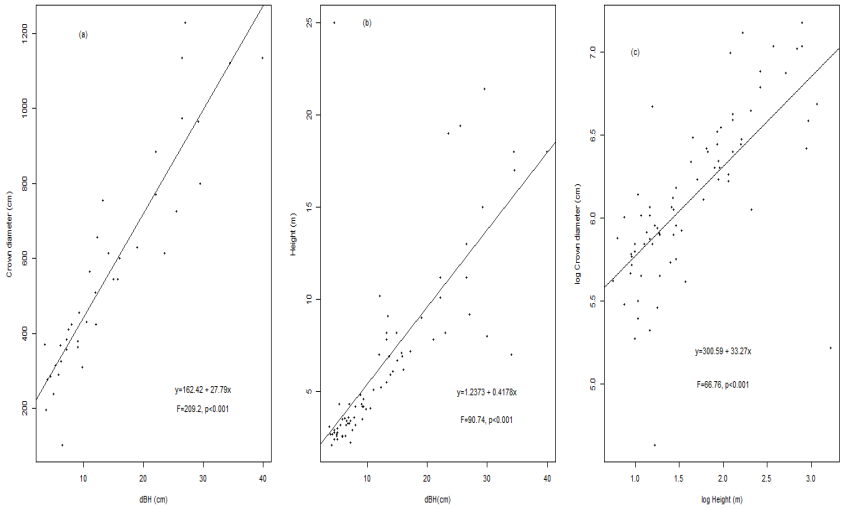

Figure 4: Relationship Between (a) Crown Diameter and DBH (b) Height and DBH (c) Crown Diameter and Height of *Abies spectabilis*

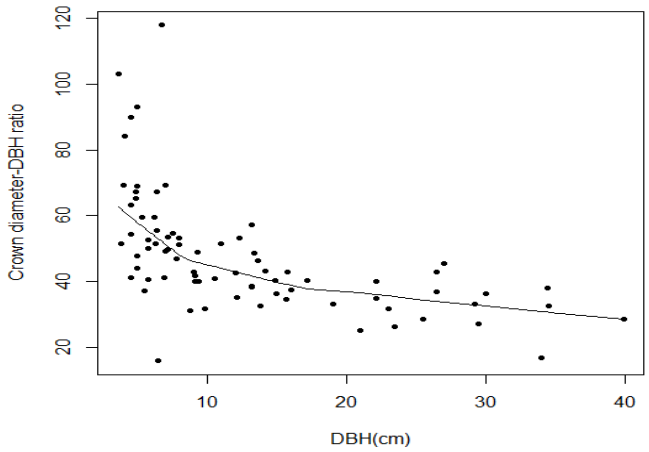

Figure 5: Crown Diameter–Stem Diameter Ratios at Different DBH for *Abies Spectabilis*

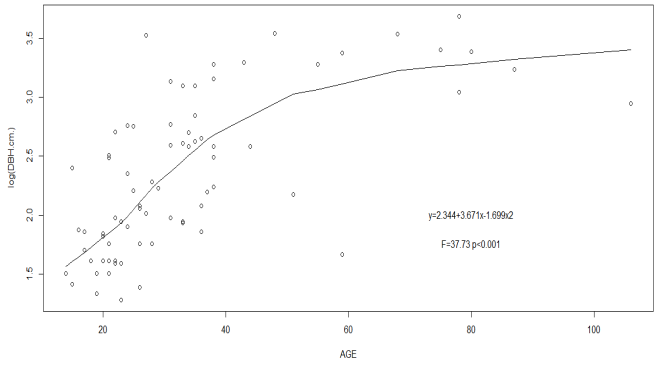

Figure 6: Relationship Between Age and DBH Of *Abies Spectabilis* Population Using LOWESS Smoother in Polynomial Second Degree Equation

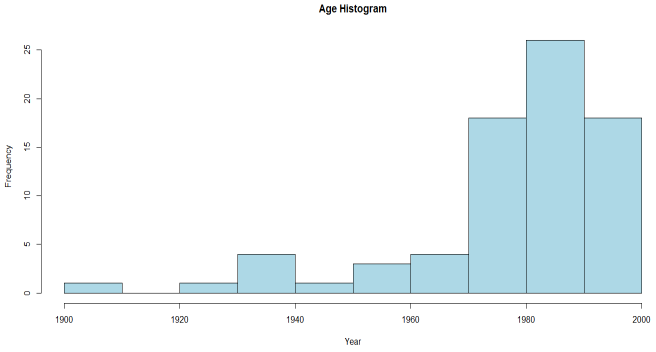

Figure 7: Age Frequency of Tree of *Abies spectabilis* in Lho Village, Manaslu

Recent Regeneration and Climate

Age-class histograms for *A. spectabilis* showed that trees could be dated back to the early 20th century. Establishment in this population occurred at low levels before 1900, at moderate levels from 1970 to 1980, and at high levels between 1996 and 2002s and recent regeneration has increase substantially after 1970s (Figure 7) which is consistent to the findings of other studies (Gaire et al. 2011; Gaire et al. 2013a; Liang et al. 2011; Lv and Zhang 2012). During the last 40 years, there have been significant and positive correlations between recruitment and mean annual temperature (5-year average) ($r = 0.35$, $P<0.5$). There are significant negative correlations between recruitment and mean annual precipitation ($r = -0.36$, $P<0.5$) and recruitment and autumn precipitation ($r = -0.72$, $P<0.000001$). All of the seasonal temperature facilitates seedling recruitment with the highly significant positive correlations between recruitment and mean autumn temperature ($r = 0.71$, $P < 0.000001$) (Figure 8).

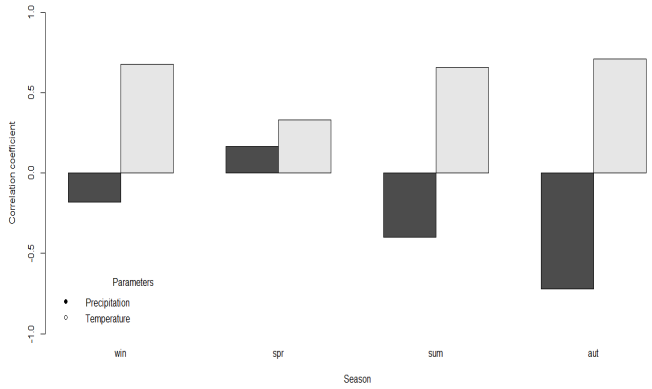

Figure 8: Correlation Coefficients of Recruitment with Seasonal Mean Temperatures and Mean Total Precipitation (1971–2000). (Winter: Dec-Feb, Spring: Mar-May, Summer: Jun-Sept, Autumn: Oct-Nov)

Rate of Shift

Altogether 77 seedlings, 112 saplings and 76 trees of *Abies spectabilis* were encountered. The youngest individual of *A. spectabilis* was encountered at an altitude of 3,752m whereas the oldest tree was at an altitude of 3,642m asl (Figure 9). The youngest individual was found to be of 5 years and the oldest with an age of 106 years. This indicates that it took 101 years to shift to the highest altitude by 110m (1.08m/year). Thus, vertical rate of treeline shift is found to be 10.8m/decade with reference to 1911 treeline, which is slightly lower when compared to the studies done in Himalayan pine in the Western Himalaya (Dubey et al. 2003). However, other study by Suwal (2010) and Gaire et al. (2013b) reported upward expansion of *A. spectabilis* by an average of 34m/decade and 26.1m/decade respectively.

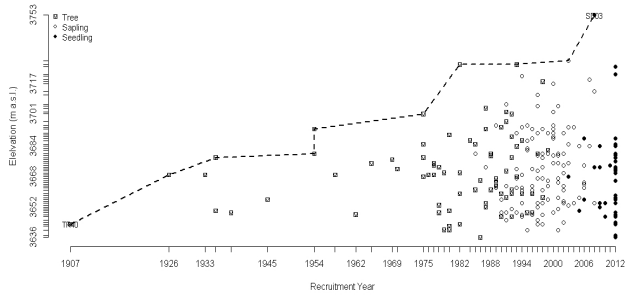

Figure 9: Establishment of Seedlings of *Abies spectabilis* from 1907 to 2012

Change in Tree line Ecotone

The digital comparison of treeline ecotone between year 1976, 1988 and 2016 found that it has changed in the past four decades. The analysis had shown that non-vegetation area in 1976 (1286.285sq. km.) has been changed by 38.9% in 2016 (925.91sq. km.). The sparse vegetation has been increased by 21.3% (75.3 sq. km.) between 1976 to 1988 and by 46.7% (200.2 sq. km.) from 1988 to 2016. Similarly, dense

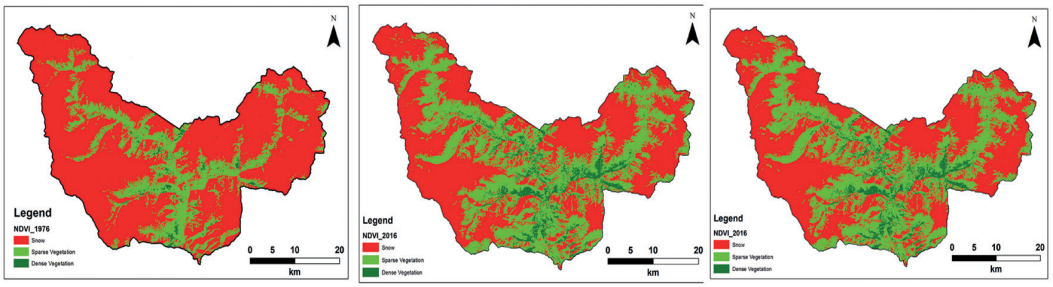

Figure 10: NDVI Analysis of Manaslu Conservation Area 1976, 1988 and 2016.

Vegetation has been increased by 78.28% (85 sq. km.) from year 1976 to 2016. This indicates that the non-vegetated snow-covered area in the year 1976 have been covered by vegetation in four decades. (Figure 10). Under the hypothesis that the climatic warming has changed the treeline dynamics, this is a reasonable assumption- the NDVI value have changed from 1976 to 2016.

Acknowledgements

This study was supported by the NAST-NCCKMC/CDKN Project. We express our thanks to Mr. Bam Bahadur Oli for their help in field investigations. We are grateful to the National Trust for Nature Conservation for their hospitality and to the NAST lab, for permission to use the DENDRO system, Mr. Prakash Chandra Aryal for support in statistical analysis.

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Population Structure, Association and Conservation of *Michelia champaca* in Panchase Protected Forest, Western Nepal

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Abstract

Population structure, association and conservation of M. Champaca was studied in Bhanjyang and Panchase Peak in Panchase protected forest using point centred quarter method for sampling trees, computing significance of association between M. Champaca and other dominant tree species, and conducting questionnaire survey. A total of 14 and 12 species of trees were found in Bhanjyang and Panchase respectively. In Bhanjyang, Michelia champaca was dominant with higher IVI whereas, Quercus semicarpifolia was dominant in Panchase. DBH of M. Champaca were higher in Bhanjyang than in Panchase. M. Champaca was found to be mixed with other broad leaved tree species such as Daphniphyllum himalense, Quercus semecarpifolia and Rhododendron arboreum yet there was no significant association. Most preferred tree species by local people for household use were Schima wallichii and Castanopsis indica. For the conservation of M. Champaca, plantation and management of this tree species is recommended.

Keywords: *Chap, Michelia, Vegetation Analysis, Panchase, Endangered Species*

Introduction

Michelia champaca belongs to the family Magnoliaceae. The natural regeneration of the species is rare, and hence often grown in nurseries from seeds with great difficulty before out-planting (Bahuguna et al, 1987; Armiyanti et al., 2010). The species has been reported to be recalcitrant or 'short-lived orthodox' due to its relatively short life span and the requirement of high moisture to maintain viability (Bahuguna et al, 1987; Bisht and Ahlawat, 1999). Seed propagation is time consuming (Zabala, 1990) and vegetative propagation through layering is not suitable for large scale planting. *M. Champaca,* one of the five species of *Michelia* present in Nepal is of least concern in IUCN threat category but overexploitation for timber has threatened its population at local scale. It has been banned for felling, export and trade by Forest regulations 1995 in Nepal. The species is found associated with *Schima Castanopsis* forest in Nepal and is one of the most useful plants having multipurpose utilization. However, population of *Michelia champaca* have number of threats due to climate change, its excessive use as well as poor regeneration. This study tends to analyze population structure, association and conservation of *M. Champaca* in Panchase Protected forest

Materials and Methods

Study Area

The study was carried out in Bhanjyang and Panchase Peak of Panchase Protected Forest at longitudes between 83° 45' and 83° 57' E and at latitudes between 28° 12' and 28° 18' N. Altitude ranges from 815 m at Harpan River to 2517 m at the peak of Panchase hill whereas the forest ranges from 1450 m to the peak and receives more than 5000 mm precipitation per year. Panchase is a rich area in biodiversity (Koirala, 1998), possessing a total of 310 plants, out of which about 100 species are NTFPs and 113 orchids.

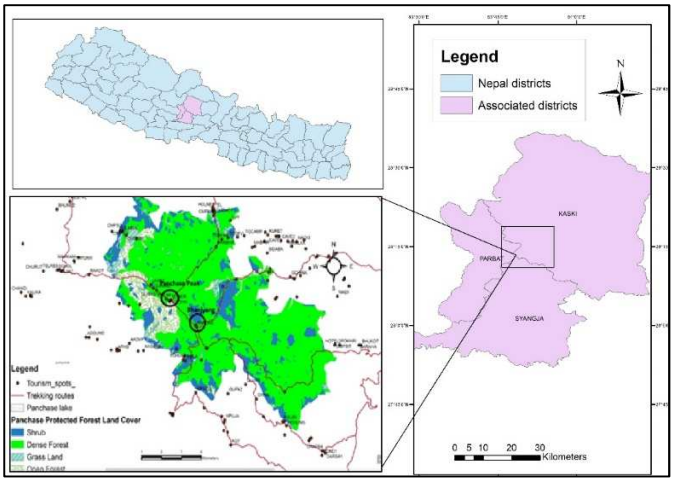

Figure 1. Study Area

Point Centered Quarter Method (Cottam and Curtis, 1956) was used for quantitative sampling of tree vegetation for which 30 points were taken at regular intervals of 20 m. For each sampling plots, geographical coordinates, diameter of trees (DBH ≥5 cm) and height were measured. Species were recorded by their vernacular names and later matched to scientific names using species identification manuals. Relative density (RD), frequency (RF) basal area (RBA) and Importance value Index (IVI) were calculated using Mueller-Dombois and Ellenberg, (1974) and degree of association of *M. Champaca* was assessed using Chi-Square test (Curtis JT and Mclntosh, 1950). Social conditions such as management system adopted, people's perception toward forest and conservation of *M. Champaca* were assessed using household socio-economic survey for which 25 randomly sampled households in Arthar and Bhanjyang were taken.

Results and Discussion

Quantitative Parameters of Trees

Density, Basal Area, Frequency and IVI

In Bhanjyang, the total basal area and the number of the trees were found to be 3.87 m^2 and 60 respectively. Among the measured trees, *Michelia champaca* exhibited the highest density Relative frequency, density and basal area (Table 1). Other associated dominant trees were *Daphniphyllum himalens, Alnus nepalensis, Ficus auriculata,* and so on. A total of 14 tree species were encountered during the sampling in Bhanjyang.

Table 1. Quantitative Parameters of Trees in Bhanjyang

S.N.	Name of Trees	No. of Trees	RD (%)	Freq. (%)	RF (%)	BA (m^2)	RBA (%)	IVI (%)
1	*Alnus nepalensis*	5.00	8.33	26.67	8.70	0.39	9.98	27.01
2	*Daphnyphyllum imalense*	14.00	23.33	60.00	19.57	0.35	9.08	51.98
3	*Ficus auriculata*	3.00	5.00	13.33	4.35	0.60	15.41	24.76
4	*Ficus nerifolia*	3.00	5.00	20.00	6.52	0.29	7.46	18.98
5	*Garuga pinnata*	2.00	3.33	13.33	4.35	0.28	7.33	15.01

S.N.	Name of Trees	No. of Trees	RD (%)	Freq. (%)	RF (%)	BA (m^2)	RBA (%)	IVI (%)
6	*Lyonia ovalofolia*	3.00	5.00	13.33	4.35	0.05	1.18	10.53
7	*Maesa chisia*	3.00	5.00	20.00	6.52	0.01	0.18	11.70
8	*Maesa macrophylla*	1.00	1.67	6.67	2.17	0.01	0.16	4.00
9	*Michelia champaca*	19.00	31.67	93.33	30.43	1.40	36.29	98.39
10	*Prunus cerasoides*	1.00	1.67	6.67	2.17	0.01	0.16	4.00
11	*Quercus semecarpifolia*	2.00	3.33	13.33	4.35	0.17	4.40	12.08
12	*Pinus wallichiana*	1.00	1.67	6.67	2.17	0.03	0.81	4.65
13	*Viburnum mullaha*	1.00	1.67	6.67	2.17	0.28	7.30	11.14
14	*Xylosma controversum*	2.00	3.33	6.67	2.17	0.01	0.33	5.83
	Total	60	100	306.67	100	3.87	100.089	300

In Panchase, the total basal area and the number of the trees were found to be 6.29 m^2 and 60 respectively. Among the measured trees, *Quercus semecarpifolia* exhibited the highest density Relative frequency, density and basal area (Table 2).Other associated dominant trees were *Rhododendron arboreum, Michelia champaca, Maesa chisia* and so on. A total of 12 tree species were encountered during sampling in Panchase.

Table 2. Quantitative Parameters of Trees in Panchase

Name of trees	Number	RD	Freq. %	RF %	BA (m^2)	RBA %	IVI
Alnus nepalensis	1.00	1.67	6.67	2.22	0.00	0.06	3.95
Cinnamomum tamala	1.00	1.67	6.67	2.22	0.07	1.12	5.01
Daphnyphyllum himalense	3.00	5.00	13.33	4.44	0.14	2.17	11.61
Eurya sps	1.00	1.67	6.67	2.22	0.01	0.08	3.97
Garuga pinnata	3.00	5.00	20.00	6.67	0.03	0.45	12.12
Halode	1.00	1.67	6.67	2.22	0.09	1.44	5.33
Maesa chisia	4.00	6.67	26.67	8.89	0.07	1.09	16.65
Michelia champaca	6.00	10.00	40.00	13.33	0.80	12.77	36.10
Quercus semecarpifolia	23.00	38.33	86.67	28.89	3.79	60.20	127.42
Rhododendron arboretum	10.00	16.67	40.00	13.33	1.22	19.46	49.46
Pinus wallichiana	3.00	5.00	20.00	6.67	0.03	0.40	12.07
Xylosma controversum	4.00	6.67	26.67	8.89	0.05	0.79	16.34
Total	60.00	100.00	300.00	100.00	6.29	100.04	300.04

DBH Class Distribution of Trees in Bhanjyang and Panchase

The distribution of trees in different diameter classes showed that there were greater number of trees within size class 5-15cm in both the study areas (Figure 2a and 2b). The number of trees decreased with increasing diameter. However, the tree diameters were greater in Panchase than in Bhanjyang. The inverse J shaped curve obtained showed that the forest is regenerating and in intermediate stage

of growth. The average DBH of *Michelia champaca* was found to be 28.8 cm in Bhanjyang and that at Panchase was 33.25 cm.

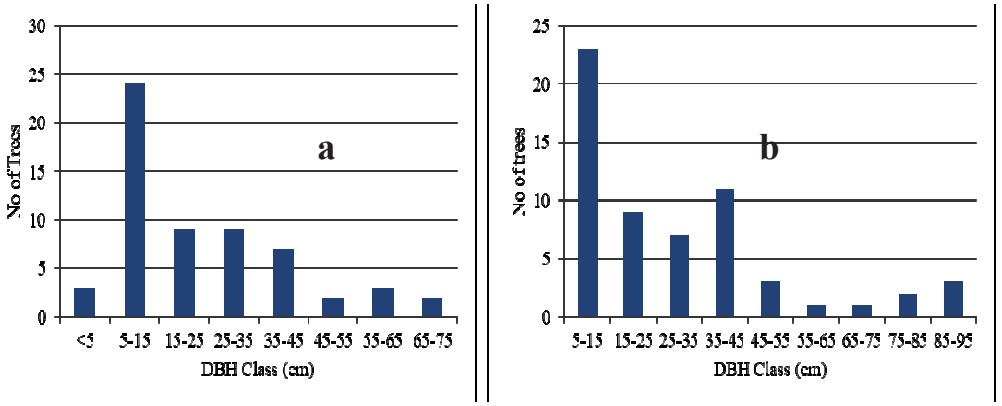

Figure 2. Trees DBH Class Distribution in Bhanjyang (a) and Panchase (b)

Comparative description of number of *Michelia champaca* available in the Bhanjyang and Panchase according to their DBH class shows that the number of *M. Champaca* is higher within the diameter size of 25-35 cm in Bhanjyang to that of 5-15 cm in Panchase (Figure 3). Out of total 19 individuals, 7 belong to the class size 25-30, 6 within the class size 15-25 in Bhanjyang. However in Panchase, out of total 6 individuals, 2 have been recorded within the class size 5-15 and remaining in other class sizes equally.

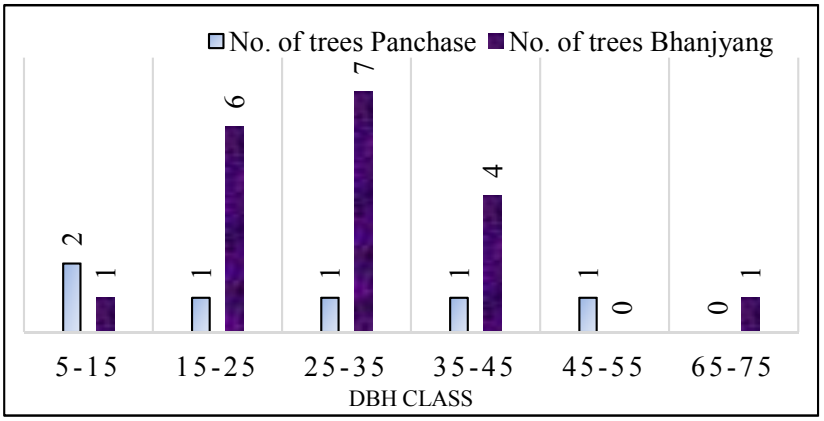

Figure 3. DBH Class Distribution of *Michelia champaca* in Bhanjyang and Panchase

Association of Michelia champaca With Other Tree Species

Association of *Michelia champaca* was tested with *Quercus semecarpifolia, Daphnyphyllum himalense* and *Rhododendron arboreum* (Table 3). The χ^2-test with Yate's correction shows no significant association between *Michelia champaca* and *Quercus semecarpifolia* as well as between *Daphnyphyllum himalense* and *Rhododendron arboreum* as compared with the tabulated value ($\chi^2(0.05, 1) = 3.841$).

Table 3. Association between Different Species with *Michelia champaca*

S.N.	Association	(Calculated)
1	*Michelia champaca* and *Quercus semecarpifolia*	0.121
2	*Michelia champaca* and *Daphnyphyllum himalense*	0.179
3	*Michelia champaca* and *Rhododendron arboreum*	0.053

Utilization and Conservation Status of *Michelia champaca*

Tree Species Preference and Utilization of *Michelia champaca* by Local People

From the questionnaire survey, it was found that the most preferred tree species by local people were *Schima wallichii* and *Castanopsis indica*. Very less people (4%) preferred *Michelia* tree from the Panchase Protected Forest (Figure 4a). *Michelia champaca* tree is not commonly used for timber as well as fodder as the availability of the species is less. But results of socioeconomic survey also revealed that *Michelia* has highest use in the areas where it is available as timber because of the good quality of heartwood (Figure 4b). Besides, this species has multiple use such as fodder, fuel wood etc. Only 4% people among all respondents reported that they are not using the species for any purpose.

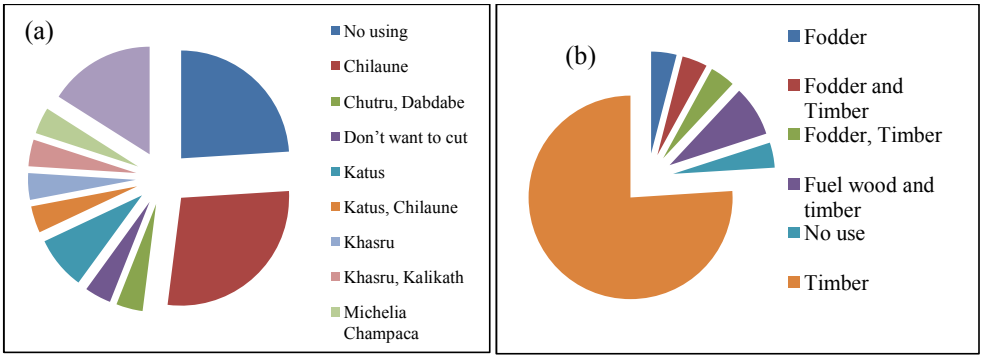

Figure 4. Species Preference by Local (A) And Purpose of Use of *Michelia Champaca* (B)

Michelia Champaca has its multiple uses. Mainly, it is used as a timber species because of the quality of the wood. In some parts it is preferred as a fodder species and in other parts this species is used as a medicinal plant to cure dieses like diabetics. It is also used to produce perfumes and used in industries as well. This plant species is declining in number for its multi-purposive applications.

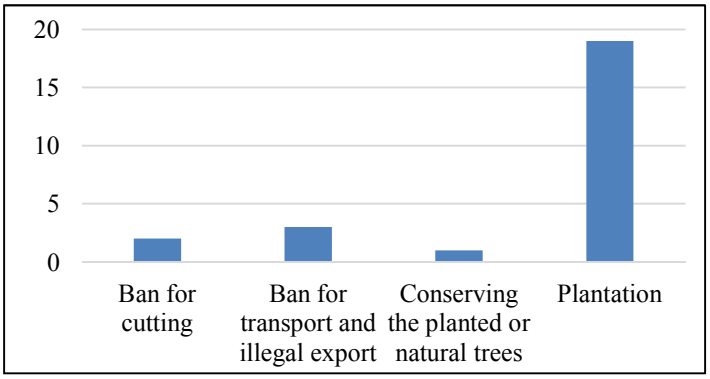

Figure 5. Respondent's Suggestions for Conservation of *M. Champaca*

A total of 25 households were selected for the questionnaire survey. Most of them (76%) suggested plantation of *Michelia* tree for its conservation. Other options for its conservation are banning for cutting, banning for the illegal transport and export (Figure 5).

Conclusion

Population structure, association and conservation of *Michelia champaca* was studied. Total number of tree species recorded in Bhanjyang and Panchase were 14 and 12 respectively. Michelia champaca was dominant in Bhanjyang. It was found to be mixed with other broad leaved trees such as *Daphniphyllum himalense, Quercus Semecarpifolia* and *Rhododendron Arboreum* but the association of *M. Champaca* with these species was not significant. Most preferred tree species by local people for household use were *Schima Wallichii* and *Castanopsis Indica*. In case of Michelia trees when available, the preference was to use this tree species as timber. *Michelia* was also found to be used for fuelwood and fodder. For the conservation of *Michelia* tree in the Panchase area, local people suggest for plantation and management of this tree species as it is not abundant and is limited in distribution. Assessment of population and conservation status of such multipurpose tree is necessary for its proper management and conservation.

Acknowledgements

We thank EbA tools validation and integration for resilient mountain ecosystem project, Central Department of Environmental Science, Tribhuvan University for the research grant.

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Post Disaster Management on Agriculture Land: A Case of 2008 Koshi Flood of Nepal

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Abstract

This research was conducted to study the flood impacts and the effectiveness of post disaster management on agricultural land in Sripurjabdi Village Development Committee (VDC). Household survey was carried out to collect the data followed by key informant interview and focus group discussion. For soil analysis, soil samples were collected from the green, yellow and red zone as categorized by DAO, Sunsari. The t-test was performed to test for differences in physico-chemical parameters of soils among these zones and signified at 5% level of significant. The average cultivated land before the flood was found to be 4.98ha/HH that was 1.44ha/HH after flood. This was mainly because of the deposition of sand over the agricultural land. The sand % in soil from Red and Green zone was found to be higher than yellow zone. The organic matter was found to be higher in Green zone (2.68%) that was significantly different with Red zone (1.56%). Similarly, the nitrogen content was also higher in Green zone (0.05%) as compared with Yellow and Red zone. The average available phosphorus and potassium were also higher in Green zone (203.93Kg/ha). For the recovery, 892.81ha of affected land were reclaimed through incorporation of tillage, land leveling and compost fertilizer. Locals cultivated on the damaged land with vegetables (pointed gourd) and sugarcane. Research on the identification of plant species that grow and give higher production on sand deposited agriculture land is needed to improve livelihood of locals.

Keywords : *Koshi flood, Livelihood, Recovery and Soil Nutrient*

Introduction

Nepal experienced a devastating flood mostly in Terai region frequently in Koshi River. On the 18 August 2008, Koshi breached its embankment and millions of people were affected by flood in the bordering region of Nepal and Bihar state of India. The disaster occurred due to the breach of eastern embankment of the Koshi barrage at Paschimkushaha and affecting Haripur, Sripurjabdi and Paschimkushaha, Laukahi, Ghuski, Narshimha, Madhuban and Basantapur VDCs of Sunsari district (NRCS, 2008) and six districts of North-East Bihar of India (Dixit, 2009). Koshi deluge affected 42,765 people from 7,563 families of Sripurjabdi, Haripur and Paschimkushaha VDCs (OCHA, 2009). Sripurjabdi VDC was one of the most highly affected VDC (Thapa, 2012) affecting around 2,043 ha of agricultural land (DADO, 2008).

Disaster Risk Management (DRM) measures are designed to protect livelihoods and the assets of communities by mitigation, preparedness and advocacy. Generally, in the context of Nepal, priority of DRM is given to during disaster phase. The process of recovery is the most poorly understood and has been the least well researched of the four phases – mitigation, preparedness, response and recovery (Rubin et al., 1985). Data and information on the loss and damages along with the activities carried out during disaster are regularly reported. But only a few activities have been carried out for the rehabilitation and restoration (UNESCO, 2009). Rehabilitation and reconstruction programs are development opportunities and therefore their sustainability is an important issue (Nakagawa and Shaw, 2004). Thus, this study provides the impacts of flood on agriculture land and also provides how post disaster management activities were carried out for agriculture land in the Sripurjabdi

VDC.

Materials and Methods

Study Area

The study area is the Sripurjabdi VDC, lies in the lower western part of Sunsari district in Koshi Zone of Eastern Nepal. Flood affected regions and households were categorized into four categories based on damaged land i.e. extreme red (ER), red (R), yellow (Y) and green (G) zone based on survey, aerial map of flooded area and other digital mapping procedure by District Administrative Office (DAO), Sunsari. Since, Sripurjabdi has no green zone; the soil samples were collected from the ward number 4 and 5 i.e. green zone of Haripur VDC which is nearby VDC of Sripurjabdi VDC (Figure 1).

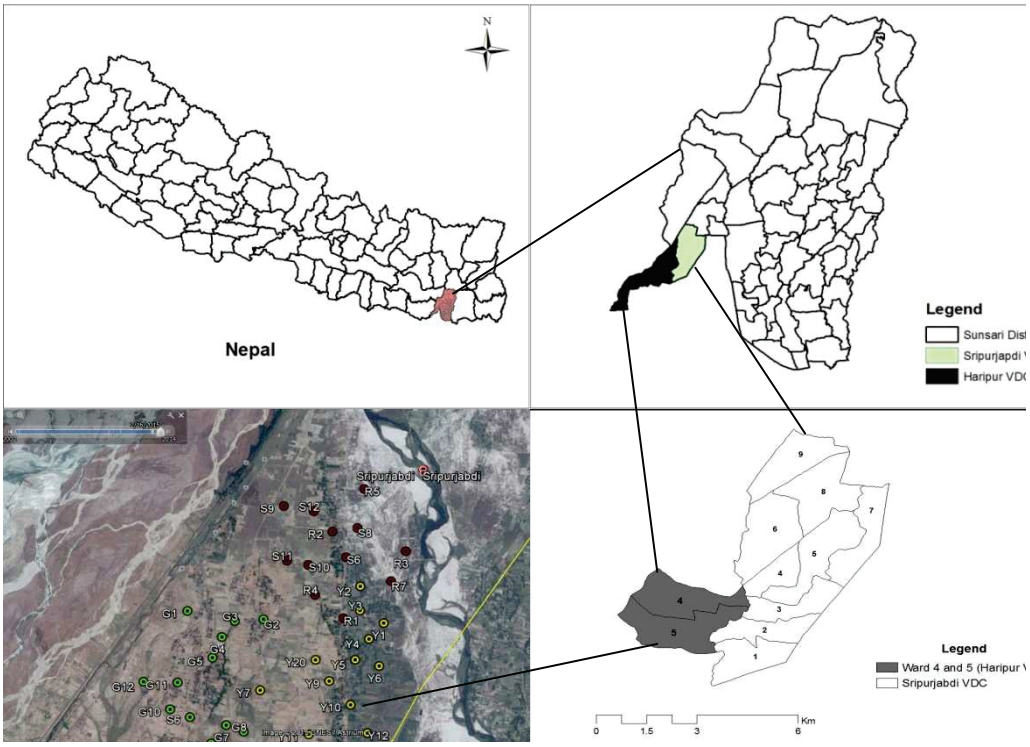

Figure 1. Location Map of Study Area

Reconnaissance Survey

Preliminary field visit was carried out on 15th January, 2014 to 20th January, 2014 to gather the information of the Sripurjabdi VDC.

Household Survey

Household questionnaire survey was conducted on May, 2014. Simple random sampling was used for the household survey and the household were selected randomly using random table. The sample size for the household survey was determined by the equation given by Daniel and Terrell, 1992. In simple random sampling, the formula for it is given by,

$$n = \frac{Nz^2S^2}{Nd^2 + z^2S^2}$$

where, d= maximum desirable sampling error
z = value of normal deviate as determined by portion of time d can be exceeded
S^2 = population variance and
N = size of population

Here, N = 3,260, z = 1.960, d = 0.5. The S^2 was determined through land hold size. For this, 30 household were surveyed to know their current land hold. The S^2 was found to be 5.282. Therefore, Seventy nine questionnaires were asked to the local people of Sripurjabdi VDC.

Focus Group Discussion

The focus group discussion was carried out in two groups to obtain information on their actions, coping strategies and experiences in response and recovery phases.

Key Informant Interview

The key informant interview was carried out using semi-structured questionnaires with key informants representing government and non-governmental organizations, local organizations, teachers and farmers.

Physico-chemical Analysis of Soil

Soil Sampling

The soil sampling was done in May 2014. Soil samples were collected from agriculture land categorized as green, yellow and red zone. A total thirty six soil samples, 12 from each zone were sampled randomly by using random table.

Method of Analysis

Laboratory analysis of soil parameters were done by using NARC (1996) and Trivedi and Goel (1996) prescribed methods. The Table 1 shows the method of measurement for various parameters of soil.

Table 1. Methods and Instruments Used for Analyzing Physico-chemical Parameters

SN	Parameters	Equipment/Methods
1	Soil Color	Soil Color Chart
2	Depth	Measuring Tape
3	pH	pH Meter
4	Electric Conductivity	Conductivity Meter
5	Texture	Hydrometer
6	Organic Matter	Walkey and Black Method
7	Nitrogen	Kjeldahl Digestion method
8	Phosphorus	Spectrophotometric Method
9	Potassium	Flame Photometric Method

Data Analysis and Interpretation

The collected data were processed in the software Statistical Package for Social Sciences (SPSS 16.0 version) software and Microsoft Excel in order to calculate necessary indices. An independent t-test (statistically significant at $p \leq 0.05$) was performed to compare soil nutrient content between red, yellow and green zone by using SPSS 16.0. The ARCGIS 9.3 was used to make maps and Google Earth 2014 was used to plot the location of soil sampling sites on the map.

Results and Discussion

Impact of Flood in Agriculture Land

All the agriculture land of Sripurjabdi VDC was affected by Koshi flood. The average cultivated land was decreased by 3.53 ha/HH by flood. The major crop grown in the VDC was paddy before flood followed by wheat and the average productivity of paddy and wheat before flood was found to be 5.13 ton/ha and 3.51 ton/ha respectively. The cultivated land was decreased due to the deposition of sand on agriculture land which makes it inappropriate for the farming. This may be the reason that the productivity of the major crop (paddy) grown in the agriculture land followed by wheat was consequently decreased. Mohyuddin and Ranzan (2011) also reported in their study that the annual production of land had decreased to half and the land generated revenue had decreased to 50 % due to impact of flood in Basti Sheikhan in Muzaffargarh district, Punjab.

Table 2. Impact of Flood on Agriculture Land

Before 2008 Flood Disaster			After Flood		
Average Cultivated Area (ha/HH)	**Crops**	**Average Productivity (ton/ha)**	**Average Cultivated Area (ha/HH)**	**Crops**	**Average Productivity (ton/ha)**
4.98	Paddy	5.13	1.44	Paddy	1.34
	Wheat	3.51		Wheat	2.56
	Potato	10.19		Potato	9.8

Chemical and Physical Soil Fertility Parameters

Some selected chemical and physical soil properties have been used as indicators for the soil fertility status of agriculture land in the study area. The comparison of average value of various soil

parameters by applying t – test between red and yellow zone (R and Y zone), red and green zone (R and G zone) and yellow and green zone (Y and G zone) were shown in Table 4.

It was found that the maximum frequency of color found in the red zone was the light gray color i.e. 50 % whereas minimum frequency of color found in the red zone was light brown i.e. 8.3 % (Figure 2). Similarly, the particle size distribution showed that the high sand texture (87.29±0.87 %) was found in red zone and the high silt texture (18.17±2.05 %) and clay texture (4.95±0.53 %) were found in yellow zone (Figure 3). The results were lower than the study of Eni et al. (2011) in Itigidi, Nigeria (mean 66.2 % sand, 18 % silt and 15.8 % clay) and Gautam and Mandal (2013) in moist tropical forest of Sunsari district (sand 45.0±2.7, silt 37.9±2.3 and clay 17.1±1.0). Likewise, the soil texture in red and green zone was of the sand type and sandy loam type soil was in yellow zone (Figure 4). Sandy loam texture is usually have low to moderate water-holding capacity and good permeability (Cogger, 2011) and is very common in the Terai region (Poudel and Shah, 2003).

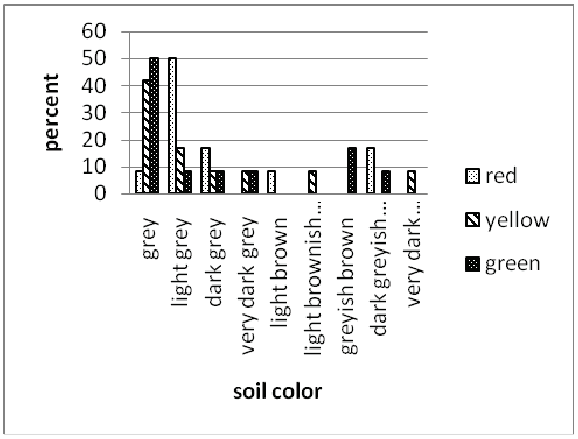

Figure 2. Soil Color

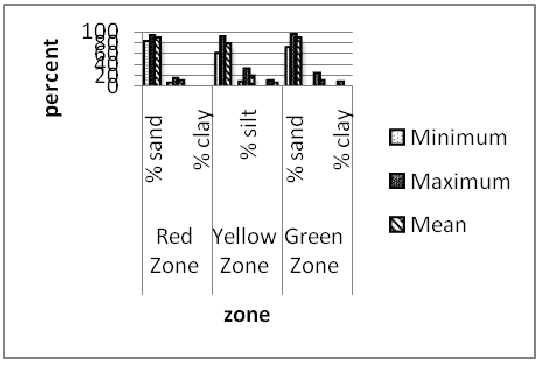

Figure 3. Texture

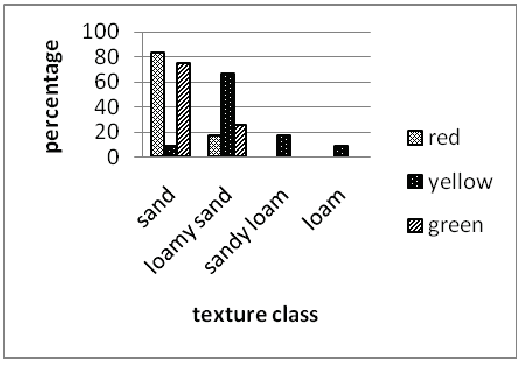

Figure 4. Texture Class

It was found that the soil pH ranged from 7.82 to 8.85 in red zone and 7.66 to 8.7 in yellow zone (Table 3). It showed that the soil was alkaline in nature according to NARC (1996) which was similar to the finding of Kalshetty et al. (2012) in cultivated areas in Bagalkot district in Karnataka State. However, the soil pH was found neutral ranging 6.1 to 7.28 in green zone which is the optimum pH range for most plants. The alkaline soils in yellow and red zone may be due to minimal organic matter and decomposition activity in these soils. There was no significant difference in mean pH

between Y and G zone at $p<0.05$ whereas R and G zone and R and Y zone were found significant difference in mean pH i.e. $p<0.05$.

The study showed that maximum Electric Conductivity (EC) was found in the yellow zone i.e. 363 µS and the minimum EC was found in the red zone i.e. 66 µS. The study showed no significant difference in the mean EC between all zones. The organic matter was found 1.56 % in red zone, 2.35 % in yellow zone and 2.68 % in green zone. According to soil fertility rating chart of Soil Management Directorate of the Department of Agriculture, the soil had medium organic matter which might be due to rapid decomposition and mineralization of organic matter under relatively high temperature. The organic matter of the soil in study area lied within the range of values reported by Rai et al. (2011) in Dehradun city in India (mean 1.95 %), Gautam and Mandal (2013) in moist tropical forest of Sunsari district (mean 3.07 ± 0.15).

The average nitrogen was found low in all soil samples according to the NARC (1996) for Terai region (<0.075 %). The average nitrogen content in red zone was very low i.e. 0.023 % as compared to the yellow and green zone. This may be due to low organic matter, low soil moisture and low nitrogen fixing microorganism. The available phosphorus in red zone was found low according to NARC (1996) which is also similar to the study of Regmi and Zoebisch (2004) in middle hill region of Nepal. The available phosphorous was found high in yellow and green zone. The reason for the higher phosphorous content on yellow and green zone could be due to the higher levels of pH and the use of fertilizers that improved the general soil condition and provided some phosphorus to the soils.

The mean potassium was found to be 130.32 kg/ha, 152.235 kg/ha and 171.42 kg/ha respectively in red, green and yellow zone. It showed that the potassium content in soil was medium according to NARC (1996). Potassium content is quite essential for the proper growth and development of crops. Most K in plants is found in the above-ground portion. The crop roots take up K actively from the soil. Its parent material and use of organic fertilizers affect the potassium content of soil. Thus, these may be the reason for K in studied areas. There was significant difference in mean potassium between R and Y zone and R and G zone. Tsheboeng et al. (2013) found that K content was lower ($p<0.05$) during high flood than during low flood.

Table 3. Mean, Standard Error (SE) and Standard Deviation (SD) of Soil Parameters at Red, Yellow and Green Zone

Parameters	Site					
	Red		Yellow		Green	
	mean±SE	SD	mean±SE	SD	mean±SE	SD
pH	5.18±0.07	0.25	6.34±0.12	0.42	7.28±0.19	0.66
Conductivity µS	96.08±11.09					
	38.41	120±23.29	80.69	110±4.76	16.49	
Organic matter %	1.56±0.22	0.76	2.35±0.29	1.02	2.68±0.28	0.98
Nitrogen %	0.02±0.01	0.04	0.04±0.01	0.05	0.049±0.01	0.06
Phosphorus kg/ha	27.79±4.407	4.41	108.7±16.19	56.11	203.93±23.95	82.95
Potassium kg/ha	130.32±4.88	16.91	152.24±8.22	28.47	171.42±4.67	16.17

Table 4. Comparison of Average Value of Different Parameters at Different Site (t - test)

Parameters	Site		
	R and Y	R and G	Y and G
	t-test value		
Sand %	3.954 p>0.05	0.317 p>0.05	-2.744* P<0.05
Silt %	-4.011* P<0.05	-0.433 p>0.05	5.661* P<0.05
Clay %	-2.749* P<0.05	-0.333 p>0.05	2.073* P=0.05
pH	6.487* P<0.05	7.460* P<0.05	1.176 p>0.05
Conductivity µS	-0.930 p>0.05	-1.181 p>0.05	0.410 p>0.05
Organic matter %	-2.142 P<0.05	-3.128* P<0.05	-0.811 p>0.05
Nitrogen %	-1.436 p>0.05	-7.345* P<0.05	-3.293* P<0.05
Phosphorus (kg/ha)	-2.292* P<0.05	-6.085* P<0.05	-2.030 p>0.05
Potassium (kg/ha)	-2.292* P<0.05	-6.085* P<0.05	-2.030 p>0.05

Note: * Indicates the Significant Difference in the Average Value of the Parameter

Recovery of Agriculture Land

The government had provided NRs. 250 thousand per bigha (1 bigha=0.6773 ha) of agriculture land for people belonging to the extreme red zone and NRs. 200 thousand per bigha for people belonging to the R zone and NRs. 150 thousand for people belonging to the Y zone for the rehabilitation of their damaged agriculture land. But no effort was initiated by the local people to clear the sand deposited in their agriculture land. Instead of recovering the damaged agriculture land, people have bought land in another place such as Inurwa, Morang and Jhumka through the compensation given by GoN. Because of sand deposited in their cultivated land, local people are also doing labor work as an alternative livelihood strategy.

The aftermath of a flood poses a monumental challenge to local officials. Homeless citizens need replacement housing. Agriculture land needs to be reclaimed. Water and other public services must be restored to maintain public health and to support other recovery activities. Local business need to be reestablished to restore the local economy (Berke, 1993). Most of the support activities, for instance support to cultivation by NGOs/INGOs were concentrated in less affected regions (yellow and green zone) (Ghimire, 2012). The local people accused that there was no support for the recovery of agriculture land in red zone. However, some of the affected land (ward no. 1, 2, 3, 4, 6 and 7) were reclaimed through the application of incorporation tillage and land leveling and the application of compost fertilizers with the help of Saptakoshi Flood-Affected Reconstruction Agriculture and Livestock Service Office. They had applied incorporation tillage in ward no. 1 (50.25 ha), 2 (40.47 ha), 4 (29.50 ha), 6 (47.96 ha) and 7 (49.27 ha) and land leveling in ward no. 6 (47.96 ha) and 7

(49.27 ha) respectively in the year 2009/10 by using crawler dozer. They had also reclaimed the highly damaged area i.e. ward no. 6 (160.54 ha) and partially damaged areas in ward no. 6 and 8 (81.53 ha) through the application of same procedure in the year 2010/11. Similarly, in the year 2011/12, they had reclaimed land in ward no. 9 (99.88 ha), 8 (73 ha) and 5 (56.32 ha). Total 892.81 ha land in VDC was reclaimed till the year 2012 (MoAD, 2012). However, there were still 1172.56 ha of lands which were not reclaimed.

Furthermore, the research revealed that the damaged land was suitable for the vegetable farming. The major crops grown by farmers along the sand deposited land were watermelon, bottle gourd, cucumber, summer squash, bitter gourd, pumpkin, pointed gourd and sponge gourd. Eni et al. (2011) found that vegetables (Cassava, pepper, potatoes and tomatoes) were cu1tivated in soils with 69 per cent sand content and has a textural class known as sandy loam. The study also found that pointed gourd (*Trichosanthes dioica*) was most widely grown vegetable in the VDC. People were getting benefited from this farming and more people were showing interest on pointed gourd plantation in large scale in their affected land. Another easily grown farming in the flood affected land was the sugarcane (*Sacharum officinarum*) farming. The seventy three local farmers started commercial sugarcane plantation in 69.54 ha land (MoAD, 2012). These will not only generate income and enhance livelihood but also rejuvenate the affected lands.

Conclusion

The study reflects overall impact on agriculture land because of sand induced land degradation. For the recovery, local farmers had used farming on sand deposited land as an adaptation strategy. Pointed gourd was most widely grown vegetable in sand. The 892.81 ha damaged land were reclaimed by incorporating tillage, land leveling and use of compost fertilizers. GoN had played an important role during response phase. However, there was lack of coordination among the organizations. The majority of organizations were involved in during disaster phase i.e. relief and response. Fewer organizations were found participated in post disaster management phase such as recovery/rehabilitation of agriculture land. Thus, study pointed out the need for further rethink to identify options that are helpful to improve the livelihood of people in the Sripurjabdi VDC.

Acknowledgements

The authors are grateful to Central Department of Environmental Science, Tribhuvan University and United Nations Development Fund (UNDP) for providing Strengthening Disaster Risk Management in Academia (SDRMA) research grant for studying.

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Feasibility of MSW Landfill Site by Using Geographical Information System in Lekhnath Municipality, Nepal

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Abstract

Lekhanth Municipality is facing solid waste management problems due to lack of disposal site. This study aims to find out the appropriate number of landfill sites, determined by the integration of GIS and multi-criteria evaluation. There were two stages to the process: GIS stage and Geotechnical evaluation, consisting of site investigation and laboratory assessment of the geotechnical characteristics of individual site. These suitable areas were further examined by deploying the Boolean operation and AHP method in order to obtain relative importance weights followed by the application of OWA for a calculation of suitability index. In the final map, data were assorted into four suitability classes, i.e. Very high, high, moderate and low suitability which represented 0.07526%, 13.92310%, 74.65107 % and 11.35057 % respectively. As a result, one highly potential site was taken from Rithepani-2 for the vulnerability analysis. Vulnerability analysis shows 43%, 41% and 16% for low, moderate and high risk level respectively.

Keywords *MCE, GIS, Boolean Operation, AHP, OWA*

Introduction

Due to urbanization, environmental sanitation, including solid waste management becomes a critical issue (Devkota et al., 2004) in least developing countries. The process of finding an appropriate place for the waste disposal is a difficult task due to the shortage of land, along with the regular public opposition. Social and political opposition to landfill siting have been indicated as the greatest obstacle for successfully locating waste disposal facilities (Lober, 1995). The "not in my backyard" (NIMBY) and not in anyone's backyard" (NIABY) phenomena (Erkut and Moran, 1991, Kao and Lin, 1996, Chang et al., 2008, Kontos et al., 2003) are becoming popular nowadays creating a tremendous pressure on the decision makers involved in the selection of a landfill site. Whereas the combination of GIS and Multi-criteria Evaluation (MCE) has been routinely adopted as an approach to assess the suitability of an area to host a landfill (Buenrostro et al., 2008).

Materials and Methods

Study Area

The study area covered the jurisdiction of the 15 wards of Lekhnath Municipality (now under Pokhara Lekhnath Metropolitan City) for the spatial analysis, which is situated between 28°09'N to 84°04'E in Province-4 of Nepal. This municipality with 15 wards among which wards 1, 2, 3, 6, 8, 11, and 12 are urban and other remaining wards are rural. Wards 1, 2 and 3 are along highways and they are also city areas and most populated wards among all whereas other wards are also becoming densely populated day by day (LM, 2008).

Methodology is divided into three phase's i.e. Preliminary analysis phase; Multi-criteria phase and Suitability phase.

Preliminary Analysis: The documentation of the criteria for the potential landfill site selection was done in this phase. So, comparative study review of other related works on landfill selection criteria was done along with the expert's consultation. Eight important criteria were identified for landfill siting namely; slope (less than 150), forest area (more than 300 m), swamps (more than 350 m), residential area (more than 500 m) , surface water (less than 1000 m), access roads (less than 500 m), agricultural land (more than 200m) and rivers (more than 300 m).

The database system was developed based on the landfill selection criteria which was achieved after digitizing different data sets required for the study and it was supported by ArcGIS 9.3 software ©ESRI, 2008. Distance maps or proximity maps were prepared with Euclidean distance with reference to pre-defined criteria. Slope constraint map was prepared using 3D-Analyst tool through surface analysis. Furthermore each data layer was reclassified on a scale of 1-2, with '2' being the suitable areas for the landfill and '1' being unsuitable areas.

Multi-criteria Ealuation (MCE): This part mainly focused on the weighting the reclassified raster maps which was obtained from the preliminary analysis i.e. after the application of Euclidean distance. Each raster map was given weightage by internal and external process. There are a number of integration models in GIS. Probably the simplest and best known model type is based on Boolean Operation (Nas et al., 2008). Internally each reclassified raster map was assigned weight by Boolean Approach (Nas et al., 2008). The output is a binary map because each location is either satisfactory or not. Constraints maps indicating areas, which are suitable (represented by 1's) and not suitable (represented by 0's) for the landfill siting process. Furthermore raster calculation was done with the constraints maps for the suitability analysis. In practice, it is usually unsuitable to give equal importance to each of the criteria being combined. Evidence needs to be weighted depending on its relative importance (Nas et al., 2008). So, each map layer was weighted by using Analytical Hierarchy Process (AHP) as an external weighing system (Javaheri et al., 2006). In the AHP method, all the criteria were compared against each other according to the comparison 9-point continuous scale (Satty1980).

Suitability Analysis

Suitability analysis was done in two phases; before the field study and after the field study.

Before the Field Study:

The weightage raster maps were used to get a suitability map by Boolean Approach which was categorized into three level of suitability i.e. low (<3), moderate (3-6) and high (>6) suitability. For the final suitability analysis Boolean approach and AHP were integrated in the Overlay Weightage Analysis (OWA). In this method, each factor maps were assigned ranking with different weights with a common scale (0-10), where a score of '0' indicated no constraint and a score of '10' indicated a total constraint. Before applying OWA, these calculated scores are standardized to measure evaluation scale of 1 to 9 which was further categorized into four suitability index i.e. low (<2), moderate (2-4), high (4-6) and very high suitability (>6). Weights are generally assigned to these maps to express the relative importance. In order for the output map to be meaningful and consistent, map weights influence must be 100%. This suitability map was used to locate the possible appropriate sites for the municipal solid waste disposal site. This also helps to exclude the sensitive areas while retaining sufficient areas for further evaluation for the field validation. The recent landuse verification was done through Google Earth for the suitability map along with ground truthing process.

For the field validation geotechnical study was the crucial factor in the selection procedure of the landfill site. The geological formation, bed rock characteristics, lithology and fracturing and the

condition of the topsoil and the sub-soil highly determine the suitability of the site for the landfilling. Sizing procedure for the landfill site was also considered as the part of geotechnical study.

For the field study, an appropriate site was selected for the geotechnical study after the spatial analysis and ground truthing process, excluding the inappropriate sites for the landfilling of solid waste. Nine sampling plots were selected for the soil sample by using grid system. Soil samples were collected at 1m depth by using Auger, which was further analyzed in the laboratory by using Sieve analysis for the soil map. Whereas, the soil hydraulic conductivity was predict from particle-size distribution. Regarding moisture of topsoil, Soil pH and Moisture Meter was used for the determination of the moisture of the selected site.

After the Field:

The data obtained from field works was further analyzed by using Arc GIS 9.3 software and its extensions. After sieve analysis with the help of gradation curve, Coefficient of curvature (Cc) and Uniformity Coefficient (Cu) were calculated, which determine soil types and also helps in the analysis of hydraulic conductivity.

Uniformity Coefficient (Cu) = D_{60}/ D_{10}

Coefficient of Curvature (Cc) = $(D_{30})^2/ D_{60}*D_{10}$

Where, D_{10}, D_{30} and D_{60} were the maximum size of the smallest 10%, 30%, and 60% of the sample respectively. For sand, if Cu is greater than 6 and Cc between 1 and 3, it is considered as well graded. However, for a gravel to be well graded Cu should be greater than 4 and Cc must be between 1 and 3. For GIS analysis, well graded soil was given higher weightage than poorly graded soil. Table 1 shows the weightage given to different soil type.

Table 1: Weightage Given to Different Soil Type

S.N	Type of Soil	Weightage
1	Well graded gravel (GW)	2
2	Poorly graded gravel (GP)	1
3	Well graded sand (SW)	3
4	Poorly graded sand (SP)	1

Hydraulic conductivity is the ability of a porous medium to transmit water through its voids (Alyamani and Sen, 1993). Since measuring hydraulic conductivity in the field is costly and time consuming, indirect method like Hazen rule is used. Hazen (1982) proposed the following relationship between saturated hydraulic conductivity and soil particle diameter.

$Ks= c (d_{10})^2$

Where, Ks is expressed in cm/sec, c is a constant that varies from 1.0 to 1.5 and d_{10} is the soil particle diameter (mm) such that 10% of all soil particles are finer (smaller) by weight (Cronican and Gribb, 2004, Hazen, 1892). During GIS analysis, low weightage was given to high hydraulic conductivity and high weightage to low hydraulic conductivity. Table 2 shows the different weightage given to different hydraulic conductivity.

Table 2: Weightage Given to Different Hydraulic Conductivity

S.N	Hydraulic Conductivity (m/day)	Weightage
1	Below 10	3
2	10-15	2
3	More than 15	1

Similarly moisture map was developed with help of data collected through pH and moisture meter having (1-8) scale measurement. Higher moisture reading was given more weightage than lower moisture rate. Moisture having >3, (1-2) and 1 was given weightage of 3, 2 and 1 respectively.

Furthermore, geological map also prepared with the help of engineering geological map of Pokhara, obtained from Department of Mines and Geology and incorporated in the Arc GIS 9.3 for the further analysis. Low weightage was given to the area with sink hole. Table 3 shows the different weightage given to geological condition.

Table 3: Weightage Given to Geological Condition

S.N	Geological Condition	Weightage
1	No Sink Hole	3
2	Low Sink Hole	2
3	High Sink Hole	1

Finally the soil map, soil moisture map, infiltration map, geological map and hydraulic conductivity map developed from Inverse Distance Weighting (IDW), interpolation method was used for the vulnerability mapping through raster analysis. According to ArcGIS 9.3 "Inverse distance weighted (IDW) interpolation determines cell values using a linearly weighted combination of a set of sample point." The weight is a function of an inverse distance.

The final vulnerability map was categorized into three risk level i.e. high (>6), moderate (3-6) and low risk (0-3). Area with the least vulnerable areas was considered as the best possible area for the solid waste disposal site in the municipality.

Results and Discussion

In an effort to get a comprehensive outcome of determining the optimal number of landfills needed for Lekhnath Municipality, a wide range of parameters were taken in the multi criteria analysis. The parameters used in this study for landfill site selection, are especially spatial factors which includes; agriculture, forest, river, swamp, lakes, settlement area, slope and roads. Constraint (binary) maps are used to distinguish lands that are suitable for landfill siting ad those lands that are restricted. The constraints maps are produced by merging each individual theme with the study area. This procedure creates a constraint map for each theme containing only two classes represented by 1's (for suitable land) and 0's (for unsuitable land) on the basis of Boolean Operation.

Surface water Buffer: This criterion has a direct effect with land suitability for being used as a solid waste landfill site. It was assumed that farther the landfill site from the surface water more the appropriate and suitable place for the landfilling. Figure 1 shows 45.3374% was under the suitable

areas whereas 54.6626% was under the unsuitable areas.

Swamp Buffer: Distance less than 350m was considered as the unsuitable area for the selection process. Figure 2 shows 75.2419% was under the suitable areas whereas 24.7581 % was under the unsuitable areas.

River/ Well Buffer: To protect groundwater from the probable contamination distance more than 300m was considered as the possibility site for landfill site with reference to well and river. Figure 3 shows 80.6297% was under the suitable areas whereas the 19.3703 % was under the unsuitable areas.

Forest Buffer: No landfill site is allowed to be built near the forest area. Possible land more than 300m from forest area was considered as the possible site for solid waste landfill with respect to the forest. Figure 4 shows 29.6821% was under the suitable areas whereas the 70.3179 % was under the unsuitable areas.

Agriculture Buffer: Since the Lekhnath Municipality is one of the agriculture high productions, distance more than 200m was considered as the possible area for the solid waste landfilling with reference to the distance from farmlands. Figure 5 shows 45.3374% was under the suitable areas whereas 54.6626% was under the unsuitable areas.

Settlement Buffer: The residential constraint map Figure 6 was created in order to define a limit around residential area that would protect the population from landfill hazards, such as scavenging animals and strong odor. It shows the settlement buffer where 90.0682% was under the suitable areas whereas the 9.9318% was under the unsuitable areas.

Road Buffer: A landfill location must be close to the road network to facilitate transportation and consequently to reduce relative costs. However, aesthetically and logically a buffer of 500m is done, less than 500m road access was considered as the possible sites for the solid waste landfill site with reference to the distance from roads. It shows the road buffer map Figure 7 where 93.3945% was under the suitable areas whereas the 6.6055% was under the unsuitable areas. Slope: Slope less than 150 was considered as the suitable place for the landfill site.

Slope Map: Figure 8 shows the slope map in which 74.2559% was under the suitable areas whereas 25.7441 % was under the unsuitable areas. Generally less than 12% slope is considered as the best areas for the landfill site with respect to the slope landscape.

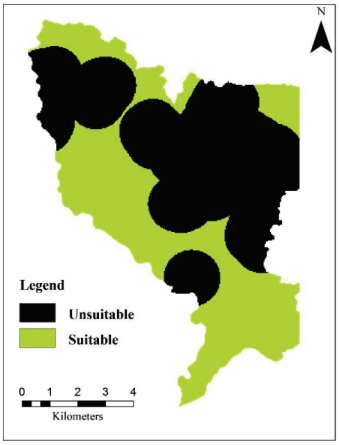

Figure 1: Water Buffer

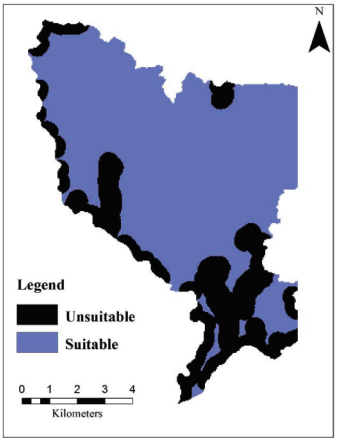

Figure 2: Wetland/Swamp Buffer

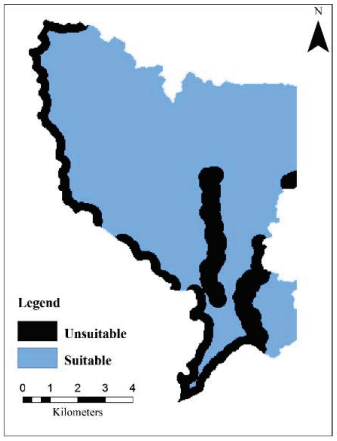

Figure 3: River Buffer

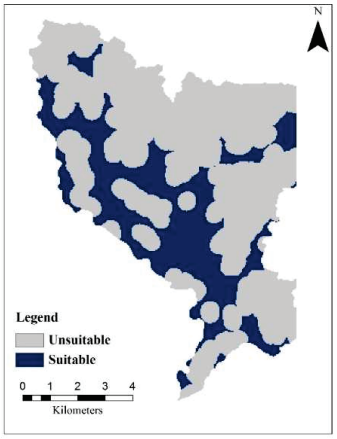

Figure 4: Forest Buffer

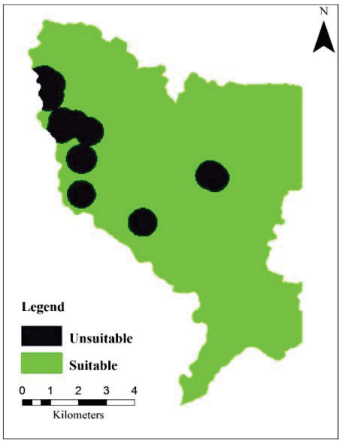

Figure 5: Residential/ Settlement Buffer

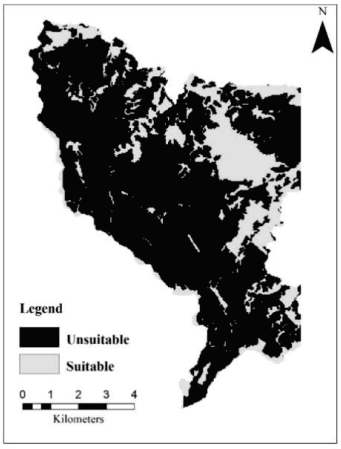

Figure 6: Agriculture Buffer

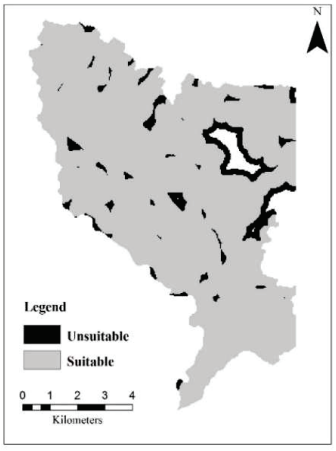

Figure 7: Road Buffer

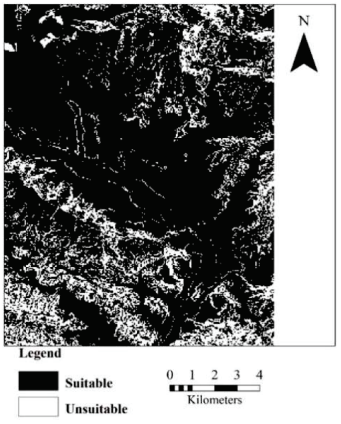

Figure 8: Slope Map

After the application and satisfaction of criteria, all the buffer maps were overlaid for the suitability analysis. Figure 9 shows the constraint overlay map through Boolean approach, in which 69.68%, 16.09% and 14.23% were under the low, moderate and high suitability respectively.

Table 4 shows the criteria of ordered weights that were used in the site selection process. According to the external weights generated by the AHP method on the basis of pairwise comparison, the maximum weight (0.414631) was placed on sanitation issue which consists of a surface water, river and swamp areas. The environmental issue had the second highest weight (0.297965) which consists of forest areas and agriculture areas. The third highest significance was attributed to public issue (0.162468) which consists of residential areas. The fourth significance was attributed to an economical issue (0.124937) which consists of a slope and road areas.

Table 4: Weight Assigned Through External Process (AHP)

Issues	Weight	Importance (%)	Investigated items	Importance (%)
Sanitation Issue	0.414631	41.50	Distance from surface water Distance from river Distance from swamps	18.5 9.0 14.0
Environmental Issue	0.297965	29.80	Distance from forest Distance from agriculture	14.9 14.9
Public Issue	0.162468	16.20	Distance from settlement	16.20
Economical Issue	0.124937	12.50	Distance from roads Slope	5.5 7.0

From the final suitability map (figure 10), 0.07526% was assigned for very high suitable site, 13.9231% was assigned to the highly suitable site, and 74.65107 % was assigned to the moderate suitability areas whereas 11.35057 % was assigned to the low suitability areas. After the recent landuse verification through Google Earth, only one site (E 84.037334- N 28.177545) was found under the very high suitable area. Whereas 4 sites (Site 2: E 84.046099- N 28.161460), (Site 3: E 84.046090- N 28.155254), (Site 4: E 84.090706- N 28.118282) and (Site 5: E 84.099403- E 84.099403) were identified from the highly suitable areas; reconnaissance and inspection survey was conducted for each location through ground. Each element of the evaluation criteria was used as a guide to make a judgment on the character of each site.

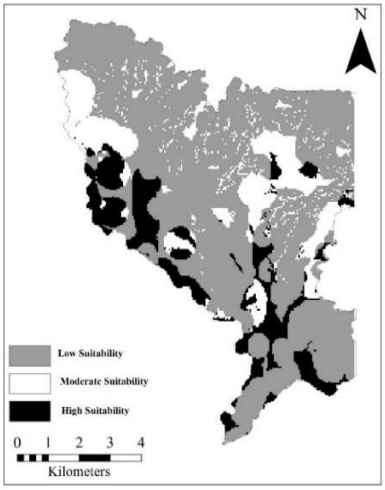

Figure 9: Boolean Approach Map

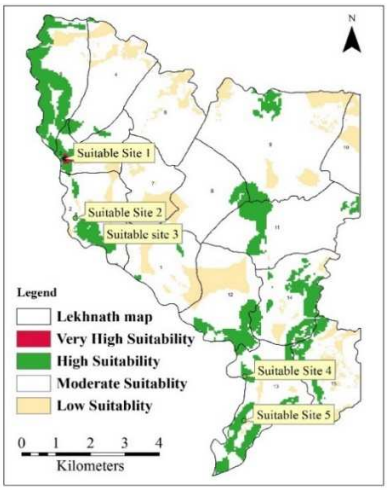

Figure 10: Final Suitability Map

After the ground truthing process, only one potential site was selected for the geotechnical procedure. The potential landfill site 2 was selected, which is located at Ward no: 2, Rithepani of Lekhnath municipality. The most potential site has the total area of around 4 hectares. After the standard sieve analysis test following results was obtained. This result was used to determine the type of soil and analysis of the hydraulic conductivity.

Table 5: Results of the Geotechnical Study

SN	D_{10}	D_{30}	D_{60}	Cu	Cc	Soil type	Moisture	Hydraulic Conductivity (m/day)
1	0.11	0.18	0.53	4.07	0.47	GP	1.00	14.60
2	0.106	0.5	0.9	8.4	2.62	SW	2.00	9.70
3	0.12	0.15	0.5	4.16	0.37	GP	3.00	12.44
4	0.103	0.4	0.8	7.27	1.81	SW	1.00	10.45
5	0.14	0.48	0.8	7.76	2.79	SW	2.00	9.16
6	0.105	0.28	0.6	4.28	0.93	GP	1.00	16.93
7	0.12	0.39	0.71	6.76	2.04	SW	2.00	9.52
8	0.106	0.18	0.71	5.91	0.38	GP	3.00	12.44
9	0.11	0.39	0.7	6.60	2.04	SW	2.00	9.70

With the help of those results (Table 5), vulnerability mapping was done to determine the risk level of the most suitable site. Detail of soil map, moisture map, hydraulic conductivity and geological map were presented below.

Soil Map: Figure 11 shows the results of the soil map. High, moderate and low risk consists of 20%, 33% and 47% respectively of the total areas of the most suitable site. Both well graded as well as poorly graded soil shows presence in the field. Moisture map: Figure 12 shows the moisture map of the study site. Moisture was taken for single season only i.e. September-November. High, moderate and low risk consists of 30%, 53% and 10% respectively. Hydraulic Conductivity Map: With based on the Hazen rule, following hydraulic conductivity map, was prepared for the most suitable site. Figure13 consists of high, moderate and low risk level of 15%, 41% and 44% respectively.

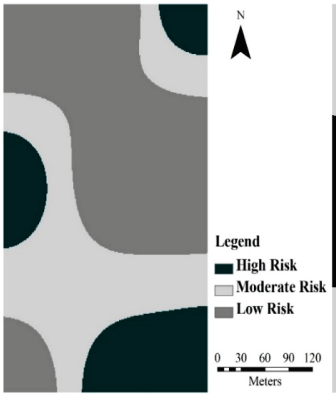

Figure 11: Soil Map

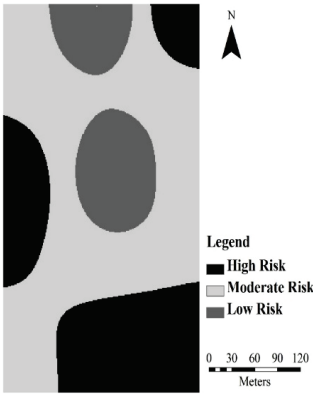

Figure 12: Moisture Map

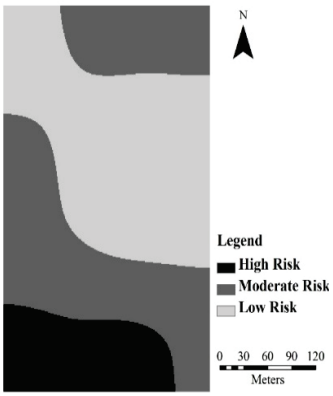

Figure 13: Hydraulic Conductivity

Geology Map: With reference to the Engineering Geological map of Pokhara, prepared by Department of Mines and Geology, it was found that the study site was under the low-sink hole areas. 100% was under the moderate risk level.

Vulnerablity Mapping: Figure 14 shows the final vulnerability map of the most suitable site with three grades of risk zones. Vulnerability map consists of 43%, 41% and 16 % for low, moderate and high risk level for the most suitable site for the municipal solid waste disposal in Lekhanth Municipality.

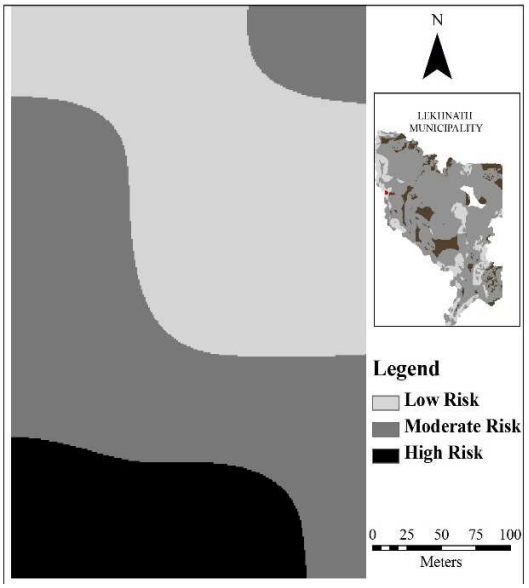

Figure 14: Final Vulnerability Map

The combination of AHP method with GIS in our experiment proves it is a powerful combination to apply for land-use suitability analysis. The outcomes from the integration of AHP method with GIS as compare to Boolean operation, only fewer areas are selected for the intended purpose. It is expected that the method can be used as a guide to the implementation of MSW site in Lekhnath Municipality with a view to decrease the operating and environmental cost with social acceptance.

The selection of final MSW site, however, requires further detail geotechnical and hydrogeological analyses; presented methodology however shows determination towards the protection of groundwater as well as surface water.

Vulnerability analysis mapping revealed that the area of less threat on nature with higher percentages of low risk zone in the proposed area.

Hence, it's worthy to recommend the application of this tool in different planning aspects for solid waste management. It is also anticipated that the study will help relevant municipality authorities and agencies, gives an outline for selecting suitable landfill site.

Acknowledgments

We express our thanks to Mr. Kiran Bhusal, Madan Kumar Suwal and Dr. Dhundi Raj Pathak for their help in GIS works and field investigations. We were grateful to the Lekhnath Municipality during the field verification, CIUD for Agar support and Solid Waste Management Technical Support Centre.

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Sustainable Forest Management and its Practice in Nepal

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Abstract

This paper highlights the practice of Sustainable Forest Management in Nepal. The word Sustainable Forest Management (SFM) is common among forestry professionals as well as in environmentalists which dreams the forest to make economically viable, socially acceptable and environmentally bearable. If the forest is sustainable, this would provide equal amount of timber and fuel wood on the basis of annual increment. Further the forest management activities would be directed towards creating normal age gradation/age classes and normal growing stock of the forest. In Nepal, forest is the major natural resource that covers 44.74% of land masses. Although forest covers huge area, deforestation, degradation and fragmentation are deteriorating growing stock than we have in the past. Next the growing population and the devastating earth quake are resulting to increase the demand of timber and fuel wood sharply. The growth of forest mainly in terai and inaccessible areas are decreasing because of the presence of mature trees. In those conditions, managing the forest in a sustainable manner by regulating yield for perpetuity isn't easy job as we desire. However different forest user groups are practicing different forest management models to regulate the yield with the assistance of government. Based on the experience from academic tour (M.Sc. Forestry) on SFM organized by Institute of Forestry, Pokhara, discussion and interaction with forest experts i.e. district forest officer and field manager (Assistant Forest Officer, User Group Members) and reviewing the literature, it is attempted to explain how yield is regulated in selection/shelter wood system under different forest management models particularly in community and collaborative forest in Nepal.

Keywords: *Sustainable Forest, Increment, Yield Regulation, Silvicultural System*

Introduction

Yield is the volume or number of stems which is removed annually or periodically to attain the objective of forest management. This requires harvesting trees regularly and should be as possible as equal with the amount of annual increment. If the amount of harvest doesn't match with annual or periodic increment, the forest will be either over stocked or under stocked. Generally, it is under stocked due to excessive harvesting and leaving the forest without management. To address this, yield needs to determine in such a way that a forest can supply same amount of forest product continuously over the working plan period. Besides this, only yield determination isn't enough, it also needs to prescribe how much, when and where to cut the trees. In other words, yield should be prescribed on how to realize or the methods to regulate it? This is termed as yield regulation and dealt as the method to achieve sustained yield. The concept of sustained yield which is a theoretical concept, however can be attainable. The proper fusion of silviculture systems and yield regulation method can contribute to achieve sustained yield. However it is still debate on correlation of yield regulation method and silvicultural system.

According to DFRS (2015), it is reported to 47.74% of land of Nepal is covered by forest and can significantly contribute to peoples livelihood and the nations GDP. This requires effective management of forest by implementing the concept of yield regulation.

Demand and Supply of Timber and Fuel Wood

According to MFSC (2013) the projected timber and fuel wood demand is highest in the terai and lowest in the mountain. The demand of total current fuel wood in Nepal is about 10.5 million tons per year and this would increase to 11.7 million tons in 2020, and to about 13 million tons by 2030. This shows the demand is approximately doubling within a decade. Similarly, the demand of timber in 2030 will be 5.05 million m^3 till 2030 which was 3.76 million cubic meter in 2011. Next the supply of timber is estimated to be 1.15 million m^3, 1.81 million m^3 and 0.22 million m^3 for Terai, hills and mountains respectively in 2011. The supply would increase to 1.53 million m^3, 2.32 million m^3 and 0.27 million m^3 in 2020 and 2.13 million m^3, 3.20 million m^3 and 0.35 million m^3 in 2030 for Terai, hills and mountains respectively (Kanel et al., 2012). To fulfill the existing demand, timber is being imported from different countries. According to Federation of Forest Based Industry and Trade Nepal, at least 29,344,422 cubic feet of timber was imported from Malaysia, Indonesia, Burma, Vietnam, New Zealand, Denmark, Africa and Australia at the cost of Rs 88 billion in 2014/15. This seems interesting that Nepal is importing wood which indicates that forest isn't still managed although government authorities has claimed that the forest condition has been improved but the growing stock has decreased. It is said that community forestry has brought many more changes in forest management sector but there is lacking in fusion between traditional and scientific knowledge..

Forest Condition and Potentiality of Sustained Yield

DFRS (2015) has reported that the total forest area of Nepal has increased to 40.36% whereas the shrub land has decreased to 4.39%. There is 51.1% of the total forest area lying outside the protected area. Out of this 2.18 million hectare is lying under reachable forest and 90% of the reachable forest with 80% growing stock has been found within 2500m that seems feasible to management.

According to DoF (2072) community forests of Nepal are covering about 18,00,000 ha with 20,000 community forest user groups by 24,00,000 households. MFSC (2013) has stated that 8% of the terai / inner terai, 75% of the hill and 16% of the high Himalayas forests are handed over to community forest used groups. Another model, collaborative forest, has been extended approximately on 65000 ha land.Between this, the first model has been adopted since a long ago, however, the forest condition doesn't get changed as the forest user and the technicians have anticipated in the forest operation plan. Further Nepal is taken as the example as the biologically richest country but the country itself is importing timber from outside the countries. This shows demand is high and the supply doesn't meet the current scenario. Although demand of forest product is high, the potential yield in slight growth scenario would be 3.1975 million m3 (in slight growth scenario) and it would be 2.6 million m3 per year after excluding the total yield of fragile Siwalik region. In the same scenario potential annual revenue (considering Rs 400 and 150 per cft for sal and others respectively) would be Rs. 29,242,500,525 which would create direct employment in harvesting and logging is 41000-82000 persons per year (Kanel et al., 2012).

Yield Regulation and Silvicultural System

Yield regulation is a difficult task which demands experience of at least a crop rotation age. Although Nepal is pioneer in community forest management, it doesn't have a single site which is managed throughout the rotation period. Nepal is primarily following selection system to manage the community forest (CF) which seems more complex as well as difficulties in carrying all the treatments prescribed in the operational plan i.e. regeneration, tending and harvesting simultaneously in the same area. The forest user groups are practicing their plan with the assistance of forest technicians

and prescribing to remove dead, dying, disease and down fall trees on the basis of forest resource assessment where the harvesting is carried under the limitation of Annual Allowable Cut (AAC). Thus this system follows the mechanism of yield regulation through increment/volume where the whole area is divided into different blocks and the forest product is collected from the block. This system has continued in all CF before the practice of shelter wood system or the scientific forest management system applied in collaborative forest management system. Later, those CFs which have economically valuable species, they have renewed their forest operational plan to operate shelter wood forest management system. Now only a few forest user groups of terai and hills have such type of plan due to the limitation of budget for preparing the plan with scientific justification. In scientific forest management system, they have vision to regulate the yield either by area and number of stems or only by area which is as same as in Collaborative Forest Management (CFM).

The another silvicultural system i.e. clear felling system is the simplest method among the which is found practiced by Sagarnath Ban Bikas Pariyojana (SBP) to supply the demand of forest products. The project is also taken as successful project because it is capable to sustain the resource by itself. However, the system can't be replicated in other natural forest due to the signatory party of Convention on Biological Diversity (CBD). To address the voice of distance users, CFM has introduced in the terai and the term scientific forest management used to divert the people's perception from traditional forest management and vision the sustained yield through irregular shelter wood system. In this system, the whole forest is divided into periodic blocks so that the rotation age coincides with total number of periodic blocks. Regeneration period is fixed and harvesting is carried during that period in a single periodic block. After blocking, growing stock is assessed by applying Hanzlik formula and the periodic blocks are numbered on the basis of highest growing stock to lowest growing stock. Among the blocks, the block which has more stocks is taken as regeneration block, next one is marked to carry for prepatory felling and the remaining blocks are separated for improvement felling and thinning. Before applying the treatment, stem mapping is carried in areas starting from the block having matured crop with the highest stock or the area where regeneration is needed at first. For yield regulation, yield has defined either in terms of area and number of stems or only by area. This has been practiced by making coupe or distributing felling in the regeneration block or taking prescribed number of over mature trees. In this way, the same numbers of stems are removed from the first or regeneration block which gives age class equal to the regeneration period. Till to date, CFM groups of Nawalparasi and Rupendehi are working on the first periodic block of Shorea robusta forest where they have planned 80 and 10 years rotation and regeneration period successively for Sal sps. In the beginning, the manager and the user themselves are in doubt whether the regeneration will come or not. After 1st regeneration felling at Tilaurakot Sajeydari Ban (TSB) of Kapilvastu district, the regeneration doesn't appear at all due to bad seed year. Next year, the field is ploughed to favor the regeneration and it has come as we desire. Contrary to this, seedling coppice has appeared in regeneration felled areas of Lumbini Sajeydari Forest (LSF) of Rupendehi district. The treatment like weeding, cleaning are carried which has resulted to increase the number as well as the growth of the desired species specially light demander like Sal. Comparing regeneration from seeds with seedling coppice, the growth of seedling coppice has found outstanding so that the regeneration period of these two sites doesn't match practically to carry out thinning where LSB needs to carry 1st thinning in 5 years but TSB must wait until 10 years. This is caused due to the nature of regeneration i.e. seeds or seedlings. Next, mother trees which are left accordingly as the scientific forest management guideline 2071 but the number of those trees are found more and seems to create problem over regeneration during harvesting. So the managers are taking back decision to remove mother trees from the block.

Basis of Yield Regulation

In the beginning, forest operational plan of community forests are more oriented towards conservation. Later, they have focused on management of commercially valuable species like Sal, Khair, Asna, etc. and dreamed to regulate the forest on the basis of volume/annual increment. They get yield in form of Annual Allowable Cut (AAC). After the whim of scientific forest management shelter wood system, has purposed to regulate the yield by controlling volume and the number of stems per hectare in TSB and in some CF. But LSB has followed area control method to regulate the yield in Rupendehi district.

Policy Provision

Master plan of forestry sector is the major policy document which has envisioned for managing the nations forest under different forest management regimes. There is also forest act, regulation, directives and guidelines. Comparing selection system with shelter wood system, selection system has followed the more conservative method of yield regulation. According to this, no one can harvest the crop equal to the increment. Besides this, all the growing stock except advance growth of the working unit of the regeneration felling area can be collected in shelter wood system. This shows policy favors the shelter wood system than selection system.

Scope of Yield Regulation in Sustainable Forest

In Nepal, people are practicing different forest management model i.e. CFM, CF, lease hold, government managed forest etc. Next the country has almost half of the reachable forest. Similarly demand and supply analysis shows that the forest product demand is becoming scarcer in every year. Policy has been improving to address this and to make the forest more sustainable in coming days. Technicians, local/indigenous people are making sound plan together by analyzing the cost and benefit and taking consideration with environment as well as socio cultural aspects. Forest user groups of terai and some of the hills are motivated towards sustainable management of forest for economic benefit and environmental services. Yield regulation activities have been planned in operational plan. The government, INGOs and local NGOs are supporting for good governance. Over all the condition of governance in forestry sector has been improving and the initial result of scientific forest management has found positive towards sustainable forest management.

Challenges

Yield regulation is the challenging job which is always threatened by many factors. At first, the manager should have sound plan with clear vision that the forest will be like this after the completion of the rotation. Next, the crop rotation period is usually long so the investment and the returns are the major concern. This means all the users and technicians can't carried it. Some of the forest user groups which have commercially valuable stock, there is possibility to implement the plan but there exist serious issue of good governance. Members of the user groups are blaming committee for the non-transparency in fund mobilization. Despite this benefit sharing is another issue. Most of the opportunity and the information is hold by the elite people. This is symbolizing bad governance but condition isn't same in all CF. Besides above, there is lacking trust among stake holders and acting as a barrier to implement the plan.

Conclusion

CF user groups have started to manage their forest since a long ago for satisfying their needs like fuel wood, fodder and timber. Thereafter they attempt to shift from traditional to commercial forest

management system. Now a day, their concerns are growing on ‘’ how to produce maximum saleable volume?’’ In this way the demand of forest product, concept and the practice of forest management have made them to shift from selection system to shelter wood system. This has resulted positive symbols in the forest and contributing peoples livelihood as well as in GDP of the nations. Overall, the practice is still in piloting. The results seem positive and would help to regulate yield in such a way that directs towards sustained yield and helps to improve not only in economic benefits but also in forest health. This seems wider scope of yield regulation in different models of forest management particularly in CFM & CF.

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Potential of Conservation Agriculture for Cereal Based Sustainable Farming System and Scaling-Up in Eastern Indo-Gangetic Plains of Nepal: Case of Sunsari District.

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Abstract

Conservation agricultural practices have been found to be the climate smart and labor smart sustainable agricultural production technologies. The decline in productivity, increase in the cost of cultivation, labor intensive practice affected the cereal based farming system in Nepal particularly at the Indo-gangetic plains. SRFSI has been working in responses to concerns about the sustainability of the cereal based farming system at Sunsari and Dhanusha district of Nepal. This study was conducted to assess the adoption and scaling up of conservation agriculture in addition to input usage, production, net profit, B:C ratio, labour use etc of CA practice in Sunsari district, eastern indo-gangetic plains of Nepal. The study employed structured questionnaires survey and key informant survey as the main data collection tools. Project reports were taken as secondary data. The primary data related for the semi-annual report and annual report of the SRFSI project were collected jointly by the DADO, Sunsari and RARST, Tarahara. Study revealed that farmers had several tangible advantages and getting higher productivity through these practices. This study assessed the potential of CA based practices in Rice-Wheat and Rice-Maize farming system to improve the yields, net profit for sustainability of the cereal based farming system.

Keywords : *Rice-Wheat, Rice-Maize, Farming system, Terai, EIGP, Conservation Agriculture*

Introduction

The Indo Gangetic Plains (IGP) is a vast are of fertile land with about 255 million hectares across four major countries: India, Pakistan, Nepal, and Bangladesh. Eastern Indo-gangetic plain (EIGP) is better endowed with natural resources particularly land and water. The productivity of rice-wheat farming system is low (6.2 tons/ha) as compared with Western (W) IGP (10 tons/ha) (Yadav, Yadav and Singh, 2008). Despite its superior resource endowments EIGP is a food deficit region. It is found to be the house of the most poor and disadvantaged people. The Terai and plain areas of the country belongs to the EIGP region and has a potential to national and regional food security, however the productivity of food crops is very low, yield gap is high, sparse agricultural knowledge and service networks, and lack of sustainable and climate smart agricultural technologies.

Rice-Wheat and Rice-Maize farming system of Asia is labor, water, capital and energy intensive and due to which becomes less profitable and in a threat. The productivity of major cereal crops has declined or stagnated during the last decades. Decline in productivity, increase in the cost of cultivation in these cropping system is significant in terms of food sovereignty. The input use efficiency of the cereal based farming system is low and similarly the soil organic matter has been found to be very low as a result of fact the productivity of most of the crops has been stagnated in the EIGP of Nepal.

Due to crop residue removal and excessive soil tillage, the soils are prone to wind erosion and lose residual moisture. The organic matter content in the soil is very low as there is very lesser use of FYM and residue retention in the soil. Due to these factors there is a wide yield gap between the potential and actual crop yields of most of the cereal crops. In addition several climatic stresses have escalated the yield gap for most food crops. Hence, the development of new integrated resource management strategies is urgently needed for sustainable crop production in the region. There is a need to increase water productivity (amount of grain production per unit of water application, kg grain m^{-3} water) of wheat under irrigated management.

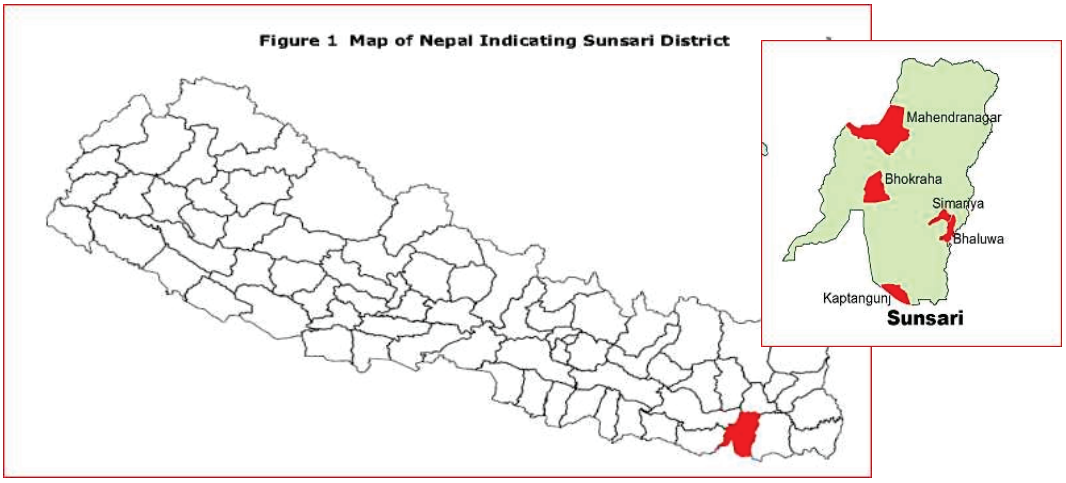
Wheat crop is the second most important crop for the plain and terai areas with area and production. The area under wheat crop has been found diminished due to several constraints. Land preparation practices mostly 2-3 times after the harvest of rice for wheat crop is the major yield limiting factor in Nepal. Under conventional practices the crop production is influenced by the tillage, residue, nutrient, water management practices and type of cultivar. Decades of intensive tillage, removal of crop residues, and excessive use of chemical fertilizers have contributed to lower soil fertility leading to low crop productivity in EIGP of Nepal. Hence considerable efforts are needed to increase wheat crop production and meet the anticipated increase in food demand. This works concerns about the breaking yield barriers and ensuring sustainability of rice-wheat farming system in EIGP, Nepal.

There is a demand of different climate smart and efficient technologies in these farming systems which are able to reducing cost of cultivation and boosting productivity of the cereal based farming system including Rice, Wheat and Maize crops (Thierfelder et al., 2013). Different studies found that there is a huge yield gap between the potential and actual crop yields realized by the farmers (Pokharel, 2016). Flooded and Puddled soil as required by rice in conventional practices consumes lot of water and increases the cost of cultivation. Increased use of chemical fertilizers, asymmetry of planting schedules has increased the susceptibility of the pests in the rice-wheat farming system (Gupta et al., 2002). Land preparation practices mostly 2-3 times after the harvest of rice for wheat crop is the major yield limiting factor in Nepal. The Sustainable and resilient farming systems intensification in the eastern Gangetic Plains (SRFSI) has been working in responses to concerns about the sustainability of the Rice-Wheat, Rice-Maize and Rice-Lentil, Rice-Mungbean systems in eastern indo gangetic plains of south Asia. The SRFSI is a regional four year multi-partnership project (May 2014 to June 2018) managed by CIMMYT with ACIAR funding and the major implementing agency in Sunsari Nepal are DADO, Sunsari from DoA, Nepal and RARST, Tarahara from NARC, Nepal (SRFSI, Semi-Annual Report 2016). In Nepal, the SRFSI research on conservation agriculture has been testing in Sunsari and Dhanusha district to improve the productivity of cereal based farming system in a sustainable manner.

Material and Methods

The study was conducted in Sunsari district in the Eastern Region and belongs to eastern indo-gangetic plains of Nepal. Geographically, the district is located in the latitude of 26º 25' to 26º 55'N and the longitude of 86º55' to 87º21' E (Figure 1). The head-quarter of the district is Inaurwa municipality.

The total area of the district is (1257 km^2) 1, 25,700 ha with cultivable land area of 81,756 ha which consisted of 65.04% of the total land area (DADO, 2014). The cultivated land is 74,353 ha, forest land area of 23,204 ha, pasture land 6,471 ha, and others 15,459 ha. Of the total cultivated land, irrigated land constituted 65,850 ha of which seasonal irrigated area constituted 19, 800 ha. The average temperature of the district varies from 10-20^{0}C in the winter to maximum 35 to 43°C in the summer; and average annual rainfall is around 1943mm.



The primary data related for the semi-annual report and annual report of the SRFSI project were collected jointly by the DADO, Sunsari and RARST, Tarahara. The semi-annual and annual reports of the project have been reviewed and to assess the partial economics and production details of the different cereal based farming system. There are 5 nodes for long term trial, opportunity trial and out-scaling blocks in: Mahendranagar, Bhokraha, Kaptanjung, Simariya and Duhabi Bhaluwa VDC since the beginning of this project. The farmers opting conservation agriculture consists more than 150 in the district and in each nodes there are at least 10 farmers in each node. A semi-structured questionnaire was developed to explore the advantages experienced, input costs, management costs, problems with the RCT on cereal based farming system with the 60 farmers of Sunsari district 10 each from 5 nodes and rest 10 from Devanjung VDC the neighbor VDC of Kaptanjung.

Results and Discussion

Grain yields of Rice

Rice is the first important crop in Sunsari district and grown mainy on main season (June-July). Most of the farmers growing with DSR and UnTPR experienced two to three weeks early in harvesting of the crop. In long term trial of Rice-Wheat farming system the rice yield under different three treatments was shown in Table 1 and there is an average grain yield advantage of 5.4% over conventional tillage and manual transplanted rice. UnTPR followed by ZTW is found to be more beneficial than other treatments. The grain yield was 8.11 tons/ha with harvest index 0.52, B: C ratio 2.96.

Table 1. Summary Results (Grain yield tons/ha) on Rice 2015-16 of Long Term Trials in Sunsari Nepal (Rice-Wheat or Rice-Wheat-Mungbean Systems) (n=162)

Treatments	Sunsari
CTTPR-CTW	3.02
CTTTPR-ZTW	3.20
ZTDSR-ZTW	3.21
UPTPR-ZTW	3.14
Grain (%) over CT	5.4

(CTTPR- Conventional tillage and manual transplanted rice, ZTDSR-Zero tillage direct seeded rice, UPTPR- Unpuddled mechanized or manually transplanted rice, CTW-Conventional tillage wheat, ZTW-Zero tillage wheat).

Grain Yield of Wheat

Wheat is the second important crop in Sunsari district and grown in the winter with the residual soil moisture after the harvest of rice. Most of the farmers growing with ZTW experienced two weeks early in harvesting of the crop and bold size grain. In long term trial of Rice-Wheat farming system the Wheat yield under different three treatments was shown in Table 2. CTTPR-ZTW followed by ZTDSR-ZTW is found to be advantageous.

Table 2. Summary Results (Grain yield tons/ha) of Long Term Trial on Wheat, 2014-15 (n=153) (Rice-Wheat-Mung Beans System)

Treatments	Sunsari
CT	3.15
ZT	3.06
Mean	3.11
Yield gain (%)	-3.01

(CT-Conventional Tillage and ZT-Zero Tillage)

Grain Yield of Rabi Maize

Maize is the third important crop in Sunsari district and grown especially in the winter season. Most of the varieties grown by farmers are of hybrids and targeted to sale as raw materials of Feed Industry. Most of the farmers opting ZTM experienced several advantages like: less seed requirement, fertilizer use efficiency, less water for irrigation, proper crop stand. In long term trial of Rice-Maize farming system maize yield was found highest in UPTPR-ZTM system with grain yield 6.86 tons/ha with harvest index 0.50.The annual average rice-maize system yields 13.1 tons/ha grain yield with harvest index 0.49 (Shown in table 2).

Table 3. Summary Results (Grain yield tons/ha) of Long Term Trial on Rabi Maize, 2014-15 (n=123) (Rice-Maize system)

Treatments	Sunsari
CT	8.05
ZT	8.12
Mean	8.41
Yield gain (%)	0.41

Table 4. Summary Results (Grain yield tons/ha) on Rabi Maize 2015-16 of Long Term Trials in Sunsari Nepal (n=100)

Treatments	Sunsari
CTTPR-CTM	6.49
CTTTPR-ZTM	5.81

Treatments	Sunsari
ZTDSR-ZTM	5.86
UPTPR-ZTM	6.86
Grain (%) over CT	-4.79

Advantages Associated With CA Practices

The area under conservation agricultural practices in Sunsari district is increased during recent years. The out-scaling is going through the District Agriculture Development Office, Sunsari. As from the household survey following advantages have been observed.

Table 5. Advantages experienced with CA based practices of sampled households in 2015-16 of Sunsari district (n=60).

S.N.	Factors	ZT-Wheat	ZT-Maize	DSR-Rice
1.	Optimum sowing time	58(96.67)	42(70.00)	52(87.00)
2.	Less seeds per unit area	54(90.00)	54(90.00)	57(95.00)
3.	Seed germination high	58(96.67)	55(91.67)	35(58.34)
4.	Crop establishment good	57(95.00)	57(95.00)	30(50.00)
5.	Low weed infestation	54(90.00)	54(90.00)	26(43.44)
6.	Pond time low	60(100.00)	60(100.00)	52(87.00)
7.	Incresed irrigation efficiency	60(100.00)	60(100.00)	60(100.00)
8.	Increased fertilizer efficiency	57(95.00)	51(85.00)	47(78.34)
9.	Disesase/Insect infestation low	33(55.00)	37(61.67)	26(43.34)
10.	Days to maturity early	54(90.00)	49(81.67)	60(100.00)
11.	Increase in yield	41(68.34)	32(53.34)	37(61.67)

Major Inputs Used in CAP

Farmers used 20 Kg more rice seeds than the recommended seed rate while lesser in DSR and UPTPR practices in the SRFSI project area of Sunsari district. It is shown in Figure 2. Similarly, the other inputs DAP, Urea and MOP also varies among the different rice growing system. DSR and UPTPR consume significantly lesser amount than the puddle and manual transplanted system.

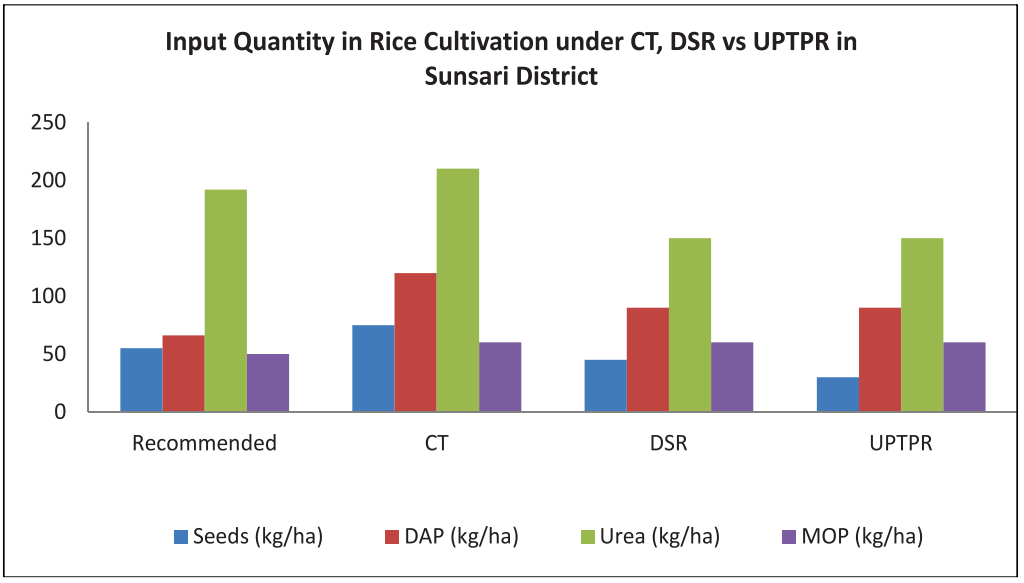


Fig 2. Quantity of Inputs (Seeds, fertilizers) Used in Rice Cultivation Under Different Cultivation System in Sunsari District 2015-16.

Farmers used double amount of wheat seeds in conventional practices than the recommended seed rate. For ZT, farmers used nearer to equal quantity of recommended seeds. The chemical fertilizers and time to irrigate is also low as compared to the CT wheat shown in Fig 3.

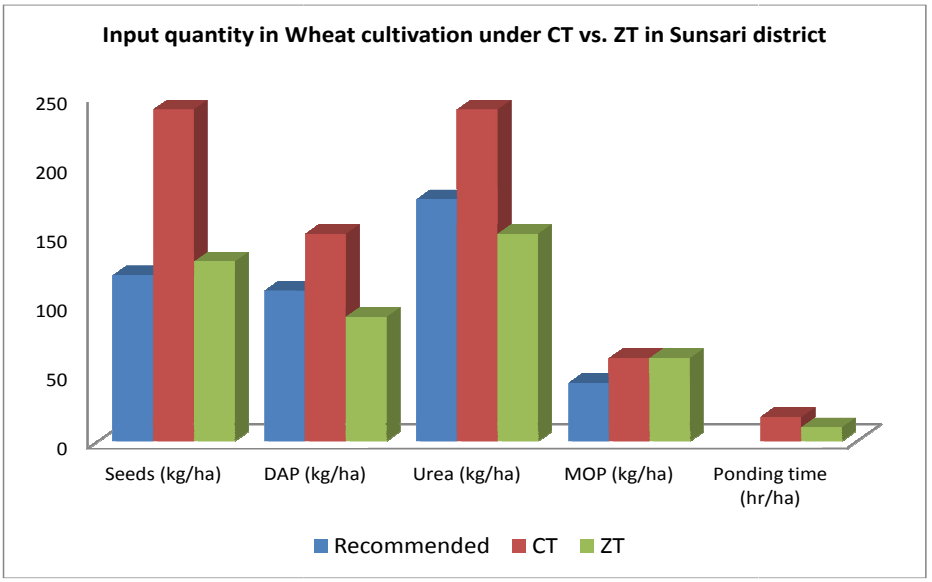


Fig 3. Quantity of Inputs (Seeds, Fertilizers) used in Wheat Cultivation Under Different Cultivation System in Sunsari District 2015-16.

Farmers used 6 kg lesser seeds in ZTM as compared to the CT maize. The chemical fertilizer is also low as compared to the CT Maize shown in Fig 4.

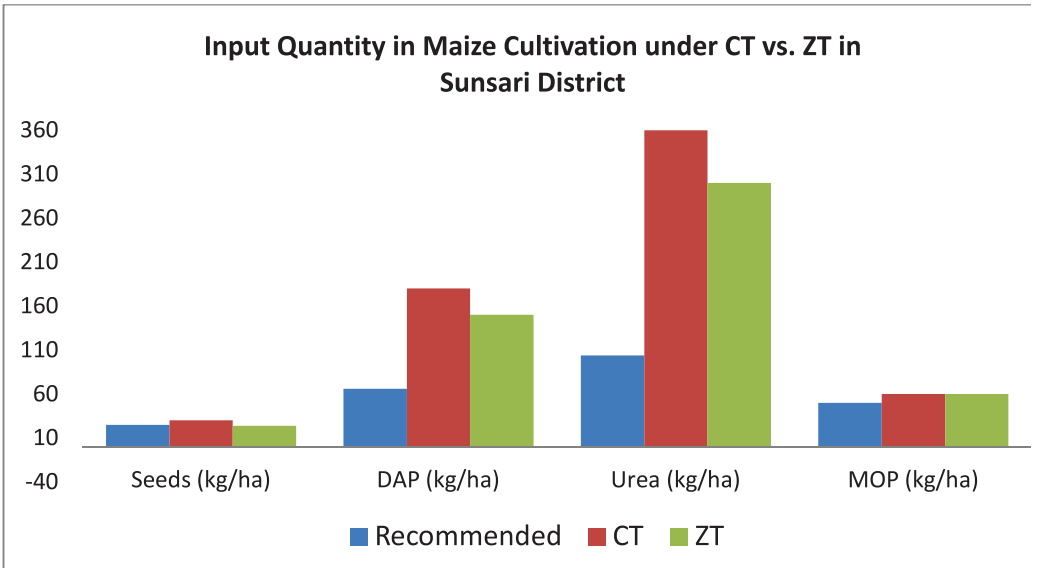


Fig 4. Quantity of Inputs (Seeds, fertilizers) Used in Maize Cultivation Under Different Cultivation System in Sunsari District 2015-16.

Weed management in CA based farming practices has been found to be effective by using herbicides. The weed management cost seems a big threat to out-scale the resource conservation technology. The differences between the costs of weed management in CT and ZT/DSR practices for Rice, Maize and Wheat crop in Sunsari district is shown in Figure 5.

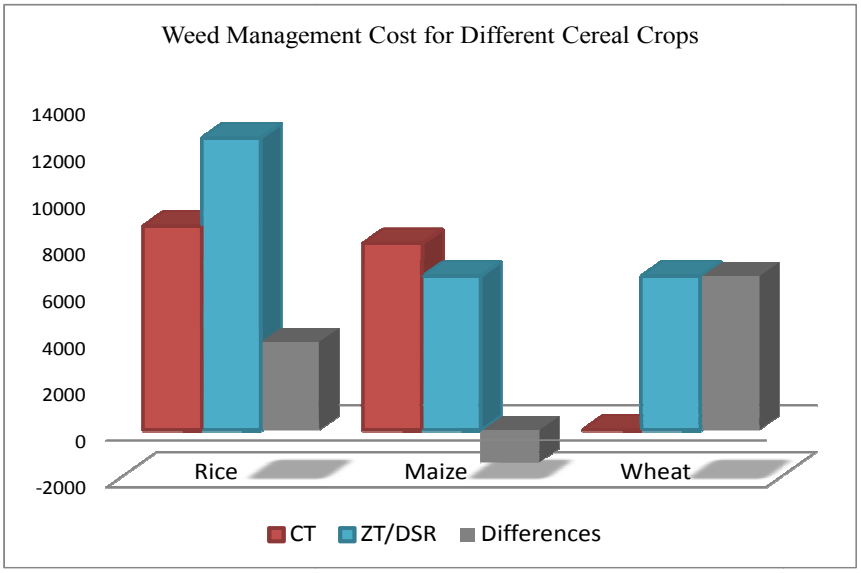


Fig 5. Weed Management Cost in CT and ZT/DSR Practices in Rice, Maize and Wheat Crop in Sunsari District 2015-16.

Partial Economics of Long Term Trials on Rice-Wheat and Rice-Maize Farming Systems in Sunsari

The partial economics of long term trials on rice-wheat farming system 2015-16 in Sunsari district is shown in Table 6. The CTTPR+ZTW has the highest grain yield 8.19 tons/ha with biomass yield 16.09 tons/ha. The net profit was found highest in UPTPR+ZTW treatment NRs. 1,57,514 per ha with B:C ratio 2.96 followed by ZTDSR+ZTW with net profit NRs. 1,39,386 per ha with B:C ratio 2.78. The conventional practices of rice transplanting followed by conventional sown wheat has net profit of NRs. 1,30,040 per ha with B:C ratio 2.27. It is found that the labor use (person per day per ha) has also lower in the conservation based agricultural practices shown in Table 6.

Similarly the partial economics of long term trials on rice-maize farming system 2015-16 in Sunsari district is shown in Table 7. The UPTPR+ZTM has the highest grain yield 13.1 tons/ha with biomass yield 26.54 tons/ha. Here, the net profit also highest for this treatment with NRs. 2,37,440 per ha with B:C ratio 3.47. The conventional practice of rice transplanting followed by conventional maize has net profit NRs. 1,79,510 per ha with B:C ratio. It is found that labor use (person per day per ha) for CA based treatment (UPTPR+ZTM) is 74 whereas for conventional practice is 106.

Extent of Adoption of CA Technologies

Survey results and interview with the field technicians of SRFSI at five different nodes indicate that the number of farmers adopting different CA practice varies from node to node depending upon the socio-economic characteristics and topography of the land. In Bhokraha Node the area under CA practices is about 170 hectares with 100 ha wheat, 60 hectare maize and 10 ha for sunflower whereas in Kaptanjung node 100 hectares with Wheat and 60 hectares with maize. Similarly in Mahendranagar, Sallbani the Kidney Bean is dominant with 60 hectares under ZT followed by 40 hectares with maize and 5 hectares with Sunflower.

In Simariya and Duhabi VDC where the Tharu community are dominant which prefers rice most and wheat occupies 25 hectares wheat and 3 hectares rice in Simariya and at Duhabi 20 hectares wheat and 2 hectares maize is under ZT. In addition to these some VDCs like Aaurabani, Chittaha, Rasi, Satterjhora, Amahaiibela occupies about 80 hectares under ZT wheat.

Spread of the CA Technologies in Sunsari District

The spread of CA technologies for wheat in Sunsari district has been facilitated through policy support from District Agriculture Development Office and addition of farmer's visit to demonstration plots, training programs, dissemination of leaflets and pamphlets about the advantages of CA technologies. It was reported that there are altogether 250 farmers throughout the district opting zero tillage technology in different cereal crops.

Problems Associated with the CAP

Most of the farmers opting RCT practices in cereal based farming system in Sunsari district are facing the problem with the availability of zero tillage and happy seeder machine in time. In district there are altogether 12 ZT machines (including multi-crop) and 1 Happy (Turbo) seeder machine used for sustainable intensification of RCT in district. The other problems encountered is that there is a clay attachment problem in the zero tiller nearer to the seed and fertilizer drill pipe, due to which clogging is observed. Although the application of FYM/compost to cereal crops in district is negligible, its application and best application of nitrogenous fertilizers is also found problem to farmers. Regarding, weed management for the few years is also found problem. As,

there is Innovation Platform (IP) well established and functional in each node the newly released and developed technique was quickly diffused through IP so that these problems associated with inputs were managed in Sunsari district.

Steps for Up Scaling of CA Technologies in EIGP, Nepal

Key informant survey and Focused Group Discussion with the field technicians and farmers respectively in five different nodes of Sunsari district identifies that many steps and activities are needed for wide scale adoption and up-scaling of CA technologies in EIGP, Nepal. In general the following are the basic and major steps and activities needed for the up-scaling of CA technologies in EIGP, Nepal.

- Sensitization of extension agents on Conservation Agricultural Technologies (CAT)
- Establish demonstration plots in various parts of the district
- Mobilization of Field technicians with CAT throghout the district
- Facilitate the activities through Innovation Platform
- Conduct on farm research to develop novel tools and technologies.
- Conduct farmers' exchange and farmer to farmer trainings
- Conduct on farm training and hands on practice of CAT
- Mobilize farmers cooperatives in cooperative farming with CAT
- Establish custom hiring center to assist a large number of farmers with machineries and agricultural equipments.

Conclusion

The study confirms that CA based practices in Rice-Wheat and Rice-Maize farming system especially in the Eastern Indo-gangetic plains of Nepal can be a viable option for the farmers. Results show that it improves the crop productivity, reduces cost of cultivation, increased net benefits, reduces irrigation time for most of the crops and decreases labor use per hectares. This study revealed that CA based practice is the better off farmers who initially benefit from zero tillage machine and indeed scaled up in the neighbor localities.

It is found that labor use (person per day per ha) for CA based treatment in both the Rice-Wheat and Rice-Maize farming system is very low as compared to conventional practice. As the cereal based farming becomes labor intensive. Cereal based farming system of Asia has contributed immensely to fill the increasing empty stomachs but as consequently led to many sustainability issues viz. declining water resources, degrading soil health and environment degradation which is further responsible for low land productivity. Hence, the CA based practices in cereal based farming systems will surmise with the benefits for the poor and small scale farmers of EIGP of Nepal. It may therefore help the EIGP rural poor farmers' adaptation to changing climate.

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Comparative Study of Carbon Stock in Living Biomass of Community Forest and Religious Forest

(A Case Study from Urban Periphery, Kathmandu Valley)

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Abstract

Forest plays a significant role in carbon sequestration, acts as a sinks of Carbon dioxide (CO_2). It has been estimated that standing forests sequester about 20 percent of the global CO_2 emissions and are thought to provide a most cost-effective means of reducing global CO_2. Moreover it has a huge impact on the livelihood of the local people. The study was carried out in Ranibari Community Forest (RCF) and Mhepi Religious Forest (MF) of Kathmandu valley. Simple stratified sampling method was used and samples were taken with 5% of sample intensity in RCF and the whole forest of MF (as this forest has comparatively less area) was taken for data collection. The data were analysed and the carbon stock of living biomass was found to be higher in MF i.e 428.44 t/ha than in RCF i.e 286.5 t/ha. The species diversity of RCF and MF were found to be 0.87 and 0.9 respectively. This difference in species diversity and carbon stock may be due to various influencing factors like soil properties, aspect, tree growth and management practices.

Keywords : *Living Biomass, Conservation, Carbon Dioxide*

Introduction

Carbon sequestration is the process of capture and long-term storage of atmospheric CO_2 by plants during photosynthesis process or by rocks or deep sea bed storage of liquefied CO_2 (Bass et al., 2000). Forest is the important source for carbon capture and its storage and it also provides positive impact on livelihood of the local people because of its cost effectiveness and its associated benefits. The declining forest capital in urban areas raise concerns about the protection and growth of forests and active local participation in forest management (Dahal, et. al, 2009). Urban forests play an important role in ecology of human habitats in many ways: they filter air, water, and sunlight, provide shelter to animals and recreational area for people. Forest plays a relevant role as a natural process in global carbon cycle. Depending on the scientific management regime and activities forest plays the role of both carbon source and sink (IPCC, 2000). About two-thirds of terrestrial carbon is sequestered in the standing forests, forest under storey plants, leaf and forest debris, and in forest soils (Sedjo et al., 1998). There is an inextricable link between present society and past in terms of biodiversity, culture, religious and ethnic heritage. The tradition of community forests and religious forests can provide a powerful tool for ensuring biodiversity conservation through community participation.

According to the management regime, Nepal's forests are divided into five types: community forest and religious forests are among them. Religious forest are those forests that have been protected by the local people for centuries based on their cultural, religious beliefs and taboos that the deities reside in them and protect the people from different calamities. Community Forest are those forests handed over to a users' group for its development, conservation and utilization for the collective interest. This study aims to know whether the cultural and spiritual values of people towards biodiversity conservation or the involvement of people for forest management are effective in present context. The study was carried with the objective of comparing the carbon stock in living

biomass in religious and community forest. Thus, it is necessary to know the economic potential of the forest as it plays an important role in the ecosystem and life of the local people. This study helps to indicate the necessity of forests in the urban areas.

Materials and Methods

Study Area

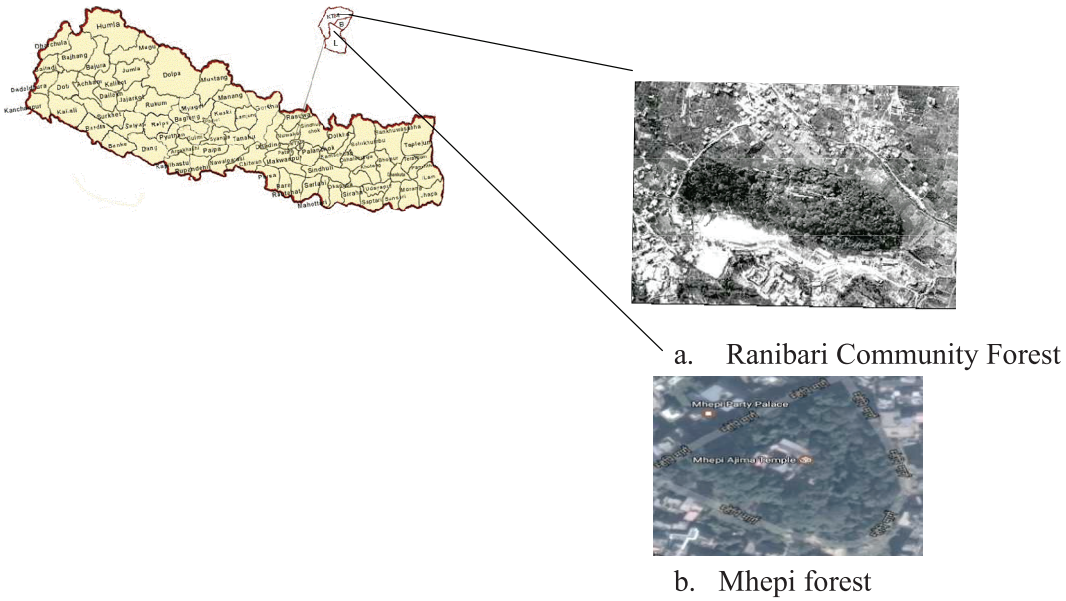
In this study two forests were taken: Ranibari Community Forest and Mhepi Forest which lies in North-East region of Kathmandu Valley.

Ranibari Community Forest (RCF):

RCF is located at the north western part of the Kathmandu Metropolitan City, is one of the few remaining community forest in urban periphery. It covers an area of 6.95ha and is located at an altitude of 1,303 m asl. The forest is floristically rich for native plant species as well as for home for many migratory and residential birds.

Mhepi Forest(MF):

Mhepi forest is located at Kathmandu city. Geographically, it lies in between 27°43'38"N and 85°18'30"E . It covers an area of 1.65 hectares and located at an altitude of 1,323m asl. There is a temple called Mhepi Ajima temple at the top, surrounded by a small forest, so called as a religious forest. The strong religious beliefs of the local people has helped to conserve the forest. Some of the medicinal plants are also conserved in this forest.



a. Ranibari Community Forest

b. Mhepi forest

Figure 1: Study Area

This study only measures the above and below ground living biomass. For the estimation of AGB, stratified random sampling technique, forest block designated by the respective CFUGs considered as strata in RCF, with 5% sampling intensity was used and in case of religious forest as a whole forest was taken to ensure enough sampling intensity. The key to stratification is to ensure that measurements are more alike within each stratum than in the sample frame as a whole (Pearson

et al., 2007). Concentric circular plots were allocated randomly in each stratum. The circular plots of radius 8.92m were taken. The Diameter at Breast Height(DBH) of the trees (>5cm DBH) and saplings (1-5cm DBH) were taken in each respective plot using D-tape and height of each tree was measured using clinometer. All the plant species in 1m*1m (diameter below 1cm) were counted as regeneration for determining the species diversity.

Data Analysis

Above Ground Tree Biomass (AGTB):

It's calculation was done by using the formula developed by Chave et.al (2005) on the basis of climate and forest stand types i.e,

$$AGTB=0.0509\times\rho\times D^2\times h$$

Where,

ρ=wood specific density (gcm^3)

D=diameter of tree at breast height (cm)

h=tree height (m)

Above-ground Sapling Biomass(AGSB):

The following regression model was used for an assortment of species to calculate biomass.

Log (AGSB)= a+b log(D)

Where,

Log= natural log

a= intercept of allometric equation of saplings

b= slope allometric equation of saplings

D= diameter at breast height (cm).

Below Ground Root Biomass (BGRB):

20% of above ground tree biomass is estimated as below ground root biomass (Forest Carbon Stock Measurement Guideline, 2011).

Total Living Biomass:

TLB=AGTB+AGSB+BGRB

The carbon content in AGTB, AGSB and BRGB were calculated by multiplying with the IPCC (2006) default carbon fraction of 0.47.

Species Diversity:

$$H' = -\frac{ni}{N}\log\frac{ni}{N}$$

Where,
H' = Shannon-Weiner diversity index
N = Total number of species

Results and Discussion

Species Diversity:

The species diversity in Mhepi forest was found to be higher than that of RCF. Various types of species like *Celtis australis, Grevillea robusta, Sapindus mukorossi, Persea odoratissima* etc. are some of the dominant species in both the forests. The difference in species diversity may be due to the variation in soil structure, human disturbance, competition among the species. Species diversity also helps in the soil improvement.

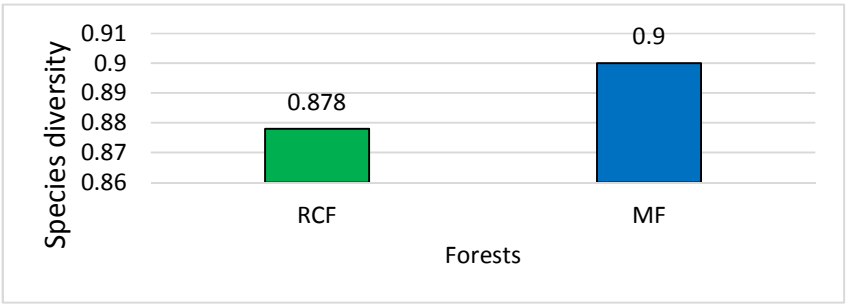


Figure 2: Species Diversity Among the Two Forestss

RCF= Ranibari Community Forest

MF= Mhepi Forest

Comparison of DBH of Tree Species

The trees having higher Dbh were found in Mhepi forest than in Ranibari Community forest. Dbh is also an important factor in determining the carbon stock.

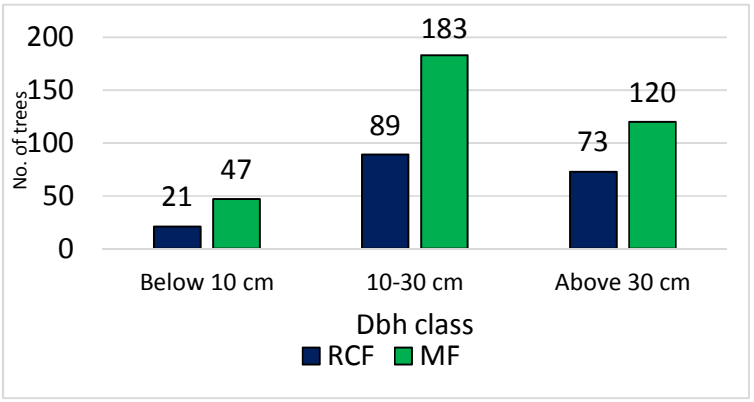


Figure 3: Comparison of DBH of Tree Species

Total Carbon Stock Analysis:

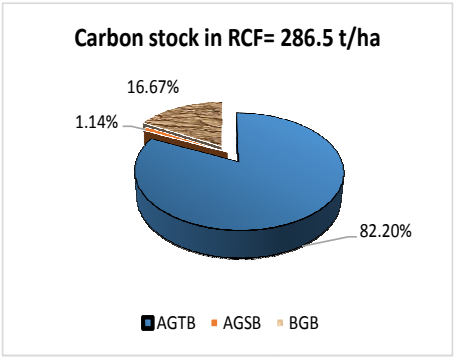


Fig 4: CS in Living Biomass of RCF

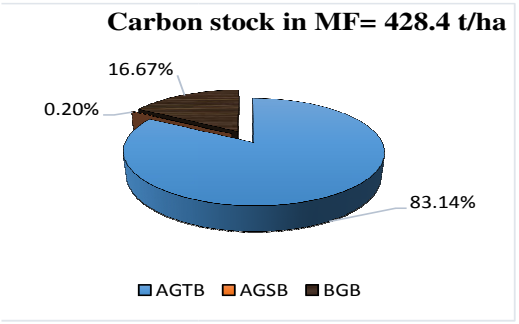


Fig 5: CS in Living Biomass of MF

Comparison of Carbon Stock in Living Biomass in RCF and MF:

Carbon Stock in Living biomass in Mhepi forest was found to be higher than that in RCF. This may be because Mhepi forest has comparatively more species diversity than Mhepi forest and due to the variation in species composition, stand density, diameter class, average tree height, management practices and soil fertility.

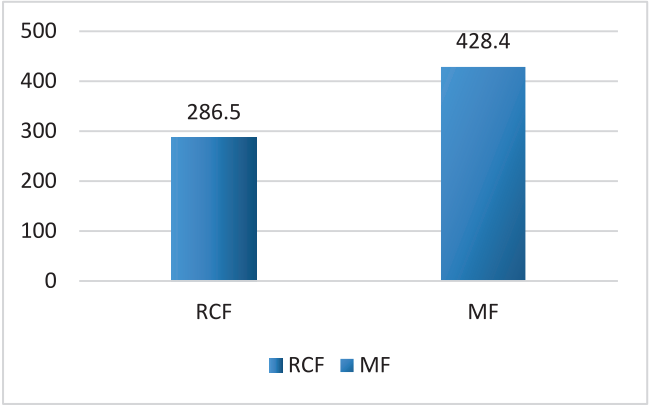


Fig 6: Comparison of Carbon Stock in Living Biomass Among Two Forests

In comparison with the average carbon stock of Shorea robusta forest in Palpa district (227.73 t/ha, Baral et. al) carbon stock in living biomass of Ranibari Community Forest is found to be greater i.e 286.5 t/ha. This might have occurred because this forest is located in the city area so it is not harvested by the local people and also various species of trees are found here and also may be due to the proper management activities, soil quality. In comparison with the study carried out by Sharma et. al(2015) in sacred groove in Gulmi (127.75t/ha), carbon stock in living biomass of Mhepi forest is found to be greater(428.4 t/ha). This might be due to the different climatic condition, variation in soil nutrients, and presence of older trees.

Conclusion

Carbon capture and storage is nowadays considered to be a crucial technology regarding the carbon abatement strategies in order to tackle irreversible climate change. Carbon stock of Mhepi forest was found to be higher than that of RCF. This may be due to different stand structures, site quality and intensities of management. However, an appropriate management is required to promote and conserve the urban forest as it maintain the greenery and helps to make the city clean and green. Thus, this study has demonstrated that forests help to offset a portion of the carbon emissions thereby contributing to climate change mitigation through the sequestration of atmospheric C to soil and vegetation and by acting as a natural carbon sink.

Acknowledgements

The author would like to express sincere gratitude to Mr. Krishna Hengaju Department of Environmental Science, Amrit Campus, Lainchaur for his continuous support, guidance and valuable suggestions. Mr. Arun Shakya, (Ranibari community forest) and Mr. Ganesh K.C (Mhepi religious forest) and my collegues for their cooperation and contribution during field work.

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Environmental Compliance Status of Crusher Industries of Dhadingtanau and Kaski District of Nepal

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Abstract

Stone crusher industries and extraction of earth material has detrimental effects to the environment and human health. Dust pollution, Noise pollution and water pollution are major environmental effects of stone crushing industries of Nepal.Government of Nepal has set various environmental standards for the control of pollution. Standard for dust emitted from cement and crusher industries is one of such standard. Thirteen crusher industries from Dhading Tanahu and Kaski disticts were selected for compliance monitoring by department of environment. Compliance monitoring was done between November 2015 and December 2016. Checklist developed by department of environment was used for the collection of information.All the crusher industries studied are near to one of major highway of Nepal, Prithivi highway. All the industries lie close to river or streams.More than 90 percent of the studied industries were found to be solely dependent on rivers and streams for raw materials. None of the industries fully comply all the provisions of the standard. Six industries out of thirteen spray water in screening or crushing units of industries. None of the industries has wind breaking walls, metallic road within industries premises, cleaning and washing practices of industry floor area and green belt around the industries.

Keywords : *Stone Crusher, Dust Pollution, Noise pollution, Water Pollution*

Introduction

Stone crushing industries is one of important industrial sector in Nepal which supplies construction material like sand and gravel. Many environmental effects are linked to these industries. Extraction of raw materials for these industries also has environmental effects.Air pollution and Noise pollution are the major environmental problems associated with stone crushing industries (sheikh et al 2011,Sivacoumar et al 2009). Exposure to Mineral dust from crusher may affect the lung growth (Green et al 2008).Dust pollution and noise pollution pose severe threat to the health of workers as well (sheikh et al 2011). Besides stone crusher industries also cause water pollution of river and streams increasing sediment load and affecting other water quality parameters (Pal and Mandal 2017). Stone crushing industries also affects the vegetation. The dust deposition on the vegetation has adverse effects (Pal and Mandal 2017, Saha and Padhy, 2012). Stone crushers effects are not limited to human and vegetation only. It may have adverse impacts on wildlife also. One study found that species diversity and population density of birds in the forest adjacent to crushers decreased (Saha and Padhy,2011).Inexpensive and locally available methods like application of water spray can reduce the dust pollution effectively (Gottesfeld et al 2008).Increasing the frequency of water spraying, implementing the use of windbreak fencing, and re-vegetation can be effective in controlling dust emission from such industries (clang et al 2010).

Government of Nepal has formulated various environmental standards for pollution control. Nepal government has formulated environmental standards for stone crushing industries. In this study the compliance status of some crusher industries of mid hill of Nepal is assessed. The actual environmental impact of crusher industries is not the scope of this study.

Legal Provision

Section 7 and sub-section 1 of Environment Protection act, 1997(EPA, 1997) states that "Nobody shall create pollution in such a manner as to cause significant adverse impacts on the environment or likely to be hazardous to public life and people's health, or dispose or cause to be disposed sound, heat radioactive rays and wastes from any mechanical devices, industrial enterprises, or other places contrary to the prescribed standards."

Crusher industries should conduct environmental study called initial environmental examination (IEE) and this report should be approved before the establishment of industry. Crusher industry is listed in the Annex 1 of Environment protection Rule (EPR, 1997). Annex 1 of EPR is the list of industry that requires IEE.

The emission limit of Total Suspended Particulate has been set600µg/$Nm^3$by Nepal government. Besides crusher industries has to maintain following conditions within industries premises.

A. Should have Dust Containment and Dust Suppression system in the machines.
B. Should construct wind breaking wall
C. Should construct Metallic roads within industry premises.
D. Should clean and wash industries premises surface regularly.
E. Should construct Green Belt around the industries.(Nepal Gazette, 2012)

Materials and Methods

Dhading, Tanahu and Kaski are hilly districts situated on the Central part of Nepal. Many crusher industries are operated in these districts. Along the Prithivi highway that joins two major city of the nation, Kathmandu and Pokhara there are many crusher industries. Thirteen stone crusher industries were selected by Department of Environment for compliance monitoring. Out of 13 stone crushing industries 2 industries are from kaski districts, 4 industries from Tanahu district and 7 industries from Dhading districts. Information was collected from November 2015 to December 2016.

Information collected during compliance monitoring is analyzed in this study. Checklist developed by department of environment was used for collecting information. During compliance monitoring information was collected by direct observation and interviewing owner or representative of the industries. General Information of the industries and information needed for evaluating the compliance to the environmental standard was collected.

Location of Industries

All the crusher industries selected for the study lies along the Prithivi Highway. Out of 13 industries 11 industries lies besides highway (less than 200m from highway). Two industries are located more than 200m from highway but less than 2 km. All the industries lie near to the river or stream. Five industries lay near to the SetiRiver, one near to Marsyangdi river and rest seven industries near to Agrahakhola a small stream of Dhading. In some places crusher industries were clustered in same places. In such places since industries don't have boundary wall industries premises are shared by more than one industry.

Sources of Raw Materials

These industries collect raw materials from floods plains of nearby rivers and streams. They collect boulder and earth materials from the river and streams. Out of 13 industries only one industry said that they collect earth materials from the private land. Rest of the industries solely depends on

river and stream for the raw materials. Hence more than 90 percent industries were found to be solely dependent on rivers and streams for raw materials. In some places extraction is done from flowing river channel also. In some places transportation vehicle were using flowing river channel for transportation path.

Results and Discussion

Initial Environmental Examination (IEE) Report

IEE report includes environmental mitigation plan made by the industries. All of the industries were unaware of the importance of the IEE report. Of the total 13 industries studied none of the industries has initial Environmental examination report in the field office. None of the representative of the industries exactly knows what IEE report is and what is written in the environmental management plan. The representative of the industries said the report may be in the head office.

Water Pollution

Out of 13 industries 6 industries of Kaski and Tanahu use water for washing the earth materials. During this process mud is washed out and fine sand to boulder is segregated. Materials having larger size are then crushed to get construction material of required size. Sediment loaded water then flows to the river untreated. Waste water from five industries flows to Seti River and from one industry flows to Marsyangdi River. The effects of waste water from such industries can be seen visually. The Color of river water changes downstream to the industries. In the river bank also settled sediment from waste water can be seen.

Another cause of water pollution is the extraction of raw materials from the river and streams. During the extraction of the materials from the river and streams rivers are loaded with sediments. In one place of Dhading district transportation vehicles generally tractors that uses flowing river as transportation path were making water turbid.

Noise Pollution

Noise from 3 crusher industries was measuredusing sound level meter while the industries were in operation. Noise was recorded at the entry point to the industries.Noise level reading was recorded for about 15 minutes at 10 seconds intervals. Then equivalent noise level Leq was calculated. The calculated Leq was 82.51 dBA, 83.41 dBAand 71.61dBA respectively. In crusher industries the main source of noise was operation of crusher machine and vehicular movement.

Air Pollution

It was observed that dust was produced during crushing of the stones. Out of 13 industries six industries that washes raw material dust from crushing was low. One industry that doesn't wash the raw material was found to spray water in crushing unit and dust from crushing unit was low in this industry. In rest six industries there was no dust control system. Another major cause of dust pollution was vehicle movement and other operations like loading and unloading of raw materials and product. None of the industries were using any methods to control dust from such activities. Windblown dust from piles of raw materials and products was another source of dust pollution. None of the industries have any type of provisions to control such dust. Since most of the industries are close to the highway the access road to the industries is either very short or almost absent. The access road where present is not metallic. Vehicular movement on the access road is another source of dust pollution.

Compliance status of industries with respect to environmental standard for dust emitted from cement and crusher industries.

Emission Standard of Total Suspended Particulate Matter

During compliance monitoring suspended particulate matter emitted from the industries was not measured. None of the industries were found to monitoring total suspended particulate emitted from their industries.

Dust Containment and Dust Suppression System in the Machines

It's not clearly mentioned in the standard what type of dust containment and dust suppression system should be installed. The dust containment and Dust suppression system found in 7 industries was spraying water. In those industries dust pollution was observed to be low. Six industries don't have any type of dust containment and dust suppression system in the machines. In those industries high dust pollution was observed.

Wind Breaking Wall

During compliance monitoring windblown dust from piles of raw materials, processed sand and surface of industries was observed. In the standard also the wind breaking walls are not defined clearly. Type of wall and their dimensions is not mentioned. However a simple type wall around the industries may be effective for windblown dust. None of the industries have any type of walls and fencing. In some places for example in Dhading many industries are located in one place as cluster. It's very difficult to define the areas of industries there. In such place constructing wall around each industry may be costly and unpractical. In this case also constructing a wall enclosing all the industries may be effective in reducing windblown dust.

Metallic Roads Within Industry Premises.

None of the industries has metallic road within industries premises. Neither the access road from major highway to the industries is metallic.

Cleaning and Washing Industries Premises Floor Surface Regularly.

During inspection cleaning and washing was not seen in any industry premises. Since the floor area of industries is not of concrete and road within the industry premises is not metallic it did not seem possible to wash and clean industries premise floor surface.

Green Belt Around the Industry

None of the industries has Greenbelt around the industry. Out of 13 industries only one industry has planted some trees within industry premises. While asking about green belt around the industries they showed us the trees in the industry premises. Hence industry authorities don't have proper understanding of greenbelt and its importance.

Conclusion

All the industries studied are on the bank of river and stream. Most of the industries lie near to major highway of the country. Air pollution and Noise pollution are major issues on all of the industries and water pollution is also one of major issues on about half of the studied industries. None of the industries has boundary wall and industries were found to be unaware of the provisions of the

environmental standard for dust emitted from cement and crusher industries.None of the industries has initial environmental examination (IEE) report in their field office.

Of the five provisions of the standards none of the industry has completely comply the standard. Few industries comply with first provision of the standard, dust containment and dust suppression system in the machine partially. Rest of the provisions is not complied by any of the studied industries.

If this standard is implemented by industries it will certainly help to reduce the environmental problems associated with crusher industriesto the large extent. Proper understanding of the provisions of the standards by the industries authorities are lacking.Some provisions of the standard are not specifically stated and clear. It is recommended to describe these provisions in more detail so that industries can understand clearly and implement them.

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Preliminary Biodiversity Assessment of Suryodaya Municipality, Ilam, Nepal

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Abstract

Community and Biodiversity are inseparable as biodiversity provides provisioning, regulating, cultural, and supporting services. In the present context, the rate of the extinction of the species is very high that is bringing the alteration in the ecosystem composition. The loss is even more severe in local level than globally. So, the timely data of the number of species present is necessary for scientists and policy makers. The preliminary biodiversity assessment of the Suryodaya Municipality identified 47 species of trees, 17 species of shrubs, 44 species of herbs, 10 species of climbers, and 21 species of grass. Similarly, 11 species of mammals, 3 species of reptiles, 3 species of amphibians, and 62 species of birds. This data is the first and one of the bases for the participatory management approach and are useful for the researcher to carry out the research on each section in deep.

Keywords : *Biodiversity, Biodiversity Assessment, Ecosystem Composition, Participatory Management Approach*

Introduction

Biodiversity is a comprehensive umbrella term for diverse variability among living organisms that includes diversity within species, between species, and of ecosystems. In general, the term 'biodiversity' or biological diversity refers to the variety of all forms of life on earth i.e. plants, animals, micro-organisms, the gene they contain, and the ecosystem they form (Mace et al, 2012). It is often described in hierarchical terms and deals with the degree of nature's variety in the biosphere. These varieties could be seen at 3 major levels i.e. ecosystem diversity, species diversity, and genetic diversity (NBS, 2014).

Biodiversity provides number of services that includes provisioning services (food, water, timber, and fiber), regulating services (regulation of climate, floods, disease, wastes, and water quality), cultural services (recreation, aesthetic, and spiritual value), and supporting services (soil formation, photosynthesis, and nutrient recycling) (Barker et al. 2010). Community and biodiversity services cannot remain isolated without each other as these services ensure the wellbeing of the community people directly or indirectly by providing basic material of living such as food, shelter, and access to goods. Similarly, they provide safety by securing resource asset, security from disasters, and secure health by providing easy access to clean water, air (UNEP,2008). Further, cultural values help to maintain good social relation in the community by the means of social cohesion, mutual respect and ability to help others. In reverse, biodiversity requires effort from the local community and stakeholders to ensure its utilisation and long-term conservation. Thus, biodiversity and community are inseparable; one requires another to complement each other. Trisurat 2006 suggested that community-based conservation is a better alternative than the state controlled management of resources on the aspect of reducing conflict and management effectiveness. Borrini-Feyerabend

et al. 2000 mentioned that participatory management approach guarantees a fair sharing of the management functions, entitlements, and responsibilities for a given territory, area or set of natural resources. The term 'participatory' refers to the involvement of rural communities and other stakeholders such as students, policy makers, scientists, conservationists, or volunteers (Tucker et al. 2005)). In participatory approach, all stakeholders work together to assess biodiversity so that they understand each other perspectives better and support in conserving biodiversity (Lawrence et.al. 2003). Furthermore, benefits of conducting participatory approach for preliminary biodiversity assessment are that the local community has more knowledge about existing wildlife, plants, and resources. It enhances the exchange of indigenous and outside perceptions, leading back to feedback/suitable solution on how to conduct sustainable resource use practices. The involvement of local people in the gathering and analysis of biodiversity data will enhance the empowerment and transparency in decision making (Tucker et al. 2005).

The millions of life forms on earth have provided different services to fulfil human needs for its growth and development. The services are the better health care, better crops, raw materials for the industrial growth, etc (Daily, G.C. 1997). The modern consumerist society, with high population, has led a negative effect on the diversity of biological resources. This combination of population growth and consumption levels is changing the planet's ecosystems at an unprecedented rate and scale (Population and Sustainability Network, 2012). Hence, the species are being extinct at fastest rate known in the geological history and most of the extinctions are tied to human activity (UNESCO, 2016). Similarly, one of the major causes is the loss of their habitat (WWF, 2010). Habitat is an ecological area inhabited by a species or a group of species where they can survive and reproduce. We can imagine ourselves without space and food. Likewise, when we alter the ecosystem composition, there are the loss and decline of species. For example, the decrease in the number of any species in a food web brings impact on the whole ecosystem. Next, exotic species or non-native species can disrupt the entire ecosystem by eating, infecting, competing, or mating with these native species (Ecological Society of America, 2006) Similarly, the climate change alters the environmental conditions and there are high chances of modern species loss. Other systematic drivers of this species loss are changes in land use, overexploitation, invasive species, disease, the concentration of atmospheric carbon dioxide and an increase in nitrogen deposition (Sodhi et al. 2009).This loss of biodiversity is creating significant issues for scientists and policy makers (Science for Environment Policy, 2016). The loss of the species on the local level are even more severe than global declines as the beneficiaries effect of many organisms on the local level are lost before they become globally extinct (Naeem et al. 1999). Therefore, data are necessary, to make policies and intervention of science, for the systematic conservation of biodiversity. On the other hand, the costs for the collection of the data are very expensive. Hence, at the initial stage, this study provides the preliminary data on the biodiversity profile of the Suryodaya Municipality, Ilam. The data can be very useful for the researchers to carry out the research on specific topics and to elaborate each section in deep to complete it. Similarly, from this data, the local community knows the richness of the species they have and can work for their conservation for the sustainable development. Finally, Preliminary Biodiversity Assessment is one of the important bases of participatory management approach that can be carried out in order to evaluate its status, values, importance, functional, and utility scope. Therefore, this assessment needs to involve active local participation in identifying biodiversity of high socio-economic value, aesthetic, cultural or intrinsic value (Tucker et al. 2005).

Study Area

The study area for the preliminary biodiversity assessment was Suryodaya Municipality. The Municipality lies in an eastern part of Ilam District, of Mechi Zone, in Eastern Development

Region of Nepal. It is a new municipality formed by merging 3 Village Development Committees, namely Phikal Bazar, Panchakanya, and Kanyam. According to CBS (2012), a total population of the municipality is 17, 240. For the preliminary study of biodiversity, the study site was Karphok, Bhalukhop, Baseli, Harkate, and Sundarpani of Suryodaya Municipality. In some cases, the municipality shares the area of the identified forest patches with the adjacent Village Development Committee. So, we decided to set the transect in these areas too because of the movement of the animals and the similarity of the vegetation in these areas. The study site, (Suryodaya Municipality) is shown below.

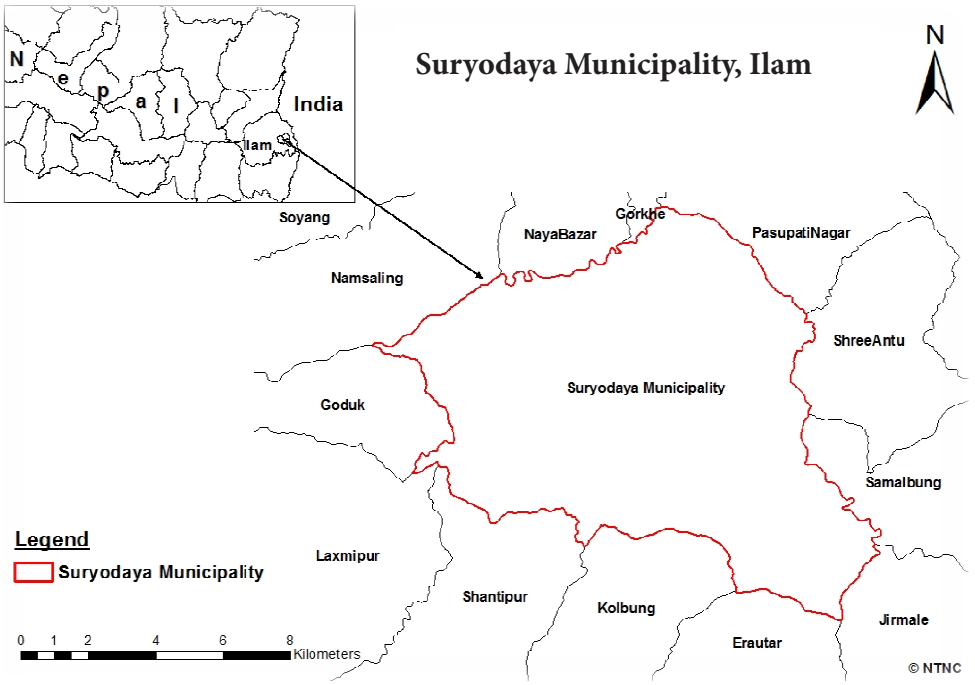

Figure 1 Map Showing the Study Area (Suryodaya Municipality)

Materials and Methods

The methodologies used for preliminary biodiversity assessment are given as follows:

Floral

Belt Transect: (Scott and Reynolds, 2007 and Consultation with NTNC staffs)

There are forest patches in the Suryodaya municipality. The major forest patches of the municipality are identified via field visit, discussion with the municipality authorities, faculty members of the Kharphok campus, and local NGOs. We identified five major forest patches namely Kharphok, Bhalukhop, Baseli, Harkate, and Sundarpani. We decided to apply the belt transect in these forest patches for the documentation of floral species. The habitat type is homogeneous for all these forest patches. *Schima-Castanopsis* type is found in Kharphok, Bhalukhop, Baseli, and Sundarpani and *Eugenia-Ostodes* are found in Harkate forest patch. Hence, the belt transect was randomly selected. Further, the existing trail also served as the belt and the selection of the belt transect depend on as

per site topography configuration. All the vegetation within 20 m, 5m, and 1m respectively left and right of the transects was recorded. A careful consideration was taken to set the transect. The number of the transect were decided according to the size of the forest patches. The details of the belt transect are shown in the figure 2. below. Similarly, the local inhabitants were consulted for the local names and medicinal values of the floral species. Herbarium was made of the unidentified species for further consultation with the experts.

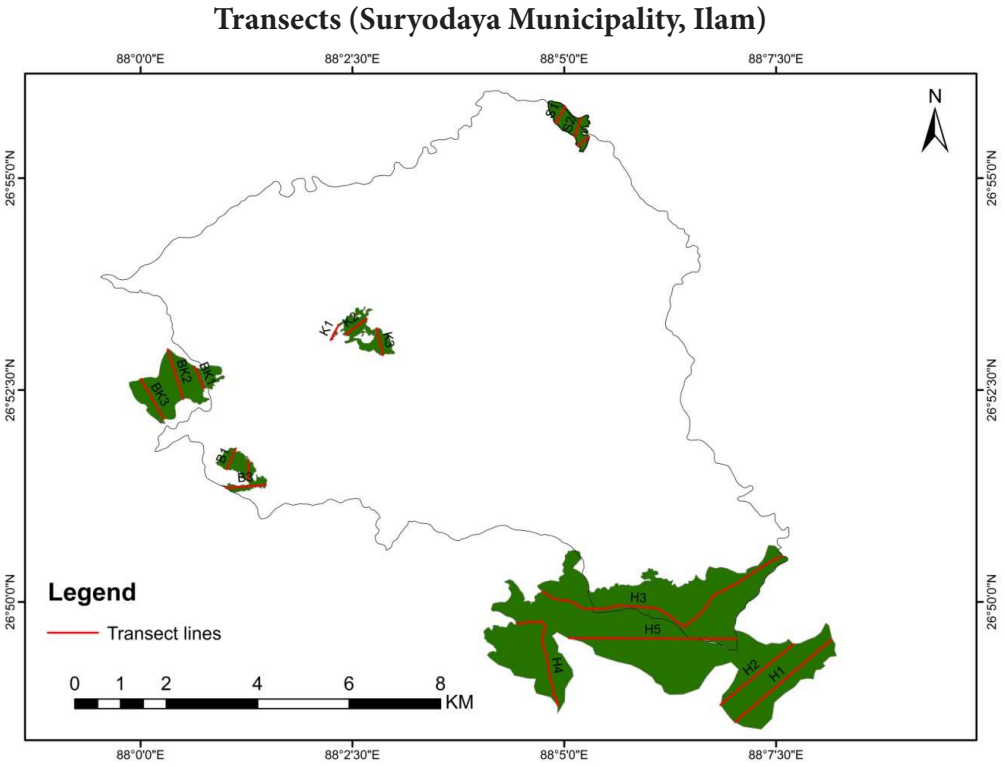

Figure 2: Belt Transect

Birds

Belt Transect

The number of the species of the birds were recorded from the Belt transect used for the vegetation survey.

Scan Sampling (Scottish Natural Heritage, 2014)

The vantage point for the scan sampling is set from the group discussion with the stakeholders as mentioned above. An equal effort was given at each vantage point. The set vantage point is shown in the figure below.

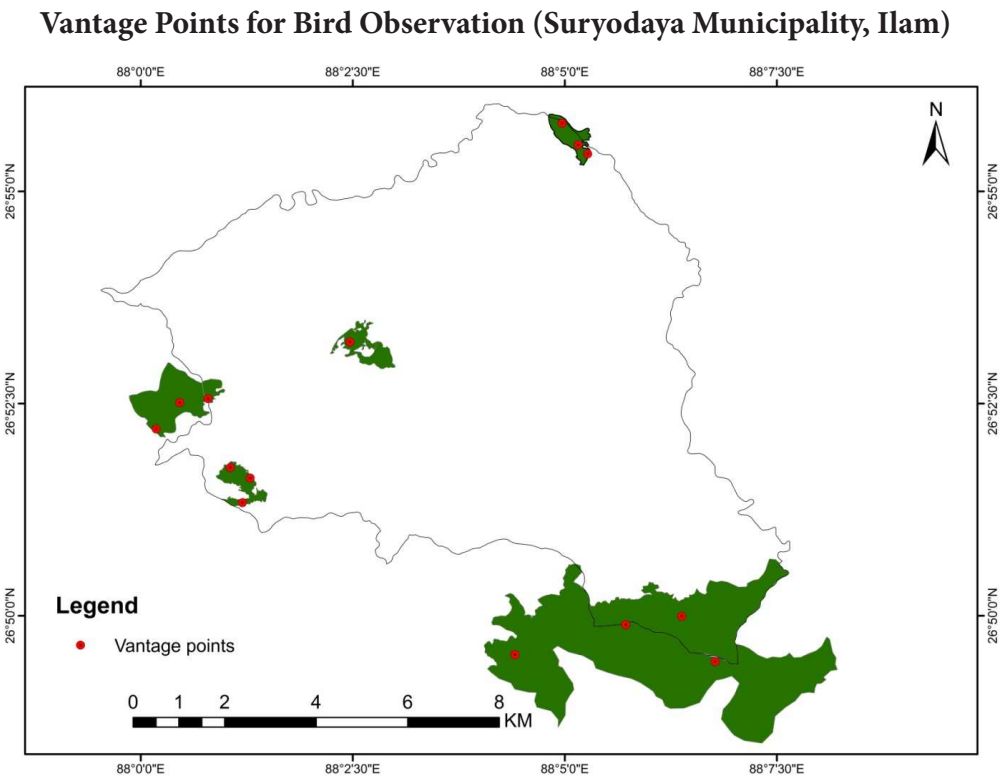

Figure 3: Vantage Point for the Bird Species Identification

Mammals

Sign Survey: (Shrestha B. and Basnet K. 2005 and consultation with NTNC staffs)

The sign of the animals (pugmark, footprint, pellets, excreates, dropping, fur, scratch and scrapes markings) in these forest patches were recorded and the checklist was prepared. The signs were surveyed systematically on the transect used for vegetation survey and opportunistic record on the forest patches.

Camera Traps Survey

A camera trap is a remotely activated camera that is equipped with a motion sensor or an infrared sensor. It is a method of capturing photographs of wild animals for identification and can also use for scientific studies with minimum human interference. Camera traps were installed to capture and identify species present in the study area. The area, to set the cameras, were decided based on the preliminary visit to the site, indirect evidence, discussion with the Suryodaya Municipality officers and staffs, related subject based faculties from Karphok Campus, teachers from different schools, and members of local conservation NGOs, and community people where there are high movements of the animals. The camera model used in the survey was Reconyx Hyperfire HC600. The photo resolution provided by these cameras is 3.1 megapixels and is equipped with an infrared sensor. Camera trap locations are represented in map Figure 4. Since the number of the camera were low, we decided to set it for 5 trap nights on each forest patches as mentioned in Wegge et al 2003.

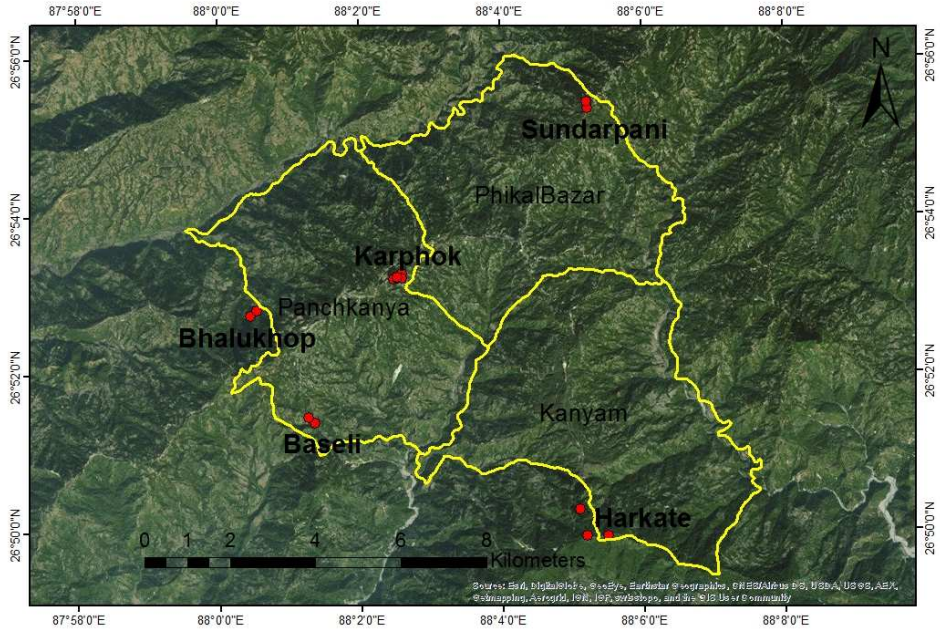

Figure 4 Map Showing Camera Trap Installation Points

Herpetofauna

Visual Encounter Survey

The method was used to identify the Herpetofauna of the area. The habitat favourable for them were identified and systematically sampled (Heyer et al 1994).

GIS

GIS is used to prepare the different maps such as administrative map, ecological map, location for camera trap stations, and transects.

Results and Discussion

Flora

The result of the preliminary biodiversity assessment carried out in Suryodaya Municipality identified 47 species of trees, 17 species of shrubs, 44 species of herbs, 10 species of climbers, and 21 species of grass. The list of flora is enlisted in Annex A.

Fauna

Eleven species of mammals, 3 species of reptiles, 3 species of amphibians, and 62 species of birds were recorded from the study site. List of mammals, herpetofauna and birds are given in Annex B, C, and D.

Biodiversity is needed to boost ecosystem productivity and each species, irrespective of their size, have an equal role to play. Hence, the large number of fauna and flora present in the municipality reflects the healthy ecosystem. The healthy ecosystem is always better to withstand and recover from a variety of disaster. Further, the greater the number of species present, the greater is the natural sustainability of all forms of life. Here the data generated from the preliminary survey demonstrated that the natural system of the municipality is sustainable if the concern authorities will priorities for the protection of the existing status. The healthy and sustainable system offers many natural services. The services are broadly divided into three types- Ecosystem Services, Biological Services, and Social Services (Vallés-Planells, et al 2014). These services are the life supporting for humankind without which there are no possibilities to survive and develop. Some of the important natural services received by the Suryodaya municipality are the protection of water resources, soil formation and protection, nutrient storage and cycling, pollution breakdown and absorption, contribution to climate stability, maintenance of ecosystems (Ecosystem Services); food, medicinal resources (examples:- Tejapat: *Cinnamomum tamala, Jatamasi: Nardostachys grandiflora,* Datiwan: *Achyranthes bidentata,* etc.) wood products (Examples:- Sal: *Shorea robusta*, Kalo Siris:- *Albizia lebbek*, Utis:- *Alnus nepalensis*, etc.) ornamental plants (examples:-Dhupisalla: *Juniperous indica*, Dhupi : *Cryptomeria japonica*, etc.), population reservoirs, future resources, etc. (Biological Services); and research, education, monitoring, recreational and tourism, and cultural values are the social services provided by the diverse biodiversity of the municipality. The presence of rich and fertile soil, most of the green pollinated fruits and vegetables of the areas, etc. of the area is possible with its high diversity. The presence of diverse climatic conditions (tropical, subtropical, and lower temperate) in the 85 km2 and the altitudinal variation supports different species of mammals (examples:- Golden Jackal: *Canis aureu*s, Common leopard: *Panthera pardus*, etc.) amphibians (examples: Asian Common toad: *Duttaphrynus melanostictus*, etc.) reptiles (examples:- Red Salamander (Pani Gohoro): *Psedotriton ruber*, etc.) birds (examples:- Silver-eared Mesia: *Leiothrix argentauris,* Red-billed Leiothrix: L*eiothrix lutea*, etc.) and vegetation. For example, Marx et al. 1999 mentioned in his study that the study on the relation of soil erosion to vegetation cover shows that the vegetation binds the soil particles and minimizes the effects of water runoff. Hence, we can justify that the vegetation covers of the present area are minimizing the loss of nutrient content soil ultimately supporting the nutrient storage and cycling. Likewise, cultivation of crops is to a large extent dependent on the availability of pollinating insects. A report from IRGC, 2008 mentioned that the pollinators produce one-third of all our foods, fruits, and vegetables. Consequently, the area with high floral species and pollinators, such as bees, might be supporting the variety of food, fruits, and vegetables. It is possible to justify that the production is dependent on the biodiversity of the pollinators of the area. For example, cardamom is one of the highly produces cash crops in the area. A research by Pattanshetti et al, 1973) mentioned that 98% of flower visitors of the cardamom are honeybees and they play a major role in boosting cardamom yields. Likewise, Suryodaya is also renowned for the tea *(Camellia sinensis)*, and the pollination of tea is possible with the insects of order Diptera. One of their most prominent characteristics is they consist one pair of membranous wings. Hence, the pollinators are an inevitable factor for flourishing tea shrubs of the Suryodaya Municipality. Similarly, the economy of the municipality is also based on animal husbandry and thousands of inhabitants are directly involved in animal dairy productions. Local inhabitance from the area highly depends on the natural resources for their domestic livestock which is possible only because of high availability of fodder species. In addition, tourism is one of the important components of the area. On a yearly basis, thousands of tourists visit the area for different activities like research, education, monitoring, recreational, aesthetic, and cultural values. Kanyam is a major hotspot and centre of attraction for tourist. The aesthetic and recreational values

of this area are the reason to attract the tourist. Once we link the biodiversity with culture, the area is even more important on the community level. For example, the major inhabitants of this region are Rais and Limbus. They are culturally rich & dependent on diverse biological resources. They use some, selected vegetation in cultural ceremonies like pooja and marriages. The best example would be Sal's leaves that are widely used on these occasions. *Dhan Nach* (Rice harvesting dance) is celebrated by indigenous communities and limbus wedding is incomplete without the piglet and local alcoholic beverages prepared from rice and barley and the goddess worshipped in the marriage are enshrined in evergreen *Cynodon dactylon* (Dubo). Similarly, the Rai celebrate *Udhauli* and *Uvauli* festivals to thank nature for good harvest. These endemic traditional practices are linked with biodiversity and increase the cultural values of the area. *Panchakanya* is a famous holy pilgrimage in the municipality where thousands of tourists come to worship goddess *Panchakanya*. Therefore, we can conclude that the presence of this diverse flora and fauna in the Suryodaya municipality increases the scope of tourism. Further, these all offers the opportunities for small to large enterprise investments and local employment that helps them to sustain their daily lives. However, there are needs for different activities like protection of the forest, basic infrastructure development (hotels, lodges, and information centers), training, awareness raising and waste management.

The conversion of the land into human-use has led on forest encroachment, habitat loss and fragmentation in the Suryodaya Municipality. The loss of space, resource, and continuous habitat fragmentation has converted the habitat into small and isolated patches. This has changed the meta-population dynamics of the species and gene flow. Consequently, the survival rate of the species decrease and hence increases the vulnerability of the species to extinct through demographic and environmental stochasticity, genetic drift, inbreeding depression, and Allee effects as described in Fischer and Lindenmayer (2007). So, it is necessary to connect these patches through corridors which are multifunctional. They act as a safety valve for the movement of the animal through the protected habitat. This dispersal of animals reduces the extinction rates by increasing the intra-fragment movements which allow exchanging the gene flow between the isolated population. Hence, the corridors help to maintain the genetic diversity and species richness. Similarly, corridors are also helpful to provide supplementary feeding habitat for animals. This helps to reduce the human-wildlife conflict. So, to conserve the biodiversity of the Suryodaya Municipality, we suggest the corridor concept.

The major threats to biodiversity are degradations, alterations, or loss of the habitats caused by humans and its developmental activities. So, we recommend the involvement of the community to conserve the biodiversity as they are the "owners" of their resources, and their support for conservation and sustainable use depends on their responsibilities, concerns, and management. Trisurat 2006 suggested that community-based conservation is a better alternative than the state controlled management of resources on the aspect of reducing conflicts and management effectiveness. This Preliminary biodiversity assessment report could be a reliable source that provides detailed information to the community for participatory based management of their diverse flora and fauna.

One of the effective tool to ensure local wellbeing, conservation and the safeguard of these service providing ecosystem can be community participation in their conservation. Therefore, (community-based) participatory management of biodiversity should be preferred for the long term and effective conservation of this variety of flora and fauna of Suryodaya Municipality.

There are different challenges that should be address to promote the biodiversity conservation in this study areas analyzed, the major threats to biodiversity conservation are alien invasive species, unsustainable agricultural practices like the use of inorganic fertilizers and pesticides that suppresses the pollinators, absence of an integrated/coordinated approach to manage biological resources, lack

of environmental awareness and sensitivities, inadequate research and findings, loophole in policies or strategies for biodiversity conservation, low level of public information and participation, high incidence of poverty etc. The possible solutions to overcome these challenges are an endorsement of indigenous knowledge and innovations, awareness raising, sustainable agricultural practices, participatory approach in conservation, cross-sectorial coordination and implementation of policies, support for biodiversity research and conservation, ecotourism promotion. The preliminary biodiversity assessment provides the possible number of flora and fauna, and the need of biodiversity. It also reflects the challenges in conservations. Hence, detail assessments are required to quantify the biodiversity and to develop a concrete local policy to conserve them.

Acknowledgments

We would like to acknowledge Suryodaya Municipality for providing us with the opportunity to carry out the preliminary biodiversity assessment of Suryodaya Municipality. Similarly, we would like to express our heartfelt gratitude to the field technician Mr Harkaman Lama and Mr Purna Lama (the technical staff of NTNC), and Jaya Rai and Sonam Yalmo without whom the data collection of the field would not have been completed. We would also like to express our appreciation to Mr Santosh Bhattarai (Conservation Officer, NTNC) for his generous suggestions in the methodology section. Furthermore, we would like to thank the Executive Officer of Suryodaya Municipality Mr Rajendra Bhattarai and other staffs for their coordination and support. We are immensely thankful to Karphok Campus especially Mr Jarsing Rai (Campus Chief) and other faculty members namely Subas Rai and Khagendra Pradhan. Also, we would like to thank all the community members for active participation and consultation. We would also like to gratefully recall the contributions of Officers of NTNC-BCC namely, Mr Ram Kumar Aryal, Mr Baburam Lamichhane, Mr Shashank Poudel, Ms Lina Chalise, Dr Aashish Gurung, and Dr Amir Sadaula (Veterinary Doctor, NTNC) in the successful completion of this assessment. We appreciate the support of different non-governmental organisations that helped directly or indirectly during the field survey.

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Burrow Characteristics and Vegetation Analysis of Pangolin Habitat in Sundarijal Forest of Shivapuri Nagarjuna National Park

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Abstract

Tracking pangolin on foot or with radio-telemetry is difficult because of it solitary and nocturnal nature, tiny foot prints and droppings, and their preference to mountain areas and hill slopes. Studying the nature of the burrows and habitat selection could be a good option. Diurnal walking surveys, GPS tracking and quadrate method were employed to study the burrow characteristics and vegetation around the burrows of pangolin. Result from desk review and field study shows that pangolin prefers sunny hill slopes between 30°- 60°with brownish red to yellowish red soil, mostly south facing burrows which are circular externally and curved internally. The diameter of the burrows ranges from 20- 30 cm. Altogether 59 species (9 trees, 14 shrubs and 36 herbs) were reported from vegetation analysis focusing on the burrows of pangolin. Result shows that pangolin prefer to build their burrows in the forest dominated bytrees like Castonopsis tribuloides, Pinus ruxburghii,Schima wallichii,shrubs like Lute Lyonia ovalifolia, Rubus ellipticus,Simlax macrophyllaand herbs like Arundinella nepalensis, Dryopteris filixmas, Cyperus kyllinga. Identifying and reducing anthropogenic activities in forest landscapes preferred by pangolin will help to protect their habitat and allow their population to flourish naturally.

Keywords : *Burrows, Habitat, Vegetation Analysis, Sundarijaal*

Introduction

A pangolin (also referred to as a scaly anteater or trenggiling) is a mammal of the order Pholidota. The one extant family, Manidae, has one genus, Manis, which comprises eight species (Nowak, 1999). It is found naturally in tropical regions throughout Africa and Asia (Gaudin et al., 2009). In Nepal only two species are recorded: Chinese (*Manispentadactyla*) and Indian pangolin *(M. crassicaudata)* (Chalise, 2008). Pangolins are found in a variety of habitats including tropical and flooded forests, thick brush, cleared and cultivated areas, and savannah grassland; in general they occur where large numbers of ants and termites are found (Nowak, 1999). In Nepal they are found to occur in the sunny slopes of Kathmandu, Bhaktapur, Dhading, Kavre, Ramechap, Sindhuli Gorkha, Bardia, Sankhuwasabha, Sindhupalchok, Taplejung (Chalise 2000; Bahndari & Chalise, 2014; Acharya et al., 1993; Gurung, 1996; Kaspal, 2008; Suwal, 2011; Thapa et al., 2014).In Nepal, Chinese pangolin is listed as a protected mammal in National Parks and Wildlife Conservation Act, 1973, endangered in IUCN Red List Data and appendix II of the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2000). From 2000, CITES has banned all commercial trade in pangolins and their parts (Shepherd, 2009).Yet, it is one of the highest traded and hunted species in Nepal (YAE and WWF, 2016). Pangolins are solitary mammals, nocturnal, highly secretive, thus it is difficult to study them in the wild and track on foot with radio-telemetry because of their preference to mountain area or hill slopes, with dense cover in their habitats and tiny footprints and droppings (Ganguly, 2013; Wu et al., 2003). Thus understanding the nature of burrows and their preference to vegetation is important. This study aims to study the burrows characteristics of pangolin and carry out vegetation analysis focusing on the burrows in Sundarijal forest of Shivapuri Nagarjuna National Park.

Materials and Methods

Study Area

This study was carried out on the southern slope of Sundarijal area of Shivapuri Nagarjun National Park (Figure 1). Shivapuri Nagarjun National Park is the ninth national park in Nepal and was established in 2002. It is located in the country's mid-hills on the northern fringe of the Kathmandu. Shivapuri Nagarjuna National Park covers large amounts of the Sundarijal area. The area is transition zone between subtropical and temperate climate. The vegetation consists of a variety of natural forest types including pine, oak, rhododendron etc, depending on altitude and aspect. Mammalian species such as Himalayan Black bear, leopard, jungle cat, and rhesus monkey are recorded. The park is also home to 177 species of birds, including at least 9 threatened species, 102 species of butterflies with a number of rare and endangered species, and 129 species of mushroom (Bhuju et al., 2007).

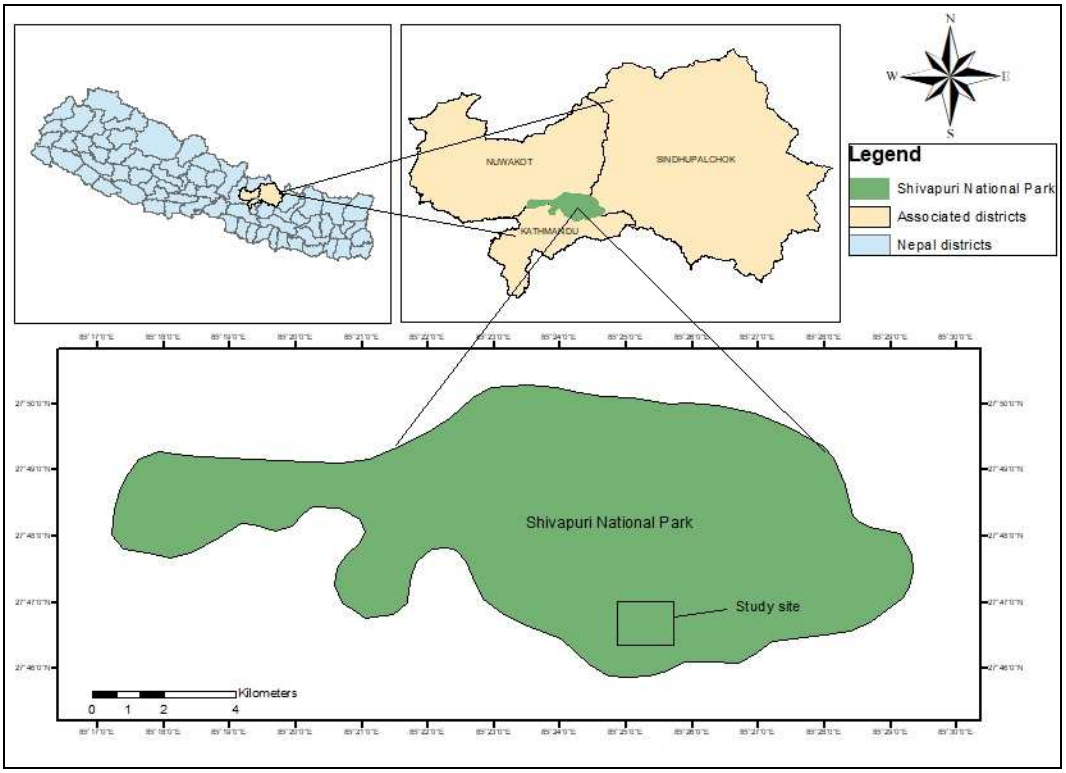

Figure 1. Map of Study Site

Before making field surveys intense desktop review was done to understand the nature and type of burrow and also to identify the burrow through the visual inspection by observing the type of slope, soil and vegetation. Diurnal walking surveys were made along the vertical transect and signs such as tracks, active or passive burrows were observed to locate the habitat of Pangolin. Diurnal surveys commenced between 09:00 and 18:00 hrs. Walking was at a slow pace and noise kept to a minimum. Periodically stopping for periods of at least five minutes to assess the surroundings, burrows were analyzed to determine if it belong to pangolin. The dimension and nature of burrows, nature and type of soil and the type of surrounding vegetation were carefully observed to match with the reviewed literature. The burrows were captured through camera and the location was tracked through GPS. However, additional night surveys and camera trapping were not conducted due to security reasons.

Once the burrows of pangolin were identified, quadrate method was used to analyze the vegetation of that area. Quadrates of size 25mx 25m were laid keeping the burrows at the center of the quadrate for sampling trees. Within the 25mx 25m area, quadrates of 5m x 5m and 1m x 1m were laid for sampling shrubs and herbs respectively. Altogether 4 quadrates were laid for trees, 12 for shrubs and 20 for herbs. Species identification was done with reference to Rajbhandari et al. (1986). Frequency, density, abundance, relative coverage, important value index (IVI), ecological dominance, Shannon's species diversity index and evenness were calculated separately for herbs, shrubs and trees.

Results and Discussion

Burrow Characteristics

About 3 km northeast of the Sundarijal Dam, on the SE facing slopes various active and passive burrows of Pangolin were marked. Four sites of burrows were taken for study. The distribution of burrows and their characteristics is given in Table 1.

Table 1. Distribution of Burrows and Their Characteristics

Location	Status/ Nature of Burrow	Diameter of Burrow	Slope	Soil Characteristics	Other Features
N 27º46.612'					
E 85º25.378'					
Elev. 1649 m	Passive	25 cm	38º	Reddish grey sandy	Circular, Curved
N 27º46.604'					
E 85 º25.377'					
Elev. 1645	Passive	28 cm	45º	Dark yellowish clay	Circular, Curved
N 27º46.646'					
E 85º25.39					
Elev. 1655m	Active	21 cm	42º	Red sandy clay	Circular, Surrounded by ants and termites, fresh pile of soil in front of the burrow, Curved
N 2746.69' E 8525.471' Elev. 1640m	Passive	26 cm	35º	Reddish Brown clay	Curved

The burrows were exactly circular in shape externally while curved internally. Diameter of the burrow varied from 21-28 cm. The soil color was reddish which varied from reddish brown to yellowish brown. The soil was sandy type and was smooth and loose. The surrounding was neither too damp nor too dry however, sufficient sunlight was falling on the burrows. Many ants and termites were moving around the burrows in case of active ones. Less deep feeding burrows were also observed around the active burrows. However, no live specimen of pangolin was observed during the field survey. Our observation of burrow characteristics was supported by several other studies.

For instance, Wu et al. (2003) shows that 89.87 % of pangolin burrows were established at 30-60° slopes. Shrestha (2005) had found the burrows in red soil at open forests with less coverage in Shivapuri National Park. Similarly, Bhandari and Chalise (2014), Suwal (2011), and Kaspal (2008) showed presence of burrows in red and brown soil which is consistent with this study. Out of the 211 burrows studied by Thapa et al. (2014) in Taplejung most of the burrows were present in forest (136) and agricultural land (65), thus indicating pangolins' preference to forest.

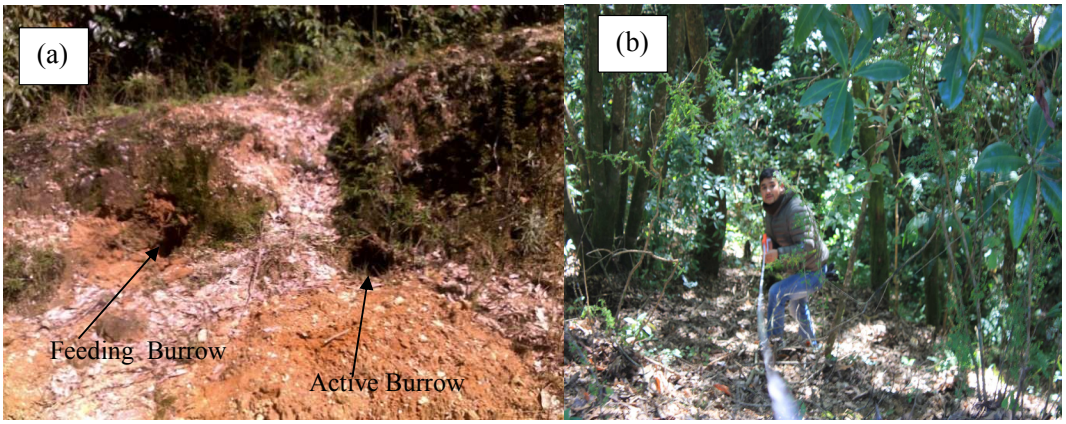

Figure 2. Pangolin Burrow in Study Site (a), Laying Quadrate for Vegetation Analysis (b)

Vegetation Analysis

The vegetation analysis was carried around the burrows of Pangolin. The study area had natural forest which has been protected for more than a decades. Grazing and collection of fallen branches for fuelwood were frequent while felling for timber was not observed.

Table 2. Result of Vegetation Analysis for Herbs (1m X 1m) at different sites (F- Frequency, RF- Relative Frequency, FC- Frequency Class, D- Density, RD- Relative Density, C- Coverage, RC- Relative Coverage, IVI- Important Value Index, H- Shannon Species Diversity Index, ED- Ecological Dominance)

Site	S.N.	Herbs	F	RF	FC	D (per m²)	RD	C	RC	IVI	ni/Nlog ni/N	ED
	1	*Arundinella nepalensis*	100	10	E	57.20	32.95	34	34	76.95	-0.53	0.109
	2	*Cyperus niveus*	60	6	C	5.20	3.00	3	3	12.00	-0.15	0.001
	3	*Hedyotis paniculata*	100	10	E	7.20	4.15	5	5	19.15	-0.19	0.002
	4	*Imperata cylinderica*	100	10	E	20.00	11.52	11	11	32.52	-0.36	0.013
	5	*Lycopodium clavatum*	20	2	A	2.40	1.38	2	2	5.38	-0.09	0.000
	6	*Sonchus arrenisis*	60	6	C	10.60	6.11	6	6	18.11	-0.25	0.004
	7	*Nephrolepis cordifolia*	60	6	C	12.40	7.14	7	7	20.14	-0.27	0.005
	8	*Cautleya spicata*	80	8	D	19.60	11.29	12	12	31.29	-0.36	0.013
	9	*Hypoxis aurea*	60	6	C	16.00	9.22	9	9	24.22	-0.32	0.008
	10	*Botrychium multifidum*	60	6	C	3.20	1.84	2	2	9.84	-0.11	0.000
	11	*Drymaria diandra*	60	6	C	6.80	3.92	2	2	11.92	-0.18	0.002
	12	*Stellaria patens*	40	4	B	1.40	0.81	1	1	5.81	-0.06	0.000
	13	*Eupatorium adenophorum*	60	6	C	4.00	2.30	2	2	10.30	-0.13	0.001
	14	*Dryopteris filixmas*	60	6	C	6.20	3.57	2	2	11.57	-0.17	0.001
	15	*Cyperus kyllinga*	40	4	B	0.80	0.46	1	1	5.46	-0.04	0.000
	16	*Ainsliaea latifolia*	40	4	B	0.60	0.35	1	1	5.35	-0.03	0.000
		Sum	1000	100		173.6	100	100	100	300	H=3.21	
II	1	*Athyrium filix*	100	20	E	8.20	21.03	22	22	63.03	-0.47	0.044
	2	*Cyperus kyllinga*	60	12	C	8.20	21.03	22	22	55.03	-0.47	0.044
	3	*Nephrolepis cordifolia*	80	16	D	6.80	17.44	18	18	51.44	-0.44	0.030
	4	*Cyperaceae digitaria*	20	4	A	0.60	1.54	2	2	7.54	-0.09	0.000
	5	*Botrychium multifidum*	100	20	E	4.40	11.28	11	11	42.28	-0.36	0.013

Site	S.N.	Herbs	F	RF	FC	D (per m²)	RD	C	RC	IVI	ni/Nlog ni/N	ED
	6	*Drymaria diandra*	20	4	A	2.40	6.15	7	7	17.15	-0.25	0.004
	7	*Stellaria patens*	80	16	D	2.60	6.67	5	5	27.67	-0.26	0.004
	8	*Curcuma longa*	20	4	A	0.60	1.54	2	2	7.54	-0.09	0.000
	9	*Tridex sp.*	20	4	A	5.20	13.33	11	11	28.33	-0.39	0.018
		Sum	500	100		39	100	100	100	300	H=2.82	
III	1	*Dryopteris filixmas*	80	10.81	D	3.00	6.58	6	6	23.39	-0.26	0.004
	2	*Cyperus kyllinga*	100	13.51	E	7.00	15.35	12	12	40.86	-0.42	0.024
	3	*Nephrolepis cordifolia*	60	8.11	C	3.80	8.33	9	9	25.44	-0.30	0.007
	4	*Cyperaceae digitaria*	80	10.81	D	6.20	13.60	11	11	35.41	-0.39	0.018
	5	*Botrychium multifidum*	60	8.11	C	6.20	13.60	14	14	35.70	-0.39	0.018
	6	*Drymaria diandra*	60	8.11	C	4.80	10.53	8	8	26.63	-0.34	0.011
	7	*Stellaria patens*	40	5.41	B	1.60	3.51	5	5	13.91	-0.17	0.001
	8	*Curcuma longa*	100	13.51	E	6.00	13.16	15	15	41.67	-0.38	0.017
	9	*Dioscorea bulbifera*	40	5.41	B	1.80	3.95	5	5	14.35	-0.18	0.002
	10	*Chilanthus anceps*	80	10.81	D	4.20	9.21	12	12	32.02	-0.32	0.008
	11	*Satyrium nepalense*	40	5.41	B	1.00	2.19	3	3	10.60	-0.12	0.000
		Sum	740	100		45.60	100	100	100	300	H= 3.27	
IV	1	*Athyrium filix*	100	10.87	E	10.80	11.11	12	12	33.98	-0.35	0.012
	2	*Cyperus kyllinga*	100	10.87	E	13.40	13.79	14	14	38.66	-0.39	0.019
	3	*Nephrolepis cordifolia*	80	8.70	D	11.40	11.73	9	9	29.42	-0.36	0.014
	4	*Cyperaceae digitaria*	60	6.52	C	8.20	8.44	9	9	23.96	-0.30	0.007
	5	*Botrychium multifidum*	80	8.70	D	6.20	6.38	8	8	23.07	-0.25	0.004
	6	*Drymaria diandra*	40	4.35	B	3.80	3.91	4	4	12.26	-0.18	0.002
	7	*Stellaria patens*	80	8.70	D	9.80	10.08	10	10	28.78	-0.33	0.010
	8	*Curcuma longa*	20	2.17	A	0.40	0.41	2	2	4.59	-0.03	0.000

Site	S.N.	Herbs	F	RF	FC	D (per m²)	RD	C	RC	IVI	ni/Nlog ni/N	ED
	9	*Dioscorea bulbifera*	80	8.70	D	5.60	5.76	6	6	20.46	-0.24	0.003
	10	*Chilanthus anceps*	40	4.35	B	1.40	1.44	1	1	6.79	-0.09	0.000
	11	*Satyrium nepalense*	80	8.70	D	5.20	5.35	4	4	18.05	-0.23	0.003
	12	*Bidens biternata*	20	2.17	A	2.00	2.06	3	3	7.23	-0.12	0.000
	13	*Isachne albens*	40	4.35	B	5.60	5.76	4	4	14.11	-0.24	0.003
	14	*Ageratum Conyzoides*	20	2.17	A	2.40	2.47	2	2	6.64	-0.13	0.001
	15	*Arundinella nepalensis*	40	4.35	B	2.60	2.67	3	3	10.02	-0.14	0.001
	16	*Cynodon dactylon*	20	2.17	A	2.40	2.47	2	2	6.64	-0.13	0.001
	17	*Eupatorium adenophorum*	20	2.17	A	6.00	6.17	7	7	15.35	-0.25	0.004
		Sum	920	100		97.20	100	100	100	300	H=3.77	

Table 3. Result of Vegetation Analysis for Shrubs (5m X 5m) at Different Sites

Site	S.N.	Shrubs	F	RF	FC	D (per m²)	RD	C	RC	IVI	ni/Nlog ni/N	ED
I	1	*Lyonia ovalifolia*	100	18.75	E	0.45	16.75	17	17	52.50	-0.43	0.028
	2	*Rubus ellipticus*	100	18.75	E	1.20	44.33	42	42	105.08	-0.52	0.197
	3	*Sarcococca coriacea*	66.67	12.50	D	0.43	15.76	14	14	42.26	-0.42	0.025
	4	*Docynia indica*	66.67	12.50	D	0.03	0.99	2	2	15.49	-0.07	0.000
	5	*Melastoma malabathricum*	66.67	12.50	D	0.15	5.42	6	6	23.92	-0.23	0.003
	7	*Berberis asiatica*	33.33	6.25	B	0.01	0.49	1	1	7.74	-0.04	0.000
	8	*Cassia mimosoides*	66.67	12.50	D	0.41	15.27	16	16	43.77	-0.41	0.023
	9	*Clematis buchananiana*	33.33	6.25	B	0.03	0.99	2	2	9.24	-0.07	0.000
		Sum	533.33	100		2.71	100	100	100	300	H= 2.18	
II	1	*Lyonia ovalifolia*	66.67	50.00	D	0.05	57.14	55	55	162.15	-0.46	0.327
	2	*Simlax macrophylla*	66.67	50.00	D	0.04	42.86	45	45	137.86	-0.52	0.184

Site	S.N.	Shrubs	F	RF	FC	D (per m²)	RD	C	RC	IVI	ni/Nlog ni/N	ED
		Sum	133.33	100		0.09	100	100	100	300	H=0.99	
III	1	*Simlax macrophylla*	100	27.27	E	0.24	54.55	52	52	133.82	-0.48	0.298
	2	*Rubus ellipticus*	66.67	18.18	D	0.04	9.09	9	9	36.27	-0.31	0.008
	3	*Norysca cordifolia*	66.67	18.18	D	0.03	6.06	8	8	32.24	-0.25	0.004
	4	*Mahonia nepaulensis*	33.33	9.09	B	0.03	6.06	9	9	24.15	-0.25	0.004
	5	*Cretagus crenulata*	33.33	9.09	B	0.07	15.15	12	12	36.24	-0.41	0.023
	6	*Zizypus incurva*	66.67	18.18	D	0.04	9.09	10	10	37.27	-0.31	0.008
		Sum	366.67	100		0.44	100	100	100	300	H=2.01	
IV	1	*Norysca cordifolia*	66.67	66.67	D	0.04	60.00	57	57	183.66	-0.44	0.360
	2	*Daphne bholua*	33.33	33.33	B	0.03	40.00	43	43	116.33	-0.53	0.160
		Sum	100	100		0.07	100	100	100	300	H=0.97	

Table 4. Result of Vegetation Analysis for Trees at four sites (25 m X 25 m)

S.N.	Trees	F	RF	FC	D(per m²)	RD	C	RC	IVI	ni/Nlog ni/N	ED
1	*Schima wallichii*	100	23.53	E	0.0064	10.60	11	11	45.13	-0.34	0.011
2	*Pinus ruxburghii*	25	5.88	B	0.0108	17.88	16	16	39.76	-0.44	0.032
3	*Alstonia scholaris*	50	11.76	C	0.006	9.93	10	10	31.70	-0.33	0.010
4	*Castonopsis tribuloides*	75	17.65	D	0.0284	47.02	44	44	108.67	-0.51	0.221
5	*Rhododendron arboreum*	75	17.65	D	0.0056	9.27	12	12	38.92	-0.32	0.009
6	*Alnus nepalensis*	50	11.76	C	0.0024	3.97	4	4	19.74	-0.18	0.002
7	*Fraxinus floribundus*	25	5.88	B	0.0004	0.66	2	2	8.54	-0.05	0.000
8	*Madhuca butyracea*	25	5.88	B	0.0004	0.66	1	1	7.54	-0.05	0.000
	Sum	425	100		0.0604	100	100	100	300	H=2.23	

Altogether 59 species (9 trees, 14 shrubs and 36 herbs) were reported from the study site. More than half of the species were herbs. Species diversity index was found to be highest in site I 27 followed by site IV, III and II. The diversity was highest in site II for trees, site I for shrubs and site IV for herbs while it was lowest in site I (trees), site IV (shrubs) and site II (herbs).This study also showed that there is a very significant strong positive relationship ($r > 0.8$)between Important Value Index (IVI) and Ecological Dominance (ED) ($p<0.001$) which indicate that the most dominant species in a site is also the most important species for that site. The highest number of species (27) was found in site I. But in site II comparatively lower number of species were reported. This may be due to the mature forest with almost closed canopy and trees were large, so the number of species was low in site II. In case of site I, lower number of trees species compared to other site is because it is pine-dominated forest. *Castonopsis tribuloides* is most dominant among tree species followed by *Alnusnepalensis, Schima wallichii, Pinus ruxburghii, Alstonia scholaris* (Table 4).Generally pine forest has lower plant biodiversity compared to broadleaved but higher shrub diversity was reported in pine forest than broadleaf forest. *Lyonia ovalifoliais* most dominant species among shrub species(Table 3). This is followed by *Rubus ellipticus, Simlax macrophylla, Mahonia nepaulensis.* The most dominant shrubs in site I, site II and siteIII were Rubus ellipticus, Lyonia ovalifolia and Simlax macrophylla, respectively. Highest density of shrub species was present in site I followed by site III and site II. This may be due to the highly elevated pine forest with almost open canopy and the ground surface exposed to direct sunlight in site I. *Arundinella nepalensis* is most dominant species among herbs species. *Dryopteris filixmas, Cyperus kyllinga, Cyperaceae digitaria, Curcuma longa* are other associated species(Table 2). The dominant species in site I, site II, site III and site IV were *Arundinella nepalensis,Dryopteris filixmas & Cyperus kyllinga* respectively. Highest density of herbs species was present in sit I followed by site IV, site III and site II. This study shows that Pangolin prefers forest with mixed types of vegetation mainly conifers and broadleaf forest. This result is consistent with Wu et al. (2003), which concluded that mixed conifers broadleaf forest was favorite habitat for pangolins and conifers forest was avoided by pangolins. This is likely because termites as pangolins' food are rather abundant in mixed forests. A very similar result was observed by Bhandari and Chalise (2014) in a study carried out in Nagarjuna forest of the same national park which showed that the burrows were mostly distributed at the range of 1450-1550 m and were also recorded beyond 2000 m, northwest aspect, in the habitat dominant with *Schima wallichii, Castonopsis tribuloides*, and *Castonopsis indicain* the canopy cover between 25-50% in brown soil with herbs and shrubs dominated by *Dryopteris sp., Imperata cylindrica, Nephrolepis auriculata, Berberis asiatica and Rubus ellipticus.* However, studies like Mahmood et al. (2015) indicate that habitat preference of pangolin is site specific and may vary from season to season. Thapa et al. (2014) found that burrows were mainly *Imperata cylindrical, Nephrolepis auriculata, Dendrocalamus, Ficus nerifolia* and *Pinus roxburghiiand* 38 species were associated with the burrows.

Conclusion

Though documented as protected species, frequent seizures of pangolin and their parts indicate that they are hunted and traded excessively in Nepal. Deforestation and fragmentation of forest for cultivation has altered their habitats, thus affecting their populations. Pangolins are found to inhibit in the patches of land with specific soil types and vegetation. Identifying and reducing anthropogenic activities in such patches of land preferred by these scaly ant eaters will help to protect their habitat and allow their population to flourish in the wild. Further study is necessary to estimate the population and assess the threat of pangolin in Shivapuri Nagarjuna National Park.

Acknowledgements

We are thankful to chief warden of Shivapuri Nagarjun National and Department of National Park and Wildlife Conservation (DNPWC) for allowing us to carry out this research work.

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Effect of Climate Change on Agro-ecosystem Services and the Adaptation Measures in Nepal

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Abstract

A review was made to access the climate change impact on agro-ecosystem services in Nepal in the year 2016. Nepal's contribution (both agriculture and non agriculture) to green house gases emission and global warming is negligible but the overall impacts on agro-ecosystem services are negative except some positive impact in natural control. Increased CO_2 is expected to have positive effects by increasing the population of the natural enemies. However, higher intensity of abiotic (heat and water) stresses and biotic (intra and inter species competitions) because of global warming impacted on pollination, decomposition, symbiosis and the natural control, thus affecting overall plant growth and reproduction. To overcome the problems; documentation of the evidences, vulnerability assessment, listing the possible adoption measures with awareness raising, policy lobbing and step ahead for the implementation of the research, conservation and management of agro-ecosystem servicers and environment friendly activities for the climate change resilience and restoring agro ecosystem services for crop production in Nepal is needed.

Keywords : *Ecosystem, Pollination, Decomposition, Symbiosis, Natural Control.*

Introduction

The climate change is a natural phenomenon related to changes in the concentration of the greenhouse gases (water vapor, CO_2, CH_4, N_2O, SO_2, CFCs, PFCs, HFCs, SF_6, etc.) in the atmosphere of the earth's surface, which trap infrared radiation and thus cause the greenhouse effect resulting changes in the air temperature, precipitation patterns, sea-level rise, and melting of glaciers. Human activities, such as fossil fuel combustion, deforestation, and some industrial processes have led to an increase in greenhouse gases concentration (Central European University, 1999). An Agro ecosystem is formed by dynamic interactions between living and non-living elements in a defined area. Each element has its special characteristics and role in the system that, as a function of time and place, will influence the distribution and population of living organisms. The term ecosystem also involves nutrient and energy flows within the system. Living elements include plants, insects (pests, pollinators, natural enemies, symbiotic agents and decomposers), microbes and other living organisms. Non-living elements comprising weather components such as: temperature, relative humidity, wind, sunshine, rain and soil. There are some examples of climatic change effects on agro-ecosystem in Nepal. Among them the effect on food chains, natural control, decomposition of organic matter, symbiosis and pollination are most important.

Natural Control

Natural control is the ecological management option against the insect pests which emphasized on the natural balance of the population of natural enemies and the pest. The natural enemies are the living organism that kills injuries or causes disease in pests. It has been estimated that insects that function as predators, parasites and parasitoids provide five times more benefits to agricultural production than the damage caused by pest species (esask.uregina.ca/entry/crop_pests.html.). Animals that hunt and eat other animals are the predators. They have to consume many prey individuals in order to

live. Their bodies are designed to hunt, catch, kill and eat the prey. They generally have strong teeth or mouth-parts, sharp vision and strong legs eg. Ear wing, Rove beetle, Spider, Ladybird beetles, predatory Ants, Lace wing nymph, Ants, Tiger beetles etc. They do have distinct food web (Fig-1). Parasites consume other organisms but by entering the body of their victims and obtaining nourishment from their fluids and tissues, which weakens or even, kills the victims called host. The developing larva of the parasitic insect lives in or on the egg or body of the host, slowly weakening the host insect, which thus cannot complete its development eg. Species of wasps or flies eg. bracon, aphidus, etc. Insect parasites can be classified as follows:

- Egg parasites lay their eggs in the eggs of other insects eg. *Trichogramma chilonis* and *T. Achaeae*, against *Helicoverpa armigera*
- Larval parasites lay their eggs in or on the larval stage of other insects eg. *Cotesia plutella* and *Diadegma semiclausum* against diamond back moth
- Pupal parasites develop in the pupal stage of other insects
- Some parasites develop in the nymphal or adult stage of their hosts.

Pathogens are the micro-organisms that cause disease to pests. They enter the body of their host, living and multiplying within and hence weakening and finally killing the host. Some pathogens require more than one kind of host in order to complete their life cycles. Bacteria, fungi and viruses are kinds of pathogens. Insects attacked by pathogens are usually swollen, exhibit colour changes, move slowly, often stop eating and may be covered with a powdery substance. Example: *Bacillus thuringiensis,* nuclear polyhedrosis viruses (NPV), *Metarhizium, Trichoderma, Beuveria* etc.

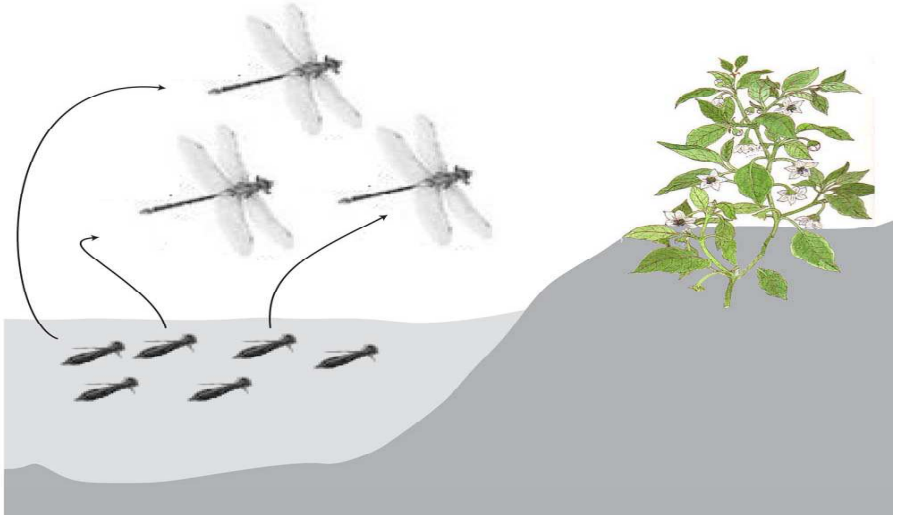

Fig-1: The Food Web of NE

Predators, parasites and parasitoids provide an essential ecosystem service that contributes to the natural control and population balance. Natural enemies (NE) and pests are co-evolved. A minimum level of pest population is needed to maintain the NEs population. NEs are self propagating, but some time need to artificial rearing and manipulate the population in agro ecosystem. Majority of the natural enemies also serve as crop pollinators and some helps on decomposition too. Natural control is environmentally sound and does not impart negative effect on ecosystem. However, the natural control services are seriously threatened due to the global warming and climate change at present,

thus limiting crop production md productivity in Nepal.

The Pollination Services

Pollination is the transfer of pollen from the male parts of the flower (the anther) to the female part (the stigma) of the same or a different flower of the same plant or the different plants. The pollen must be compatible, the stigma must recognize the pollen as being from the same or similar plant, and must allow the pollen to fertilize its ovules. The fertilization of the ovule and seed formation will occur. Pollinators are rewarded with necaterious nectar and non necaterious nectar for CHO and pollen for protein supplement.

Pollinators provide an essential ecosystem service that contributes to the maintenance of biodiversity and ensures the survival of plant species. Pollinators and pollinating plants have the mutualistic relationships. Pollinators help on crop production both by quality and quantity. For many crops, there will be no production of seeds or fruit unless pollination occurs. More seeds develop when large numbers of pollen grains are transferred. However, the role of compatible pollen is important. Well pollinated seeds, in turn, stimulate the surrounding ovary tissue to develop so that, for example, an apple with many seeds will be larger than one with few seeds. In this way, pollination improves both fruit yield and seeds. Properly pollinated seeds hold larger seed vigor, longer viability, pose higher germination capacity, seedling vigor, pest resistance, and yielding capacity. Mustard seeds contain higher oil content. At present, the diversity and population of crop pollinators are decreasing in Nepal. It is because of climate change effects and wrong cultural practices of modern agriculture.

Decomposition (Rotting) Service

Decomposition is the process by which organic substances are broken down into simpler forms of matter. The process is essential for recycling the finite matter that occupies physical space in the biome. The abiotic decomposition means "degradation of a substance by chemical or physical processes, e.g. hydrolysis and the biotic decomposition (biodegradation) is the "metabolic breakdown of materials into simpler components by living organisms", typically by microorganisms (decomposers). Some of the dipterans are scavengers and help on decomposition. Some soil microbes help on decomposition of organic matter and helps on maintaining the soil fertility & nutrients availability in a sustainable way. Wrong agricultural practices like using agro-chemicals has impacted on decompositors and soil microbes threatening their natural population.

Symbiosis

It is the attachment/relationship/association of the organisms in which one organism lives on another in such a way that both of them benefitted each other. Some symbiotic bacteria and fungi help on nutrient fixation and mutualism. VAM, Agetobactor, Mycorrhizae, Rhizobium, Clostridium are some of the examples. Climate change and use of agro chemicals on crop production are some of the factors limiting the symbiosis service in agro ecosystem.

Objective of the Study

The overall objective of the study was to access the climate change impact on agro-ecosystem services in Nepal. However, the specific objectives were: to find the role of humidity, rainfall, sun light, temperature, CO_2 level and overall climate changes on the efficacy, efficiency, population and bio geography of pollinators, natural enemies, pest and weed infestation, population of decomposisers and the symbiosis agents and the effect on ecosystem services, crop growth, overall productivity and the adoption of agro-ecosystem management practices in Nepal.

Materials and Methods

An intensive review of literature was made. The review findings relevant to Nepalese context in Nepal and across the world were collected from different secondary sources. Findings were systematically reorganized to prepare the paper.

Results and Discussion

Weak Agro-Ecosystem Management

Farmers are almost ignoring natural control and crop pollination management of their crops. Regular agro-ecosystem analysis (AESA) and survey surveillances are lacking. Destroying the habitat (bund & ridge, natural and semi natural vegetation, deforestation, firing, etc.) and shortage of food resulted lower natural enemies and pollinators population. Alternative pest control methods and hand pollination of crop plants are costlier, tedious and not effective as natural control and natural crop pollination. Use of chemical fertilizers and pesticides is hampering the population of natural enemies, soil microbes and pollinators. Predators and pollinators are more exposed to pesticides. This is why the diversity and population of natural enemies and crop pollinators is decreasing, resulting failure in natural control and crop pollination. This is causing low crop production and productivity in Nepal.

Change in Population and Bio Geography of Pollinators and NEs

Climate change effects (low and high temperature, rainfall, humidity, hailstorm, frost) needed high degree of switching the genetic and behavioral adaptation of NEs, soil microbes and pollinators. Unfavorable environmental conditions specially rising temperature year after year, variable sun light intensity, in consistent humidity (soil and air), erratic and increasing rainfall with higher runoff over the years with dry and wet stresses influencing on the availability of food (pest, pollen & nectar and the organic matter), lacking suitable habitat for shelter and breeding, inter/intra species competition, higher pesticide risks with pest resurgence and outbreak has been threatened the agro-ecosystem services. This resulted changed in pest, predators, pollinators and soil microbes' biology and the populations. The migratory territory of *Apis dorsata* invaded to *A. laboriosa* areas up to 1200m. (Previous up to 1100m.) and *A. laboriosa* territory shifted to higher altitudes. Sometime, up to 1200-4100m (previous 850-3500m.) within a decade (Pokhrel 2009). All these phenomena affected the pollination ecology and the intensity of pollination of particular crop plants in a defined geography.

Climate Change Effect on Agro-Ecosystem Services

Overall climate change effect is somewhat favorable to natural enemies (NEs) and crop pollinators in Nepal. It has been estimated that with a 2°C temperature increase NEs and insect pollinators might experience 1-5 additional life cycles per season (Yamamura & Kiritani 1998). Increased temperature could increase pest populations which provide a field for NEs propagation (Coviella and Trumble, 1999). Each year NEs population is increasing by 10% given other factors constant. The insect parasitic nematodes and some other NEs are susceptible to extreme temperature (www.ext.colostate.edu/ pubs/insect/ 05573.html). The mycophagus fungi like *Metarhizium* and *Beuveria* are also are susceptible to extreme temperature and becomes non functional beyond 30°C. Some of the plant disease causing fungi eg *Stemphyllum* becomes parasitic with increased environment temperature beyond 30°C. This has been experienced with Lentil blight and Tomato blight in Terai and mid hills in recent years. These vulnerabilities have been created from the present climate changes in Nepal.

Effect of Humidity and Rainfall

The water content in predatory insects and insect pollinators varies from 50%-90% of total body weight. A constant supply of moisture is needed for metabolic reactions as well as for the dissolution and transport of salts within the body. They need genuine source of fresh water for body metabolism. Moisture effects on NEs and pollinators can be potentially important considerations in a global climate change setting (Hamilton et.al. 2005, Coviella and Trumble 1999, Hunter 2001). Majority of NEs & pollinators sluggish and become non-functional on low humidity < 57% (books.google.com/books?isbn=1405145714...). The percentage of moisture present in the soil has been known to influence the population of soil nesting NEs, soil microbes, decompositors and the symbiosis agents. The lengthen periods of high humidity and reduced drier condition favors most of the parasitic fungus to insect and pathogen and insect parasitic nematodes. Longipes (0.5mm.), the reddish predatory mites (feed on spider mites and other mites) requires greater humidity and higher temperature (www.naturalinsectcontrol.com/product.php?id=000000219). Some NEs and pollinators enter into diapauses at adverse relative humidity.

In Nepal the rainfall pattern is changing in season, duration, intensity and amount. Pre-monsoon rain, delay monsoon, unusual precipitation, decreased rainy days and increased intense rainfall events are the common features of rain fall with climate change. The number of annual rainy days decreased, dry days increased, evapo-transpiration increased (mid western Terai, Mustang, Ramechhap) and increasing number of rainy days with >100 mm rain. Increased evapo-transpiration also affects on soil moisture. The linear line of all Nepal's monsoon rainfall during the year 1971-2005 is in increasing trend. During the period, 1975, 1984 and 1998 were the years with peak total rain fall in Nepal (Baidya and Karmacharya, 2007). Precipitation changes in this pattern can impact on pollinators, soil microbes, predators, parasites and insect pest & diseases resulting in a complex dynamic agro-ecosystem. Some NEs and pollinators are sensitive to precipitation and are killed or removed from plants by heavy rains. Flooding the soil can damage the soil nesting predators, parasitoids and parasites and soil microbes. Soil erosion can reduces soil fertility and microbe's population. This made alteration on humidity and affecting agro-ecosystem services in Nepal. In addition, global warming would cause an increase in rainfall in some areas, which would lead to an increase of atmospheric humidity and the duration of the wet seasons in nepal. Combined with higher temperatures, these could favor the development of fungal diseases.

Effect of Sun Light

Higher intensity of sun light lowered the efficacy of microbial NE eg NPV, Metarhizium etc and desiccation to soft bodied predatory insects. Light is an essential ecological factor for many biological processes such as orientation or rhythmic behaviors of NEs, the periods of occurrence and activity. Optimum sun light is necessary for plant pollination. Anthesis and the pollen dehesion from the anther need a definite degree of sunlight and below which it seizes completely. Lower light intensity also hampers on nectar production. These phenomena helps on shifting behavior on pollinators eg honeybee on prolong brown clouds starts collecting propolish rather than pollen and nectars collection. This creates food shortage and stops brood rearing. Thus the population of the pollinator decrease and deficit pollination also reduces crop yield.

Effect of Higher CO_2 Levels

Nepal's contribution on CO_2 emission is only 9,747 Gg/yr (Nepal National Communication, 2004) but the global warming and climate change vulnerabilities are very high. CO_2 effects on NEs and insect pollinators can be potentially important considerations in a global climate change setting

(Hamilton et.al. 2005, Coviella and Trumble 1999, Hunter 2001). Increased CO_2 levels results denser canopies and provide larger hunting areas for the predators (Coviella and Trumble, 1999) and nesting site for the pollinators. Increased CO_2 concentration increases in the levels of simple sugars in plants may have stimulated the additional insect feeding and can also activate the predators to pest (Hamilton et al. 2005). Moreover, increased CO_2 concentration increases the C:N ratios in plant tissue resulting slow insect pest development and increase the length of life stages vulnerable to attack by parasitoids (Coviella and Trumble. 1999).

Effect of Temperature

Extreme temperatures can potentially affect NEs, pollinators and soil microbes' survival, development, geographic distribution, and population size. Temperature is probably the single most important environmental factor influencing pollinators and soil microbes and insect behavior, distribution, development, survival, and reproduction (Coviella and Trumble, 1999). Higher the temperature accelerates OM decomposition and nutrients exhaustion. Temperature can impact NEs physiology and development and can exert different effects (Bale et al 2002) eg. diapauses. Temperature <10°C and >35°C in maize causes pollen sterility, failure in pollen shedding and imparts silk balling, that influences pollination service. Foraging of pollinators depends on temperature and other climatic conditions. The optimum temperature for natural control varies to the type of predators and the prey. Aphidius can be effective and functional with the average temperature of 50F or above (www.greengardener.co.uk/product.asp?id_pc=4 &cat=4&id...). Whitefly parasites can only control greenhouse whiteflies if daily average temperatures exceed 72 to 75°F (www.vegedge.umn.edu/vegpest/beneficials /glw.htm). Spider mite can explode under conditions of high temperature (above 85° F.) and low relative humidity (below 60% RH). The life cycle of NEs and insect pollinators can shorten from 30 days to 3.5 days when temperature increase from 60-90°F (www.hydro-gardens.com/spidermite.htm). The body temperatures of active hymenoptera may remain with temperature rise up to 39°C, optimum 15-35°C for their survival, fecundity and wavering efficiency. In some social predatory insects like Formica, Vespa, etc chemical regulation of body temperature is also known. On an average 15-35°C is the ideal temperature for optimal strength for plant pollinator control, decomposition and soil nutrients availability. Extreme temperature reduces over all performances on survival and development of natural enemies, pollinators and decompositors. Many pollinators and the NEs are poikilothermic (cannot regulate body temperature). Low temperature results high fecundity and longer survival of winter predators which are in low species diversity (Coviella and Trumble, 1999). Higher temperature results higher fecundity and survival of summer predators within a range of 15-35°C. Increased temperature could increase pest populations which provide a field for NEs propagation (Coviella and Trumble, 1999). The length of the life cycle of Ladybugs (both adults and larvae are predators of aphids) varies depending upon temperature, humidity, and food supply (www.gardeninsects.com/ ladybugs.asp). The insect parasitic nematodes are beneficial NEs however; they are susceptible to extreme temperature (www.ext.colostate.edu/pubs/insect/ 05573.html). Metarhizium and Beuveria are also susceptible to extreme temperature (>30°C) conditions. It has been estimated that with a 2°C temperature increase NEs might experience 1-5 additional life cycles per season (Yamamura & Kiritani 1998). Nepal's average temperature rise is 0.06°C/year. However, the rate is higher in mountain (0.08°C/year) followed by hills and the Terai (0.04°C/year). The days and nights are becoming warmer and Nepal faced twelve warmest years since 1987 to 2005 (eg. 2006) (Shrestha et.al., 2000). This situation has seriously affected on agro-ecosystem services like palnt pollination, natural control, decomposition and symbiosis in Nepal.

Effect on Predator to Pest Ratio

Global warming is widening the ratio of predator to pest. Ideal ratio should be more than 0.5 in case of *Trichogramma* to *Helicoverpa* (books.google.com/books?isbn=0643067582...). However, the ratio is ideal examples in many of the natural enemies to their host. In an upland agro-ecosystem in Nepal, the ratio was found only 0.08-0.18 during the month May to October and is in decreasing trend year after year (Pokhrel, 2003). The potentiality of natural control under agro forestry ecosystem at Khairanitar Tanahu, 2003 is given in Table-1 and Fig-2. Restoration of the ratio to 0.5 is important to have effective natural control of crop pests.

Table-1: Monthly Caught Insect Pests and Predators (Nos.) in the Light Trap, Khairanitar, 2003

SN	Order	Total number of insect caught/months						
		May	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**
Insect pest								
1	*Coleoptera*	1210	391	600	258	328	103	0
2	*Lepidoptera*	251	335	274	145	176	198	161
3	*Isopterra*	420	1265	6331	1194	446	714	664
4	*Dictyoptera*	5	13	16	0	0	0	0
5	*Hemiptera*	81	89	873	114	326	158	100
6	*Homoptera*	79	102	145	44	200	225	19
7	*Orthoptera*	53	141	41	19	24	0	0
	Grand total	2099	2336	8342	1774	1500	1398	959
Natural Enemies								
1.	*Coleoptera* (Tiger beetle)	0	35	185	52	5	0	0
2.	*Orthoptera* (Grasshopper)	0	23	0	0	0	0	0
3.	*Odonata* (Dragon/damselfly)	2	8	10	16	52	35	0
4.	*Hymenoptera* (Wasps)	309	127	425	62	145	97	170
5.	*Dictyoptera* (Mantids)	8	20	16	16	12	8	2
6.	*Neuroptera* (Lace wings)	17	9	15	14	0	0	0
	Total	336	222	651	160	214	140	172
	Ratio	0.16	0.1	0.08	0.09	0.14	0.1	0.18

Source: Pokhrel, 2003

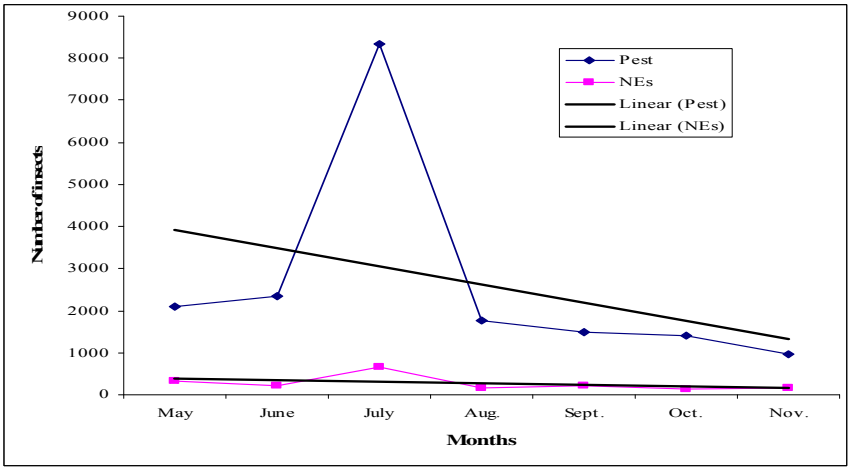

Fig. 2: Population Relationship of Pest and Natural Enemies in Agro-Forest Ecosystem, Khairahanitar, 2003 Source: Pokhrel, 2003

Effect on Pest out Break and Natural Control

Climate change is also responsible on changes in bio-types of some insect pests, races of pathogens, population and types of natural enemies and overall changes in the performance of the ecosystem services including the behavioral and physiological changes of the service providers. There are some critical examples of pest outbreak and natural control in Nepal. Rice BPH/WBPH was outbreak in 1996 in Chitwan (Fig-3) and their natural control was found effective (Table-2) with Mirid bug and other natural enemies (Pokhrel et.al., 1998/1999). Rice white fly Alleurocybotus osidus Maria reported as a rice pest in 2003 in Nepal and was first time in the world history (Fig-4). Predator (Encarsia sp.) was closely associated for its natural control (Pokhrel & Thapa, 2008). Citrus psylla found upto 1400m altitude in mid-hills (Gorkha) in Nepal which was limited with in 1000m previously. Banded caterpillar was outbreak on mango in Sarlahi farm for the first time in 2011. *Helicoverpa armigera* became a serious pest of wheat in Kathmandu and western Nepal, which was not reported wheat pest in the past.

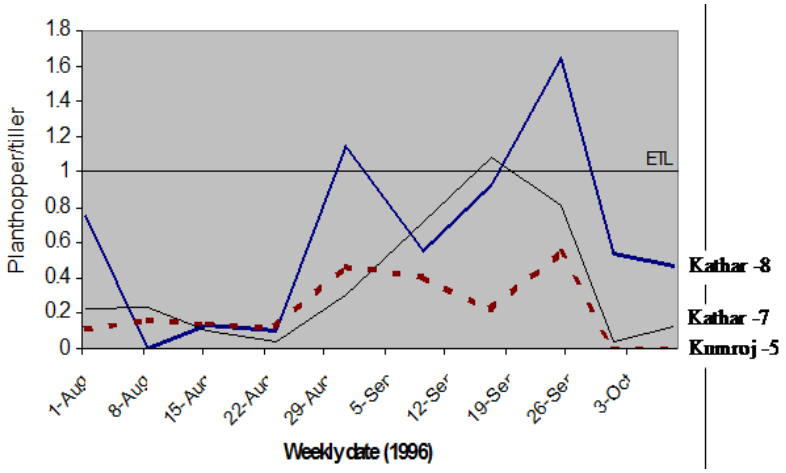

Fig-3: Outbreak of BPH/WBPH in Chitwan, 1996 (Pokhrel, 2009)

Table-2: NE of Plant Hopper Found In Eastern Chitwan Nepal

SN	Type of NE	Common Name	Scientific Name	Family
1	Predator	Lady beetle	*Micraspis sp.*	Coccinellidae
2	Predator	Ground beetle	*Ophionea nigrofasciate (Schmidt-Goebel)*	Carabidae
3	Predator	Crickets	*Anaxipha longipennis (de Haan)*	Gryllidae
4	Predator	Grass hopper (L. horned)	*Conocephalus longipennis (Stal)*	Tettigoniidae
5	Predator	Plantbug (Miridbug)	*Cyrtorhinus lividipennis, Reuter*	Miridae
6	Predator	Damsel flies	*Agriocnemis spp.*	Coenagrionidae
7	Predator	Dragon flies	*Crocothemis spp.*	Libellulidae
8	Predator	Wasps	*Panstenon sp.*	Pteromalidae
9	Parasite	Wasps	*Gohatocerus spp.*	Mymaridae
10	Parasite	Wasps	*Anagrus sp.*	Mymaridae
11	Parasite	Wasps	*Oligosita spp.*	Trichogrammatidae
12	Parasite	Big headed flies	*Tomosvaryella sp.*	Pipunculidae
13	Predator	Wolf spider	*Lycosa sp.*	Lycosidae
14	Predator	Dwarf spider	*Atypena sp.*	Linyphiidae
15	Predator	Long jawed spider	*Tetragnatha sp.*	Tetragnathidae
16	Predator	Orb spider	*Argiope sp.*	Araneidae
17	Predator	Lynux spider	*Oxyopes sp.*	Oxyopidae

Source: Pokhrel, 2009

Fig.4: Rice Hispa *Dicladispa armigera* **(Olivier) After Submergence and Rice Whitefly** *Aleurocybotus occiduus* **Maria under Warm Humid Condition in Chitwan Nepal, 2003**

A number of mycophagus fungi has been reported from different geography of Nepal with different species, subspecies and ecotypes. Trichoderma is an example. However, isolation, pure culture preparation, multiplication and use against soil and foliar pathogens is remaining quite behind. The effect of climate change and the modern agricultural practices, including the effect of irrigation and agro chemicals on them is still to be studied.

Effects on Weed Infestation

A very important point to consider is that weeds would undergo the same acceleration of cycle as cultivated crops, and would also benefit from carbonaceous fertilization. Since most weeds are C^3 plants, they are likely to compete crop plants. However, on the other hand, some results make it possible to think that weed killers could gain in effectiveness with the temperature increase. However, it may also cause an increase on the emission of GHGs. At present, some of the new weed species and some other exotic weeds are invading in agricultural and semi-agricultural area (*eg. Lantana spp*) in Nepal. Some other shifted their distribution range to higher elevation. This phenomenon is closely associated with climate change in Nepal.

The Decreasing Trend of Pollination Service

Pollination ecology emphasizes maximization of pollination and optimization of forager's strength for successful crop pollination and productivity in the modern agriculture system. The number of pollinators required can be calculated from the following formula:

N=d/PE x Y/T x a (Sihag, 2000)

Where,

$$\text{Nos. pollinators required} = \frac{\text{Floral longevity /receptivity}}{\text{Pollinating efficiency}} \times \frac{\text{Average floral density}}{\text{Avg. foraging duration}} \times \text{Cropped area}$$

Example-1: Honeybee colonies needed for buckwheat pollination

N=d/PE X Y/T x a

$$= \frac{28\text{days}}{12\text{ flowers/min}} \times \frac{40000\text{ flowers/m}^2}{6\text{ hours/day}} \times 1\text{ ha} = \frac{1120000}{72} = 14755\text{ foragers/ha}$$

ie. each strong honeybee colony consists around 20000 workers with 25% foragers ie 5000 / colony.

$$N = \frac{14755}{5000} = 2.9\text{ colonies (2-3 colonies recommended/ha)}$$

The number can be reduced from calculating the intra species and inter species competitions. The number of natural pollinators specially the solitary bees and wild bees required for buckwheat pollination in mountain agro ecosystem, mammal pollinators, the number of bats required for butter tree pollination in mid hills and the number of natural pollinators required for some other cross pollinating crops in Tarai and different geography in Nepal is reported deficiting in recent years. The populations of most popular crop pollinators the honeybees are also decreasing year after year (Pokhrel, 2009). The reason behind it is mainly climate change, wrong cultural practices and excess use of agrochemicals. Because of this, the yield of mountain crops like buckwheat and apple are decreasing year after year. This is true with several others cross pollinating crops throughout the country. Rise in temperature gave opportunity of multiple cropping in mountain. For an example cultivation of maize after buckwheat within a year become possible in Mustang resulted exposure of the brood in diapauses of solitary bees to the predators on tillage and cultivation increased several folds. Because of which, the population of solitary bees decreased by two third, it created pollination deficit with buckwheat, resulting limited buckwheat yield to 33% (1500 kg vs 500 kg ha). It also created the situation of pollination deficit on apple, that blooms just after buckwheat and the solitary bee is the common pollinator and has resulted lower fruit set and yield of apple. Thus pollination ecosystem has been affecting year after year.

Effect on Decomposition Services

Soil productivity has been changed remarkably from Terai and inner Terai. Higher soil temperature is responsible for faster decomposition of the OM and decreased the availability of soil nutrients for a longer period, and affected soil microbial activities and finally on growth and development of plant in different stages. The soil organic matter found up to 1% in Terai of Nepal. It is decreasing year after year because of higher decomposition rate because of global warming and the decreasing trend of organic manure use. ADS targeted to increase the soil organic matter up to 4.00% in Nepal. If is very difficult in pace of percent global warming. In the other hand, the trend of using chemical fertilizer is increasing and the use of organic manure is decreasing year after year. Residue management is also a serious problem. Excess use of agrochemicals is imparting toxicity in soil, reducing soil microbes including decompositors and symbiosis agents. Moreover, the higher temperature because of global warming is mainly responsible for lower carbon content in Nepalese soil.

Effect on Symbiosis

Rhizobium bacteria in Legumes, mycorrhizae in Litchi and *Alnus*, VAM in different crop plants, etc. are responsible for areal nitrogen fixation in root rhizosphare. These symbiotic agents are closely associated and nourished from plants. The effect of climate change eg temperature rise, excess rainfall and surface run off, use agro chemicals and common cultural practices to the symbiosis service and crop production is still to be studied.

Conclusion

The frequency of abiotic and biotic stresses in agro-ecosystem has been increased at present time because of global warming in Nepal. The increased temperature, with uneven rainfall pattern, with changing hydrology, ecology, biology and geography is affecting agro-ecosystem services. Climate change adaptation can reduced these vulnerabilities and negative effects. For this, documentation of the evidences, vulnerability assessment, listing the possible adoption measures with awareness, raising, policy lobbing and implementation of the activities step ahead for the climate change resilience on restoring the agro-ecosystem services is needed in Nepal. For this, following points are recommended:

Recommendations

- The policy option against this may include developing and declaring the national agro-ecosystem conservation and management policy focus on research, development and extension education, back up with agro-ecosystem conservation and management plan with setting out the effective programs and budget, participatory program planning, monitoring, evaluation and effective implementation.
- There is immense need to conduct basic and participatory research on ecosystem services that include, pollination, pollination deficits/needs of crop plants, develop tools and networks for pollinator and NEs identification, socio-economic value of ecosystem services, developing conservation packages of good agro-ecosystem management practices.
- It is also important to develop agro-ecosystem database for developing decision-support system that includes: agro-ecosystem surveys; develop standard methodologies for sampling/monitoring, develop GIS maps/site and target land area, compilation of agro-ecosystem bibliographic databases, establishing national agro-ecosystem information management system (NPIMS) and web net working is needed for identification, conservation, pollinator-plant relations and resource need ecosystem services.

- For maximizing diversity and abundance of natural enemies, pollinators and decomposers in agro- and natural ecosystems, i.e. high value habitats and associated biodiversities to improve agro-ecosystem is needed.
- The bad practices like over-grazing, honey hunting, slash-burning, deforestation, firing, soil erosion, etc should be prohibited.
- Beekeeping primarily for crop pollination and production of hive products should be encouraged, migratory beekeeping should be adopted, hiring Apis colonies for crop pollination should be initiated,
- Conservation of the natural and indigenous pollinators' adoption of IPM/IDM, organic farming, community forestry, declaration of protected area, and establishing biodiversity garden etc are needed. Protection of the NEs and pollinators nesting site eg the ridges, bunds, natural and semi natural vegetation and the nests eg the solitary bees which adults die after the bloom end and the brood activated from diapauses on the next blooming season.
- Preparation of floral calendar and planting the crop/s to have bloom round the year (mix/relay/sequential/multiple/stripe cropping etc.) to conserve the natural pollinators or the artificial feeding is necessary. Incorporate crop pollination friendly cultural practices better crop management for best attraction of the pollinators and NEs is needed. Saving the agro-ecosystem service providers is most needed for this the judicious use of agro-chemicals, i.e. fertilizer, pesticide, and management of industrial and agriculture wastes is needed. Extension education on agro-ecosystem services is also needed.
- Identify target farmer groups and land areas, develop scheme for year by year expansion of ecosystem services /site, improving institutional capabilities and human resources development through agro-ecosystem management training with FFS approach, monitoring and survey surveillances of pollinators, NE and pests, assessing economic value of agro-ecosystem services, including environmental impact, awareness raising and the promotion of best management practices, integration of indigenous knowledge and mass awareness is important. It also includes education and training including course curricula development and use in colleges and universities and web-site with database of agro-ecosystem services.

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Analysis of Population Distribution in Nepal by Ecological Regions

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Abstract

Population distribution of Nepal among three ecological regions is uneven. Population data from the latest census in 2011 showed the highest population in Terai and least in Mountains. Population proportion living in Terai is increasing, while the proportion of people living in the hill and mountain is declining over the years. Availability of facilities, infrastructures, productive land in Terai and difficult topography of Hill and Mountain are the reasons behind this pattern of population distribution.

Keywords : *Terai, Hill, Mountain, Facilities, Migration*

Introduction

Spatial distribution of population represents the relationship of human habitat to the physical boundaries. It is a fundamental determinant of both the societal impacts and anthropogenic drivers of global change (Pozzi et al., 2002). The spatial distribution of a country may be affected by socio-cultural, economic, environmental, historical and developmental factors. The population growth and the spatial distribution will lead to the extension of urbanization which has direct impact on natural resources and the environment (Pozzi et al., 2002). The pattern of the spatial distribution of population in Nepal is very uneven.

Geographically, Nepal is divided into 3 regions called Ecological zones (Table 1). There are Mountains (the Northern Range), Hills (the Mid Range) and Terai (the Southern Range) as three east-west ecological belts (CBS, 2015). Ecological zones reflect the climatic conditions and the variation of land use, diversity and others. Mountains are defined as area that lies between the altitude of 4877 and 8848 meters, while Hills are defined as area that lies between the altitude from 610 to 4876 meters. Altogether these regions comprise about 77 percent of the total area. The Terai region lies below the elevation of 610 meters (MoHP, 2011).

Table 1 Ecological Divisions of Nepal

S. N.	Ecological zone	Area (km^2)	Land Area Percentage
1	Mountains	51817	35.2
2	Hills	61345	41.7
3	Terai	34019	23.1
	Total	147181	100

As these three regions differ from each other in climate and topography, population distribution is also different in these regions. The demographic composition, social and marital habits, and economic levels differ substantially from one area to the other (CBS, 1977). Mountain region includes the rocky areas of the Himalayan range which are not appropriate for human settlements. Hill region is suitable for human settlements where many valleys and river basins are located. Terai is most fertile and low-lying region of Nepal (Pathak and Lamichhane, 2014). It is usually known as

the grain house of Nepal (CBS, 2015).

This study will depict and analyze the population distribution of Nepal according to ecological regions in different census years.

Materials and Methods

This study has used the data of published documents from the Central Bureau of Statistics, Government of Nepal. Various literatures have been reviewed to analyze the available information.

Results and Discussion

Nepal has been conducting population censuses in every 10 years since 1911. The last census of 2011 is the eleventh census. Table 2 indicates the population in ecological regions of census years from 1971 to 2011. The proportion of the population is gradually declining in Mountain and Hill and steadily increasing in Terai (CBS, 2014). According to latest census 2011, Terai alone accounted for 50.27 % of the total population, whereas Hill and Mountain accounted for 43% and 6.73 % of the total population respectively.

There is the increasing trend of the proportion of population living in Terai. Out of the Nepal's total population of 8256625 according to the census year 1952/54, Terai's share was 35.2 %. This was 36.4 % out of the population of 9412996 in 1961 (MoHP, 2011, Pathak and Lamichhane, 2014). In 1971, Terai accounted for 37.6 % of the total population. This increased to 48.43% in the 2001 census and 50.27 % in the 2011 census. There has been a noticeable decrease in the populations of Mountain and Hill from 62.4 % in 1971 to 49.73 % in 2011. The declining trend is observed in both the Mountain and the Hill Regions.

Table 2 Population Distribution of Nepal by Ecological Regions (1971– 2011)

Ecological Region	Census Year									
	1971		1981		1991		2001		2011	
	Population	%	Population	%	Population	%	Population	%	Population	%
Mountains	1138610	9.9	302896	8.7	1443130	7.8	1687859	7.29	1,781,792	6.73
Hills	6071407	52.5	7163115	47.7	8419889	45.5	10251111	44.28	11,394,007	43.00
Terai	4345966	37.6	6556828	43.6	8628078	46.7	11212453	48.43	13,318,705	50.27
Total	11555983	100	15022839	100	18491097	100	23151423	100	26494504	100

Source: Census Reports from CBS; MoHP, 2011; Pathak and Lamichhane, 2014

Some of the reasons for the disproportionate distribution of population among ecological regions of Nepal could be unequal distribution of resources, availability of productive land in Terai, difficult topography of Hill and Mountain, disparity in socio-economic development and the lack of basic facilities and infrastructure in these regions; and lack of access to information (MoHP, 2011). These factors have led to increased migration from Hills and Mountains to the Terai and at the same time flow of immigrants from the bordering country have played major role in the increased population in the Terai region (MoHP, 2011).

There is a long tradition of movement of people from one place to another in Nepal for economic, social, cultural and other reasons. Migration of hill populations increased after the control of endemic malaria in the Terai and the warm river valleys (ADB/ICIMOD, 2006). Until 1951, Terai was covered with dense forest and highly infested with malaria and other communicable diseases. The diseases were controlled, and deforestation increased resulting in an increase in human settlement

and a change in the pattern of population distribution by Ecological Zone (CBS, 1995 in Pathak and Lamichhane, 2014). Agricultural land and employment opportunities are still the pull factors for the outflow of people from Mountain and Hill to Terai (Pathak and Lamichhane, 2014). A greater population shift from hills/mountains to Terai region would have greater political consequences (Subedi, 2016).

Conclusion

Analysis of population distribution of Nepal according to three ecological regions shows that population proportion of Terai is highest among others. Population trend analysis of these regions over the years shows the decreasing trend of population in Mountains and Hills and increasing trend of population in Terai. More population pressure in Terai has encroached the productive land and there is the overexploitation of natural resources. Environmental degradation is the emerging threat in Terai. Increased population proportion with the mixed culture and identity in Terai has become the political and social issue. Therefore, population management with the overall socio-economic development of three ecological regions is necessary.

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Comparison of Solid Waste Composition and Management Practices between Traditional and Modern Community

(A Case from Kirtipur, Khokana, Bode and Apartment/Housing of Kathmandu Valley)

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Abstract

Solid waste and its management has become the major concern in Kathmandu Valley. With the major objective to show the difference in the MSW composition and its management in two different types of communities found in the Kathmandu valley, the study was carried out in 2017. The waste composition of the both communities were seen similar type with high amount of the organic waste followed by the non-degradable waste like plastic, glasses, and other wastes. However, the waste management techniques were different between two types of the communities. The maximum household of traditional communities manage by segregating the waste in which organic waste by compositing, plastic and paper waste by incarnation, selling to scrape collector, and other wastes by the waste collection service. But, the modern communities only manage the waste by waste collection services.

Keywords : *Recycling, Compositing, MSW (Municipal Solid Waste), Waste Collection Service*

Introduction

MSW is the waste which is mainly produced by the household containing degradable waste like organic waste and paper, and non-degradable waste like plastics, glasses, textile, rubbers etc. The waste in Kathmandu consist of high amount of organic waste i.e 63.22% and followed by 10.8% plastic, 9.02%paper and rest different other wastes like glass, rubber and the textile. (Environment Audit Report, 2015). The waste composition slightly differ according to the socio-economic groups (Kamran et.al, 2015) and its management also depends on socio-economic and culture (Ashan and Zaman, 2014). The different kinds of the waste management techniques can be seen within the communities found in Kathmandu valley. The existing tradition communities still practices segregation, composting whereas modern communities manage the waste through the waste collection service. The apartments has the mismatching way of sorting the waste (Ordonez et.al 2014) so waste sorting in the household of apartment plays vital role in its management and increase of the resource recovery.

Materials and Methods

Study Area

As per the study required, the research area was selected within Kathmandu valley as it includes both traditional and modern communities. The community from the Kritipur (Kathmandu), Khokana (Lalitpur) and Bode (Bhaktapur) served as the traditional communities where as different apartments and housing colonies of the Kathmandu valley served as the modern communities.

Method of Data Collection

Primary Source of Data

For the information related to the public opinion about the waste composition, segregation and its management practices household survey was performed through the set of questionnaires. The questionnaire covered the both quantitative data and quantitative data for the effective study. The questionnaire sampling was done for the traditional communities where as the key informant interview was done for the modern communities. The information was also collected from the focused group discussion like cleaners, solid waste management team etc.

Sampling Methods: The study area consist of both the traditional as well as the modern communities but all the area doesn't serve as the traditional and the modern community. So, purposive sampling was done for the site selection. Resonance survey was carried out before the real study to know the status of study area and fixing the sample size.

Sample Size: The size of the samples are different for the different types of communities. According to Census 2011, the total household in the ward no 21 of Khokana is 1056, ward no. 8 of Bode has the total household 646 and ward no of 2 of Kirtipur has 1856 household. The sample size of the apartments and the housing colonies is 22 all over the Kathmandu valley since the number of apartments and housing is around 51. These sample represents the 10% of the study areas which is enough to know the solid waste composition and the management of the study areas as the representative samples.

Secondary Source of Data

The available literature which is in the form of the research reports, thesis, journals articles, books and review of the articles or abstracts as well as unpublished and published materials, rules and regulation, environmental relevant acts are extract for the information related to the study.

Data Analysis and Interpretation

The data collected was analyzed with the help of different tools and methods. The collected primary and the secondary data was processed and interpreted. The quantitative analysis was done with the help of the computer software using MS excel 2013 and MS word 2013 for the result and its interpretation. The results were represented by using the different graphs and the pie charts.

Results and Discussion

The Traditional Community

- Types of waste produced in the traditional communities

The maximum type of the waste produced in the traditional communities are bio degradable waste like organic waste, animal manure along with papers. The non- degradable wastes are plastic waste, papers and other wastes like metals, rubbers, wood etc are very limited.

Waste Composition

Table 1: Waste Composition in the Traditional Communities

Study area	Types of waste	High (60-80%)	Moderate (40%-20%)	Less (20%-10%)	Very less (>/10%)
Khokana	Organic matter	92 %	8%		
	Plastic			67%	33%
	Paper			32%	68%
	Glasses/bottles				7%
	Others (metals, wood etc)				13%
Kirtipur	Organic matter	88%	12%		
	Plastic		29%	65%	6%
	Paper		20%	76%	4%
	Glasses/bottles			09%	43%
	Others (metals, wood etc)				27%
Bode	Organic matter	85%	15%		
	Plastic		9%	54%	37%
	Paper		2%	39%	59%
	Glasses/bottles			6%	5%
	Others (metals, wood etc)				23%

The waste composition in the study area is shown in Table 1 where the perception of studied household are represented in the percentages .In an average the organic waste is high than other wastes like the plastic, paper, glasses and other wastes in all the traditional community.

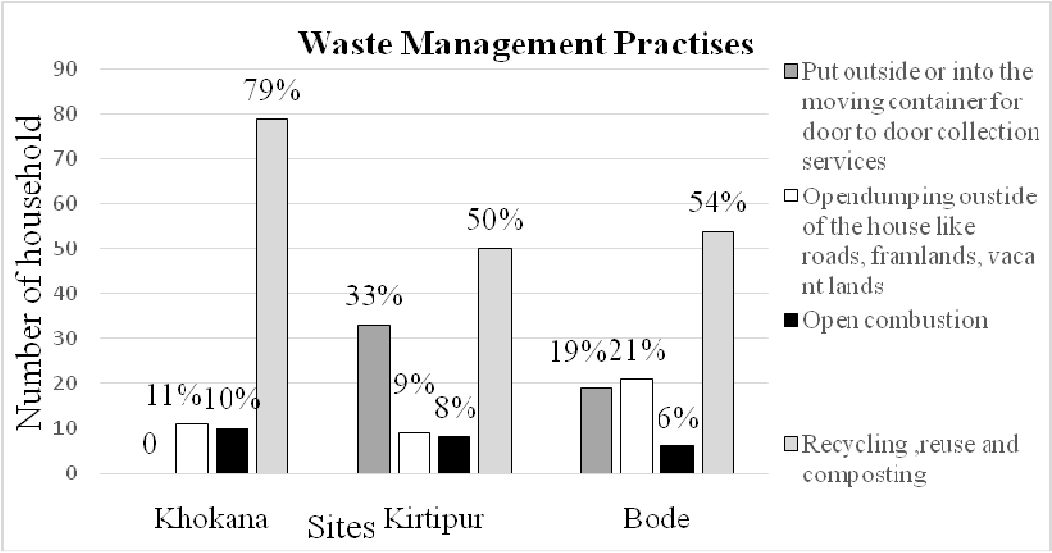

Figure 1: The Waste Management Practices in Traditional Communities

Out of total surveyed household, 61%of the traditional communities manage their waste by recycling, reusing and composting, 14% manages waste by open dumping, and 18% manages waste by waste collection service and the 8% by open combustion. So, it can be concluded that the traditional communities promote the recycling, reusing and composting for management of waste as shown in figure 1

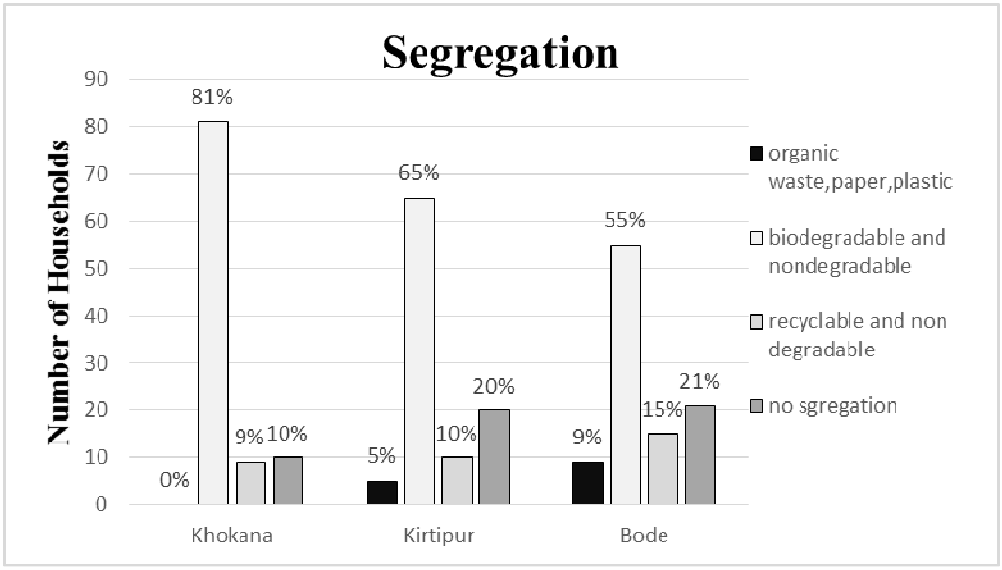

Figure 2: The Waste Segregation Methods in the Traditional Communities

The above bar graph (fig: 2) shows the different waste segregation methods in the three different traditional communities of Kathmandu valley.Out of total household surveyed in the traditional communities, 67% segregate the waste produced into biodegradable and non-degradable and 5% segregate the waste produced into the organic, plastic, paper.

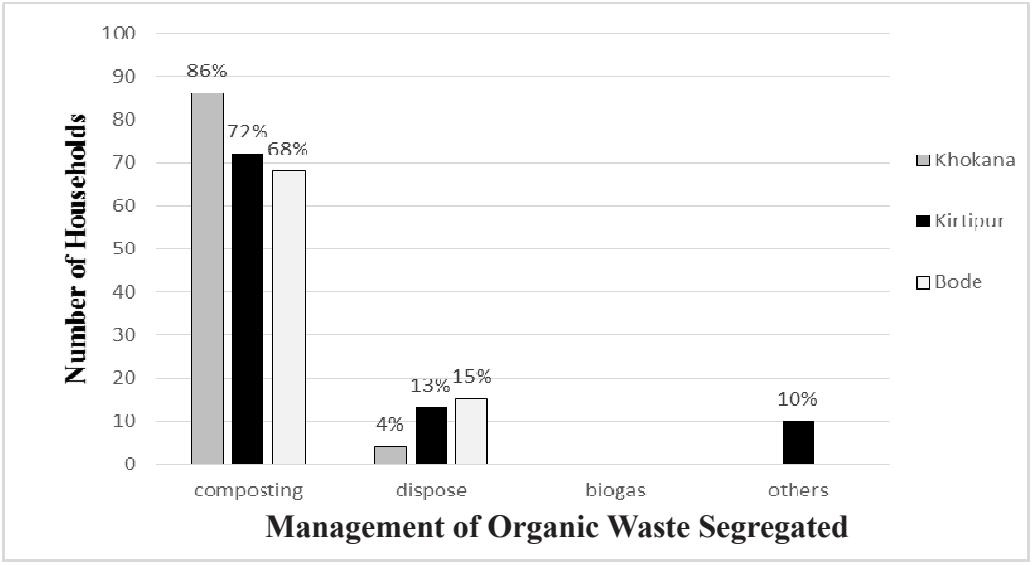

Figure 3: The Waste Management of the Segregated Organic Waste in Traditional Communities

From the above bar graph (fig 3) Out of the total surveyed household in the traditional communities, 76% manage the organic waste by composting techniques rather than direct dispose or making bio gas.

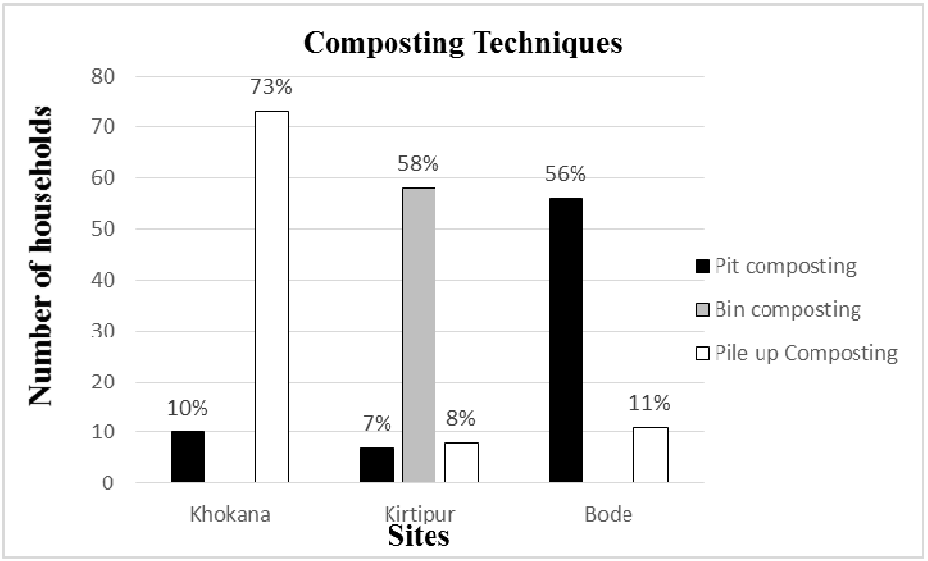

Figure 4: The Composting Techniques Practice in Traditional Communities

Out of total surveyed household in traditional communities, about 26% of the household use the pit composting and 57% of the household use pile up composting in Khokana which is shown in the above bar graph (fig:4). The bin composting is only used in the Kirtipur and about 65% uses bin compositing, 7% uses the pit and 8% uses pile up composting .In Bode, out of total household surveyed 56% use pit composting and 11% use pile up composting.

Modern Community

- Types of the waste produced in the modern communities.

The modern communities produces the different kinds of wastes which consist of biodegradable waste like organic waste i.e kitchen vegetable waste and papers like cartoons. The non-degradable waste like plastic waste like plastic rappers , polyethene bags and plastic bottles, glass bottles, paints, metals, construction materials like cement, sand and bricks .

- Waste composition

Table 2: Waste Composition in Modern Communities

Study area	Types of waste	High (60-80%)	Moderate (40%-20%)	Less (20%-10%)	Very less (>/10%)
Housing and apartments	Organic matter	81%	19%		
	Plastic		58%	42%	
	Paper		66%	34%	
	Glasses/bottles		31%	69%	
	Metals			15%	5%

Study area	Types of waste	High (60-80%)	Moderate (40%-20%)	Less (20%-10%)	Very less (>/10%)
Housing and apartments	Construction waste and textiles			8%	
	Others (sanitary waste, paints, etc)				13%

81% of the modern communities has the high organic waste composed of 60%-80%, 58% has the moderate plastic waste composed of 40%-20%, 66 % has the moderate paper composed of 40%-20%, 69% has the less glass waste composed of 20%-10%, 15% has less metal waste composed of 20%-10% and 13% has the other waste composed of less than 10% which is shown in table 2.

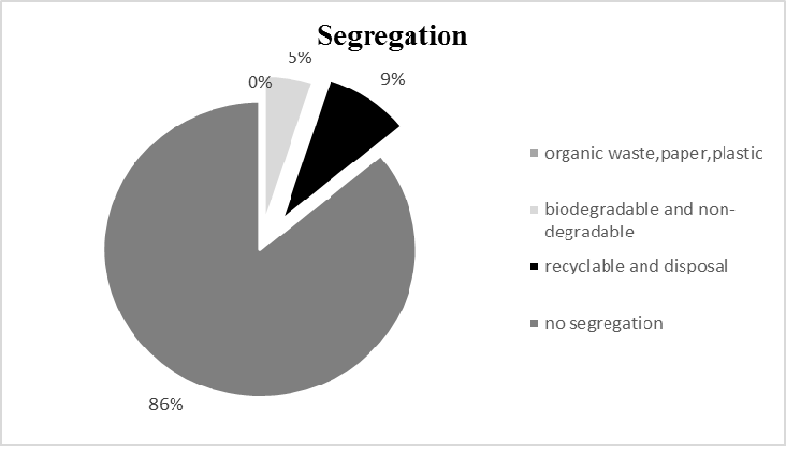

Figure 5: The Waste Segregation Method Used in Modern Communities

The pie chart (fig 5) shows that in modern communities 86% of household do not use segregation method. 5% of modern communities segregate their waste as degradable and non-degradable whereas 9% of modern communities segregate their waste by recyclable and disposal. Though there is the segregation of the waste, the segregated waste is directly disposed. The wastes like glass bottles, metals, cartoons are only sold by the waste collection workers which is segregated.

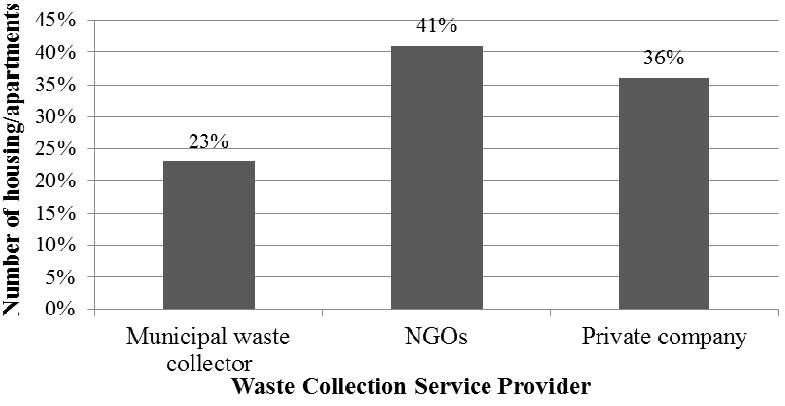

Figure 6: The Waste Collection Service Provider in Modern Communities

From the above graph fig 6, in modern communities 41% of waste is being collected by NGOs, 36% by private company whereas 23% of waste by municipal waste collector.

Comparative Study on Types of Waste Produce on Both Communities

In an average the both communities has the high amount of the organic but the amount of other waste is different. The plastic waste along with the paper and glasses waste is high in the modern communities than the traditional communities. Along with rapid population and urban growth rates, problems connected to MSW are increasing. Nepal consists with varying population size and living standards. Thus, the produced MSW differs both in terms of quantity and quality within the country (Khanal et. al, 2010)

Comparative Waste Management between Two Communities

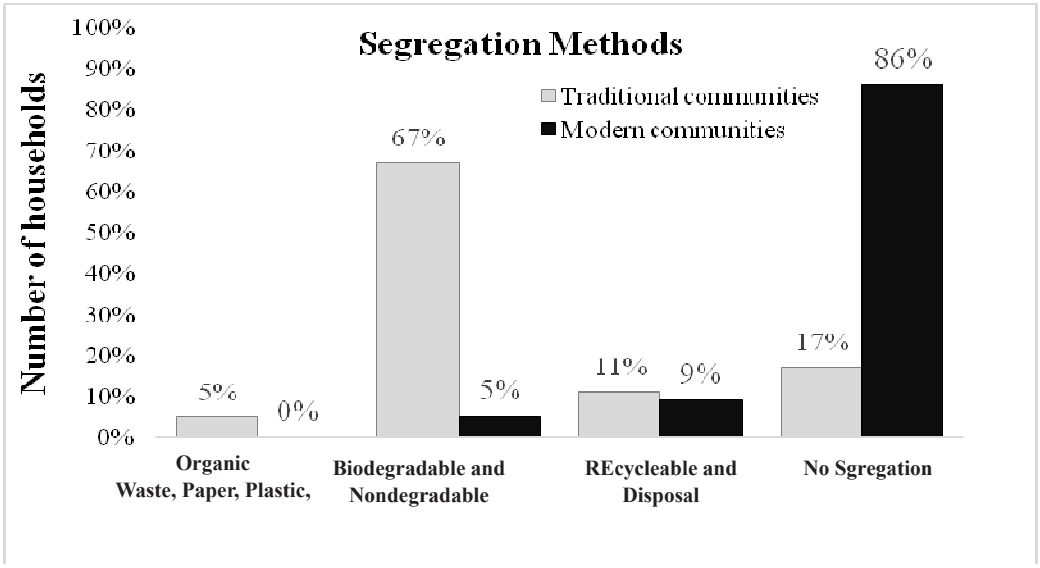

Figure 7: The Comparison between Two Communities in the Segregation Methods

Out of the total household surveyed; maximum(86%) of modern communities have no any segregation methods but only 5% and 9% of the waste is segregated as biodegradable and non-degradable and recyclable and disposal respectively. However, the majority (73%) of traditional communities have the segregation methods but only few (17%) don't have any segregation methods which is shown in above figure 8. The segregated waste in the traditional communities is managed by composting, reusing or selling it to scrap dealers. However, the waste which is segregated in the modern communities is directly disposed or collected by the waste collection service.

The major of the waste is segregated in the traditional communities for recycling or reusing and for composting but there is very few or almost negligible number of the modern communities segregate the waste. The compost is prepared through the different techniques like pit composting, pile up or the bin compositing while the compost is used as organic fertilizer in the agriculture fields or the kitchen gardens. Still the traditional communities of the Khokana and Bode has the "shaaga", the traditional way of making the compost is found. The integration of mineral fertilizers with organic (e.g. animal manure and compost) has been recommended to increase crop production (Negassa et al., 2005). So the composting from the waste is higher in the traditional communities. But the modern

communities have no any space available for composting furthermore no use of the composting which leads to no segregation of the waste. This difference is due to the difference in the occupation and the living standard of people living in different communities.

People living in the apartments of the Dhaka are aware about the segregation but do not practice any waste separation method (Ashan and Zaman 2014). This study also shows that maximum number of the apartments do not segregate the waste although people have the good knowledge of the benefit of waste. However, the apartments of Bengaluru has the waste segregation method. The waste are separates into three types i.e dry wastes is collected once a week, wet wastes like organic waste is collected every day and the rejected wastes thrice a week (Mani, 2015). The segregation is the easy way of waste management in apartment. But the modern communities in Kathmandu have least segregation.

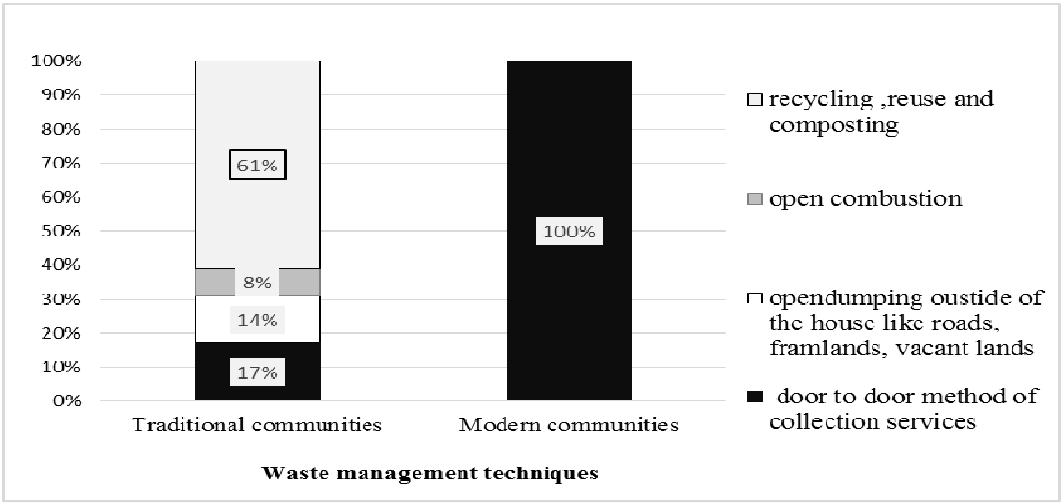

Figure 8: The Waste Management Practices between Two Communities

The above bar graph (fig 7) shows that almost all of the modern communities manage their waste by the door to door method of collection services and the maximum (61%) of the traditional communities manages the waste produce by recycling, reusing and composting techniques then other techniques, 8% burns the waste especially waste like plastic, paper, wood and the rubbers, 14% open dump the waste in the barren land, forest or roadside where as 17% uses waste collection service. All most all the modern communities manages waste by the waste collection service provided by the different NGOs, private companies like "NEPSEMAC", "Pariwarten"," MahilaSamuha" and municipalities which utilizes the waste. In traditional communities, plastic is used to make the new products like "Sukul", table mat, "dhakii" whereas the unusable papers, metals items, glass bottles etc are sold to the scrap dealer "kawaddhi" with the concept of money from the waste or use waste collection service in the traditional communities. Still these wastes are combusted in the traditional communities which they have been practicing since long time ago. Only few items like metals and bear bottles are only sold by the workers of the modern communities.

Conclusion

Over all it can be concluded that the types of the municipal waste produced in the both communities is almost similar. The both communities consist of the municipal waste like organic waste, plastic, paper and glasses but the modern community consist of the waste like textiles, paints, sanitary waste

and construction waste. Maximum household surveyed has the segregation system in the traditional communities where as the very minimum modern communities has the segregation system. Almost all the modern communities uses the waste collection service for the waste management whereas the most the traditional communities follow the different composting techniques to manage organic waste. The traditional communities sells the plastic, paper, bottles and metals to the scrap dealers but the modern communities directly dispose or give away to the waste collectors .Hence from the study, it can be concluded that the traditional communities have a better waste management practices than the modern communities.

Acknowledgement

We are grateful to Tri Chandra Multiple Campus, TU for providing the opportunity and Mr. Lila Khatiwada the engineer of the DUDBC for providing the list of the modern communities.

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Compliance Status of Hospital Waste Management Practices of Some Major Hospitals in Kathmandu Valley

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Abstract

The improper management of healthcare wastes by the hospitals may pose a serious threat to human health and environment. Nepal Government has set various acts, rules, guidelines and standards regarding the health care waste management. Department of Environment is carrying out regular monitoring of the hospitals to know the compliance status of the hospitals in terms of health care waste management. The overall objective of the monitoring is to assess the healthcare waste management practices due considering the legal provisions of Nepal Government. Six hospitals from the Kathmandu valley were selected randomly and information was collected through direct interview to the hospital staffs and observation of the hospital area. The various aspects of healthcare waste management like segregation, collection, treatment and disposal along with waste water treatment were monitored with reference to the legal provisions and it was found that almost all the hospitals are not fully complying with Nepal Government legal provisions in those various aspects. There is huge room for the improvement in the various aspects of healthcare waste management including the development of waste water treatment facilities.

Keywords : *Healthcare waste, Compliance, Waste Segregation, Waste Collection, Waste Treatment and Disposal, Waste Water Treatment.*

Introduction

Background

The World Health Organization (WHO) has defined health-care waste as all the waste generated within health-care facilities, research centers and laboratories related to medical procedures. In addition, it includes the same types of waste originating from minor and scattered sources, including waste produced in the course of health care undertaken in the home (e.g. home dialysis, self-administration of insulin, recuperative care). According to Solid Waste Management Act of Nepal, 2011 medical waste means the hazardous waste produced and discharged from hospitals, clinics, pharmacies, dispensaries, blood banks, pathology labs, veterinary institutions and health research centers and hazardous waste means the goods, substances and radioactive rays discharged in different forms which cause to degrade the natural environment and harm human health and life of other animals.

WHO has classified the health care wastes broadly into non risk health care waste, health care waste requiring special attention, infectious and highly infectious waste, other hazardous waste and radioactive waste. Non-risk health care waste is sub-categorized into recyclable healthcare waste, biodegradable healthcare waste and other non-risk health care waste. Waste requiring special attention is subcategorized into human anatomical waste, sharp waste, pharmaceutical waste, cytotoxic pharmaceutical waste and bloods and body fluid waste.

A study report carried by Department of Environment showed that there are 63 hospitals having 25 or more beds in the Kathmandu Valley, 45 in Kathmandu district, 13 in Lalitpur district and 5 in Bhaktapur district. The annual non-risk general waste production is 1545.22 MT of which 926.51 MT is degradable and 618.71 MT is recyclable waste. The annual production of healthcare risk waste is 566.10 MT (396.55 MT of infectious waste, 41.62 MT of Pathological waste, 43.92 MT of Sharp, 26.82 MT of Chemical waste, 5.71 MT of heavy metal contaminated waste, 1.65 MT of Radioactive waste, 2.01MT of pressurized container, 17.45 MT of Pharmaceutical waste and 30.39 MT of Cytotoxic waste). The total annual waste generation from hospital is 2111.32MT. The waste generation per bed has been found to be 0.66kg/day as against 0.24kg/day of healthcare risk waste. The percentage of healthcare Risk-Waste is 27% of the total while the general waste is 73%(DoENV, 2014)

The improper management of healthcare wastes by the hospitals may pose a serious threat to human health and environment (*Michael, Scott, Jason* and *Piero*, 2009). In response of the proper management of health care wastes, Nepal Government has formulated and enforced different policies, laws and bylaws. Department of Environment under the Ministry of Population and Environment has been carrying out compliance monitoring of the hospitals with reference to environmental laws, bylaws and standards. This article has been prepared on the basis of the information collected from the compliance monitoring work carried out by team of the Department of Environment.

Existing National Acts, Rules and Guidelines

Environment Protection Act (EPA), 1996 and Environment Protection Regulation (EPR), 1997

There are different provisions in EPA and EPR regarding pollution control, Initial Environment Examination (IEE) and Environment Impact Assessment (EIA) which are directly or indirectly related to health care waste management. Clause 7(1) of the Act states that "Nobody shall create pollution in such a manner so as to cause significant adverse impact on the environment or likely to be hazardous to public life and people's health or dispose or cause to be disposed sound, heat, radioactive rays and wastes from any mechanical devices, industrial enterprises or other places contrary to the prescribed standards.

The chapter 3 of EPR has provided various provisions under rules 15 to 20 for preventing and controlling pollution. These provisions include stopping emission and discharging solid waste against the standards (rule 15) to install and maintain properly the the equipments or treatment plants.

Also the EPR has stated that hospitals in between 25 to 100 beds should undergo the IEE and hospitals having bed more than 100 beds should undergo EIA prior to their establishments.

Waste Water and Incinerator Standards

Under EPA and EPR Nepal Government has enforced various standards by publishing in Nepal Gazette and the standards related to hospitals are:

- Nepal Gazette, Section 64, No 3, Part 3, 2058 B.S- Generic standard for the waste water to be discharged into inland surface water and public sewers. Various parameters like pH, BOD, Total Suspended Solids etc and their permissible limits are prescribed in this standard.
- Nepal Gazette, Section 51 No 30, Part 5, 2071 B.S- Chimney Height and emission for incinerator. Various parameters like Total Suspended Particulate Matter, Carbonmonoxide, Dioxin, Furan etc and their permissible limits are prescribed in this standard.

The Compliance of These Two Standards is Legally Mandatory for the Hospitals.

Solid Waste Management Act, 2011

This Act provides the legal basis for the regulation of health care waste management. Section 4 sub-section 2 and 3 has made provisions for the responsibility of medical waste management.

Sub-section 2 states that the responsibility for processing and management of hazardous waste, medical waste, industrial waste or chemical waste under the prescribed standards shall rest with the person or institutions that has generated the solid waste. It implies it is the responsibility of the hospital for the management of hazardous medical waste.

Sub-section 3 states that if the medical institution requests for the management of solid waste remained after processing of hazardous medical waste for using a sanitary landfill site constructed by the local body, the local body may manage the solid waste or allow the institution to use the sanitary landfill site by levying fees as determined by the local body.

Section 5 of the act states that it shall be the duty of medical institution to reduce the quantum of solid waste by making arrangements to dispose the disposable solid waste within their own area or making arrangement for the reuse and discharging the remaining solid waste thereafter.

Section 7 of the act clearly states that hazardous waste shall not be discharged in the solid waste collection center or transfer station.

Health Care Waste Management Guidelines, 2014, Department of Health and Services, Ministry of Health and Population

Health care waste management Guideline, 2014 has designated the Health Care Waste (HCW) into two major categories: Non-risk waste and hazardous waste. The non-risk waste should not be mixed with other types of health care wastes. Non-risk waste should at least be separated into biodegradable and Non-biodegradable. Risk healthcare wastes should at least be separated into six categories as pathological waste, infectious waste, sharp waste, cytotoxic waste, pharmaceutical waste, other hazardous waste. The guideline has directed provisions for waste minimization, waste segregation and collection, waste storage and transportation, waste treatment and disposal and public awareness for the Health Care Waste Management. Also the guideline has made the provision for the formation of Waste Management and Occupational Health and Safety Committee: At least seven members committee in chairman of hospital management head. Furthermore, the guideline has differentiated the responsibility of waste producers, local bodies and the national level institutions in managing the health care waste.

Guideline for Health institution Established, Operation and Upgrade Standard, 2070

This guideline is published by Ministry of Health and Population regarding establishment, operation and upgrading of the healthcare facilities. It stress on the implementation of the mitigation measures mentioned in the IEE or EIA report. This guideline has provision of waste management, regarding separation of general waste and hazardous waste at the source itself, collection and transportation and proper disposal of the waste. It has provision of final safe disposal of Healthcare risk waste after making them disinfected and use of digital equipment instead of mercury based equipment.

Objectives

Although the general objective of the monitoring is to know the health care waste management practice of the hospitals in Kathmandu valley, the specific objectives are:

- To know the approval status of Initial Environmental Examination(IEE)/Environmental Impact Assessment (EIA), their implementation and Status of self monitoring.
- To monitor the different aspects of solid waste management practice of the hospitals.
- To monitor the waste water treatment system of the hospitals

Materials and Methods

Six major hospitals inside the Kathmandu valley were selected randomly for the monitoring program. Three hospitals were selected from Kathmandu district, one from Lalitpur district and two were taken from Bhaktapur district. The monitoring was carried out from 24 to 28th May 2017. A questionnaire form was developed to acquire the required information for the monitoring program. The form was filled up by the monitoring team through consultation with the senior staffs of the hospital administration as well as the personnel involved in waste handling/management. The monitoring team also visited the hospital wards having waste segregation buckets, waste collection site, waste treatment areas having autoclave, incinerator etc and as a whole hospital premises. Also the team visited the waste water exit points from the hospital premise before mixing in to the public sewerage systems.

Results and Discussion

Initial Environmental Examination(IEE)/Environmental Impact Assessment(EIA)approval, their implementation and Status of self monitoring.

One hospital out of six was not found carrying IEE/EIA work. This hospital was established before the enforcement of IEE/EIA provision by Nepal Government. Two hospitals have approved the EIA while the remaining three hospitals have approved IEE.

Neither of the hospitals was found aware in using the EIA or IEE documents. All the hospital managements were found unaware of using the IEE/EIA document prescribed mitigation measures and implementation of Environmental Management Plan.

Neither of the monitored hospitals had carried out the self monitoring work like the emission test from incinerator, measurement of waste water parameters, noise level etc. to ascertain the compliance of standards.

Different Aspects of Health Care Waste Management Practice of the Hospitals

Waste Segregation

National health care waste management guideline as outlined above has provided the basis for waste segregation in Hospitals. While considering the non-risk waste, all the hospitals monitored were found to have provisions for waste segregation and three hospitals out of six were found to have carried out good segregation practice in comparison to the rest three hospitals. When the risk-waste are considered neither of the hospital have fully followed the guidelines provisions. In terms of risk-waste handling also three hospitals were found to use trolley to segregate the health-care risk waste. Rests of three hospitals were not found using the trolley system and only red bucket has been used for the placement of risk healthcare waste. Disposable syringes from all the hospitals were found keeping them separately. The labeling system of the bucket used in waste segregation was not uniform amongst the hospitals as guided by the guidelines.

Waste Collection

Two hospitals out of six were found to havewell prepared waste collection site. There are different segments/chamberspreparedto collect and store the segregated waste from the wards. There was no risk for the waste to be affected by rainfall. Another two hospitals although have allocated some area for waste collection but there was neither different chambers to collect the segregated waste nor the rooftop/shed to protect the waste from rainfall. In these hospitals the segregated wastes from the wards were found mixed in the collection site theirby converting all the wastes into risk waste. The waste collection site of remaining two hospitals although consists of shed house but there was not found the sufficient chambers to collect and store the segregated wastes.

Waste Treatment and Disposal

Three hospitalsout of six were found to have autoclave for the treatment of autoclavable risk waste. Risk waste treatment by using autoclave was found efficient only in two hospitals and found not efficient in the third one where the risk and non-risk waste were mixed in the collection house. Among these three, one hospital was found to have pit for the treatment of anatomical/pathological waste. Of the rest three, one hospital was found to have incinerator and it was informed that all except bio-degradable and recyclable wastes including plastics were burned there. There was no any pollution control device installed in the incinerator. It was also informed that thermo-regulation system of the incinerator was not working correctly. So the incinerator was found to be non-complying with the national standards of incinerator. Rest two hospitals do not have any waste treatment system or facility and risk and non-risk wastes were found mixed in the collection site.

Three hospitals out of six were found to have contracted to the private organization for the disposal of the waste, two hospitals contracted with both private and municipalityand one with municipality only for the ultimate disposal of the waste. It was informed by all hospitals that wastes are taken to the municipal waste disposal site for the final disposal. All the hospital administrations were found unaware about the mode of transportation and did not follow when the wastes were taken out from the hospitals.

The situation of health care waste management is still similar to the study conducted at hospitals of Nepal by MoHP with support from WHO (MoHP, 2012) which have concluded that the waste management system is poor.

Wastewater Treatment System

Three hospitals out of six were found to have discharged the waste water into the public sewerage system directly without any kind of treatment. One hospital although have established treatment system recently but was not found in operation and the waste water was bypassed to the public sewerage system.

One hospital informed that it has been using some screens to separate the solid content and also using some disinfecting chemical like HOCl before discharged into the public sewer system. But there was not found any waste water treatment facility in the hospital.

Another hospital claimed that they have septic tank to collect and percolate the waste water into the ground but the septic tank couldnot be traced out during the monitoring. Waste water treatment facility was not found there. Liquid wastes including hazardous chemicals and laboratory wastes have not been addressed inalmost all institutions.

Conclusion

The compliance status of health care waste management of all the monitored hospitals was not found satisfactory. The hospitals were not aware of implementing the different mitigation measures proposed in IEE/EIA documents. Neither of the hospitals had carried out the self monitoring of waste water, dust and gaseous emissions from the hospitals.

Only two hospitals were found carrying waste segregation, collection, treatment and disposal quiet satisfactorily while the rests were not found carrying out in accordance with the provisions outlined in health care waste management guidelines. Although Solid Waste Management Act, 2011 has clearly defined the responsibility of the hospitals to take care of the health care risk waste by themselves, the situation was found worse in three out of six hospitals. The incinerator operated was not complying with the government standard of Incinerator.

Neither of the hospitals was found to have operated waste water treatment facility for the treatment of waste water and had discharged their waste water directly into the public sewers. Generic waste water standard was found non-compliance in all the hospitals.

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Status of Climate Extreme Event Migrants on Urban Squatters at Santi Tol, Pokhara, Nepal

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Abstract

Climate extreme events have become a global threat and migration has become the major strategy that the people adopt as an adaptation to those events. The study focuses on assessment of current status of climate extreme event migrants and their livelihood challenges in the settlement currently living at Santi Tol-18, Pokhara. Both primary and secondary sources were used for the study. Questionnaire survey was the main tool. Census method was used to find out the climate extreme event migrants among the slum-dwellers and purposive sampling technique was used to choose the respondents among the migrants.12.04% of the migration was due to some forms of climate extreme events like floods, landslides and drought. They are living there with minimum access to any forms of facilities, economic resources and least participation in any development activities.

Keywords : *Climate Change, Slum, Hazard, Migration, Livelihood*

Introduction

Climate change is "a change in the state of the climate that can be identified (for example, by using statistical tests) by changes in the mean and/or variability of its properties and that persists for an extended period, typically decades or longer." (Pachauri & Reisinger, 2007)

According to the State of the World's Cities Report 2006/2007 including modification "a slum household is a group of individuals living under the same roof in an urban area who lack one or more of the following five conditions: access to improved water, access to sanitation, durable housing, sufficient living area, and secure tenure." (Moreno & Warah, 2006/2007)

Squatters (referred to as *Sukumbasi* in Nepal), on the other hand, are slum-dwellers settling on land without legal right, neither as tenants nor as owners. In the urban context, *Sukumbasi* are squatters unauthorized to reside where they do, while they may still own land elsewhere in the country. (UN, 2012)

Climate change does not affect people equally. The related disasters and impacts often intensify existing inequalities, vulnerabilities, economic poverty and unequal power relations. (Pachauri & Reisinger, 2007) Migration from the areas affected by climate extreme events is just an strategy for adaptation. Migration is a result of multiple issues including economic, social and political causes accentuated by changing environmental conditions as well as by demographic conditions. So, the links between environmental changes and migration is extremely complex and unpredictable. (NEU, 2015)

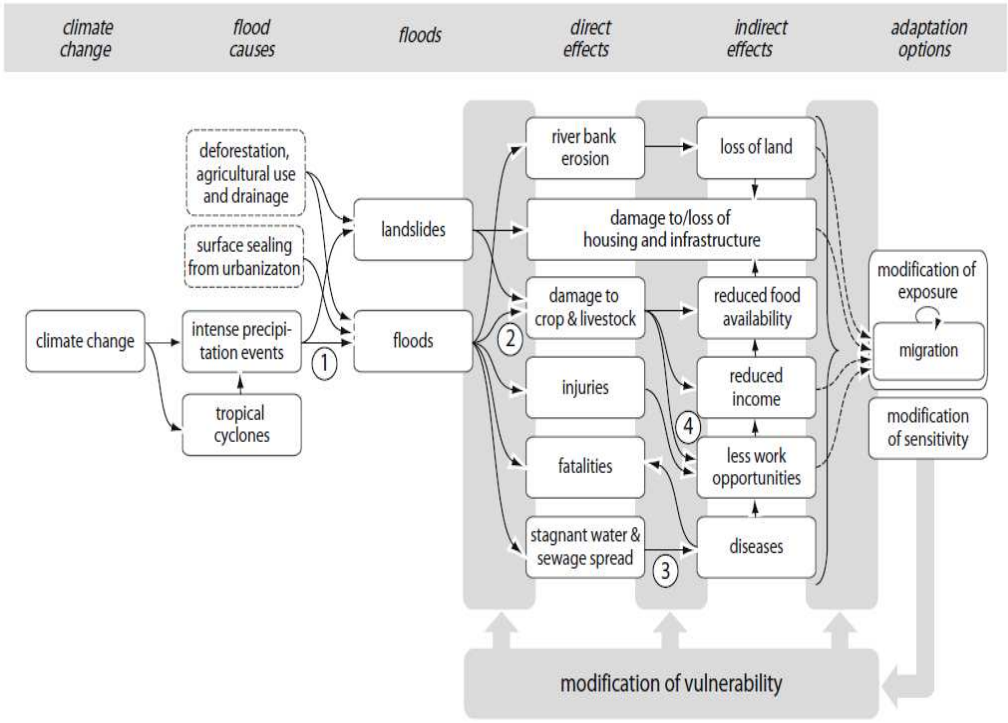

Figure 1 : Conceptual Model of the Influence of Climate Change on Migration through Flooding (Influences Vary In Strength. Boxes With Dashed Lines are External Factors.)

Source: (Perch-Nielsen, Battig, & Imboden, 2008)

Figure 1 gives us an overview of how flooding, as a consequence of climate change, can influence migration. Climate change can cause a lot of serious troubles. It can alter the way people use agricultural land and can lead to deforestation which is very important cause of floods and landslides. Intense precipitation events and tropical cyclones add those extreme events as well. These events affect human and their livelihood directly and can cause harm indirectly as well. River bank erosion, stagnant and sewage water spread, damage to crops, livestock, housing, infrastructure causing injuries and fatalities are direct effects. People may get diseased some of whom may lose lives. The events and these consequences have various more harmful impacts like loss of land, diseases, fewer opportunities, less income and decreased food availability. All these misery leaves people with very few choices they can make and migrating to some place with better opportunities always seem better than living in hardship.

Migrants have developed squatters in various parts of the country. Santi tol is the marginalized area of the Pokhara valley. Most of the problems the slum-dwellers face can be seen in this place. Much less focus is given to this area by the government and non-governmental sectors. The study is conducted to achieve a clear insight of the living status and the problems faced by the environment extreme event migrants in the area.

The objectives of the study were to identify the climate extreme event migrants and to access their current living status and livelihood challenges.

Materials and Methods

The study was conducted in Santi Tol which lies in Pokhara-Lekhnath Metropolitan City of Kaski district. Pokhara is a city in central Nepal located at 28.24 N, 83.99E, 200 km west of Kathmandu. The study area is far from the Prithivi highway and market area and lies near to the Pokhara landfill sanitary site.

The study was based on both primary and secondary sources of data. Primary data was collected on field survey with the help of questionnaire survey, interview and field observation. Census method of data collection was done to identify climate extreme event migrants. Then purposive sampling was done to select respondents to access the current status of climate extreme event migrants and their livelihood challenges. Various published and unpublished journals, research articles and newspapers were reviewed for secondary data. Data obtained from household survey was analyzed by using Ms-Excel and SPSS program.

Results and Discussion

Migrants

Among the 80 respondents from 80 families, 77 were migrants and 3 were non-migrants. Among 77, 10 families i.e. 12.96% migrated in response to climate extreme events. Other causes were: in search of better opportunities (45.45%) followed, business (27.27%), social (10.38%) and services(3.89%) respectively.

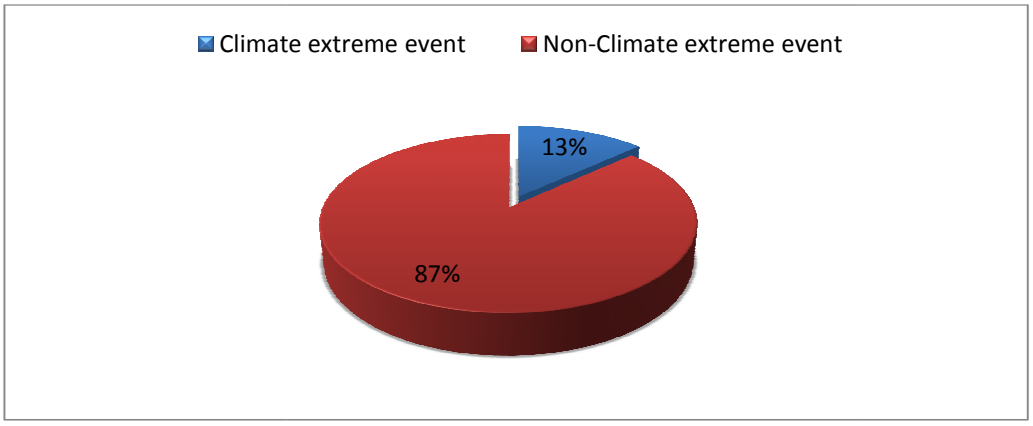

Figure 2: Climate Extreme Events Migrants and Other Migrants

Climate Extreme Events

Among the total of climate extreme event migrants (12.96%); floods, landslides, and drought related lower agriculture production accounted for 30%, 30% and 40% respectively.

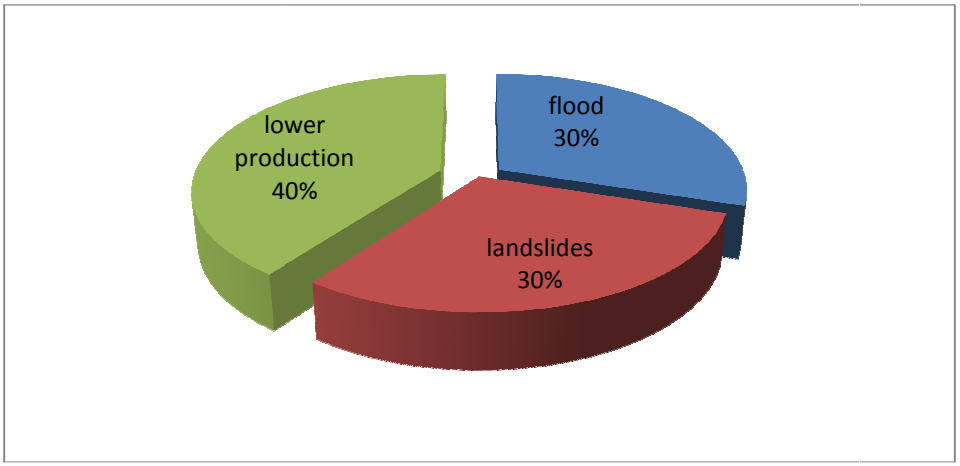

Figure 3: Climate Extreme Events Indicator

Current Status

From the study it was found that most of the houses were made up of block with cement mortar (60%) with roof made up of tin (80%). Most of the men from the slum were engaged in labour work earning daily wages, driving and farming whereas women were mostly involved in agriculture and household activities. Among the 10 families who stated their monthly income, the monthly ranged from Rs.1000 to Rs.10000 which is nowhere sufficient to meet the daily needs in today's expensiveness with an average family size being 6 in the squatter.

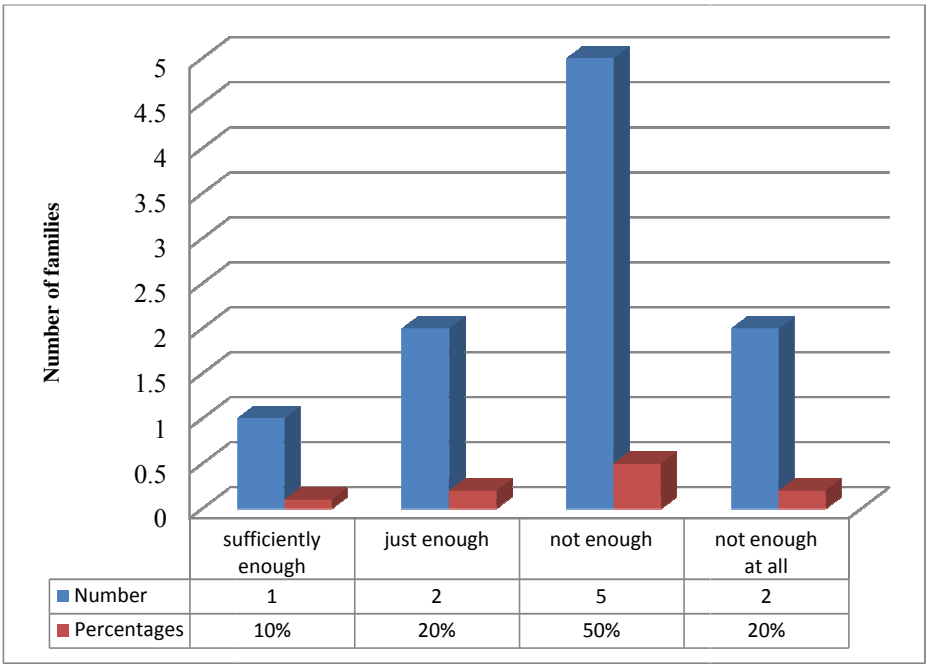

Figure 4: Sufficiency Level of Monthly Income

Livelihood Challenges

The major challenge that the slum-dwellers was of illegal settlement and the consequences of poorly constructed shelter. The smoke from the firewood they use for cooking and dust from the roads, the unhealthy odor from the sanitary landfill site and polluted water are continuously deteriorating their health. Low income and unnecessary expenses on alcohol use has made education and health the less prioritized sectors.

The climate extreme events induced migration has started to come into play giving rise to urban squatters and poor scenario of the livelihood of the affected migrants. This problem has created worst scenario in the developing and underdeveloped countries where the government cannot execute sufficient budget for the post-disaster management and also the management of those haphazardly formed urban squatters. Although there is lack of empirical evidence regarding the role of environment driven migration in Nepal, there is a bourgeoning interest in the issue and its implications (Department of Foreign Employment, 2013/2014). The respondents were themselves an evidence for climatic events driven migration in the squatter.

The migrants were mainly affected by landslides, floods and low agricultural production. Two families were victims of the huge landslide that occurred in Bhagabati Tar Panchayat of Kaski district in Western Nepal on June 5, 1976. Another one was victim of landslide which occurred in Central Nepal, on August 1 1968 (Nepal hazard risk management, 2011).

Two families were affected by GLOF and a family by flood (that occurred in Syangjha district in 2055 BS). Data recorded by (ICIMOD, 2007) shows altogether 2,315 glacial lakes have been identified in Nepal and about 14 GLOFs recorded to have occurred between 1935 and 1991 in Nepal.

During present decade almost each year, at least few parts of the country experience either a short or long dry period even within the wet season (DHM, 2001-2009). Drought related low agricultural production and its consequences on life of farmers led a few farmers, mainly from the eastern part of the country, to leave their place and reside in the Santi tol squatter area.

Conclusion

The study was set out to find out the climate extreme events induced migrations and access the living status and livelihood challenges of the those migrants. There were a few climate extreme events migrants in comparison to migrants who came there for better opportunities. Slum dwellers are facing the problem of unhealthy and poorly sanitized household conditions; lack of supply of drinking water, limited access to education and health facilities; lack of legal opportunity for their permanent home and land as well. With low income and limited opportunities, their living standard is very low. The challenges they are facing to upgrade their living status is also very tough. The improvement of their living status without help of government or other organizations seems very doubtful.

Migration has only offered a way to adapt to the prevailing and persistent climate change and climate change induced hazards. The benefits of migration and the formation of urban squatter have been shown to be neither comprehensive nor do they seem to be sustainable in the long-term.

Recommendations

Based on the study, following recommendations can be made:

- Researches should be carried out to find out the actual climate change migrants and correct data should be published based on which plans and policies could be executed to develop

the life standard of the migrants.

- Adaptation to climate extreme events such as flood, landslides, and drought is very urgent for retaining some people in their place of origin. It will reduce the future load of climate change migrants in Pokhara valley. At the same time, managing the existing squatter settlement at Pokhara will be easier. To achieve the expected result, there must be strong work coordination among government, NGOs and Pokhara squatter community.
- Government should support secure land tenure and affordable housing with the intention that future generations can have adequate access to basic infrastructure services such as electricity, water and sanitation, proper housing which the present generations are not accessed.

Acknowledgements

We would like to express our deepest appreciations the respondents without whom the study would never have been complete. We are thankful to SchEMS for providing us opportunity to work under this research title. Also, we wants to say "thank you" to all those who helped us completing our study and who may have been left out unwittingly and tender apologies for not acknowledging you individually.

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Preparation and Characterization of Solid Contact Cd (II) Ion-Selective Electrode by Co-precipitation Method

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Abstract

Monitoring of Cadmium is essentialas it is a toxic heavy metal and an environmental pollutant. Among many ways to monitor cadmium in environment, usage of Ion Selective Electrode (ISE) for onsite measurement is currently on rise due its low cost, simplicity and reliability. A key feature of using ISE is that it can measure ionic activity of selected ion, in presence of different ions in a solution. Three different Cd ISEs were prepared by varying the mass ratio of active elements in the electrodes. The mass ratios were 1:2, 2:1 and 1:1 of cadmium sulphide (CdS) and silver sulphide(Ag_2S); they are named as CdS_1, CdS_2 and CdS_3, respectively. The prepared Cd-ISEs were characterized for its crystalline phase by using X-ray diffractometer. Working pH for CdS_1 ISE is (1-8) while that is enhanced to pH (1-9) for CdS_2 and CdS_3. All the Cd-ISEs show linearity up to $1x10^{-5}MCd^{2+}$ using $CdNO_3$ solution. The response of the sensor depended on the preconditioning of sensing membrane before use and rinsing of the sensor during use.

Keywords : *Cd^{2+}Ion-Selective Electrode, Simple Co-Preccipitation Method, Environmental Pollution, Nernstian Response, Selectivity Co-efficient.*

Introduction

Cadmium occurs associated with other metalssuch as zinc, copper, lead, iron and steel.Inaddition, it also associated with fossil fuel (coal, oil gas, peat, and wood), cement and phosphate fertilizers. Use and dispose of these metals in our daily life in different forms such as nickel-cadmium batteries, cadmium containing paint pigments, and artificial manure pollute the environment which would consequently affect living organisms (Freiser, H., 1981). Cadmium is extremely toxic with bio-accumulative and bio-magnification capability. Excess of Cadmium is also known to cause adverse effect on human health such as kidney failure, high blood pressure, skin problems, lung diseases and chronic anaemia (Peralta-Videa, 2009,). Furthermore, irrigation with cadmium contaminated water had been reported to cause itai-itai disease, in Japan. So, Cadmium pollution is one of the most serious environmental problems in the world (Shunyang, et al., 2011).

Detection and quantification of cadmium is important in the field of environmental monitoring, waste management, developmental biology, and clinical toxicology. There are various methods to analyze Cd ions. These include sophisticated instrumental methods such as induced couple plasma (ICP), Atomic Absorption spectra (AAS), Flame photometry (FP), Anodic stripping voltammetry (ASV) among others. As these methods are expensive and require adequate expertise to handle such instruments so it is necessary to develop a simple analytical tool which is rapid, accurate, low cost and easy to handle during analysis. A variety of ion selective electrodes have been reported for determination of cadmium ion. In these electrodes, different compounds in a PVC based membranes and ligand based membranes are used for the detection of Cd^{2+} (Vlasovand Bychkov, 1987). The preparation and characterization of homogeneous Ag_2S based electrode have been reported by different authors(Young, 1986); van derand Oostervink,1979; Manguel and Pineros, 1998); Peralta-

Videa et al., 2009).Shunyanget al. (2011) have prepared all solid state Cd^{2+} ISE and characterized with pH response, Nernstian response, lower detection limit. They show transduction of ion to electron through membrane via EIS measurement. There is growing demand of ISE and therefore more and more researches are focusing on improving the performance of such ISE by optimizing the materials, preparation methods and fabrication process. This study aims to study the effect of composition of constituent materials on the response of ISE towards cadmium ion in aqueous medium.

Experimental

Co-Precipitation of Sulphides

The active component of the sensor was prepared by simple co-precipitation method. Firstly, required volume of cadmium nitrate (Fisher Scientific) and silver nitrate (Fisher Scientific) solutions was mixed in a beaker. The mixture was slowly poured into another beaker containing adequate amount of a molar sodium sulphide (Qualigens) solution to obtain co-precipitation of CdS and Ag_2S. Nomenclature of electrodes with their composition ratios are given in table 1. To ensure completion of the precipitation reaction the mixture was heated up to 50°C to 60°C while continuously stirred with a magnetic stirrer for an hour. The black precipitate was then filtered off by 4g sintered glass crucible and washed several times with distilled water to remove sulphide and metal ions. Finally, precipitate was again washed with nitric acid and was dried at 100°C to 110°C in a hot air oven for 24 hour. The precipitate thus obtained was grounded into fine powder and sieved through 45-micron sieve (Fisher Scientific Co. N 325) to maintain particle size up to the mesh size.

Table: 1 Name of Samples with their Composition Ratio

Reactants	Ratio of $Cd(NO_3)_2$ / $AgNO_3$	Sample name	Percentage Composition
$Cd(NO_3)_2$ (CDH, 99.0%) $AgNO_3$ (Fisher Scientific, 99.8%) Na_2S (Qualigens, 99.0%)	1:2 2:1 1:1	CdS_1 CdS_2 CdS_3	33.3%Cd:66.7%Ag 66.7%Cd:33.3%Ag 50.0%Cd:50.0%Ag

Possible reactions for the precipitations are given below(vogel's 1989):

$1Cd(NO_3)_2 + 4AgNO_3 + 3Na_2S \rightarrow CdS\downarrow + 2Ag_2S\ (black)\downarrow + 6NaNO_3$ (1:2)

$2Cd(NO_3)_2 + 2AgNO_3 + 3Na_2S \rightarrow 2CdS\downarrow + Ag_2S\ (black)\downarrow + 6NaNO_3$ (2:1)

$1Cd(NO_3)_2 + 2AgNO_3 + 2Na_2S \rightarrow CdS\downarrow + Ag_2S\ (black)\downarrow + 4NaNO_3$ (1:1)

Fabrication of Electrode Body

The powdery co-precipitatewaspelleted and housed into a polypropylene body by silver back contact as reported in our o previous work(Yadav, 2011; Nakarmi and Yadav, 2016) and Schematic diagram is given below:

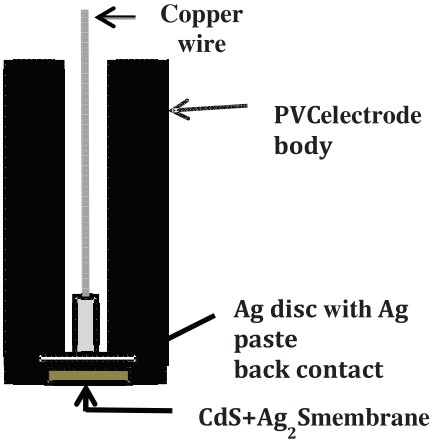

Fig.1: Schematic Showing Assembly of Cd-ISE in a Polypropylene Body

Physical Characterization of the Membrane

The bulk resistance of the pelleted membrane was measured by using 4-probe method. Phase characterization was done with the help of X-ray diffractometer (X' Pert MPD-OEC, with Cu-Kα radiation at 40kV and 40 mA).

Response Characterization of the Cd-ISE

The response of thus fabricated Cd-ISE was tested in varying concentration of Cd^{2+} ion using $Cd(NO_3)_2$ solutions using different media. Similarly, the effect of pH on the stability of measured potential was checked by varying the pH from 1 to 10 and potentiometric titration of Cd^{2+} ion using Cd-ISE was carried out against standard solution of EDTA to check it suitability for using as indicator electrode in potentiometric titration. Stock solutions of 1M $Cd(NO_3)_2$(CDH, 99.0%) and 5M $NaNO_3$ (Fisher Scientific, 98%) were prepared in double distilled water by adding calculated amount of AR grade. For daily experiment, fresh solutions in the concentration range of 10^{-1} to 10^{-6} M were prepared by serial dilution from stock solution. Methanol and ascorbic acid was used to study the effect of de-oxidant.

The electrochemical cell consisted of CdS/Ag_2S ISE and a saturated calomel electrode connected through a salt bridge (KNO_3 in agar agar).The experimental cell can be represented as

Hg | Hg_2Cl_2(s), KCl(sat)|| test solution | CdS_1|CdS_2 |CdS_3-Ag_2S ISE

Results and Discussion

Resistance Measurement

The four-point probe method used for the measurement of bulk resistance of the pressed pellet membrane gave resistance typical of semiconducting materials. Resistance values showed by CdS_1, CdS_2 and CdS_3 samples were respectively 7.50x 106W, 1.16 x 106W, 1.16 x 106W(Pearce, et al.,2006, Maryniak, et al., 2013,Bindu, S and Suresh, 2014).

Phase Characterization

X-ray diffraction patterns of pressed pellets of all samples were taken in diffraction angle of 20 to 50 degree at a scan rate of 0.05deg/sec. All the peaks were identified by using JCPDS database and

showed the presence of binary phase of CdS (JCPDS data card no. 80-0019 CdS) and Ag_2S (JCPDS data card no.14-0072) existing as separate phase. The peaks for CdS were obtained at 26.50(002), 28.40(112), 36.74(530) and that for Ag_2S were at 24.74(110), 25.10(111), 26.76(12), 34.62(121), 36.74(220), 37.94(120) and 44(103). The result shows that the co-precipitates were in pure state, polycrystalline in nature and no ternary phase was observed. The intensity ratio of CdS to Ag_2S was found to depend on the ratio of CdS to Ag_2S.

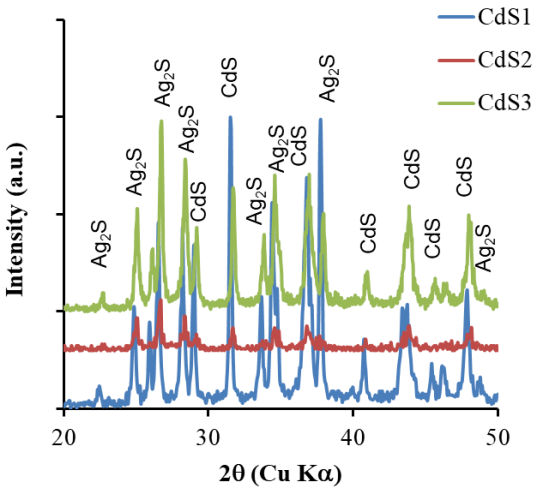

Fig.2:X- Ray Diffraction Pattern of Co-Precipitate of Cd ISE Samples

Response Characterization

Effect of pH on the Potential Response

The effect of pH on electrode response was studied by measuring the Emf of 10^{-3} M Cd^{2+} ions solution along with 0.1 M $NaNO_3$ at various pH. The pH of the solution was adjusted with nitric acid and sodium hydroxide. The result is shown in Fig. 3. It is obvious that the Cd-ISE of present study shows a stable cell Emf in pH range of 1 to 9for CdS_2 and CdS_3 but it is slightly diminishedin the case of CdS_1 (pH 1 to 8). This suggests that the membrane is insensitive to hydrogen ion and hydroxide ion and work well in this pH range.

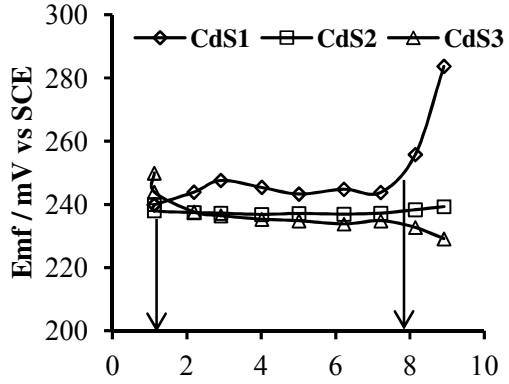

Fig.4: Effect of pH on EMF Output of the Cadmium ISE

Nernstian Response to Cd^{2+} Ion

The response of the Cd-ISEs with different concentration of cadmium ion was monitored under various conditions, namely $NaNO_3$, methanol and ascorbic acid. The results are shown in Fig.5a-c. It is obvious that the CdS_3 electrode in $Cd(NO_3)_2$ with $NaNO_3$, methanol and with ascorbic acid gives linear response in the concentration range 10^{-1} to 10^{-5} M. The general trend in all the 3 sensors in 3 different electrolytic condition is that the Nernstian slope gets better with the addition of methanol and ascorbic acid, Nernstian slopes was better in CdS_3 and CdS_1-ISEs (25mV/decade) compared to CdS_2 (19mV/decade). These media provide antioxidant condition, thus preventing dissolution of sulphides precipitates from the pellet. The linearity also get slightly better with the addition of methanol and ascorbic acid, so slightly lower concentration that $1x10^{-5}$ m Cd^{2+} can be measured. It was noticed that the response of the sensor was greatly affected by pre-conditioning of electrodes prior to use and rinsing of electrodes during use(Badal, 2012).

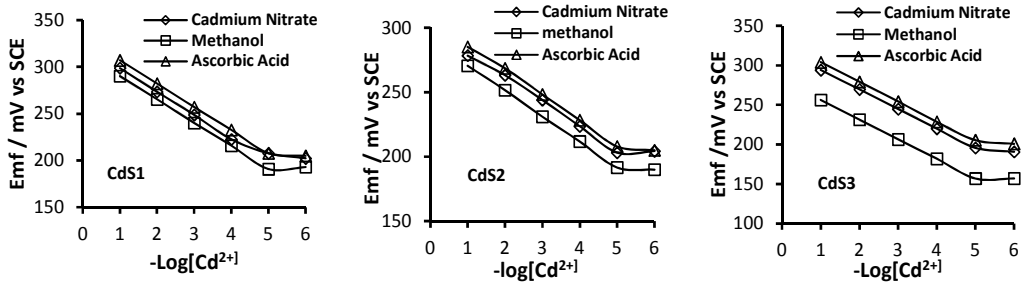

Fig. 5a-C: Potential Vs. Concentrations Plots of Three Different Cadmium Ion-Selective Electrodes Prepared by Simple Co-Precipitation

Application of Prepared Cd-Sensor

Potentiometric titration is a good way to determine the concentration of Cd-ion in an unknown and turbid or colored solution by using ion-sensor as indicator electrode. End point is recorded between equi-molar solution of cadmium nitrate and EDTA giving a sharp end point when all Cd-ion get consumed by EDTA. Among them CdS_3 shows more sharp end point and therefore result of only CdS^3-ISE is shown in Fig.6. The end point was obtained at 10 mL of EDTA as predicted ad therefore shows that Cd-ion can be estimated from unknown sample by locating the end point sharply.

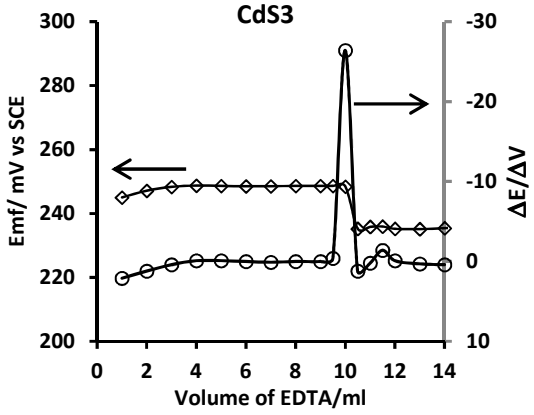

Fig. 6: Potentiometric Titration of 10 mL 10^{-2}M $Cd(NO_3)_2$ Against EDTA Solution Using CdS_3 ISE

Conclusion

Low cost heavy metal Cd ion selective electrode is successfully prepared in laboratory with three different compositions, CdS_1, CdS_2, and CdS_3. The co-precipitateswere polycrystalline in nature, composed of binary phase of Cd and Ag sulphides. The pH range where potential was stable up to 1-9 and Nernstian response to Cd-ion was observed up to 10^{-5}M concentration. The Nernstian slope and linearity was marginally better in methanol and ascorbic acid media. The laboratory fabricated Cd-ISE showed good behavior with respect to using as indicator electrode in potentiometric titration for the determination of Cd-ion in unknown sample.

Acknowledgements

Authors would like to acknowledge the financial support of University Grants Commission, Sanothimi, Bhaktapur, Nepal for providing PhD grants to Ms. Krishna Badan Nakarmi and for Faculty research grants-2011 to Amar Prasad Yadav.

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Spray Deposition of Tin Sulphide Thin Films and Study its Optical Properties

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Abstract

We have prepared tin sulphide (Sn_xS_y) thin film on glass substrate by spray pyrolysis technique using tin chloride and thiourea as starting material. The deposition was carried out at temperature of 275^0C and 350^0C and also at different deposition time. The XRD measurements show that the films prepared at these temperatures contain different phases of tin sulphide compound. The sample prepared at 275^0C shows the presence of SnS, SnS_2 as well as Sn_2S_3 phase. However, at 350^0C, Sn_2S_3 phase is not found. Optical transmittances were observed to increase with increase in deposition time. The optical transition occurring in the material is found to be direct type. The band gap of this film prepared at 275 ^{0}C and 300^0C is found to be 2.8 eV and 2.90 eV, respectively.

Keywords : *Sulphide, Optical Transition, Pyrolysis*

Introduction

Recently, thin film of tin sulphide has attracted considerable attention because of potential application in number of solid-state device such as photovoltaic (Anderson and Morton 1945) photo electrochemical (Patil and Fredgold 1971 and Said and Lee 1973) and photoconductivity cell(Nair and Nair 1991). There exist several report on structural (Hoffman and Kristallogr 1965) electrical (Albers Hass et, al 1960) and optical (Anderson and Morton 1945) characteristics of these material Tin forms several binary sulphid such as SnS, SnS_2, and Sn_2S_3. These could be very interesting for the photovoltaic conversion (Anderson and Morton 1945) of solar energy into electrical energy. Its optical property like band gap of 1.3eV (Hass and Corbey 1961) and high light absorption coefficient (Parrenteeau and Corlone 1990) make it suitable as an absorber layer in the fabrication of thin film of heterojunction solar cell. The thin film of SnS_2 having a band gap 2.2 eV (Lokehande 1990) is more suitable for photoconductivity photo electrical cell and hetrojunction solar cell. Further, its constituent element being abundant in nature and not possessing any health and environmental hazards has an additional advantage. The three compounds (SnS, SnS_2, Sn_2S_3) of the system are interesting from technological point of view.

The film of this material has been prepared by different method such as chemical melt growth (Anderson Albers and Wasscher 1961), chemical vapour deposition (Albers and Maesen 1960) and electrolysis deposition (Schonherr and Stter 1975). In this paper we describe the preparation of the thin film by spray pyrolysis technique and characterize the film by XRD and optical absorption study.

Materials and Methods

Thin film of tin sulphides were prepared as follows. The two separate solutions of $SnCl_2$. $2H_2O$ and Thiourea of same concentration (.1M) were initially prepared and mixed in equimolecular proportion. Ordinary microscopic glass slide was used for film deposition. Before deposition the glass slide were washed by detergent, then boiled in 1:1 dilute HCl for about one hour and then cleaned in, trichloroethyene, methanol and acetone successively. The glass substrate was

first heated by using locally made hot plate. Its temperature was controlled by temperature controller made of JETEE Company, of Taiwan. The glass substrate was enclosed by glass box of about 8"x 4"x 2" in size. First, mist of the $SnCl_2$. $2H_2O$ solution of concentration 0.1M was generated by using nebulizer and mist was passed through the glass box to the heated substrate. The deposition is carried out till all solution (14ml) was converted to mist. This roughly takes about an hour. The sample were prepared at two different temperature 275°C and 350°C keeping all the parameters same.

Results and Discussions

The results of X-ray diffraction and optical transmittance measurement for the thin film prepared at the two different temperature 275°C and 350°C is given below. All the thin films deposited at both temperatures is observed to be good shinning. They were observed to be strongly adherent to the substrate. It was so adherent that we could not remove the film completely even scratching the film by any sharp edge of glass or metal by several times.

The film deposited at the lower temperature (275°C) is observed to be golden yellow in color and show mirror shining. We have tested the conductivity of the film using multi meter. And the film deposited at the lower temperature (275°C) is observed to be non- conductive. The film deposited at higher temperature (350°C) is appeared to be white cloudy deposition in transmitted light and appeared to be greenish pink color in reflected daylight. The film prepared at higher temperature i.e. 350°C show good conductivity.

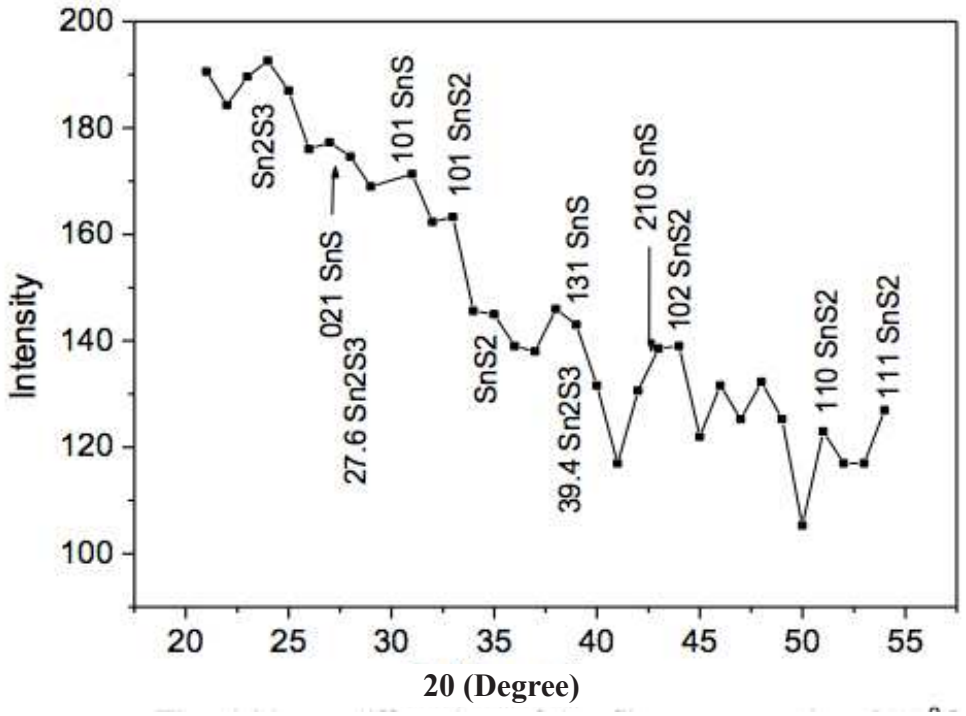

Fig. 1 X-ray Diffraction of the Film Prepared at 275°C

The X-Ray diffraction profiles of the film formed at two different substrate temperatures are depicted in fig 1 and 2. The spectra clearly show the presence of different phases of the tin compounds. The XRD profiles are indexed by comparing the peak position with the XRD pattern of SnS_2 and SnS. From figure 1 it is seen that the peaks at 32.95, 43.98,

50.92, 53.87 correspond to the reflection form (101), (102), (110) and (111) plane of SnS2 phase. The peak at the 2 position, 27.58, 30.6, 38.97 and 42.7 corresponding to the reflection form (021), (101), (131) and (210) plane of SnS phase. Similarly, the peak at 24.01, 27.6, 39.4 position is due to the reflection from different phase of Sn_2S_3 phase. This shows that at low deposition temperature at 275°C all SnS, SnS_2 and Sn_2S_3 phase are present in this film. Figure 2 depicts the XRD profile of the film deposited at the higher temperature 350°C. Here, again we see that the peaks at position 33.1, 50.6 and 53.6 correspond to the reflection form (101), (110) and (111) plane of SnS_2 phase. In similar manner peaks due to presence of other phase are indexed as shown in figure. In fig. 2 no peak corresponding to the Sn_2S_3 phase were found. Thus, we find that at higher deposition temperature Sn_2S_3 phase is not found.

We have measured the optical transmittance of the sample at two different temperatures 275°C and 350°C. Fig. 3 depicts the variation of the transmittance (T %) with wavelength (nanometer) for the sample prepared at two different temperature with all other deposition parameter same.

From the figure we find that the transmittance increases with increasing deposition temperature. The transmittance at higher temperature 350°C has higher transmittance. This may be due to the presence of Sn_2S_3 phase at low deposition temperature and absent at higher deposition temperature.

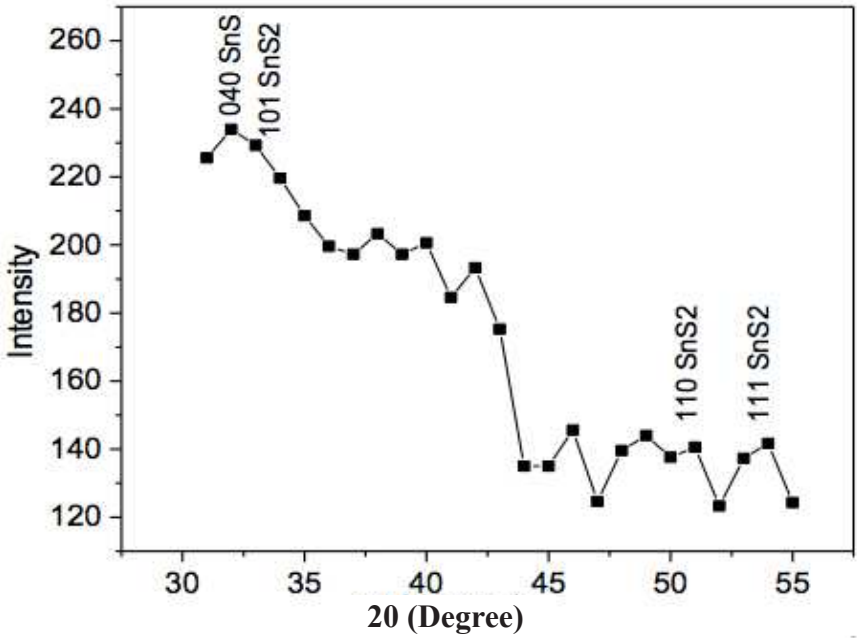

Fig. 2 X-ray Diffraction of the Film Prepared at 350°C

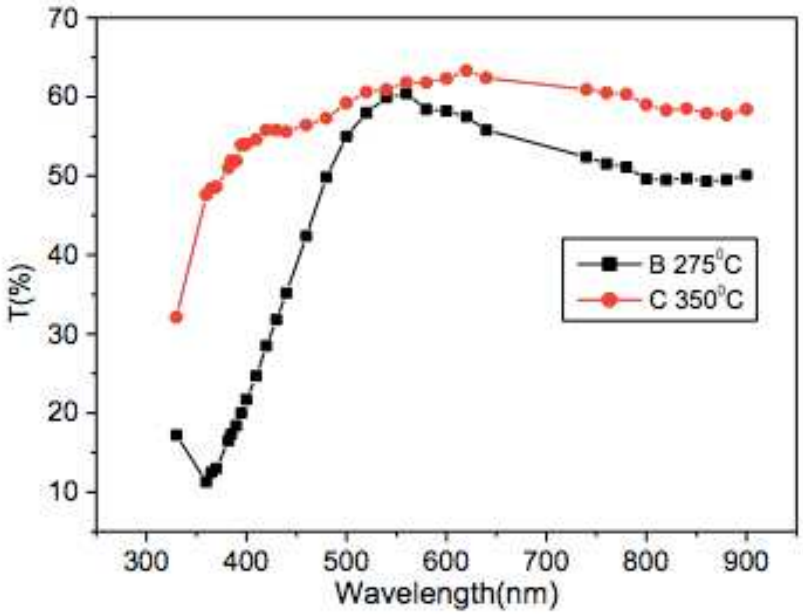

Fig. 3 Plot Showing Variation of Transmittance with Wavelength for Two Deposition Time

Fig. 3 depicts the variation of the transmittance (T %) with wavelength at two different deposition time keeping the substrate temperature fixed to 275°C From this figure we see that transmittance at higher wavelength decrease with increasing deposition time, which is obviously due to increase in thickness of the sample with deposition time.

In order to determine the optical band gap of the material and the type of optical absorption responsible for optical absorption we use equation by Bardeen (Bardeen et. al

1956). For direct transition the absorption coefficient is related to band gap Eg as

$hv = A(hv-Eg)^n$

where, n = 1/2 or 3/2 for direct allow transmission and A is constant. h is Plank constant and v is frequency. For indirect transmission is given by

$hv = A(hv-Eg \pm Ep)^n$

Where, Ep is the Energy of absorbed (+) and emitted (-) photon and n=2 for allowed transition and n = 3 for forbidden transition. Thus, by plotting $(hv)^{1/n}$ vs hv for different values of n material one can find out the possible transition occurring and the corresponding energy gap of the material. To decide the band gap we plot $(hv)^{½}$ vs hv, $(hv)^2$ vs hv.

Fig 4 depicts the plot for $(hv)^{½}$ and $(hv)^2$ vs hv for the film deposited with.1M $SnCl_2$ solution at temperature C. The curve with symbol (■) is for $(hv)^2$ vs hv and the curve with symbol (•) is for $(hv)^{½}$ vs. hv curve. From this figure, we see that curve can be fitted to be straight line. This indicates the direct optical transition occurring in the material is direct type. We have calculated band gap by fitting the straight portion of the curve by using linear fit. The band gap thus calculated is found to be 2.87 eV.

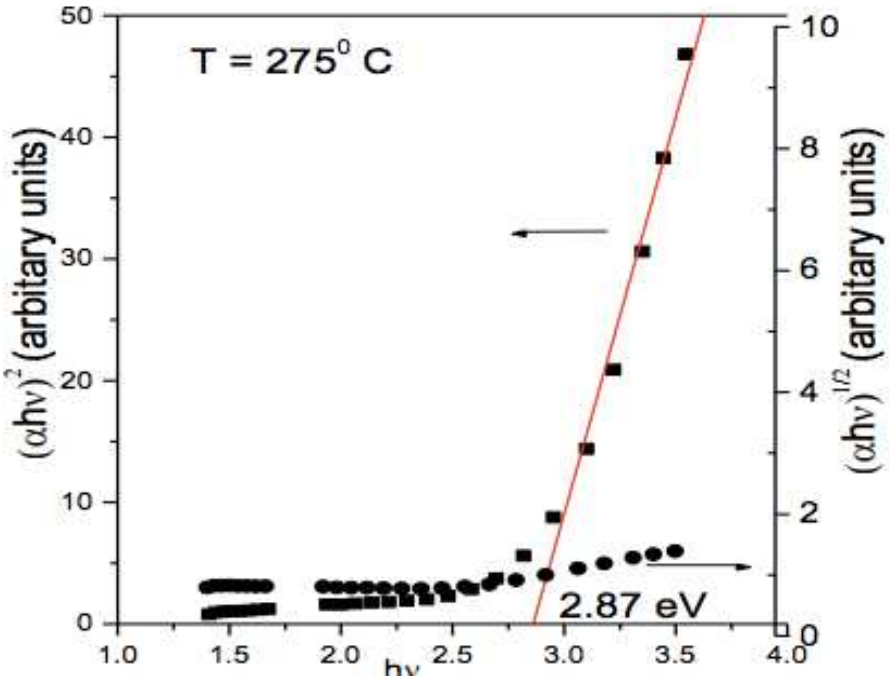

Fig. 4. Plot Showing Variation of (hν)½ and (hν)² vs. hν for Deposition Temperature T = 275°C

Fig 5 depicts the (hν)½ and (hν)² vs. hν plot for film prepared at 350°C temperature. Here again we see that straight line can be fitted in the (hν)² vs hν curve. Again we find that optical transition occurring in this curve is also of direct type and the band gap is found to be 2.90 eV.

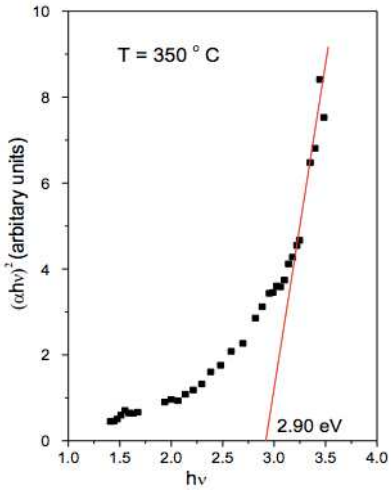

Fig. 5. Plot Showing Variation of (hν)½ and (hν)² vs. hν for Deposition Temperature T = 350°C

Conclusion

Spray pyrolysis technique has been successively utilized for depositing tin sulphide (Sn_xS_y) film on glass substrate. The film deposited at 275°C is observed to contain SnS_2, SnS and Sn_2S_3 phases. But at higher deposition temperature (350°C) Sn_2S_3 phase is missing .The optical transmittance occurring in both sample is observed to be direct type. The band gap calculated for the sample prepared at 275°C and 350°C is found to be 2.87eV and 2.90 eV, respectively.

Reference

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Documentation of Climate Change Adaptation Practices: A Case of Dandigurase and Mahadevsthan VDC in Sindhuli District of Nepal

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Abstract

Climate change has adversely affected in lives, food security, crop and livestock production, forest and water resources. To mitigate the effects of Climate Change, people of different lifestyle have developed their capacity to cope with and adapt to climate change. Farmers with their long experience in farming developed and practiced the traditional knowledge to cope with the changing environment in their farming systems. A study was carried out in August 2017 in Sindhuli district of Nepal to document the best adaptation strategies to cope with the adverse effect of climate change on agriculture. Study showed that construction of wastewater collection pond, rainwater harvesting pond, micro irrigation, plastic pond and poly-tank for irrigation, innovation in seedbed preparation for the plantation of rice, use of organic mulch and plastic sheet and lift irrigation system were major coping strategies to mitigate the effects of climate change on agriculture in that district. The current article deals with the all available adaptation practices followed by farmers to cope with the effects of climate change in Sindhuli district of Nepal.

Keywords : *Climate Change, Adaptation, Irrigation, Agriculture and Rainwater*

Introduction

Currently, climate change has been a serious threat to the global society. Natural resources including water, biodiversity, agriculture and other important components such as food security and human health will be the most affected aspects by the climate change impact (Dieudonne, 2001). According to the definition of IPCC, "Climate change is the change in climatic condition over time occurred either due to anthropogenic or nature induced causes, which remains for decades or even longer period of time showing distinct variation in its mean" (IPCC, 2007).The earth's climate is changing gradually and has been challenging the whole world. The LDCs will be the ones which will be highly affected though they have not contributed much in increasing the level of green house gases (GHGs) and have low adapting capacity to climate change (Orindi & Eriksen, 2005). Referring to the criteria set for the least developed countries by Economic and Social Council of the United Nations, Nepal is among the 49 LDC's likely to be affected by climate change in the days to come (Saleemul et al., 2003).

Agriculture in Nepal is totally dependent on weather and climatic conditions. Increasingly, unusual changes in climate as increase in temperature, elongated dry spells, irregular monsoon, intensity of rainfall and its patterns are being noticed in Nepal. Climate change would lead to crop failure and add more pressure on food supplies (Randerson, 2008). Local level impacts as loss of local land races, plant and animal species, changes in cropping patterns, scarcity of water due to drying of wells, decrease in agriculture productivity have been noticed in Nepal (Regmi et al., 2008). More than 80 percent of Nepalese farmers are dependent on agriculture. Changes in rainfall patterns and prevalence of erratic rain have already been experienced by farmers in Nepal. Rainfall starts earlier

and ends late, as a result paddy planting month has been dry and late planting resulted in reduced paddy yield. Farmers have been trying to adopt the changing climate to maintain the yield of rice, the main food in Nepal (Reid et al., 2007).

As agriculture is highly sensitive to climate/weather, the production processes are impacted by any type of changes in it. Significant changes noticed in the climatic conditions such as droughts, rise in sea- level and increasing irregularities in rain fall patterns already had immediate impacts on food production, distribution infrastructure, and incidence of food emergencies, livelihood assets, opportunities and human health in both rural and urban areas. This will ultimately affect food security (FAO, 2007). Nepal is an agricultural country and most of the farmers are dependent on rain-fed agriculture for their livelihood. Climate change has been experienced in Nepal and it is predicted that the effects of climate change and variability is likely to increase in coming days. Farmers have already started adopting various adaptation measures to cope with the effects of climate change on agriculture. Thus, it is important to study whether the adaptation measures undertaken by farmers are heading towards positive direction or not.

Objective

The objective of this study was to document the best adaptation strategies to cope with the effects of climate change on agriculture in Sindhuli district of Nepal.

Materials and Methods

Study Area

Dandigurase and Mahadevsthan VDC of Sindhuli district were purposively selected for the purpose of the study. The required data for this study were collected through field observations, focus group discussion and interaction with farmers of different age group. The secondary data were collected from the various publications and reviewed different literature in internet. Study was carried out in August 2017.

Results and Discussion

From the study best adaptation strategies to cope with the effects of climate change on agriculture in Dandigurase and Mahadevsthan VDC of Sindhuli district of Nepal were explained as under;

Wastewater Collection Pond

The sources of waste water were mainly the water from washing and cleaning, domestic waste water and rain water, which were generally collected in pond and used for irrigating crops in dry season. The collected water in collection pond was also used in case of shortage of water for vegetable farming in kitchen garden.

Rainwater Harvesting Pond

Collection of wastewater in pond is governed by several factors such as soil type, soil moisture, its construction as well as maintenance. In this practices rain from the roof of building were collected through plastic pipes and driven through canal. During rainfall, rainwater was collected in this canal and passed out to pond, which was finally used for irrigation and also for the purpose of livestock drinks

Micro Irrigation from Well or River

Farmers of Dandigurase VDC of Sindhuli district use underground water for irrigation. After

constructing an artificial well in the farmland, farmers succeeded in large-scale production of vegetables even in the dry months. We observed following different irrigation practices as adaption options of climate chand in study site.

On-Farm Polythene Pipe After the water was pumped up or lifted through the pump sets from the river called Ghaghar Khola, lifted water was either distributed directly in farm field or stored in concrete pond, which later on was used for farming.

Drip-Irrigation System For the irrigation in tomato crop farmers were using drip irrigation using the plastic drum and separate low cost polythene pipes.

Laying Polythene Pipe The pipe was directly connected to the pump sets. Farmers could use river water and well water for the irrigation by laying the polythene pipe only at the time when pump was operated. This type of irrigation practices was widely adopted while planting the paddy crops in Dandigurase and Mahadevsthan VDC of Sindhuli district.

Plastic Pond and Poly-Tank for Irrigation

During water shortage period from mid-February to mid-June, farmers faced extreme shortage of irrigation water in vegetables like tomato, cauliflower, cabbage etc. Local people of the study site had experienced maximum decrease in water table in water shortage period. In Dandigurase and MahadevsthanVDC of Sindhuli district two type of pond were observed. One was Cemented pond and other was plastic covered pond. Local people constructed pond in which waste was stored and applied for irrigation in dry periods. Construction of plastic pond was supported by District Agriculture Development Offices, Sindhuli through President Chure Conservation Program.

Lift Irrigation System

The lift irrigation system was constructed in Mahadevsthan ward no 2 and Dandigurase ward no 8 VDC of Sindhuli district by district agriculture development office of Sindhuli district with the support from President Chure Conservation Program. Water was lifted from Ghaghar Khola. Local people said that there was difficulty in growing vegetables due to lack of irrigation water in earlier days. With the lift irrigation system, the vegetable yield was very good and the farmers now could think of diversifying their crops. They planned to grow tomatoes, beans, cauliflower and bitter gourd in the field in large scale. A relatively small initiative had brought about a huge transformation in the village.

Innovation in Seedbed Preparation for the Plantation of Paddy Crops

Lack of water to irrigate the seedbed, drying of delicate paddy seedlings from the intense sun were the major climatic effects faced by the farmers during the rice plantation. Second week of Jestha was the popular date in study site for the seedbed preparation of rice. The respondent remembered that around 20 years back, farmers did not experience problem of intense sun and shortage of irrigation water while it is prominent these days. To protect the seedling of rice from adverse climatic effects , farmers cover the sowed dry seeds by thin layer of soil and green mulch, which protected paddy seeds and seedlings from intense sun, from birds and also helped to conserve soil moisture.

Use of Organic Mulch and Plastic Sheet

Lack of irrigation water and decreased frequency of rainfall in dry season has limited vegetable farming in dry season. It was further exacerbated by increasing ascendancy of weeds and insects in vegetable. To minimize the problem of water shortage mulching was the best practice adopted by farmers of the study sites. Organic mulch was applied in tomato, chilly, cauliflower, onion, garlic etc for conserving soil moisture for longer duration. Similarly mulching was found to reduce

preponderance of weeds and check insect and pest infestation.

Conclusion

The traditional knowledge is the wisdom, and practices of local people gained over time through experience and passed over to their younger ones from generation to generation. This knowledge has played a significant role in coping and mitigating climate change effects and its variability. Adaptation to climate change includes all adjustments in behavior or economic structure that reduces the vulnerability of society to changes in the climate system. From the study we found variety of coping strategies to minimize the effect of climate change and traditional knowledge provided the basis for development of coping strategies. Not only the traditional agricultural practices the farmers are using to cope with the climatic variability but, people also use the modern technologies like drip irrigation system in Mahadevsthan ward no 2 and Dandigurase ward no 8 VDC of Sindhuli district to increase food production in the highly elevated lands where there is acute shortage of water.

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Characterization of Activated Carbon Prepared from Waste Material for Removal of Heavy Metals from Aqueous Solutions

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Abstract

Activated carbon prepared by chemical activation with phosphoric activation of Lapsi seed stone, the waste material, of Lapsi fruits has been used to remove heavy metals ions by adsorption from aqueous solution. Batch adsorption experiments were conducted for the adsorption of heavy metal ions. The activated carbon was characterized by Iodine number, Methylene blue number, SEM, FTIR, Boehm titration. FTIR and Boehm titration shows the presence of surfaced functional groups such as carboxyl, phenolic and lactones. Iodine number and Methylene blue number of the activated carbon are found to be 845.0 mg/g and 277.0 mg/g respectively. The adsorption of heavy metal ions is dependent on pH. Maximum adsorption capacity of the activated carbon is found to 131.0 mg/g, 37.0 mg/g, 28.0 mg/g for Pb (II), Cd(II) and Ni(II) respectively. This study demonstrated that the activated carbon prepared from Lapsi seed stone could be used for the removal of heavy metal ions in water treatment.

Keywords : *Adsorption, Adsorption Capacity, Lapsi Seed Stone, Chemical Activation, Phosphoric Acid*

Introduction

Heavy metal ions such as lead, cadmium, nickel,etc. are considered as hazardous to the environment due to their toxicity and non-biodegradability even at low concentrations. Many industrial processes such as smelting, metal plating, mining pigments, cadmium-nickel-batteries, brass manufacture discharge aqueous effluents containing heavy metals [Raoa et al; 2006].Cadmium , lead and nickel ions are among the most common heavy metal pollutants found and cause harmful and serious problems. Hence the toxic metal ions should be removed from water.

Conventional physicochemical techniques for removal of toxic metals from water include coagulation. Precipitation, ion exchange, electrochemical treatments, and reverse osmosis [Lesmana et al; 2009]. However, these methods have the disadvantages like generation of large volume of sludge, high operational costs and difficulty in treatment of large volume of wastewater containing low concentrations of metals.

Hence, adsorption as one of the most popular and effective technologies, has been widely studied over recent decades, because of its high efficiency, easy handling, and availability of different adsorbents. Adsorption process has been exclusively in water treatment and many studies has been carried out to find the inexpensive and chemico-physiccaly feasible adsorbent.

Many reports explored the development of low cost activated carbon from cheaper and readily available agricultural wastes such as rice husk [Chuha et al; 2005] coconut shell [Kula et al; 2008], olive stone [Mouni et al; 2011], coconut [Sekar et al; 2004], Peanut shell [Anna et al; 2011], hazelnut husks etc. have been tested in the production of activated carbon in developing countries. In this study Lapsi seed stone has been utilized to prepare activated carbon for the removal of heavy metals from aqueous solutions since the seed stones are readily available and can be used as a viable adsorbent for the removal of heavy metals.

Materials and Methods

Preparation of Adsorbent

The waste materials used in the preparation of activated carbon (adsorbent) are Lapsi seed stones, the waste products of Lapsi fruits which were collected from Fruits and Vegetable Market, Kalimati. Lapsi seed stones were exposed from the fruits by boiling and collected. The seed stones were washed with distilled water and dried at 110°C oven and crushed with electric grinder and sieved to obtain the size of 300 µm.The dried mass was mixed with 50% H_3PO_4 in the ratio of 1:1 and carbonized at 400°C for hours and cooled . The activated carbon was washed with distilled water several times by warm distilled water and dried. The carbon was then cooled and sieved to obtain particles of size 106µm. The activated carbon prepared was indicated by PAALSC (Phosphoric acid activated Lapsi seed stone carbon) and applied as adsorbent for the removal of heavy metal ions.

Chemicals

All the chemicals and reagents used in this study are of analytical grade.Distlled water prepared in the laboratory was used to prepare the stock solution of heavy metals.0.1M HCl and HNO_3 were used to adjust pH of the solutions.

Instruments

Digital pH meter was used to measure the pH of solutions. The adsorption experiments were carried out by using Shaker (Digital VDRL Rotator-RPM-S).The concentrations of Heavy metal (II) ions were determined by atomic absorption spectrophotometer (AAS –VARIAN-AA240FS). UV/ Vis spectrophotometer (CECIL- CE-100) was used to determine the concentration of methylene blue.

Adsorption Experiments

Batch experiments of adsorption were performed in 50 ml stoppered conical flasks .The flasks were being agitated on Digital VDRL Rotator- RPM-S at 225 rpm for identified time intervals. The effect of contact time, adsorbent dose and solution pH was studied. Each experiment was carried out by suspending 0.05 g of adsorbent in 25 ml adsorbate solution taken in the conical flasks under the optimum conditions set out for the experiments. Since pH is a critical parameter in the process; therefore pH of the solutions was adjusted by addition of NaOH and HCl.The effect of pH and contact time on the adsorption of heavy metals ions by PAALSC at different pH, contact time and adsorbent dose was at room temperature.

The amount of metal ions adsorbed can be calculated by the following equation.

$$q_e = \frac{(C_o - C_e) \times V}{W} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where Co and Ce are initial and equilibrium concentration of metal ion (mg / L) respectively, W, the mass of adsorbent in gram (g) and V is the volume of the solution in liter (L).

The percentage of removed metal ions (Rem %) in solution is calculated by using following the formula

$$\text{Rem}(\%) = \frac{(C_o - C_e) \times 100}{C_o} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Results and Discussion

Characterization of Activated Carbon

Characterization of activated carbon prepared was done by FTIR Spectroscopy, Boehm Titration, Methylene blue number, Iodine number, SEM.

Fourier Transform Infrared (FTIR) Spectroscopy

The FTIR spectra of dried unloaded activated carbon (PAALSC) and Heavy metal (II) ions loaded activated carbon were examined to study surface functional groups and were presented in Figures 1 and 2 respectively. The FTIR spectra of unloaded activated carbon exhibit a broad band at 3419 cm^{-1} due to the presence of hydroxyl groups on the adsorbent surface. The band located at 1725 $cm^{-1}$is ascribed to the stretching vibrations of carboxylic groups or to conjugated carbonyl groups(C=O) in carboxylic and lactones groups. Asymmetric stretching vibrations of ionic carboxylic groups (-COO-) appeared at 1571 cm^{-1}. The bands 1725.0 cm^{-1} and 3419.0 cm^{-1}were observed in activated carbon. The presence of these bands in activated carbon may due to the action of activating agent in functionalizing the carbon during its preparation. Similarly comparing heavy metal (II) ions unloaded activated carbon with Heavy metal (II) ions loaded activated carbon the bands at 3419.0 cm^{-1} and 1571 cm^{-1} were shifted to higher wave numbers 3454.32 cm^{-1} and 1587cm^{-1} respectively and whereas 1725 cm^{-1} band was disappeared in l Heavy metal ions (II) loaded activated carbon. This indicates that the functional groups were involved in the adsorption of heavy metal ions (II) ions onto the activated carbon.

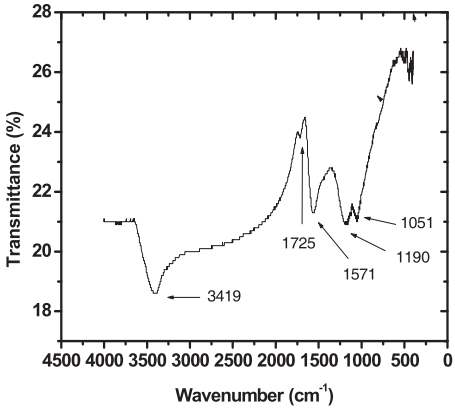

Figure 1: FTIR Spectra of Heavy Metal (II) Ions Unloaded PAALSC

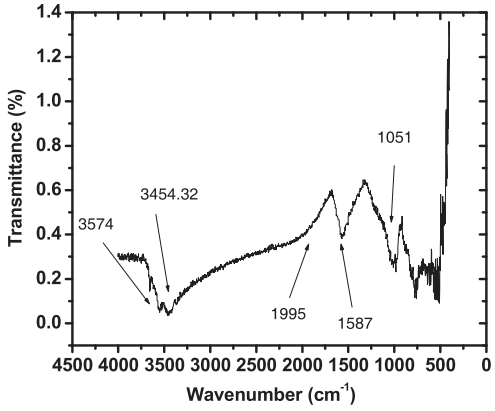

Figure 2: FTIR Spectra of Heavy Metal (II) Ions Unloaded PAALSC

Boehm Titration (Surface Functional Group Determination)

To determine the concentration of acidic functional groups Boehm titration was performed. The milli-equivalent of different acidic functional groups present in activated carbon prepared by chemical activation at 400°C (PAALSC), are presented in Table 1.

Table 1 Boehm Titration Results of PAALSC

Adsorbent	Surface Functional Groups in Milli Equivalent Per Gram (meq/g)		
	Carboxylic	Phenolic	Lactones
PAALSC	0.9	0.6	0.7

Scanning Electron Microscope (SEM)

Scanning Electron Microscope (SEM) of the carbons prepared without activating agent and with H_3PO_4 as activating agent 50 % H_3PO_4 is presented in Figure 3. Figure 3(a) is the SEM of carbon prepared from Lapsi seed stone without any activating agent. The surface is heterogeneous and hardly any pores are visible. Figure 3 (b) is the SEM images of activated carbon prepared by using H_3PO_4 as activation agent. In the SEM image (b) a number of pores with different diameters are observed [Shrestha et al; 2015]. This development of porous structure may be attributed to the dehydrating effect of H_3PO_4. Phosphoric acid being a strong dehydrating agent removes oxygen and hydrogen from Lapsi seed stone as water, and that promotes the development of porous structure.

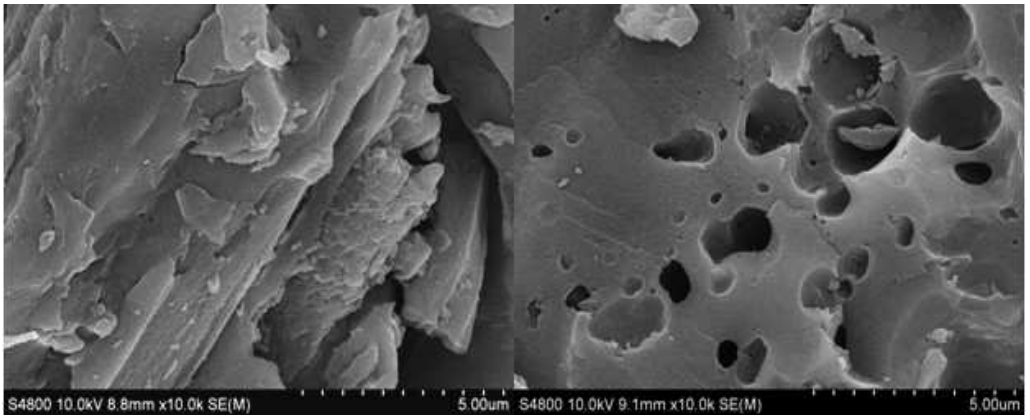

Figure 2. SEM Photographs of (a) Carbon Prepared Without Activating Agent (b) Activated Carbon Prepared using 50 % H_3PO_4 at 400°C.

Methylene Blue Number and Iodine Number

Iodine number gives approximate measure of the micropore content while methylene blue number indicates mesopore distribution in the activated carbon [ASTM-D4607-94 -2006]. Iodine number and Methylene blue numbers are used to estimate approximate surface area and concentration of micro and mesopores [Raposo et al., 2009]. The iodine number is defined as the amount of iodine adsorbed per gram of activated carbon at an equilibrium concentration. Methylene blue number is defined as the amount of the dye adsorbed by one gram of the adsorbent.

Iodine number and Methylene blue number of activated carbon are shown in Table 2

Table 2 Methylene Blue Number and Iodine Number of PAALSC

Adsorbent	Methylene Blue Number mg/g	Iodine Blue Number mg/g
PAALSC	277.0	845.0

Adsorption of Heavy Metals Ions

Batch adsorption experiments were carried out to study the adsorption of Heavy metal ions Pb(II), Cd(II) and Ni(II) from aqueous solutions. The results showed that the optimum pH, contact time and adsorbent dose for the removal of Pb(II) , Ni(II) and Cd(II) ions are found to be 5 for Pb and Ni , 6 for Cd(II); 180 minutes [contact time, 2g/L(adsorbent dose)]respectively. The maximum adsorption capacity for Pb (II),Cd (II) and Ni (II) ions adsorption onto PAALSC is shown in Table 3.

Table 3 Maximum Adsorption Capacity for Pb (II), Cd (II) and Ni (II) Ions Adsorption Onto PAALSC

Heavy metal ions	Maximum adsorption capacity mg/g
Pb(II)	131.0
Cd (II)	37.0
Ni (II)	28.0

Conclusion

Lapsi seed stone, the waste product of Lapsi fruit has been utilized to prepare activated carbon by chemical activation with phosphoric acid .The activated carbon can be used as an adsorbent for removal of heavy metal (II) ions from aqueous solution. The adsorption of heavy metal (II) ions is found to be greatly dependent on the pH of sample solution. The optimum pH for the adsorption of heavy metal (II) ions onto PAALSC is found to be 5 for Pb(II) and Ni(II) and 6 for Cd(II).FTIR and Boehm titration shows the presence of surface functional groups such as carboxyl, phenolic and lactone. SEM image of activated carbon exhibits pores of different diameters. Maximum adsorption capacity of the activated carbon is found to 131.0 mg/g, 37.0 mg/g, 28.0 mg/g for Pb (II), Cd(II) and Ni(II) respectively. The result demonstrated that the activated carbon prepared from Lapsi seed stone by one step phosphoric activation is expected to be economically feasible for the removal of heavy metal (II) ions from aqueous solutions.

Acknowledgements

The author would like to express sincere gratitude to Prof. Dr. Raja Ram Pradhananga, Kuleshwar, Kathmandu for his continuous encouragement, motivation and invaluable suggestions. Acknowledgement also goes to Prof. Dr. Amar Prasad Yadav, Central Department of Chemistry, Tribhuvan University, for his encouragement and valuable suggestions. Thanks also go to Nepal Bureau of Standards and Metrology, Balaju, Kathmandu for the measurement of heavy metal ions by AAS.

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Environmental Analysis of Metal Ions in Rice and Soil of Bangladesh

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Abstract

The study area was comprised of 4 villages of Sirajganj district, Bangladesh. Four soil and paddy (rice) samples were collected and digested in acid digestion bomb with 3:2 HNO_3 and $HClO_4$ mixture at 200°C for two hours. The concentration of metal ions was determined by GF-AAS. The concentration of Ca^{2+}, $K^{\pm}$ and Mg^{2+} were varied with the ranges from 0. 82 to 0.98 mg Kg^{-1}, 2.11 to 2.71 $mgKg^{-1}$, 0.82 to 0.94 $mgKg^{-1}$in rice sample whereas 2.77 to 3.16 $mgKg^{-1}$, 0.419 to 0.519 $mgKg^{-1}$, and 2.65 to 3.06 $mgKg^{-1}$ in soil samples respectively. The highest value of Fe, Mn, Na, Zn, Cu, Co, Pb, Ni Cr, As and Cd were 140.5 $mgKg^{-1}$, 41.22 $mgKg^{-1}$, 377.10 $mgKg^{-1}$, 34.12 $mgKg^{-1}$, 12.97 $mgKg^{-1}$, 0.17 $mgKg^{-1}$, 1.44 $mgKg^{-1}$, 1.92 $mgKg^{-1}$, 1.46, 2.21 $mgKg^{-1}$ and 0.39 $mgKg^{-1}$ found in rice respectively and 15.12 $mgKg^{-1}$, 41.22 $mgKg^{-1}$, 156.4 $mgKg^{-1}$, 39.48 $mgKg^{-1}$, 12.85 $mgKg^{-1}$, 7.22 $mgKg^{-1}$, 19.96 $mgKg^{-1}$, 16.27 $mgKg^{-1}$, 2.2 $mgKg^{-1}$, 0.24 $mgKg^{-1}$ in soil respectively. These above values from above location in Bangladesh are compared with the finding values of different countries and also compared with various agencies; WHO and Australian Food Hygiene Level.

Keywords : *Heavy Metals, Micronutrients, Rice, Soil, Sirajganj, Bangladesh*

Introduction

Bangladesh is agriculture based country having a population of about 142 million. About 84% of the total population live in the rural areas and are directly or indirectly engaged in a wide range of agricultural production. Agriculture is the single largest producing sector of economy since it comprises about 20.6% of the country's GDP and employing around 48.1% of the total labour force during the year 2010. Rice, jute, sugarcane, potato, pulses, wheat, tea and tobacco are the principal crops. The crop sub-sector dominates the agriculture sector contributing about 56% of total agricultural GDP. Rice being the staple food, its production is of major importance. Rice production was found to increase from 23.1 million tons in 1999-2000 to 27.6 million tons in 2008-2009 fiscal year (Golder et al., 2013). Heavy metals are among the contaminants in the environment. Besides the natural activities, almost all human activities also have potential contribution to produce heavy metals as side effects. Migration of these contaminants into non-contaminated areas as dust or leachates through the soil and spreading of heavy metals containing sewage sludge are a few examples of events contributing towards contamination of the ecosystems (Bieby et al., 2011). The uptake of heavy metals and micronutrients by plant from contaminated soils are of great concern because an excess of dietary intake of some of these heavy metals might be hazardous to consumers. Bangladesh has no guideline value for metal ions in soil (Tothet al., 2016). The accumulation of heavy metals and micronutrients in soils treated with raw municipal and industrial waste water

from the sludge separation from this water and now widely recognized. As a consequence, a great environmental pollution arises. The heavy metals are widely distributed in the environment, in soil, in plants and in animals. The micronutrients namely Na, K, Mg and Ca are very essential metals in human health as well as plants and animals.

Table 1. Threshold and Guideline Values for Metals in Soil

Substance	Threshold value mg/Kg	Lower guideline value mg/Kg	Higher guideline value mg/Kg
Arsenic	5	50	100
Cadmium	1	10	20
Cobalt	20	100	250
Chromium	100	200	300
Copper	100	150	200
Lead	60	200	750
Nickel	50	100	150
Zinc	200	250	400

Some of these heavy metals are essential in trace amounts, namely Zn, Fe,Mn and Cu and some are toxic, namely Pb, Cd, As, Cr and Ni (Khaleduzzaman, 2009). Heavy metals are conventionally defined as elements with metallic properties and an atomic number >20. The most common heavy metal contaminants are Cd, Cr, Cu, Hg, Pb, and Zn. Metals are natural components in soil (Lasat, 2000). Some of these metals are micronutrients necessary for plant growth, such as Zn, Cu, Mn, Ni, and Co, while others have unknown biological function, such as Cd, Pb, and Hg . Metal pollution has harmful effect on biological systems and does not undergo biodegradation. Toxic heavy metals such as Pb, Co, Cd can be differentiated from other pollutants, since they cannot be biodegraded but can be accumulated in living organisms, thus causing various diseases and disorders even in relatively lower concentrations (Pehlivan et al., 2009). Heavy metals, with soil residence times of thousands of years, pose numerous health dangers to higher organisms. They are also known to have effect on plant growth, ground cover and have a negative impact on soil micro-flora (Roy , 2007). It is well known that heavy metals cannot be chemically degraded and need to be physically removed or be transformed into nontoxic compounds (Gaur and Adholeya, 2004). Many species of plants have been successful in absorbing contaminants such as lead, cadmium, chromium, arsenic, and various radio-nuclides from soils. Phytoremediation can be used to remove heavy metals from soil using its ability to uptake metals which are essential for plant growth (Fe, Mn, Zn, Cu, Mg, and Ni). Some metals with unknown biological function (Cd, Cr, Pb, Co, Ag, , Hg) can also be accumulated (Gaur and Adholeya, 2004).The main objective of the present study was to determine the metal ions (Na, K, Mg and Ca, Zn, Fe, Mn, Cu, Pb, Cd, As, Cr, Ni) in soil and rice samples from 4 villages of Sirajganj district, Bangladesh and also to compare them against the level of metal ions from different countries.

Materials and Methods

Study Area

The study area was comprised of four villages'viz., Fokirpara, Mathpara, Dakshinpara and Poschimpara of Beluchi of Sirajgonj district. The three classes of metal ions such as essential micronutrients (Fe, Na, K, Mg, Ca), micronutrients (Zn, Co, Cu) and relatively toxic metals (Mn,

As,Cr, Ni, Pb, Sb, Hg) were determined in each of four locations of Sirajgonj district, Bangladesh.

Sampling and Measurement of Metal Ions

Four soil and rice samples were collected from farmer's field from the selected areas. The soil samples were collected from 15 cm in depth and paddy were collected from paddy field. All samples were digested in acid digestion bomb (Parr bomb UK) with 3:2 nitric and perchloric acid mixture for the determination of metal ions of the respective samples (Griepink and Tolg, 1989). The concentration of metal ions was determined by AAS (Atomic Absorption Spectrophotometer) with air acetylene flame and AAS with graphite furnace (Dhaka Laboratory, BCSIR).

Results and Discussion

Potassium (K) is alkali metal and Ca & Mg are alkali earth metals. The sufficient amount of Ca and Mg are remaining in soil. But K is remaining in soil at very low level. Extra potassium salts are cultivated in irrigation soil during the production of rice. Potassium has two roles in the functioning of plant cells. First, it has an irreplaceable part to play in the activation of enzymes which are fundamental to metabolic processes, especially the production of proteins and sugars (Johnston, 2003). No fertilizer is suggested when the air-dry K test is above 160 g/Kg (Daniel et al., 2016). The maximum average calcium, Mg, K and Na are found to be 15.750 mg/g, 6.5 mg/g 3.4 mg/g and 4.4 respectively in the soil in Serbia (Jakovljeviã et al., 2003).The irrigated soil contains: K 5.78 mg/g, Ca 3.2 mg/g and Mg 2.49 mg/g (Roy et al., 2008). Only limited records of Fe deficiency in crops grown on Australian soils were found (Peverill et al., 1999).

Table 2. Concentration of Metal Ion in Soil Samples of Different Locations of Siraggonj, Bangladesh

Sampling Locations	Concentration of Metal Ions in Soil Samples (mg/Kg)													
	Fe	Mn	Na	K	Ca	Mg	Ni	Cr	Pb	Cd	Cu	Co	As	Zn
Fokirpara,	13.25	0.167	148.4	0.482	2.89	2.87	19.69	15.01	6.77	0.23	10.99	6.22	2.20	39.48
Mathpara,	12.69	0.150	156.4	0.452	2.77	2.65	16.78	16.27	6.28	0.24	12.85	6.02	2.14	33.58
Dakshinpara	14.61	0.170	152.1	0.516	3.16	3.06	17.98	15.54	6.12	0.20	10.85	6.85	1.97	33.96
Poschimpara	15.12	0.161	145.7	0.419	3.04	2.92	18.25	14.01	6.08	0.21	9.61	7.22	2.08	36.54

The analysis co-efficient of variation was below 10%.

The dry basis soil analysis for Iron (Fe) ions showed that the maximum value (15.12 mg/kg) was for Poschimpara while the minimum value (12.69 mg/g) was found in soil samples of Mathpara area. Higher value of iron in irrigated soil is good for growing the crops. As for dry basis Manganese (Mn) ions concentration, the maximum value (0.17 mg/g) was in Dakshinpara area and the minimum (0.15 mg/g) in Mathpara area. It was reported by Jabin et al. (2014) that the maximum level was found indifferent fractions of rice bran containing 8 - 14 mg/100 g of Fe, 425 – 940 mg /100 g of Mg, 4.65 – 6.68 mg /100 g of Zn and 35 – 62 mg/ 100 g of Ca (Satter et al., 2014). The mean concentrations of Ca (62 ± 10 & 52 ± 4 mg/Kg), K (1169 ± 87 1224 ± 76 mg/Kg) and Mg (626 ± 43 & 658 ± 67 mg/Kg) ions were reported in rice collected in two regions of Tanzania (Mohammed andSpyrou, 2009). Concentration of Potassium (K^{+}) ions was found to be maximum (2.71 mg/kg) in Fokirpara area with minimum value for Mathpara area (2.11 mg/kg). The highest Calcium (Ca^{+2}) concentration (0.98 mg/kg) was reported in Fokirpara area while the lowest value (0.82 mg/kg) was found to be in Dakshinpara area. As for Magnesium (Mg^{+2}) ions concentration, it was found maximum (0.94 mg/kg) for Paschimapara area, with lowest value of 0.82 mg/g for Dakshinpara area.

In the USA, a mean zinc concentration of 56.5 mg kg^{-1} for 3045 soils from "uncontaminated" agricultural sites was reported (Alloway, 2008). In Deep tube-well irrigated soil in India, the concentration of Fe, Mn, Na, Zn and Cu are 9.0 mg/Kg, 0.89 mg/Kg, 24.9 g/m^2, 0.69 mg/Kg and 1.66 mg/Kg respectively. The concentrations of Fe, Mn, Cu and Zn in soil sample of Iran are 17936 mg/Kg, 551 mg/Kg, 27.7 mg/Kg, 55.8 mg/Kg respectively. It was reported that in Koreathe average concentrations of Cu and Zn in surface layer of the rice paddy soils (0-15cm) are 0.47mg kg^{-1} (0-41.6) and 4.47 mg kg^{-1} (0-96.7) respectively. The soil samples collected from different studied areas were analyzed in both dry and wet basis where sharp variations observed among them. The tolerance limit for lead in soils estimated by European Union is 100 mg kg^{-1}, but most polluted soils contained excessive Pb accumulation which entered the tropic chain through food materials mostly and caused health hazards(Tothet al., 2016).

Table 3. Concentration of Metal Ion in Rice Samples of Different Locations of Siraggonj at Bangladesh

Sampling Locations	Concentration of Metal Ions in Rice Samples (mg/Kg)													
	Fe	Mn	Na	Co	K	Mg	Zn	Cu	Ca	Pb	Cd	Ni	Cr	As
Fokirpara,	140.5	41.12	319	0.16	2.71	0.80	34.12	10.85	0.98	1.32	0.32	1.92	1.42	2.21
Mathpara,	101.5	41.22	352	0.17	2.11	0.88	25.70	12.97	0.89	1.44	0.37	1.88	1.29	2.01
Dakshinpara	120.3	39.24	352	0.15	2.01	0.82	32.10	9.88	0.82	1.26	0.30	1.72	1.38	1.35
Poschimpara	135.1	38.64	377	0.15	1.98	0.94	25.81	9.25	0.81	1.24	0.39	1.75	1.46	1.15

The analysis co-efficient of variation was below 10%.

The maximum dry basis Arsenic (As) metal ions value in soils samples of Fokirpara area was 2.2 mg/kg and the lowest value of 1.97 mg/ kg was found in samples of Dakshinpara. Zinc (Zn) metal concentration as per dry basis analysis was maximum in Fokirpara samples (39.48 mg/kg) while the minimum value was found in samples of Dakshinpara area (33.96 mg/kg). The Copper (Cu) metal concentration was found maximum in samples analyzed on dry basis in Mathpara area (12.85 mg/kg) and the lowest value was detected in Poschimpara area (9.61 mg/kg) samples. Chromium (Cr) ions content was highest in samples of Mathpara area (16.27 mg/kg) while the minimum value of 14.01 mg/kg was found for samples of Paschimapara area. Nickel (Ni) content was highest in samples of Fokirpara (19.96 mg/kg) and lowest content was analyzed for samples of Mathpara (16.78 mg/kg) area. Cadmium (Cd) content was maximum as per dry basis sample analysis of Mathpara (0.24 mg/kg) area while the minimum value of 0.21 mg/kg was found in samples of Dakshinpara area. Lead (Pb) metal ions concentration was maximum for samples of Fakirpara area (6.77 mg/kg) and the lowest analysis result value was found in samples of Dakshinpara area (6.12 mg/kg). Cobalt (Co) metal ions concentration was highest for samples of Poschimpara (7.22 mg/kg) while the minimum value was for samples of Mathpara area (6.02 mg/kg) as per dry basis analysis.

It is observed that level of Fe and Mn is comparatively lower in Bangladesh than the irrigated soil of India, Iran and USA. The value of Na is almost same in Bangladesh as that of India and Iran. The average value (36 -40 mg/Kg) of Zn in Bangladesh waslower than those reported in USA, Iran and India.Zinc (Zn) is an essential micronutrient and has particular physiological functions in all living systems, such as the maintenance of structural and functional integrity of biological membranes and facilitation of protein synthesis and gene expression. Among all metals, Zn is needed by the largest number of proteins. Zinc-binding proteins make up nearly 10 % of the proteomes in eukaryotic cells, and 36% of the eukaryotic Zn-proteins are involved in gene expression. Zinc is a trace element

found in varying concentrations in all soils, plants and animals and it is essential for the normal healthy growth of higher plants, animals and humans. The minimum recommended values of Zn are 15 mg/day for man and 12 mg/day for females. The EPA standard of Zn for drinking water is 5 mg/L. Someof these metals are micronutrients necessary for plant growth, suchas Zn, Cu, Mn, Ni,andCowhile others have unknown biological function, such as Cd,Pb, and Hg (Cho-Ruk et al., 2006).

In US report, 49 rice samples (*Oryza sativa L.*) showedthe concentration ranges of 1.33-180 mg/kg for Cu, 4.41-7.15 mg/kg for Fe, 5.45-25.4 mg/kg for Mn, 0.95-2.50 mg/100g foe Na, and 5.86-12.6 mg/kg for Zn (Huguet et al., 2006). In Japan, the average levels of Cu, and Zn in rice-fields were 19.5 mg kg^{-1}, and 96.4 $mgkg^{-1}$ respectively (Herawati et al., 2000). The mean concentrations of Cu (3.4 ± 0.7 & 4.0 ± 0.6 mg/Kg), Fe (Fe 23 ±3 & 31 ± 8 mg/Kg), Mn (19 ±1& 12 ± 0.5 mg/Kg), Na (12 ±1& 9± 0.6 mg/Kg), Zn (30 ±2 & 29 ± 2) in were reported in rice collected in two regions of Tanzania.

The present study showed that the Iron (Fe) metal ion concentration was maximum (140.5 mg/g) in Fokirpara area, while the minimum value of 101.5 mg/g was reported in Mathpara area. Manganese (Mn) ion concentration was found to be maximum (41.22 mg/g) in Mathpara area with minimum value of 38.64 mg/kg in Poschimpara area. Further, the results showed that sodium (Na+) ions concentration was found to be maximum (377 mg/kg) in Poschimpara area and lowest was 319 mg/kg.

The level of Na is lower than the US value in rice sample whereas Zn concentration are almost same compared to the value (20-34 mg/Kg) in rice of Tanzania, Chaina and Mexico. Iron concentration in rice samples is higher in Bangladesh than Tanzania, Chaina, Mexico snd USA. The maximum allowable concentration (MAC) for Chinese agricultural soils is 30 $mg/Kg^{-1}$for As, 250 $mgKg^{-1}$ for Cr,0.30 $mgKg^{-1}$ for Cd,50.00 $mgKg^{-1}$ for Cu,0.3 $mgKg^{-1}$for Hg, 40.00 $mgKg^{-1}$ for Ni and 250.00 $mgKg^{-1}$ for Pb.Accumulation of heavy metals in crops grown in metal-polluted soil may easily cause damage effect on human health through food chain. Fu et al. (2008) conducted an investigation on heavy metal contents in rice samples. The concentration of arsenic in paddy soil was within range 6.7 – 34 $mgKg^{-1}$ in Japan whereas in China within the range of 0.13 – 0.234 $mgKg^{-1}$. Indian paddy crops soil was found to have 2 mg/Kg of As. In the present study, the arsenic (As) content of the soil was found highest (0.18 mg/kg) in Fokirpara although there was no sharp variation observed among the studied areas. The arsenic content in Dakshinpara, Mathpara and Poschim para were 0.17 mg/kg, 0.16 mg/kg and 0.15 mg/kg, respectively. Therefore, arsenic concentration in Bangladesh is lower than Indian and China soil value. Higher value of arsenic was found in Japan than Bangladesh. The concentration of chromium in paddy soil was within the range of 16-80 $mgKg^{-1}$ in Japan whereas in China within the range of 57.96- 71.50 $mgKg^{-1}$. Indian paddy crops soil was found to be 0.001 mg/Kg for Cr.The highest chromium (Cr) was found in the soil samples of Mathpara area 16.27 mg/kg) and the lowest chromium (14.01 mg/kg) at Poschimpara area. This value is lower than the soil of Japan and Chinabut is higher than the value ofIndian.The concentration of nickel of paddy soil was within the range of 5.9 – 18 $mgKg^{-1}$ in Japan whereas in China within the range of 57.96- 71.50 mgKg-1. Indian paddy crops soil was found to have 0.267 mg/Kg of Ni. In respect of nickel (Ni) content, the soil collected from Fokirpara showed the highest value (19.96 mg/kg) followed by Dakshinpara (17.98mg/kg), Poschimpara (18.2517mg/kg) and Mathpara (16.78 mg/kg).This value is lower than the value of Japan and Chinabut higher than that ofIndia.It was reported that in Korea the average concentrations of Cd in surface layer of the rice paddy soils (0-15cm) was 0.11 mg kg^{-1} (ranged from 0 to 1.01 mg kg^{-1}). The concentration of cadmium in paddy soil was within the range of 0.16 – 0.53 $mgKg^{-1}$ in Japan whereas in China within the range of 0.14 - 7.86 $mgKg^{-1}$. Indian

paddy crops soil was found to be 0.026 mg/Kg for Cd. Cadmium is found within the range of 0.30 – 0.39 mg/Kg in the Bangladeshi soil at four locations. This value of Cd in soil samples are within the range of Japan and Korea but higher value thanIndia (Fu et al., 2008; State Key Laboratory, 2008; Heinemann et al., 2005; Tomoyuki, 2009; Deepmala et al., 2014). In the present study, the maximum wet basis Arsenic (As) metal ions value was in soil samples of Fokirpara (2.2 mg/kg) and lowest value of 1.97 mg/kg was detected for samples of Dakshinpara area. Zinc level was maximum (39.45 mg/kg) in Fokirpara samples while minimum value (33.96 mg/kg) was found in samples of Dakshinpara area. Copper concentration was found maximum in samples of Mathpara area (12.85 mg/kg) and minimum in samples of Poschimpara (9.61 mg/kg). Cadmium ions concentration was found maximum in samples of Dakshinpara (0.21mg/kg) and the minimum value (0.24mg/kg) was in Poschimpara area samples. Lead (Pb) content was maximum (6.77 mg/kg) for Fokirpara area while the minimum value (6.12 mg/kg) was in samples of Dakshinpara area. Cobalt (Co) ions concentration as per wet basis analysis in maximum quantity was found in samples of Poschimpara (7.22 mg/kg) area and the lowest value was for samples of Mathpara (6.02 mg/kg).

These values are lower than China and Japan but higher than India. The concentration of cobalt in paddy soil was within range of 4.6– 16 $mgKg^{-1}$ in Japan whereas in China within the range of 9.91-13.77 $mgKg^{-1}$. Indian paddy crops soil was found to have 0.058 mg/Kg for Co. The cobalt content ranges between 4.27 mg/kg to 4.80 mg/kg in the studied areas which is higher than soil of India and lower than soil of Japan and China. The WHO recommended permissible limit of arsenic in any rice is 1.0 mg/kg. The concentration of arsenic in polished rice produced in Japanis within the range of 0.048 – 0.15$mg.kg^{-1}$. Fu et al. (2008)analyzed different varieties of rice produced in China, Vietnam and Bangladesh and found arsenic concentration within the range of 0.094 -0.306 $mgKg^{-1}$, 0.032 -0.465 $mgKg^{-1}$ and 0.005 – 0.020 $mgKg^{-1}$ respectively. In the present study, the maximum arsenic concentration (2.21 mg/kg) was in Fokirpara area, and the minimum As in Poschimpara area (1.15 mg/kg). The maximum level of Chromium (Cr) ions in rice samples was found in Poschimpara (1.46 mg/kg) while minimum level of 1.29 mg/kg was in Mathpara area. The maximum value of Nickel (Ni) ions was found in rice samples of Fokirpara area (1.92 mg/kg) while the minimum (1.72 mg/kg) was in Dakshinpara area. The Cobalt (Co) metal ions concentration of the samples was highest in Mathpara area (0.17 mg/kg) and the minimum value of 0.15 mg/kg was found in rice (paddy) samples of both Dakshinpara and Poschimpara areas. The existence of heavy metals in rice (paddy) indicated negative effects of effluent discharged in the agricultural lands which may be considered as hindrance to increase crop yields as well as to saving the soil, nature and living beings from any future hazard. All values of rice do not exceed the WHO and Australian Food Hygiene Level i.e. 1.0 $mgKg^{-1}$. Chromium is heavy and toxic metals with the oxidation state (VI). Cr found in two varieties of Chinese rice was within the rangeof 0.006 -0.279 $mgKg^{-1}$ (Taizhou rice) and 0.062 0.424 $mgKg^{-1}$ (Commercial rice in China) whereas rice in USA, the average concentration of Cr was 0.099 $mgKg^{-1}$ and in Japan, the concentration of Cr within the range 0.0014 – 0.046 $mgKg^{-1}$. The chromium (Cr) content of rice plants was highest (1.46 mg/kg) in Poschimpara area followed by Fokirpara (1.41 mg/kg), Dakshinpara (1.32 mg/kg) and Mathpara (1.29 mg/kg). The value of Cr in Bangladeshi rice is higher than China and Japan and almost same with value of USrice. Nickel found in two varieties of Chinese (Huguet et al., 2006; Fu et al., 2008) rice was within the range of 0.339 -1.134 $mgKg^{-1}$ (Taizhou rice) and 0.201- 0.818 $mgKg^{-1}$ (Commercial rice in China) whereas rice in USA, the concentration of Ni was within the range of 0.53-0.72 $mgKg^{-1}$ and in Japan, the concentration of Ni within the range of 0.018 – 0.39 $mgKg^{-1}$.

The nickel (Ni) content of rice in Fokirpara area was highest (1.92 mg/kg) but the other three areas showed almost similar nickel content within lower level (1.88 – 1.72 $mgKg^{-1}$) in rice sample. The

level of Ni values is higher in Bangladesh than the other countries i.e. China, US and Japan. Cadmium was found in two varieties of Chinese rice within the range of 0.011- 0.660 $mgKg^{-1}$ (Taizhou rice) and 0.004 – 0.069 $mgKg^{-1}$ (Commercial rice in China) whereas rice in USA, the concentration of Cd was within the range of 2.30-4.12 µg/kg and in Japan, the concentration of Cd within the range of 0.0036 – 0.11 $mgKg^{-1}$. The highest cadmium (Cd) in rice plants (0.39 mg/kg) was recorded in Poschim para area and the lowest cadmium (0.30 mg/kg) was found in the rice plants collected from Dakhsinpara area. The value Cd found in Bangaldeshi rice is higher than China, US and Japan. Lead (Pb) was found in three varieties of Chinese rice within range 0.256- 2.601 $mgKg^{-1}$ (Taizhou rice) , 0.166- 0.745 $mgKg^{-1}$ (Commercial rice in China) and 0.045- 0.308 (Hangzhou rice)whereas rice in Japan, the concentration of Pb was within the range <0.001 – 0.086 $mgKg^{-1}$ (Raymond and Okieimen, 2011; Cheng et al., 2006).The lead (Pb) content of rice plants was highest in Mathpara area (1.44 mg/kg) followed by Fakirpara (1.4 mg/kg), Dakhshinpara (1.36 mg/kg) and Poschim para (1.24 mg/kg). The value of lead in Bangladeshi rice was lower than the value of China and higher than the rice of Japan. Cobalt (Co) was found in three varieties of Chinese rice within the range of 0.118 -0.498 $mgKg^{-1}$ (Taizhou rice) and 0.055 -0.419 $mgKg^{-1}$ (Commercial rice in China) whereas rice in Japan, the concentration of Co was within the range of 0.0019 – 0.0088 $mgKg^{-1}$. The Co concentration was found within the range 0.041-0.060 mg/kg in US rice. The cobalt concentration was found highest (0.17 mg/kg) in Mathpara and lowest (0.15 mg/kg) in Dakshin and Poschimpara area. This concentration range is lower than Chinese rice and higher value than Japan and US.

Conclusion

Bangladesh is riverine country and transport of metal ions may occur through major river system. The Padma, Jumuna and Meghna are main rivers of Bangladesh. The metal ions from upstream Himalayas Mountain flow away to lower stream Bangladesh during the rainy season or during flood. Some metal ions flow away and fall into the Bay of Bengal and some metal ions are deposited with the cropland. The fertilizers containing micronutrients (K, Ca, Mg, Fe, Co) are applied to the cropland during agriculture practices. However, the sources of heavy metals (As, Ni, Cu, Cr, Cd &Pb) may be contaminated through various mediums including industrial activities. The soil as well as rice may be contaminated with the heavy metals during irrigation with river and ground water. Some metals (Ca, Na, K, Mg, Fe etc.) are essential for soil which is taken up by rice grain. Some toxic metals (As, Ni, Cu, Cr, Cd and Pb) also remain in soil and as well as rice. Bangladesh has no standard limit of metal ion in rice. Even, Bangladesh has no regulatory limits of metals ions in cropland soil. Hence, the level of metal ions determined in the present study might be taken as baseline data of the selected soil and rice for Bangladesh.

Acknowledgements

The authors thankfully acknowledge Bangladesh Council for Scientific and Industrial Research (BCSIR), Dhaka, Bangladesh and for AAS analysis in the environmental samples.

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Preparation and Characterization of H_3PO_4 Activated Carbon Derived from Betel Nut for Removal of Fluoride from Water

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Abstract

In this study, activated carbon (AC) was prepared from Betel nut by H_3PO_4 activation at 400 °C for under N_2 atmosphere. The prepared activated carbon (AC) was characterized by Iodine number, Methylene blue number, Scanning electron Microscopy (SEM) and Fourier Transform infrared spectroscopy (FTIR). The AC showed high iodine number and methylene number of 888 mg/gm and 369 mg/gm respectively. SEM micrograph indicated that, the AC is highly microporous and mesoporous in nature. FTIR spectra showed the presence of oxygenated functional groups such as hydroxyl, carbonyl, and carboxyl on the AC surface. The AC was modified as adsorbents by compositing the AC with Al_2O_3. Percentage removal of fluoride by the composite was found to be much higher (~80%) as compared to the plain AC (~40%). The experimental result showed that, the AC prepared from Betel nut after modification could be applied for adsorption of fluoride from water.

Keywords : *Activated Carbon, Betel Nut, Phosphoric Acid, Fluoride Removal*

Introduction

Activated carbon (AC) has been the most popular and widely used adsorbent because of its high adsorptive capacity. The adsorption capacity of activated carbon (AC) is linked to surface area, pore structure and surface functional groups. According to the International Union of Pure and Applied Chemistry, pores of AC are classified in three groups: micropores (diameter < 2) nm, mesopores (2 nm < diameter < 50 nm), and macropore (diameter > 50 nm) (IUPAC, 1972). Activated carbon can be prepared by physical activation and chemical activation. In physical activation, the precursor is first carbonized in an inert atmosphere and then activated in a stream of carbon dioxide or steam. In chemical activation, the precursor is impregnated with chemical agents such as acid base and salt prior to carbonization in an inert atmosphere. Chemical activation method is more advantageous than physical activation because chemical activating agents act as dehydration agents and minimize the formation of tar during carbonization. Furthermore, the carbonization temperature in chemical activation is lower in comparison to that of physical activation. Among the different activating agents that can be used, most common are H_3PO_4, $ZnCl_2$ and KOH. One of the major applications of AC is adsorptive removal of organic and inorganic pollutants such as fluorides, nitrates, thyocyanate, selenite, vanadium, arsenic, sulfates, molybdate, and pharmaceuticals from water. Among these, the health hazardous ion, fluoride is considered as priority pollutants since fluoride is responsible for dental (discolouration and pitting of teeth) and skeletal fluorosis (pain and stiffness in the bones and joints).

Fluoride is essential for the development of tooth enamel, dentin, and the bones. It is harmful when it exceeds the permissible limit of 1.5 mg/l (WHO 2008) in water. Excess of fluoride in groundwater has been reported in the Terai region (low land) of Nepal. However limited studies have been carried so far (Bashir et al., 2014). Most of the rural population depends on the ground water sources for

drinking purposes in Nepal. For the reason, it is essential to remove the fluoride from ground water, used for drinking purpose if it is higher than acceptable value.

Various methods used to remove fluoride from water are Adsorption, precipitation, Ion exchange, electro-dialysis, etc. Among these, adsorption technique has been quite popular due to their simplicity and availability of wide range of adsorbent. Various adsorbents such as activated carbon (Arulanantham et al., 1992), activated alumina (Ghorai and Pant, 2005), bone charcoal (Abe et al., 2004), silica gel (Mondal et al., 2012), etc have been reported for fluoride removal. Among these, activated carbon adsorption has been most common. However, production and regeneration of commercial AC are very costly. For the reason, small industrial units and developing countries cannot afford using AC at large scale. As a result, low-cost and readily available alternative lignocellulosic materials from agricultural and industrial waste materials are in needed for preparation of AC. Agricultural waste materials used for the production of AC include Lapsi seed stone (Joshi et al., 2015), coconut shell (Arulanantham et al., 1992) walnut shell (Rajan and Alagumuthu, 2013) etc.

Fluoride adsorption capacity of AC can be increased by chemical modification. Due to high electronegativity and small ionic size fluoride ion, it has strong affinity towards multivalent electropositive metals ions like Ca^{2+}, Fe^{3+}, Zr^{4+}, La^{4+} Ce^{4+}. Carbon Composite adsorbents represent an attractive alternative adsorbent due to their reactivity and high selectivity towards the specific pollutants. Several composite materials such as Carbon/Pottery Composite (Hao et al., 2011), alumina supported carbon composite (Lunge et al., 2012) for removal of fluoride from water.

Betel nut (Areca nut) is the seed of the fruit of the oriental palm Areca catechu. It is native to South and South-East Asia. The literature survey reveals that Areca husk carbon (Basker et al., 2014), Areca nut shell (Geetha et al., 2009) and Areca nut coir (Chakrabarty and Sarma, 2011) had been used for the preparation of AC for various application. However, no report has been found on the utilization of betel nut AC for fluoride removal. Hence this study deals with the preparation of the AC from Betel nut and its characterization for removal of fluoride from water.

Materials and Methods

Betel nuts were purchased from local market, Kathmandu, Nepal. The chemicals used for the analy¬sis were all analytical grade purchased from Qualigen, India. Fluoride stock solution was prepared by dissolving 221 mg of anhydrous sodium fluoride in 1000 mL distilled water. Standard solutions of fluoride were prepared by subsequent dilution of the fluoride stock solution. Solutions of 0.1M NaOH and 0.1 HCl were used for pH adjustment. Fluoride ions in aqueous solution were determined by using Orion ionplus Fluoride Electrode Orion 94-09, 96-09, Thermo Electron Corporation, USA.

Preparation of Activated Carbon

Betel nuts were washed with distilled water and dried in oven at 110℃ for 24 hrs. The nuts were crushed with mortar and electric grinder. The crushed particles were then sieved to obtain the fraction of size 312 µm. Twenty grams of Betel nut powder was mixed with H_3PO_4 in the ratio of 1:1 by weight and stirred with magnetic stirrer at 70oC until partly dried. Then, sample was kept in an oven at 100℃ for overnight for 24 hours. The mixture was then carbonized in a horizontal tubular furnace at 400°C under a flow (75 ml/min) of N_2 for 3 hours. After well cooled, the AC was treated with 0.1N NaOH, subsequently washed with warm distilled water until it became neutral. The carbon was sieved to get the particles of size 106 µm and dried in an oven maintained at a temperature of 110℃ for 24 hours. The carbon was used for further study.

Characterization of Activated Carbon

Characterizations of AC were performed by determining iodine number, methylene blue number, scanning electron microscopy (SEM) and fourier Transform-Infrared (FTIR) Spectroscopy. Iodine number of the AC was determined according to the ASTM D4607-94 method (2006). Methylene blue number of the AC was determined according to the method (Raposo et al., 2009).

Preparation of Adsorbent

36.8 gm of aluminum nitrate (Al $(NO_3)_3 9H_2O$) gm was dissolved in 400 ml. distilled water and 5 gm AC was added. Then, 5M NaOH was added drop wise till the precipitation of $Al(OH)_3$ was completed. The product was dried in oven at 110°C for 12 hrs, calcined in tube furnace at 300°C for an hour. The prepared composite was washed with distilled water till it became neutral, dried at 100°C for 24 hrs, sieved to obtain a particle size of 212 µm.

Adsorption Experiments

A definite amount of Betel nut AC was suspended with 50 ml of fluoride solution in 100 ml plastic conical flasks. The suspension was agitated on Digital VDRL Rotator-RPM-S at 225 rpm at room temperature. After equilibrium, the suspension was filtered and fluoride ion concentration before and after adsorption was measured with a fluoride ion selective electrode. Percentage of removal of fluoride ions was calculated by the following equation.

$$\text{Removal } (\%) = \frac{(C_o - C_e) \times 100}{C_o} \qquad \text{.....(1)}$$

Where, Co = initial concentration of fluoride ions (mg/L); Ce = equilibrium concentration of fluoride ion (mg/L).

Results and Discussion

Characterization of Activated Carbon

Iodine number and methylene blue number of AC: Iodine number and methylene blue number of Betel nut AC is shown in Table 1.

Table 1. Iodine Number and Methylene Blue Number of AC

Activated Carbon	Iodine number (mg/gm)	Methylene Blue Number (mg/gm)
Betel nut AC	888	369
Commercial AC	955	420

Iodine number and methylene blue number are useful indicators to evaluate the adsorptive capacity of activated carbon. Iodine number is the amount of iodine adsorbed (in milligrams) by 1gm of carbon (Cleiton et al., 2011). It is a measure of micropore content (micropores having pore diameter of less than 2 nm) of the AC and relates to the ability of AC to adsorb low molecular weight substances. Methylene blue number is defined as the milligram of methylene blue adsorbed onto 1.0 gm of adsorbent (Cleiton et al., 2011). It is a measure of mesopore content (mesopores have a diameter between 2 and 50 nm) and indicates ability of AC to adsorb high molecular weight substances. Iodine number and methylene blue number of Betel nut AC were found to be comparable to that of commercial AC. It suggested that, the microporosity, mesoporosity of AC were better developed and they are also comparable to commercial AC.

Scanning Electron Microscopy (SEM) image

Surface morphology of AC was studied by Scanning Electron Microscopy (SEM). A SEM image of the AC is presented in Figure: 1.

SEM micrograph shows that, the AC has a well-developed pore network. The external surface of activated carbon filled with pores of different shape and sizes. During phosphoric acid activation, it works in two ways: (i) As an acidic catalyst in promoting bond cleavage reactions and formation of crosslink and (ii) it combine with organic species to form phosphate linkages, such as phosphate and polyphosphate esters, that can serve to connect and crosslink biopolymer fragments.

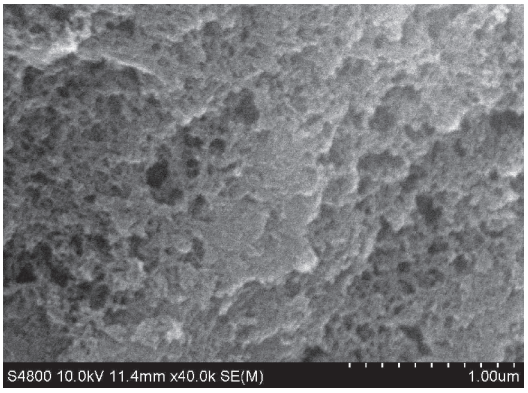

Figure: 1 SEM Images of the Activated Carbon

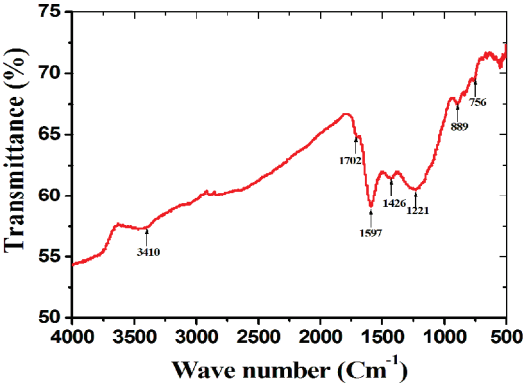

Figure: 2 FTIR Spectra of the Activated Carbon

Fourier Transform Infrared (FTIR) Spectra

FTIR spectrum of AC was recorded to study the presence of functional groups. FTIR spectrum of AC is presented in Figure: 2

FT-IR spectrum of the AC showed the absorption bands at the region of 3410 cm^{-1}, 1702 cm^{-1}, 1597 cm-1 and 1426 cm^{-1} (Figure 2). A broad band at around 3400 cm^{-1} assigned to the ŌH stretching vibration in phenols and alcohols. The band located at around 1700 cm^{-1} is related to the stretching vibration of C=O in ketones, aldehyde, lactone, and carboxyl. The band around 1597 cm^{-1} and 1426 cm-1 is attributed to the C=C stretching vibrations in the aromatic ring for most carbonaceous materials such as AC (Bostancioglu and Oruc, 2011). It suggested that, the AC contains oxygenated functional groups such as hydroxyl, carbonyl on its surface.

Adsorption Studies

Comparison on percentage of fluoride removal of Alumina, Betel nut AC and Alumina-AC composite were carried out. The percentage of fluoride removal by Alumina, Betel nut AC and Alumina-AC composite is presented in Figure 3.

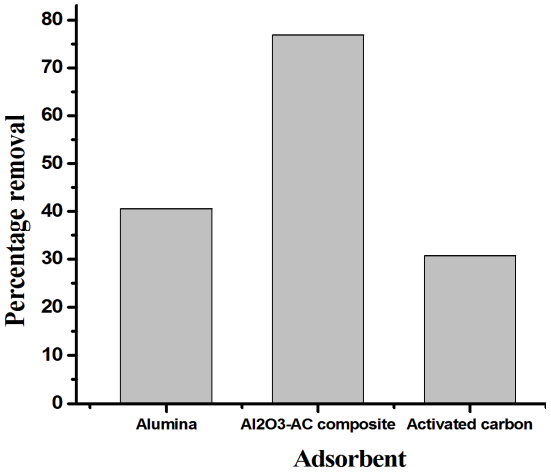

Figure 3: Percentage of Fluoride Removal by Alumina, Betel nut AC and Alumina-AC Composite

Percentage of fluoride removal by both alumina and Betel nut AC is found to be less than 40% but the adsorption capacity increased to ~ 80% by using alumina-AC composite. Thus the composite of alumina and AC is much better adsorbent than individual components for removal of fluoride.

Fluoride are adsorbed onto Al_2O_3-AC composite with formation of surface complexes. It can be explained in terms of ligand exchange (surface complex formation) of fluoride on Al_2O_3-AC composite surface. The ligand exchange reaction at the surface of the composite is thought to be the probable mechanism of fluoride removal (Khairnar et al., 2015). The fluoride ion exchange reaction is shown as below. The metallic ion acts as a bridge in between adsorbed fluoride and composite surface.

$\equiv Al\text{-}OH_2{+}{+}F^- \leftrightarrow \equiv Al\text{-}F{+}H_2O$

$\equiv Al\text{-}OH + F^- \leftrightarrow \equiv Al\text{-}F + OH^-$

Where ≡ represents the surface of the activated carbon.

Conclusion

In this study, preparation and characterization of H_3PO_4 activated carbon from Betel nut was carried for removal of fluoride from water. As shown by SEM micrograph, the AC has well developed pore structure. Iodine and methylene blue adsorption also indicates that AC is highly micro and mesoporous in nature. FTIR spectrum results indicate that prepared AC contains OH, >C= O as oxygen containing surface functional groups. To enhance adsorption capacity, the AC was modified as adsorbents by compositing the AC with Al_2O_3. The percentage removal of the composite was much higher as compared to the plain AC and Al_2O_3. The result indicated that, activated Betel nut carbon after modification can thus be used as an adsorbent for the removal fluoride from water.

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EFLGP in Climate Change Adaptation/ Mitigation: A Case Study from Triyuga Municipality

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Abstracts

The impacts of climate change are evident in different parts of the nation in various forms. On top of that, being a least developed nation, the challenges in combating such issues are even more here. In spite of it, the adaptation/ mitigation practices are needed to curtail the effects and therefore various activities are being carried out. This article is compilation of such practices conducted by Triyuga Municipality of Udaypur District to address climate change adaptation/mitigation as well as protection of environment. Such activities have been conducted in support of Environment Friendly Local Governance Programme (EFLGP) under Ministry of Federal Affairs and Local Development (MoFALD). The activities thus performed were basically field based and, the field data were obtained by the help of GPS (Global Positioning System) 64S and were analyzed through excel and ARC GIS 9.3 software. The results show that under Environment Friendly Local Governance Programme various activities were carried out to mitigate the impact of climate change from local level.

Keywords : *Climate change, Adaptation, Mitigation, Water Recharge Ponds, ICS*

Introduction

Climate change is now widely accepted as the most pressing environmental problem facing us, and planet Earth as a whole (Clarke 2009). Nepal is not an exception to it either. Even though Nepal's GHGs emission is just 0.027 percent of the total global emission (MoH 2015), Nepal is reported to be one of the most climate vulnerable countries in the world (MoE 2011). So, in order to address climate change issue as well as various environmental problems, GoN has started various mitigation and adaptation programs, one of which is Environment Friendly Local Governance Programme (EFLGP). The main objective of this program is to aware people from all strata and mainstream the climate change and environment issues in local planning process by adopting various ranges of programs and activities. The program basically uses basic and advanced indicators for household, tole/settlement, ward, village, municipality and districts levels to protect environment and encourages public to achieve such indicators.

EFLGP has been implemented by the Ministry of Federal Affairs and Local Development (MoFALD) in 14 districts of Koshi and Gandaki basin. Among which, Triyuga Municipality of Udayapur district which lies in Gandaki basin is one such project implied area. Udayapur district was selected as the NAPA report had ranked it to be very high in climate change vulnerability index (NAPA, 2010). This article is in fact a compilation of the climate change adaptation/ mitigation activities that had been implemented in Triyuga Municipality under EFLGP so that it presents an overall scenario of the possible options to combat climate change and promote environment protection.

Materials and Methods

Study Area

The project implied area is Triyuga Municipality (27° 47' 31'' N latitude and 86° 41' 30'' E longitude) of Udayapur District, Eastern Nepal which lies in province no.

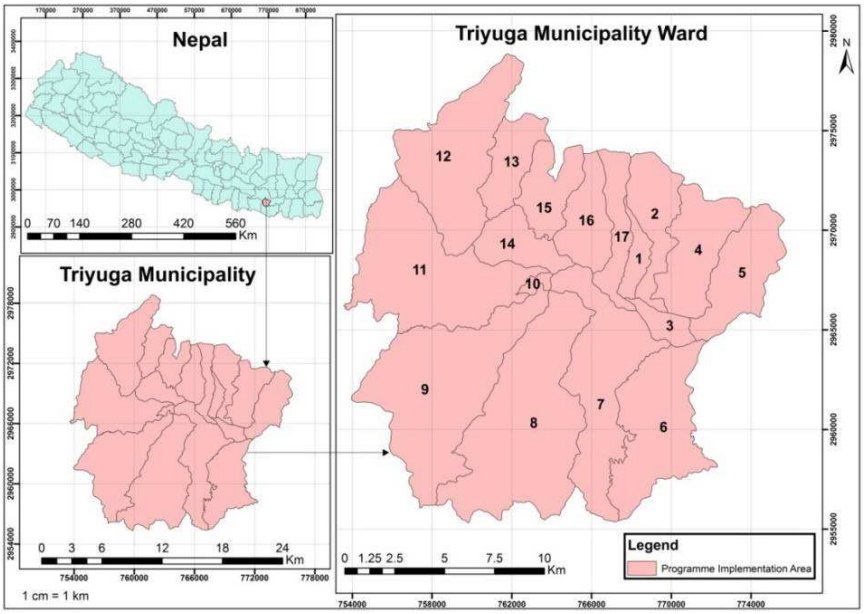

Figure 1: Map of the Study Area.

The total area of the Triyuga Municipality is 547.43 km^2, which happens to be the largest Municipality based on total area. It has altogether 16 wards and is bordered by Chaudandigadhi Municipality in the east, Udayapur Rural Municipality and Saptari District in the west, Rautamai Rural Municipality and Khotang district in north and Saptari District in the south.

Data Collection and Analysis

The program was conducted from March 2015 to July 2017 during which the data was collected. The data thus obtained was analyzed through excel. Similarly, the GPS (Global Positioning System) 64S was used to obtain data from field and the obtained data were analyzed for preparation of map by using ARC GIS 9.3 software. The photographs were taken from the field visit throughout the implementation period of the program.

Results and Discussion

The programs that were conducted under the EFLGP have been listed successively in the forth coming paragraphs with illustration by maps and supporting photographs.

Construction of Parks and Ponds

The construction of parks and ponds hold significance from various points of view in regard to conservation of environment as they enhance open space and greenery. As a matter of fact park plays an important role in the mitigation of climate change because the tree within the park is helpful in

carbon sequestration. Climate change mitigate through increasing carbon sequestration (Pokhrel et al. 2009). As for instance, a study implemented in the city of Rosario of Argentina from 2013-2014 showed that in areas with street trees and urban (garden) parks, temperatures were found to be 8-10 0C lower on an average throughout the year. Street trees and parks also contribute in decreasing direct solar radiation by providing shade, and can help lower temperatures through evaporative cooling (RUAF 2015).

In Triyuga Municipality, altogether four parks were constructed in ward no. 1, 8, 9 and 15 with a total area of 74,972 m^2. Among them, two parks were constructed whereas the remaining two were conserved. The total area of two newly constructed parks was 53,180 m2 and two conserved park was 21,792 m^2. The management of the park can be done for long term by charging certain amount on entrance whereas such provision can provide employment opportunity to local community as well. The parks and ponds have maintained greenery and open space as well as supported the farmers through fish farming.

Similarly, in case of small ponds and retention reservoirs, they could serve for a number of functions including irrigation, detention of flood water, retention of nutrients, recharging of ground water, creating aquatic habitats, fisheries, supplying animals with water and forest fire protection (Noges et al. 2010) as well. The construction of pond helps to increase in the recharge and maintenance of shallow groundwater level through a rise in water supply of vegetation by capillary water (Noges et al. 2010) and can also be considered as a measure towards climate change adaptation (Sinha et al. 2017). As for instance, the pond constructed in Barkhalpur VDC of Kapilvastu district has been used for irrigation purpose (150-200 *Bigha*s of land), fishing purpose so as to uplift the economic status of local people and recharge of ground water. Similarly, the pond constructed in *Rosera* VDC of Baitadi district has been also used to irrigate vegetables and sort out the water scarcity problem prevailing there (GWP 2014). Along with this, the study done by Sharma et al. 2016 concluded that the pond is an important means of recharging groundwater because it is an important source of water at lower elevations. Not only this, ponds are now serving a variety of purposes, including water for livestock, fish production, field and orchard spraying, energy conservation, wildlife habitat, recreation, erosion control, and landscape improvement (Deal et al. 2016).Adding to this point, the study conducted by (Bastakoti et al. 2016) refers that under rain-fed conditions with limited sources of irrigation water, community ponds could play an important role in dealing with the impact of climatic variability. Hence, wetland restoration or pond creation (Downing et al. 2008) may be promoted as a means of storing carbon.

In Triyuga Municipality, altogether 12 ponds ware excavated in ward no. 1, 3, 4, 6, 7, 8 with a total area reaching 30,113 m^2. Besides being used for water recharge, the ponds constructed were also planned to use for fish farming, recreation and disaster management like fire control during dry season when the level of river water is very low.

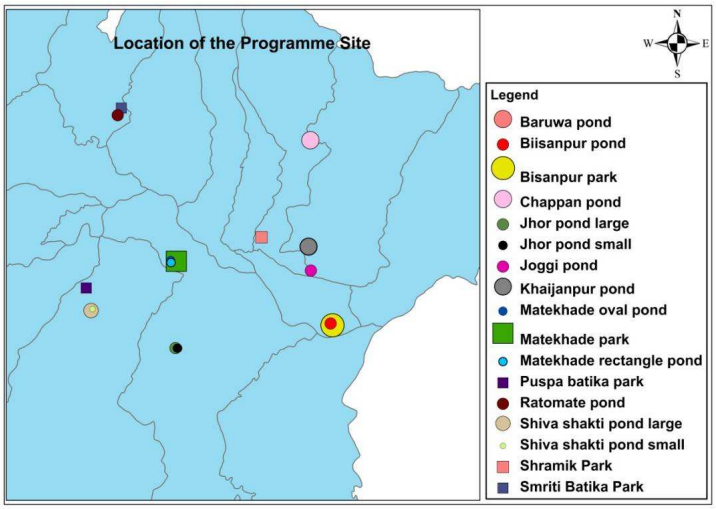

Figure 2: Climate Change Aadaptation/Mitigation Programme Implementation Site

Plantation

Plantation is considered as the most effective technique for the mitigation of climate change impacts. Trees are found to be effective to act as wind breaks, reduce heat effects, absorb pollutants, reduce noise levels and provide habitat for wild animals and birds. Similarly, afforestation of upland catchments with fast growing plantations can have significant impact on in situ water use with consequent impacts on water availability downstream (Trabucco et al. 2008). The study conducted by (Sinha et al. 2017) in *Panna*, a drought-prone district from M.P. India reveals that plantation can be considered as a measure to climate change adaptation. The fact is supported by Chand, 2011 as the study performed has revealed that planting of trees are supportive for reducing climate change impacts.

Plantation activities were done in different wards of the Triyuga Municipality as well including public land, road side, school premises, dam constructed at river bank and near households. Altogether different species of nearly 2500 number of plants were planted to maintain the greenery of the urban area and in order to mitigate the climate change impact.

Promotion of Renewable Energy

- Installation of Improved Cooking Stove (ICS)

ICS is taken as an alternative source of energy. It has been found to be supportive in reducing climate change impacts and CO_2 emission which is also illustrated in a study carried out in Meghauli VDC of Chitwan district (Chand 2011). Adding to this, the same study also supports ICS role in reducing fuel wood consumption and contributing to forest conservation thereby reducing environmental implication of GHG emission (Chand 2011). ICS can substitute kerosene and LPG that is used for cooking and lighting purposes which ultimately help in climate change mitigation, forest protection from clearing/exploitation and ecosystem/environment protection (DCEP, 2014). In Triyuga Municipality, the ICS installation work was conducted in various wards with altogether 2600 ICS being installed at household level.

Installation of Biogas Attached Toilet

Under this program, public toilets were constructed in various wards and the feed from such toilets were envisioned to produce biogas which can be supplied as fuel to nearby shop owners and community entities. Such toilets were constructed seven in number and hope to promote renewable energy and sanitation at the same time.

Installation of SolarStreet Light and Solar Tukki

Solar lights were installed in various areas of the municipality mainly in market area, hospital line and temple area where the flow of people is usually high. The street lights such installed were 70 in number. Similarly, 22 solar tukkis were distributed to economically poor members from Citizen Awareness Center of ward no. 9 who didn't have access to national electricity grid line.

Awareness of People

Awareness of the people towards combating the climate change as well as protection of environment is one of the most essential parts of the EFLGP. Aware people get more concerned towards their actions and deterioration of the environment. Even though the action look easy in itself but changing the human behavior is extremely difficult in itself. Hence, the awareness program included various types of trainings, sensitization classes and cleanliness campaigns.

Conduction of Trainings

A week long training was conducted for two times with an objective to produce stove masters of ICS. With the training and construction material provided, nearly 35 stove masters were produced which can be used to install ICS at household level.

Similarly, another such training was provided to produce environment friendly bags to 10 members from Environment Friendly Bag Production Committee formed for the same purpose. The trainees produced 2000 such bags after the training and can also be made to produce more in days to come. Also, 17 social mobilizers (SM) were also provided training on how to collect status of EFLGP indicators from household levels.

Sensitization Classes

Sensitization classes were conducted in municipality, various wards, ward citizen forum, citizen awareness centre and schools regarding the EFLGP, CC and environment protection. The students from grade 6 to 10 were counseled from 35 community schools to sensitize the issues of environment.

Community Awareness Session

Realizing the importance of pure drinking water to human health, awareness sessions were conducted in ward 6, 8 and 15 to assess the status of drinking water and identify the sources. Along with this, 10% of the source water were tested for various indicators including the coliform test to assess its status.

Environment Promotion Activities

Besides the mentioned programs, various other environment promotional activities were also conducted within the municipality which were

Conservation of water Aource/ Construction of Water Tank

For the conservation of water source, two water tanks were constructed; one to store the water from rivulet and another to store the piped water. The water tanks thus constructed facilitated nearly 75 households towards safe drinking water.

Construction of Bio-Dams

Several bio-dams were constructed along the river bank with the help of locally available vegetation such as *Amriso, Kodo, Bamboo, Sisau, Amala*. Such vegetation helped to anchor the soil and thus acting as a barrier for preventing the flood water towards the nearby irrigated lands.

Conservation of Public Land

A section of public land (nearly 12 bighas of land) was conserved by fencing to protect from encroachment and construction of parks as well as ponds were also carried out there.

Conclusion

The study shows that the various adaptation/mitigation activities were undertaken to respond the impact of climate change in different wards of Triyuga Municipality in support of Environment Friendly Local Governance Programme under Ministry of Federal Affairs and Local Development. The findings of the study indicated that the various climate change adaptation/mitigation activities which includes water recharge pond, parks, tree plantation, improved cooking stoves, solar street light, biogas toilet, bio-dam, water source conservation are important measures to cope with climate change impacts. The pond constructed is useful in water recharge, recreation, fire control when the river water level is low, fish farming. The park and tree plantation activity within the city will help to maintain the greenery and important site for picnic. The ICS installed will be helpful to reduce the fuel consumption rate and resulted to decrease the pressure on forest. This adaptation/mitigation strategy is not enough so more and more adaptation/mitigation strategy is needed to deal with the impact of climate change. The climate change adaptation/mitigation activity is immediately needed throughout the municipality to address the impacts of climate change. This work only focuses on the climate change adaptation/mitigation activities implemented throughout the municipality in support of Environment Friendly Local Governance Programme.

Acknowledgements

The author is thankful to Ms. Swasti Shrestha for her contribution during field visit and report writing.

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Good Start of REDD+ through District REDD+ Action Plans

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Abstract

DRAP is developed with key district and local stakeholders with the aim to implement the National REDD Strategy at subnational/district level. A National REDD+ Strategy is crucial for many reasons, including because a significant share of forest loss is due national level policy and governance 'drivers'. But a national strategy might be ineffective in Nepal due to the great regional differences in forest ecosystems and D&D drivers. Therefore policies and measures must be designed at the district level to take account of the specific regional or local D&D drivers as well as the specific ecosystems and social issues. There are mainly five steps involved while preparing the DRAP i.e. prepare, analyse, plan, monitor and budget. Reason for district level planning is that the local stakeholders can be involved in the planning process which increases ownership and sustainability. In other words DRAPs provide the best way of implementing the National REDD Strategy.

Keywords : *National REDD+ Strategy, DRAP, Drivers, Stakeholders, Policies and Measures*

Introduction

REDD+

Reducing emissions from deforestation and forest degradation (REDD+) is a mechanism that has been under negotiation by the United Nations Framework Convention on Climate Change (UNFCCC) since 2005, with the objective of mitigating climate change through reducing net emissions of greenhouse gases (GHG) through enhanced forest management in developing countries. National REDD+ strategies will reduce GHG emissions by lowering the rate of Deforestation and Forest Degradation (D&D) and/or increasing GHG removals from the atmosphere through forest carbon enhancement activities, for example, establishing plantations, forest landscape restoration, and improved forest management.

Rationale of DRAP

National REDD+ strategy (RS)(in case of Nepal) or National REDD+ Action Plan is mandatory under the UNFCCC for all the countries interested in receiving the international REDD+ payments. So, RS is very essential because inappropriate policies, measures and government arrangements must be addressed for REDD+ to be successful. Nevertheless, in most of the countries there are significant regional differences in forest ecosystems and D&D drivers that make it vital for REDD+ planning and implementation to take place a regional or local level.

District REDD+ Action Plan (DRAP) responds to the challenge of implementing the National RS and its components by fitting them to address locally specific D&D drivers and barriers to expansion of enhancement activities. In addition, this also allows local stakeholder to be involved in planning process which increases the transparency and social sustainability of REDD+. Finally, due to this process local stakeholder will take the ownership. This paper describes the DRAP procedure that was piloted in Chitwan District of Nepal. Due to the success of this protocol, it has been replicated

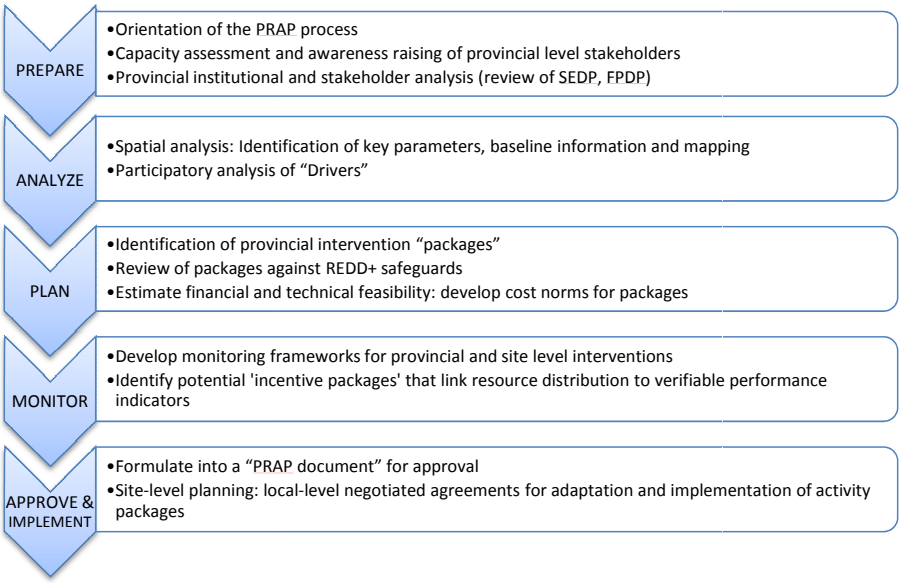
to Ilam district.

Foundation of DRAP

The DRAP process is based on 'theory of change' approach to programme design, monitoring and impact assessment. It is important to note that the theory of change approach can and should be used in combination with more 'technical' planning methods – it is not a stand-alone approach. Therefore the DRAP methodology and guidance (UN-REDD Programme, 2016 draft) emphasizes complementarity between the more qualitative and participatory theory of change approach and more technical planning methods such as spatial analysis. These experiences resulted in a published guide to spatial analysis and mapping in the DRAP process (Hicks et al. 2016).

DRAP Process

Piloting of DRAP that was conducted in Nepal have five main stages. All the stages have their own importance and they should be applied in during the consultation workshop (CW) expert workshops (EW) and field verification. The five stages are prepare, analyse, plan, monitor and budget.



Description of the Five DRAP Stages

Preparation

The preparation phase is crucial, as this ensures quality of workshops and participants to be invited in multi-stakeholder workshops. All the participants should be invited at least two weeks before the CWs. Major tasks involved in the preparation phase are as follows.

- Spatial analysis and preparation of maps for use in the workshops: these maps should include transparent overlays showing, for example, current and historical forest cover/ land use, forest tenure, livelihood dependency, current project areas, etc.;
- District level stakeholder identification should be carried with the help of formal/ informal meetings and focus group discussions.

- Selection and training of workshop facilitators: facilitators should be selected and trained prior to first consultation workshop.
- Selection of participants should be representative from government agencies, civil societies, gender, private sector, indigenous groups, etc.

Analysis

The analysis stage, as piloted in Nepal, comprises mainly two multi-stakeholder workshops attended by between 20-30 carefully selected participants. The participants should be the same for both workshops. Each workshop lasts up to two days, with the two workshops separated by a gap of about three weeks, providing time for 'hotspot' verification field trips and to process and write up data from the first workshop. At the first multiple stakeholder workshop, the 'Problem Analysis Workshop' the first main task is to prioritise and map the DF&D hotspots and high potential areas for forest carbon enhancement activities. The drivers and potential enhancement activities need to be scored by participants as regards their REDD$^+$ carbon and revenue potential.

The prioritised D&D drivers and barriers to enhancement are the 'key challenges' that the DRAP needs to overcome. Usually about 3-5 key challenges are identified. For each key challenge a working group of about 5-8 participants is formed. With the help of the maps and other preparatory data, the working groups then develop problem trees showing the direct and underlying causes of the key challenge.

At the second multiple stakeholder workshop, the 'Solution Analysis Workshop', the main task is to develop 'solution trees' or results chains that respond to the key challenges. The problem trees should ensure that the REDD$^+$ interventions derived from the solution trees have a strong cause and effect basis, and are therefore as strategic and cost-effective as possible.

Planning

Based on the pilot DRAP experience of Chitwan, more practical approach is proposed in the May 2016 draft DRAP guidance (UN-REDD Programme, 2016 draft); this is where the IPs are defined in a smaller expert group meeting comprised of the core planning team and some carefully selected workshop participants. Key tasks in the definition of IPs are to:

- Priorit and combine key results from the solutions tree into a coherent strategy (or IP) for counteracting each of the prioritised 'key challenges', and that will support and complement national PAMs identified in the National RS
- Identify a goal or quantitative objective for each IP
- Identify outputs (or sub-strategies) for achieving these objectives or goals
- Specify the activities for each output (or sub-strategy)

Basic criteria for defining the IPs include that they should have a direct impact on forest biomass, be independent (as regards their implementation) from other IPs, and be cost-effective. It is also vital to identify and analyse already existing plans and projects (e.g., of environmental NGOs) in the province in order to avoid duplication and maximise complementarity (this is also vital for the budgeting stage).

Once the provisional IPs have been identified, feasibility analysis needs to be undertaken. This involves identifying and analysing threats or obstacles to effective implementation, both as regards the likelihood of the threat and its potential negative impact or severity on the desired outcomes.

Where significant obstacles or risks are identified, feasible and cost-effective mitigation measures need to be identified. The feasibility analysis should include an analysis of political complexity, consideration (at least qualitatively) of the land use opportunity costs and DRAP implementation costs, and the likely effectiveness (or weaknesses) of incentive measures for changing current land use practices. Prioritising and deciding on the IPs also requires weighing up the potential for additional emission reductions or removals with the feasibility and cost-effectiveness of implementation. It may be desirable to consult the UN-REDD Project Management Unit (PMU) when making these judgements.

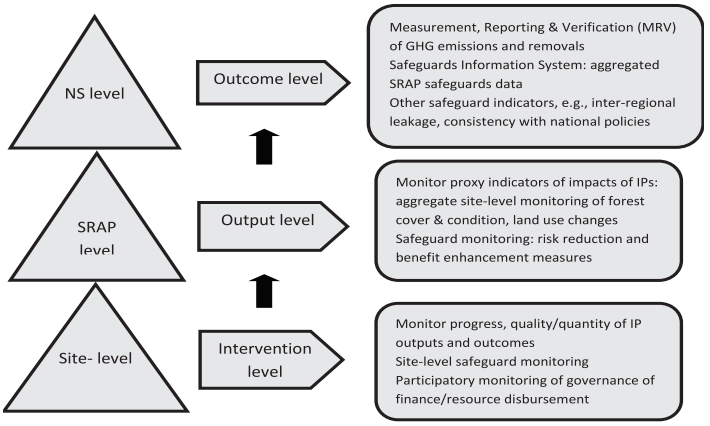
The feasibility analysis is likely to result in modification of the IPs, possibly by incorporating risk mitigation measures, or if necessary discarding an IP with low feasibility or cost-effectiveness even when the mitigation measures are included (especially since the cost-effectiveness or political viability of mitigation measures is often problematic). Such a decision would need to be carefully rationalised and communicated to the wider stakeholder group.

Following the feasibility analysis, safeguards analysis is required. The main tasks of safeguards analysis are to identify the potential or likely social and environmental impacts of each IP, assess the likelihood and severity of impact of each risk/benefit, and to identify feasible (cost-effective) risk mitigation and benefit enhancement measures.

As regards to environmental risks and benefits, a tendency was noted for participants in multi-stakeholder workshops to identify environmental risks that were emerging or minimal. It can be observed that analysis of environmental risks and benefits requires some technical expertise, especially when identifying the likely environmental impacts of enhancement activities, and it is therefore safer to undertake this in an expert group meeting, possibly supported by a biodiversity specialist.

Monitoring

There are three main levels of REDD^{+} monitoring as shown in the national level, the sub-national level, and the local level.



Monitoring plans can then be drawn up specifying the frequency, responsibility, location and cost of data collection. A similar approach can be taken to develop monitoring plans of the implementation progress of the IPs, including of the social and environmental risk mitigation and benefit enhancement measures. As for the planning and budgeting stages, it is advisable to undertake the monitoring stage in expert group meetings: many DRAP workshop participants found the monitoring stage

challenging although this was at least partly due to the limited training and capacity of workshop facilitators in some DRAP processes (Vietnam UN-REDD Programme 2016).

Budgeting

Detailed budgeting of the DRAP can follow directly on from the monitoring stage, possibly as an extension of the same expert group meeting if energy levels are sufficiently high. The required output of this stage is a five year Operational Plan that can be presented to national government and potential donors, who may wish to 'pick and choose' between the IPs. Budgeting therefore needs to be specific, detailed and transparent. The quantitative implementation targets defined in the planning stage (and that are also required for monitoring) are the starting point for the budgeting process, followed by a detailed analysis of the activities, tasks (within each activity) and resources needed.

It is also vital to ensure that the DRAP budget only computes resource requirements that are additional to those already planned and budgeted, most obviously in the Forest Protection and Development Plan (FPDP). This can be checked by undertaking a 'gap analysis' between the activities identified in the DRAP and in the FPDP, as well as in other planned state and NGO programmes and projects.

Approval and Implementation of the DRAP

The full report and planning document on DRAP should be prepared by the core team and submitted for the approval to the national decision makers. On the basis of the above, a full DRAP report or planning document needs to be written by the core planning team and submitted for approval and/ or modification by regional and national decision makers. The DRAP must also be socialised in an accessible format with sub-national stakeholder groups. A basic aspect of this, and a key component of the Cancun safeguard 'transparent forest governance', is transparency of decision-making. This means that the DRAP report needs to include the detailed analysis (for example, the flow diagrams and feasibility/safeguards analysis tables) from the DRAP workshops and expert group meetings. This detailed analysis is also essential for effective adaptive management of the DRAP.

When approved, DRAP needs to be incorporated into the national RS. A further vital step prior to implementation is to negotiate REDD$^+$ Implementation Agreements (RIAs) with local stakeholders, a step that requires the process of Free, Prior and Informed Consent (FPIC). The budgetary requirements of developing RIAs, including conducting FPIC, therefore need to be added to the DRAP budget. The final challenge before implementation is to access funding; in most cases it is expected that this will be a mixture of government and development partner's finance.

Conclusions

Based on the Nepal experience, it is proposed that the DRAP process can make a cost-effective contribution in operationalizing national REDD$^+$ strategies including to assist in meeting the Cancun Safeguards. This also aids in identifying strategic REDD$^+$ intervention packages for deforestation, forest degradation and barriers for enhancement activities. In addition, identifying social and environmental risks and risk mitigation measures will enhance the multiple benefits of REDD$^+$ that minimises the trade-offs between objectives. This ultimately compliance with the Cancun safeguards. This sort of plans will increase in the stakeholder ownership and transparency in the REDD$^+$ planning process, thereby strengthening social sustainably of the DRAP. Most importantly this will help in developing the national capacity to apply a generic planning methodology to a range of natural resource management contexts. Building provincial leadership of the DRAP process, which would in turn lead to higher level participation and improved cross-sector collaboration including in preparatory analysis. Improved integration of spatial and participatory analysis. Finally,

this will facilitate development partners financing of the DRAP by satisfying donor requirement of rigour, local ownership and participation.

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Assessment of Provisioning Ecosystem Services from Beeshazari Lake Complex, Chitwan National Park, Nepal

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Abstract

This research was an assessment of provisioning ecosystem services derived from Beeshazari Lake Complex. Household questionnaire survey and Key Informant Interview were the methods adopted to gather the data regarding ecosystem services. The result showed four major provisioning ecosystem services. They were Fuel wood, Fodder, Wild food and Medicinal Plants. Two among these, Fuel wood and Fodder were found to have a high demand being traded in the local markets. Fuel wood, fodder and medicinal plants have high importance among local users. Mushroom and ferns have enough amounts for monetary valuation. Ecosystem services of medicinal plants is still highly unused by the locals. If wisely and effectively used, locals will be highly benefitted by ecosystem services of BCL.

Keywords : *Beeshazari Lake, Wetland, Provisioning Ecosystem Services, Food and Fodder*

Introduction

The ecosystem forms the foundation of the framework, comprising the set of biophysical processes and structures producing ecosystem services, used by people to support their wellbeing (Fisher et al., 2014). Provisioning ecosystem services describe the products obtained from ecosystems, such as food, fiber, fresh water, and genetic resources.The supply of these services depends on the structure and processes of ecosystems and is reduced with ecosystem degradation (Lara et al., 2009). Nepal being one of the rich countries in water resources and wetlands, ecosystem services and payment to ecosystem services can assist a great deal in uplifting the livelihood of people (Khanal et al., 2014). At present ecosystem services are increasingly reaching eocnomic decision making through the widespread promotion of Market Based Instruments for conservation such as Markets for ecosystem services and so called Payment for ecosystem services schemes (Gómez-Baggethun, De Groot, Lomas, & Montes, 2010). Payment for ecosystem services is an approach to environmental management that uses cash payments or other compensation to encourage ecosystem conservation and restoration (Milder, Scherr, & Bracer, 2010).

Wetlands provide valuable ecosystem services that contribute to human well-being, including provisioning (e.g., food, fuel wood and water), regulating (e.g. flood control, water quality and water supply), supporting (e.g., biodiversity), and cultural services (e.g., recreation and esthetic) (Li et al., 2014). It is now increasingly recognized that PES can also contribute to broader economic development objectives such as sustained rural development, food security, and lasting poverty alleviation (Antle & Stoorvogel, 2008).

The valuation of ecosystem services can have many potential uses, at multiple time and space scales (Costanza et al., 2014). In the current context, ecosystem valuation represents the process of expressing a value for ecosystem goods or services (i.e. biodiversity, flood protection, recreational opportunity), thereby providing the opportunity for scientific observation and measurement (Farber, Costanza, & Wilson, 2002). With increasing research on monetary value of ecosystem services, interest has grown in the design of Market Based Instruments to create economic incentives for

conservation (Gómez-Baggethun et al., 2010). The valuation of ecosystem services usually consist determination of differences that changes in ecosystem services make on human well-beings, because changes in quality or quantity of ecosystem services changes the benefits associated with human activities or change the costs of those activities (d'Arge et al., 1997).

Beeshazari Lake Complex provide wide range of services that have helped to raise the economic status of the local people. Beeshazari Lake and associated wetlands area deliver goods and services of enormous value to the human society (Khanal, Gurung, Pant, Chaudhary, & Dangol, 2014). The locals from the nearby settlement area use the services provided in their everyday lives to a large extent that have a positive impact on long-term health and happiness. Understanding, assessing and monitoring ecosystem services of this wetland can lead to better policy formulation, resulting in land-use and management options that deliver more effective conservation, resilient livelihoods and poverty reduction. The study aims to fill the gaps of quantification of environmental benefits delivered by Beeshazari Lake and its surrounding forest area. The research was focused on assessing provisioning ecosystem services received by the local people of Beeshazari Lake area and listing and categorizing the provisioning ecosystem services delivered by Beeshazari Lake Complex

Materials and Methods

Study Area

The study was carried out in the Beeshazari Lake area in the Buffer Zone of Chitwan National Park, Nepal in November, 2016. The questionnaire survey was done in the settlement area around Bandevi Barandabhar Buffer Zone Community Forest. The climate of the area is subtropical and characterized by three climatic seasons, namely hot, monsoon and winter. The hot season extends from March to June, during which maximum daytime temperatures average 35.1˚C and fall to minimum 19.8˚C at night. Relative humidity is low; infrequent aggressive storms with powerful wind, blowing sand, hail and rain occurs in late March to May. The location of study are in Map of Nepal is shown in Figure 1.

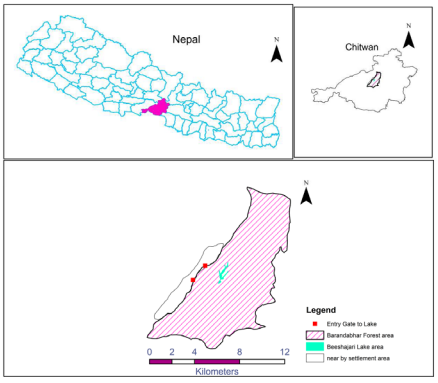

Figure 1: Study Area Beeshazari Lake, Chitwan National Park

Two methodologies was adopted for this research: a) Household Questionnaire Survey-60 HHs with clsoed end questionnaire to collect information regarding different provisioning services derived from the area, amount of each service used per year, familiarity of the locals with ecosystem services and other; b) Key Informant Interview – 9 KII was also done with key stakeholders and informants.

Results and Discussion

Household Income

The main source of income for the respondents of the study area was agriculture and most of them have the income level from Rs. 30,000-40,000 per annum (Table 1).

Table 1: Household Income

Income Per Annum	Frequency	Percentage
30,000-40,000	37	61
>40000	10	17
Don't know	13	22

Ecosystem Services

Different types of ecosystem services were found to be derived from the Beeshazari Lake and the surrounding Bandevi Barandabhar BZCF area. Every HHs uses ecosystem services extensively for their day-to-day lives but only one third (20 HHs) of the respondents were familiar with the term "ecosystem services". The household questionnaire survey revealed four main provisioning services (as listed in Table 4) important for the livelihood of the local people. They are: Wood, Wild food, Fodder and Medicinal Plants. Beeshazari Lake was formerly used extensively for fishing purposes in the previous years. However, after the ratification as Ramsar site in 2003 (National Lake Conservation Development Committee), the direct use of resources by the local people has been obliterated completely. They can only use the resources listed in (Table 2) from the surrounding forest area i.e. Bandevi Barandabhar BZCF.

Table 2: Provisioning Ecosystem Services Obtained from the Study Area

Provisioning Ecosystem Services	
Fuel wood	Fuel wood from different tree species mainly *Shorea robusta*
Fodder	Grass for cattle
Wild food	Mushroom, Edible fern *(Diplazium esculentum)*, Sisnoo
Medicinal Plants	Plants like Amla, Harro, Barro used for medicinal purposes

Important Provisioning Services in Terms of Livelihood

The importance of these services varies according to the services and the communities surveyed. It also depended upon the income and literacy of the people surveyed. Figure 2 shows the mean values for importance of the identified provisioning services. The values ranges are: 1 – Very Unimportant, 2 – Unimportant, 3 – Not clear, 4 – Important and 5 – Very Important.

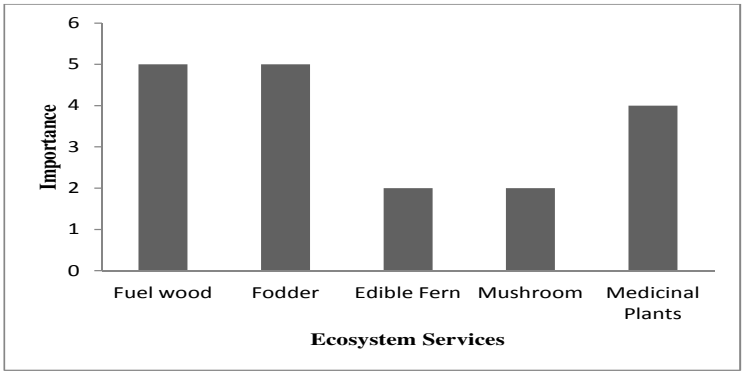

Figure 2: Importance Prioritization of Provisioning Ecosystem Services

Fuel Wood

Maximum of the respondents i.e. 98% used the forest and obtained fuel wood for cooking purposes. The small percentage that did not was from effluent families or those who had a sizeable income from the foreign employment. The annual use of fuel wood by the respondents (Table 3). It is found that there is significant association (χ^2 = 16.4, df = 3, p = 0.0009) in amounts of fuelwood used among classes.

Table 3: Annual Use of Fuel Wood

Amount of fuel wood used	Frequency	Percentage
>50	28	46
25-50	12	20
<25	13	22
None	7	12

Fodder Services

Among the respondents, 70% owned livestock and 30% didn't. Almost all of the respondents were dependent upon the forest for fodder. Only 5% of the respondents didn't use any amount of fodder. The respondents visit the forest regularly to bring fodder to feed their cattle. The annual use of fodder by the respondents (Table 4). It is found that there is significant association (χ^2 = 26, df = 3, p<0.05) in amounts of fodder used among classes.

Table 4: Annual Use of Fodder

Amount of Fodder Used Yearly	Frequency	Percentage
>50	31	51
25-50	12	20
0-25	4	7
None	13	22

Although, fuel wood and fodder use showed a weak negative correlation but the association between fodder and fuel wood collection is not significant (F= 0.21, p= 0.64). Relationship between fuel wood and fodder (Figure 3).

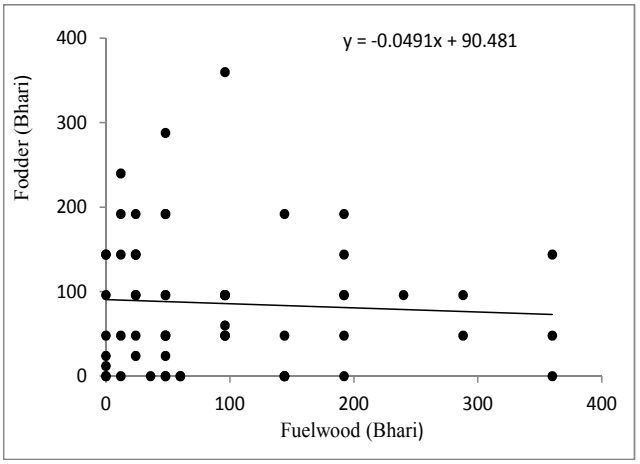

Figure 3: Relationship Between Fuel Wood and Fodder Use

Food Services and Medicinal Plant

Only about 30% of the respondents used the forest for food products. The most preferable food products that local people consume from forest were found to be *Diplazium esculentum* (edible fern), wild mushroom, *Urtica dioca* (Sisnoo), *Emblica officinalis* (Amala). However, only mushroom and edible fern were used in enough amounts for monetary valuation. The annual use of mushroom and edible fern (Table 5). It is found that there is significant association (χ^2 =94.1667, df = 4, $p<0.05$) in amounts of edible fern and (χ^2= 75, df = 3, $p<0.05$) in amounts of mushroom among classes.

Only 18% of the respondents used the forest for medicinal services. Medicinal plants that were harvested from forest were found to be *Terminalia chebula* (Harro), *Terminalia bellirica* (Barro), *Emblica officinalis* (Amala), *Centella asiatica* (GhodTapre) etc. The annual use of medicinal plants by the respondents (Table 6). It is found that there is significant association (χ^2 = 63.7, df = 2, $p<0.05$) in amounts of medicinal plants. Only 3 out of 49 HHs uses 1-2 kg/year and 8 HHs uses 0-1 kg/year medicinal plants parts from the Beeshazari lake area.

Table 5: Annual Use of Edible Fern and Mushroom

Amount Used per Year	Edible Fern (Neuro)		Mushroom	
	Frequency	Percentage	Frequency	Percentage
0-10	6	10	5	8
10-20	5	8	6	10
20-30	4	7	4	7
>30	3	5	3	5
None	42	70	42	70

In this study, only 30% of the respondents used Edible fern and wild mushroom but the total amount used did not exceed 30 kilograms. Dangol, (2008) showed that edible fern *(Diplazium esculentum)* and wild mushroom are very popular among the local people. Edible fern has been recognized as one of the most important wild food item for local people of Chitwan and as a species sold in urban markets. However, in this study these two (edible fern and wild mushroom) were not traded by the respondents in the local markets. The study of Dangol, (2008) also mentioned that both indigenous and new migrant residents use the available plant resources for different purposes which bring economic benefit to the households and provide valuable food, vegetable and medicinal products that maintain human health and general wellbeing of the household in the Western Chitwan. But in this present study, medicinal plants was a provisioning ecosystem service found to be mostly unused by the respondents despite their wide availability in BLC. It was mostly due to the fact that many people were not aware that the forest area possessed plants that could help as medicines.

Status of Ecosystem Services

The ecosystem services, according to the respondents, have changed in numbers and status as compared to the past decade. The size of the forests had considerably increased. However, the amount of services made available to the local people had contrasting developments. Overall, there has been hardly any increase in the ecosystem services made available to the respondents (Figure 4). The values of increase and decrease range from: 1 – >75%, 2 – >50%, 3 – >25%, 4 – >10%, 5 – 0% and 6 – Unknown.

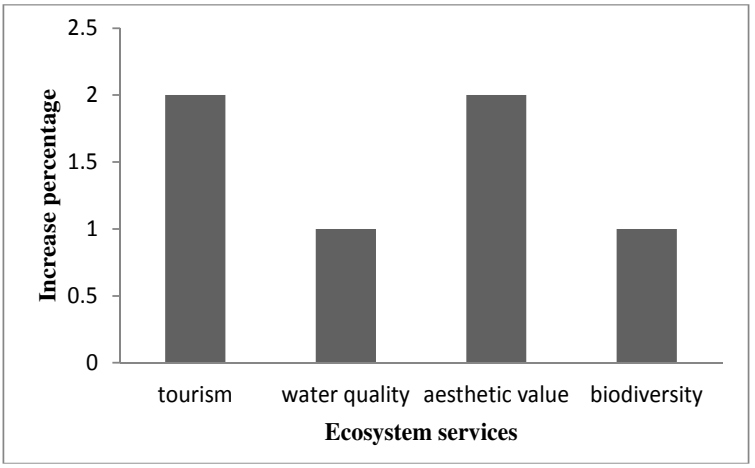

Figure 4: Increase in Ecosystem Services

The resources of wetland are directly associated with the livelihood of local people. The ecosystem services are found to support a significant proportion of the surrounding of buffer zone households. More than 44,000 households living in the buffer zone area are directly or indirectly dependent on resources from the area (Bhusal, 2014). In this present study, the results show that the local communities depend heavily on numerous directly used provisioning ecosystem services provided by the Beeshazari lake complex for their subsistence and wellbeing. In this study, the major provisioning ecosystem services were identified, the amount of services used were quantified (physical dimension measurement) and monetary evaluation were conducted to estimate the value of provisioning ecosystem services delivered by BLC. This study also elicits the WTP of local people for the services used by the local population and for the conservation activities of Beeshazari Lake Complex. Thus, ecosystem services should be seen as an integral part of any poverty reduction strategy in Nepal. There are a total of 1500 households in the Beeshazari Lake Complex, a significant proportion of which live very close to the forest area.

Quantification of Provisioning Ecosystem Services

The local people used fuel wood and fodder in a large scale. Fuel wood was found to be the major source of fuel for cooking purpose. Maximum of people, 70% owned livestock and required fodder to feed them. The respondents in total used approximately 5472 bharis of fuel wood and 5160 bharis of fodder annually (Table 6). The quantification uses the unit "bhari" as there isn't a direct conversion of it to kilograms. Typically one bhari ranges from 30-50 kilograms.

Table 6: Quantity of Provisioning Ecosystem Services Used

Annual use of Fuel Wood	Total use (in bharis)	5472
	Average use per family	91.2
	Maximum use per family	51
	Minimum use per family	0
Annual use of Fodder	Total use (in bharis)	5160
	Average use per family	86
	Maximum use per family	47
	Minimum use per family	0

Provisioning ecosystem services are the group of end products achieved directly from the ecosystem (Wallace, 2007). Even among the provisioning ecosystem services delivered by BLC the local people were found to be more concerned with the services which provided them with more direct benefit such as fuel wood and fodder which carried the most weightage in importance value (as shown in Figure 2). In this study, 98% of the respondents were prefering fuel wood for cooking as opposed to other sources of energy such as LPG, Kerosene stoves or electricity. Similarly, Lamsal et al., (2015) also found that 95% of the households extract fuel wood from the Ghodaghodi Lake Complex (GLC), apart from other resources including fish, fodder, trapa (*Trapa natans, T. bicornis*) and sal (*Shorea roubusta*) leaf for their livelihood. There was only a small proportion i.e. 2% that did not use fuel wood at all was from families with a more stable economic status in this study with the reason they had high salary from foreign employment. Additionally, another most important service was found to be fodder with a high proportion of the respondents owning livestock, they depended upon the forest's resources to feed their cattle.

Conclusions

This study emphasizes on the key provisioning services received from the study area, their monetary value, and the willingness to pay for the conservation of the ecosystem services. The major provisioning ecosystem services delivered by BLC to local people directly was found to be fuel wood, fodder, wild food and medicinal Plants. Among those, the most important were fuel wood and fodder with 96.7% of the respondents benefiting from them directly.

Acknowledgements

We would like to express our gratitude to Department of Environment for financial support. We are also heartily thankful to Mr. Devraj Sapkota, the Chairperson of Barandabhar Community Forest User Group for being a valuable source of information. We are also thankful to all the local people. This study would not have been possible without their support and cooperation. We would also like to acknowledge Mr. Man Kumar Dhamala, Ms. Suchana Dahal and Mrs. Bina Amatya for their support and cooperation during this research work.

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Park People Interface: The Case of Resource Extraction and Crop Depredation in Buffer Zone of Suklaphanta National Park

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Abstract

Present study explores the situation of park people interface in Suklaphanta National Park (SNP). Buffer zone of Suklaphanta National Park (SNP) leads a heavy pressure into the forest for firewood, fodder, and grazing of livestock and NTFPs. About 87% of the household (HH) depends on the National park for fuel wood and fodder. In average, the fuel wood and fodder consumption per HH was found to be 3,455Kg /HH/ Yr and 7814.11 Kg/HH/Yr respectively. The depredation of the crops by wildlife is one of the major factors creating negative attitude towards conservation goals. The agricultural fields adjacent to the reserve are serving as the second habitat for wild animals. The crop loss by the wild animals in the study area was found to be 1409.96 quintals. The loss per HH was estimated to be Rs 4,731.67 per year. Apart from crop damage, the wild animals like elephant (Elephus maximus) was found to be associated with house damage problems, and human injuries. Change in crop composition, maintenance of trenches, Compensation mechanism, practice of agro - forestry and plantation of mentha, chilly, and other cash crops were unpalatable to wild animals and in turn enhance livelihoods thereby reducing the park- people problems.

Keywords : *Park and People, Buffer Zone, Crop Depredation, Forest Resources, Livelihood*

Introduction

From the last few decades, Nepal had been giving importance for in site conservation of Biological species through establishment of protected areas in representative ecological zones. Biodiversity conservation policy had focused on forest management had been re-directed towards community participation after the mid-seventies. The establishment of buffer zone is an incremental step in effort to apply participatory methods and collaborative management in biodiversity conservation (Budhathoki, 2005). Traditionally, National park and reserve management have focused on protected areas only and rarely does park authority have jurisdiction of the land outside park boundaries (Oldfield, 1988). However conservation of biological diversity inside protected areas is possible only when rights of people are addressed. There is a close linkage between forestry and rural people in Nepal where people from rural area mostly depend upon the forest resources to meet their fuel wood, fodder and timber (Gautam, 2006). Lack of alternative resources forced local people to intrude the park's resources.

Prior to the establishment of the Parks & reserves, local people were free to collect firewood, fuelwood, timber, fodder and thatch grass from the forest. Local people were dependent upon it for grazing and fodder for the livestock, bamboo and medicinal plants for their livelihood & fishing and hunting for a major source of protein. With the declaration of Parks & reserve in such areas many people have been legally restrained from using their traditional rights and had no legal rights to procure compensation for their lost benefits (Upreti, 1985). Thus, Parks and reserves are facing sever challenges of conflicts. These conflicts were highly interactive, multi dimensional, strongly biased, belief ridden & plainly subjective (Nepal & Weber, 1993). Indigenous people had evolved

certain forms of co-existence with wildlife around them which permitted both to survive (Nepal & Weber, 1993). The restriction imposed on the resources used by the local people to meet their basic need lead to deterioration of the Park-people relation (Shrestha, 2006). Crop damage by wild animals, livestock killing, injury by wild animals, poor relation with protection units, illegal fodder collection and lopping of trees, illegal grazing, timber theft, poaching etc are major issues raising the conflict between the park and people. (UNDP/HMGN, 1994-2001).

Present study explores the situation of park people interface in Suklaphanta National Park (SNP), which is located in Far-western Terai on southwestern edge of Nepal. Growing population in the Buffer zone of Suklaphanta National Park (SNP) leads a heavy pressure into the forest for firewood, fodder, and grazing of livestock and NTFPs on the forest, which in those days were their traditional rights to use but were presently forbidden. Moreover the wild animals of Park caused losses by damaging the agricultural crops, this further aggravates the problem, thus creating a negative attitude towards the park. Due to excessive depredation of the crops by animals such as Elephant *(Elephus maximus)*, Deer (Axis axis), Wild Boar *(Sus scrofa)*, etc, people near SNP are forced to take action against them. Despite its several successes in biodiversity conservation, threats to sustainable biodiversity conservation in SNP continue due to some sort of conflicts at different scales. So park people conflict needs to be addressed in terms of spatial and temporal variation. The research aims i) to determine Status of resource utilization and ii) to assess the problems of crop depredation and find out the pitfalls in biodiversity conservation and livelihood issues.

Materials and Methods

Study Area

The study was conducted within the buffer zone of Shuklaphanta National Park (SNP). SNP is a protected area in the Terai of the Far-Western Region, Nepal, covering 305 km2 of open grassland, forests, riverbeds and tropical wetlands. In 2017, the status of the protected area was changed to a national park. The park is rich in floral diversity consist of 700 species of flora, including 553 vascular plants, 18 pteridophytes, 410 dicots and 125 monocots. The faunal diversity includes 46 mammal species, 423 bird species, 12 reptiles and amphibian. Major vegetation types are Sal forest, tropical mixed hardwood forest, riverine forest and grassland. The research was carried out in eight different wards (small villages) of Bhimdatta municipality (viz; 13,14,15,18,19) and Mahakali municipality (viz; 3,4,1), which lie in the buffer zone of SNP along the periphery of forest boundary. The selection of those areas is based on judgment sampling, since those areas were inflicted with serious problem of crop depredation. The study was entirely based on the primary and secondary data.

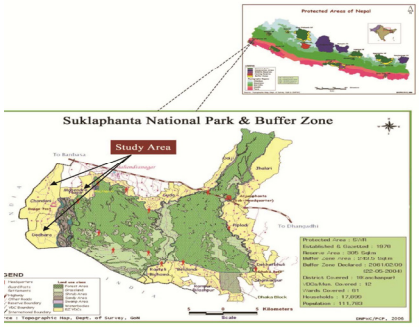

Fig: Map showing Suklaphanta National Park and Buffer Zone

Fig 1: Map of Study Area

Estimation of Crop Damage

The crop damage i.e the loss per unit area and loss per HH for major crops was calculated using following formula given below (Jnawali, 1989)

$$x=(xE-xA)/(xL\_c)$$

$$xL=xE-xA$$

Where, x = Loss per unit land , xE = Expected yield (Expected productivity) prior to crop loss ,xA = Actual yield (Observed productivity) after crop loss ,xLc = Total cropping land of that field, xL = Total Loss (Kg).

Quantitative data on Observed Productivity (Actual Productivity/ yield) (xA) of the crops, since last two years were collected through HHs interview. The data on expected productivity was used as reference data to calculate crop loss and it was obtained from District Agriculture development Office (DADO), Kanchanpur. Expected productivity (xE) of the crops refers to the productivity, if the crops had not been depreded by the wild animals (Jnawali, 1989; Nepal and Weber, 1993; Limbu, 1998). The expected productivity was measured on the basis of annual harvestings made from the Pilot plots.

Socioeconomic Survey

Total 291 HHs , were included for socioeconomic survey. The sample size (n) of the household in the study area was determined by using statistical formula (Arkin and Colton, 1963; cited in Sharma, 2000) at 95% confidence level.

$$n=(NZ^2 \times P(1-P))/(Nd^2+Z^2 P(1-P))$$

Where, n = Sample size ; N = Total no. of households

Z = Confidence level (at 95% level Z = 1.96)

P = Estimated population proportion (0.05, this maximize the sample size)

d = Error limit of 5% (0.05)

Set of questionnaire were used to collect the data on extent of crop damage, livestock depredation, human harassment and resource extraction. The survey was conducted by direct interview with household interview using structured and semi –structured questionnaire with some close ended and some open ended questions. The HHs survey was validated by focus group discussion (FGD), direct observation and key informant interview.

Data Analysis

The quantitative data obtained was analyzed using Statistical package for social science (SPSS) and statistical measures Chi-square test, and Z-test.

Results and Discussion

Socio - Economic Status

The total numbers of male respondents surveyed were 63.6 percentage whereas female respondents were 36.4 percentage. Among a diverse ethnic community in the vicinity of SWR, Chhetri constituted 38.3 percentages followed by occupational caste 28.7 percentage. Those included, Luhar, Kami, Damai and Sarki. Janajatis (Tamang, Magar, Gurung, Newar,Tharus) Consituted about 13.8

percentage. The Brahmin, Chhetri, Janjatis (except tharus) and occupational caste were all migrants from the hills. Brahmins and Chhetri shows the population dominancy over others.

Table 1: Distribution of HH According to Ethnicity

Ethnicity	Total HH	
Brahmin	57	(19.5)
Chhetri	111	(38.3)
Janjati	40	(13.8)
Occupational caste	83	(28.7)
Total	291	(100)

Data in Parenthesis Are in Percentage

About 79 percentages of the households were dependent on agricultural activities. Rests of them were involved in business (4.8%), government job (4.5%), and private job (2.7%). Likewise 6.5 percentage of the HH were engaged in wage labour, and 2.1 depend on remittance.

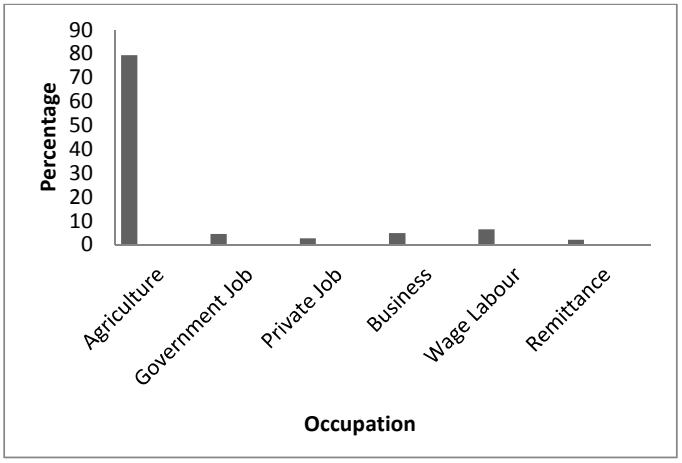

Fig 2: Distribution of Population by Occupation

Majority of the population shows landownership. About 4% of the respondents were landless. Their source of income was wage labour. Remaining 96 percentage had landownership. Among them 53.5 percentage had small farm (0-0.3 ha of land), 28.2 percentage had medium farm (0.31-0.6 ha), 17.5 percentage had big farm (0.61-1.8 ha), and about 1 percentage had bigger farm (> 1.8 ha) as shown in table.

Table 2 : Land Categorization and Land Ownership

Land category(in ha) n=291	Scale in ha.	Total HH
Landless	0	11 (3.7)
Small Farm	(0 - 0.34)	150 (53.5)
Medium Farm	(0.31 – 0.6)	79 (26.2)
Big Farm	(0.61 -2.7)	49 (17.5)
Very Big Farm	(≥2.72)	2 (0.7)

Data in Parenthesis Are in Percentage

Firewood/Fodder Consumption and its Sources

Majority of the HH (93.5%), out of 291 HHs, depends on fire wood as major source of fuel. National Park, Government Managed Forest, Community Forest (CFs) and drifted wood were the major sources of household fuel wood. Majority of the HHs (87 %) seems to depend on SNP for firewood as source of fuel as shown in table 3.

Table 3: Major Source of Firewood & Fodder

Source of firewood & fodder (n=272)	Total HH	Percentage
Wildlife park	236	87.0
Government Managed Forest	1	0.4
Private land	6	2.2
Community Forest	9	3.3
Drifted wood	20	7.3
Total	272	100

The annual consumption of firewood (FWC) for the sampled household was found to be 9,39,900 kg of firewood and 21, 25,440 kg of the fodder respectively. 87 % of household demand for fuel wood was single-handedly by SNP .In average, the fuel wood and fodder consumption per HH was found to be 3,455Kg /HH/ Yr and 7814.11 Kg/HH/Yr respectively.

Similarly it was observed that big farm sized HH had higher consumption of fodder than small farm holding. This indicates household with large farm size require high amount of fodder as they have large number of livestock. The statistical analysis (z_{α}, 0.05 =9.225) also showed that the proportion of the people using forest products for firewood & forage was not equal.

Table 4: Total Amount of Firewood Consumption

Fire wood consumption (n=291)		
Total HHs using firewood resources	**FWC (Kg/yr)**	**FWC (Kg/HH/Yr)**
272 (93.5)	9, 39,900	3,455.5

Data in Parenthesis Are in Percentage

Table 5: Total Amount of Fodder Consumption

Fodder consumption (n=291)		
Total HHs using fodder resources	**Fodder consumption (Kg/yr)**	**Fodder consumption (Kg/HH/yr)**
272 (93.5)	21, 25,440	7814.11

Data in Parenthesis Are in Percentage

The major forest products harvested from the Park were - fire wood and fodder. Previous studies (Pande 2000, Joshi 2002) found that most of the HH (92%) used firewood from park. This study also showed that the extraction of fire wood, as a critical problem, still existed at the same rate (93.5%). The main reason for this was due to the absence of Community forest in Buffer Zone area of Park.

Generally poor people preferred to collect firewood rather than buying it from the market (Bhatta, 1994) and they have a tendency to exploit nearby forest first than to think of a sustainable use. Not only fodder and firewood but also timber theft was a serious problem over there causing conflict.

Impacts of Wildlife on Community

Different kinds of fauna including birds created problems to the inhabitants living near the Park. Not all the animals of the Park were problem breeders, there were a very few. In SNP the pest species consisted of elephant, wild boar, monkey, deer, nilgai, peacock and porcupine. Occasionally, tiger, jackals, foxes and pythons also create minor problem. About 85 percentage of the respondent of total HH surveyed showed the problem from animals. In case of Bhimdatta municipality, problem seemed to be serious in ward number 13, 14, 15, and 19. Whereas in case of Mahakali municipality (Dodhara- chandani) ward number 4 had a higher problem (88.9%) than ward number 3 (31.3%) but ward -1, is free from wildlife disturbances.

Table 6 : Response Regarding Problems Caused due to Wild Life

Response(N=291)	Number	Percentage
Yes	245	84.1
No.	46	15.8
Total	291	100

People residing the adjoining areas of park, were the victims of problems raised by the wildlife. Among them, were crop damage, local harassment and harm to cattle (livestock depredation).Crop damage was the major problem in the study area. Of the total respondents, facing the problem of crop damage (n=245), 99 % agreed that wildlife damage their crops. The crop damage was not merely by feeding but also due to raiding during grazing crops. The main reason for the field raid might be fondness of the field crops, which were soft and palatable.

Table 7: Kinds of Problems Caused due to Wild Animals

Problems (n=245)	Number of HH	Percentage
Crop Damage	243	(99)
Human Harassment (including human injuries) + crop damage	30	(12.2)
Livestock Depredation + crop damage	13	(5.3)

Data in parenthesis are in percentage. percentage added up more than hundred due to multiple responses.

Land Coverage by Major Crops

Paddy, wheat mustard and maize were the major crops of the study area. Other crops such as pulses and vegetables were also grown in the area. The cropping sequence in the lowland was Maize - Paddy in summer & rainy season followed by wheat and mustard in winter. From the study it was found that every HH of the different wards grew those crops. But paddy and wheat were grown as the major crops. The study showed that paddy, mustard, maize and wheat were grown in 87.17 ha, 7.55 ha, 3.54 ha, 86.14 ha of cultivated land as shown in figure 3.

Fig. 3: Land Coverage by Different Crops

Assessment of Crop Loss

The incidence of crop damage varied considerably among study area. This may be due to distance of the agricultural fields from the Park boundary and the type of field crops. Elephant *(Elephus maximus)*, Deer *(Axis axis)* and Wild Boar *(Sus scrofa)* seem to be more nuisances among the wild life that cause considerable loss of crops. The study showed that crop loss was dependent upon the different crop stages. Elephant preferred to feed on mature paddy and wheat and usually come in fields in cluster and raiding was massive whereas deer feed on young stage. Study showed that the wild boar was the most destructive wild animals. Wild boar damaged paddy, wheat and maize when they started to produce seed (milky stage).When the fields were observed, it was found that boar uprooted most of the crops, than it could consume. Table 8 shows the estimation of crop loss on basis of major crop types.

Table 8: Estimation of Crop Loss by Major Crop Types

Crop Types	xLc (in ha)	xE (in quintals)	xA (in quintals)	xL (in quintals)	X (Per unit ha)	Percentage Loss
Maize	3.54	150.54	37.64	112.9	31.89	74.9
Wheat	86.14	2111.35	1387.1	724.25	8.40	34.30
Paddy	87.17	3178.86	2623	555.86	6.37	17.48
Mustard	10.84	47.91	30.9	16.95	2.24	35.37

Where, X= Loss per unit land, xE= Expected yield prior to crop loss, xA = Actual yield after crop loss, xLc = Total cropping land, xL = Total Loss

Paddy, one of the major cereals of Nepal was cultivated in 87.17 ha area in the study site followed by wheat and mustard. The estimation of crop loss depicts 724.25 quintals loss of wheat, followed by 555.86 quintals of paddy. The expected production of the paddy was 3178.86 quintals whereas the amount harvested by farmers per season was 2623 quintals. The data shows the significant loss

in the yield of major crop types during harvesting period. The statistical analysis i.e. Chi-square test (χ^2) showed significant difference between expected and observed productivity of the major crops. χ^2 test for major crop types viz; maize [($\chi^2_{4, 0.05}$ =139.13), wheat [($\chi^2_{6, 0.05}$ =28), paddy [($\chi^2_{6, 0.05}$ =19.77) and mustard [($\chi^2_{6, 0.05}$ = 13.548) reveals that there was significant loss in expected production of crops due to wildlife. This concluded that the loss in expected production (as per the census of District Agriculture development office (DADO)) was prevailed there. This might be done by the wild animals of SNP, which is also verified by (χ^2) test. The highest percentage of loss was found in ward number 19, 14 and 13 of Bhimdatta municipality where visits of elephants *(Elephus maximus)* and wild boar *(Sus scrofa)* were frequent. This might be due to damage of existed barrier and the open boundary of the Park. At Mahakali municipality *(Dodhara & Chandani)* few percentage of HH reported on crop damage. The reason might be due to the presence of Mahakali River in the border between these VDC and the Park. The river acted as a good geographical barrier for small ungulates. However large animals like elephant could easily cross the barrier and raid the crops. According to the HH reporting there was occasional visit of elephant.

Preventive Measures

The major traditional techniques used by villagers as preventive techniques, use of scare –crow, were the use of noise making devices, shouting, spending nights at machan, using dogs, fencing, use of trench and firing. About 50% reported that firing was very effective. Chasing with flames was effective for elephants. Due to the lack of maintenance of trenches, and somewhere with insufficient depth and width, they became useless and seemed to be ineffective. Netted wire and barbed wire fences were less effective for wild boar and elephant. However they seemed to be good barrier for deer. In some cases *Euphorbia sps*. was seen at the boundary. A living Euphorbia fence might be effective biological fence, even for elephants.

Conclusion

Socioeconomic status in the vicinity of SNP revealed that majority of HH depends upon subsistence agriculture system. The major problems in the study area are: heavy reliance on national park resources, Lack of alternatives, poor socio-economic condition of the villagers, and crop depredation by wildlife, which aggravate the situation of conflict between local people and park. Huge amount of fodder and firewood were extracted from the park. The attraction of wild animals towards human settlement was mainly due to two reasons: herbivores were attracted by crop fields and carnivores by livestock. Thus the agricultural field adjacent to the reserve was serving as the second habitat for wild animals. The migratory behaviour of the wild animals varied and they could not be taught to migrate only inside the Park boundary. The study showed the total crop loss by the wild animals was found to be 1409.96 quintals with a heavy economic loss of Rs 13, 76,916 per year. The loss per HH was estimated to be Rs 4,731.67 per year. Apart from crop damage, the wild animals like wild elephant was found to be associated with house damage problems, and human injuries. There were no cases of human death by wild animals, though 5 persons were injured by attack of wild elephant along with their house damaged in Bhimdatta Municipality. The other factors affecting the crop damage were following: i) Distance from forest to the field. Distance and crop loss had an inverse relationship ii) The volume of crop loss increased as the size of land holding and frequency of crop raid increased and iii) Presence and effectiveness of barriers between the cropping farm and the reserve. Compensation mechanism, practice of agro - forestry and plantation of mentha, chilly, and other cash crops were unpalatable to wild animals and in turn enhance livelihoods thereby reducing the park- people problems.

Acknowledgement

The author is grateful to local people for providing information during questionnaire survey. Sincere thanks goes to Terai Arc Landscape (TAL) for financial support and to the park authorities for technical assistance.

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Status of Tea Production in Relation to Climatic Variables and Soil Parameters Analysis

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Abstract

Soil physical and chemical properties play a vital role in growth and production of tea plant (Camellia sinensis). The eastern region of Nepal has suitable climate and geography for tea cultivation. In this study, climatic factors (temperature and rainfall) and soil parameters (texture, moisture, pH, electrical conductivity, organic matter, carbon, total Nitrogen (N), available Phosphorus (P) and exchangeable Potassium (K) important for the growth of tea plant were analyzed. The study was conducted in four tea estates during August-December, 2016. Production of tea was recorded for a period of one month. Result showed that Kechana tea estate had the highest and Ilam tea estate had the lowest quality of soil among the study sites. Production of tea was expectantly highest in Kechana tea estates and lowest in Mishra tea estates. Analysis of climatic variables and soil physiochemical parameters were consistent with the production in these study sites.

Keywords : *Camellia Sinensis, Tea Estate, Eastern Nepal, Soil Physiochemical Parameters*

Introduction

Tea industry serves as a major employment opportunity for the population in eastern part of Nepal (Poudel 2010). Nepal's economy is highly dependent upon agricultural sector. The country is susceptible to changes in agricultural product due to the change in weather. The eastern region of Nepal has suitable climate and geography for tea cultivation. The type of soil necessary for the tea plantation is characterized by the pH value ranging from 4.5 to 5.5 having good drainage facility, good water holding capacity and ample organic matter. The temperature ranging 12.5ºC - 30ºC is the best for tea cultivation. For a soil to be fertile and productive, wide variety of ions must be available in correct proportion. The extent to which nutrient is available to the plant is determined by soil texture, moisture content, acidity (pH) and electrical conductivity of the soil. Soil nutrient and available water has a great role in agricultural crop growth and production (Adhikary, et al 2008; Bajracharya,et al 2007; Bhagat et al 2010; Carr et al 2008)

Materials and Methods

Study Area: The study was conducted in four different tea estates (TE) of Jhapa and Ilam district of south-eastern Nepal namely Kechana Tea Estate (Kechana TE), Mishra Tea Estate (Mishra TE), Ilam Tea Estate (Ilam TE) and Kanyam Tea Estate (Kanyam TE) as shown in figure 1 below.

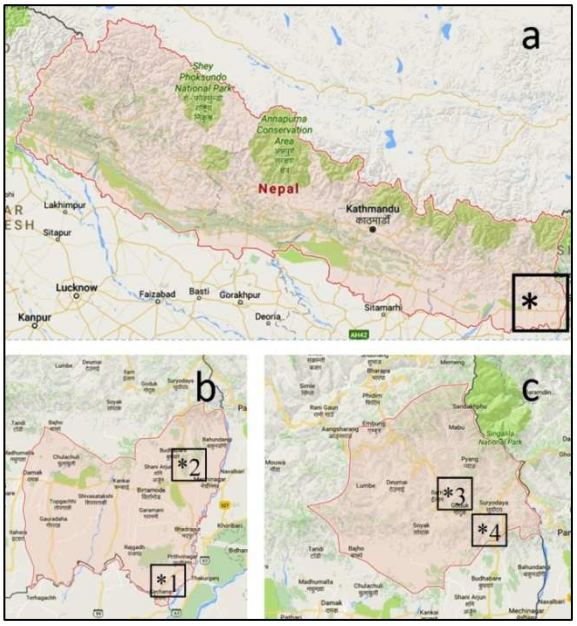

Fig 1: Figure Shows map of Nepal and the District Selected for Study. a) Map of Nepal with Approximate Location of Atudy Ilam TE; b) map of Jhapa district showing Kechana TE (*1) and Mishra TE (*2); c) Map of Ilam District Showing Ilam TE (*3) and Kanyam TE (*4)

Soil Sample Collection: Stratified soil sampling method was applied to collect soil sample. From each TE, the sector containing approximately 5 % of the total cultivated land was assigned as the representative area. Each area was divided into smaller sections and random sampling was applied within each section. Four replicate samples from 30cm depth were taken from each study sites by preparing a cavity of 10 cm diameter and 30 cm depth into the soil. Three hundred grams of soil was collected using stainless steel scoop subsequent to removal of leaves, grass and large external objects. The sample was stored in plastic bag and labeled as follows: sample type (stratified sample), identification tag (location name, field ID, sample number, date, time, and signature) and GPS location. Four different samples were collected from each TE.

Soil Physiochemical parameter analysis: All procedures are explained briefly in table 1.

Table 1: Physical and Chemical Parameters and their Standard Methods Used During Laboratory Analysis

Physical Parameters	Method Used
Soil Texture	Sieve method (ASTM) Air dried homogenized soil sample (100 gm); Sieve sizes 2mm, 1mm, 500 µm, 250 µm, 125 µm, 63 µm and 53 µm; 20 min mechanical shaking; Weight proportion of particle expressed on soil textural triangle
Soil moisture	Oven dry method Fresh homogenized soil sample (100gm); oven dried at 100 °C for 2 hours; cooled in desiccators and difference of weight calculated

Soil pH	10gm soil mixed in 50ml distilled water; allowed to stand for 30 min; pH of supernatant measure with pH meter
Electrical conductivity	10gm soil mixed in 50ml distilled water; allowed to stand for 60 min; electrical conductivity of supernatant measure with conductivity meter
Organic matter	0.5 gm of air dried homogenized soil; 1N potassium dichromate ($K_2Cr_2O_7$), 20ml conc. Sulphuric acid (H_2SO_4); Incubation (30 min at room temperature); 200 ml of deionized water, 10 ml orthophosphoric acid, 5 drops of diphenylamine indicator; Titration with 0.2 M ferrous ammonium sulphate (FAS: $Fe(NH_4)_2(SO_4)_2.6H_2O$)
Nitrogen	Kjeldahl method 20ml of distilled water, 100 ml of 0.32% potassium permanganate ($KMnO_4$), and 100 ml of 2.5% sodium hydroxide (NaOH) & anti-bumping substance in Kjeldahl flask; Ammonia gas collected in conical flask with 20ml boric acid indicator; Lower open end of the condenser of Kjeldahl assembly was dipped into the conical flask; In approximately 30 minutes, 100 ml of distillate was collected and titrated with 0.02N sulphuric acid (H_2SO_4)
Phosphous	2.5 gm of air dried homogenized soil sample, 25 ml of 0.03N ammonium fluoride (NH_4F) and 0.025N hydrochloric acid (HCl); 30 min mechanical shaking. Solution filtered through Whatman filter no 42; 10 ml filtrate transferred to a 50 ml volumetric flask; 2 ml of ammonium molybdate ($(NH_4)_6Mo_7O_24.H_2O$) and 2 ml of stannous chloride reagents and distilled water (to balance to 50ml); shaken gently. Absorbance of the solution read at 660 nm with 0 optical density for blank on a colorimeter; Optical density reading was used to determine the corresponding ppm on a standard curve.
Potassium	4 gm of air dried homogenized soil sample, 20 ml of 1N ammonium acetate (pH 7); mechanical shaking 15 min; The solution was filtered through Whatman filter no 42 and aspirated into the flame. Top, zero and intermediate standard frequency were checked. Calibration curve was used to determine the corresponding ppm

Secondary Data Collection (temperature, rainfall and productivity data): Monthly average rainfall and maximum/minimum temperature data recorded in the metrology department in and/or nearest station from each of the estates, over a period of last 30 years, was obtained from department of Hydrology and Meteorology (DHM), Nagpokhari, Kathmandu, Nepal. In addition daily maximum and minimum temperature was recorded for a period of one month and total rainfall was measured during the same period from all the study TEs. Production was recorded by weighing the total green tea leaf harvested by the field labor on a daily basis over a period of one month. Total daily harvest was calculated by summation of harvest by each labor from respective TE.

Results and Discussion

The study areas ranged from an altitude of 59 mtrs to 1580 mtrs from sea level and the location is as shown in table 2.

Table 2: Location of the Study Area

Sample No	District 1 : Jhapa		District 1 : Jhapa		District 2 : Ilam		District 2 : Ilam	
	Estate 1 : Kechana TE		Estate 2 : Mishra TE		Estate 1 : Ilam TE		Estate 2 : Kanyam TE	
	elevation	GPS address	elevation	GPS address	elevation	GPS address	elevation	GPS address
S1	61 m	26°24.624' N 87°59.474' E	152 m	26°41.629' N 88°00.739' E	1256 m	26°54.687' N 87°55.488' E	1580 m	26°52.313' N 88°04.742' E
S2	60 m	26°24.428' N 87°59.744' E	149 m	26°41.622' N 88°00.820' E	1217 m	26°54.635' N 87°55.406' E	1568 m	26°52.190' N 88°04.703' E
S3	61 m	26°24.663' N 87°59.750' E	148 m	26°41.548' N 88°00.802' E	1199 m	26°54.643' N 87°55.387' E	1539 m	26°52.180' N 88°04.650' E
S4	59 m	26°24.521' N 87°59.500' E	148 m	26°41.577' N 88°00.751' E	1207 m	26°54.604' N 87°55.330' E	1529 m	26°52.255' N 88°04.657' E

S=GPS location of different areas from where soil sample were taken from each site Soil Physiochemical properties: Texture of the soil was similar in all the study sites. Result of the analysis showed silt-loamy soil in all the samples. Soil Moisture ranged between 9.42 and 29.36 %. Soil samples from Kechana TE contained the least amount of moisture whereas that from Kanyam TE had the highest moisture content. Soil pH was found to vary from 5.5 to 7.3. Majority of the samples showed similar pH, except for Mishra TE slightly higher than the other. Soil electrical conductivity analysis showed that soil obtained from Ilam TE was least conductive whereas that from Kechana TE was most conductive, with a range of 13.0µosmole/cm–28.4µosmole/cm. Soil sample contained 0.41% to 2.8 % of organic matter. In an average, organic matter content was least and most in Kechana TE and ILAM TEs respectively. Highest amount of carbon was seen in soil obtained from Ilam TE whereas the lowest in Kechana TE with a range of 0.23% to 1.63%; explained in figure no. 2 below.

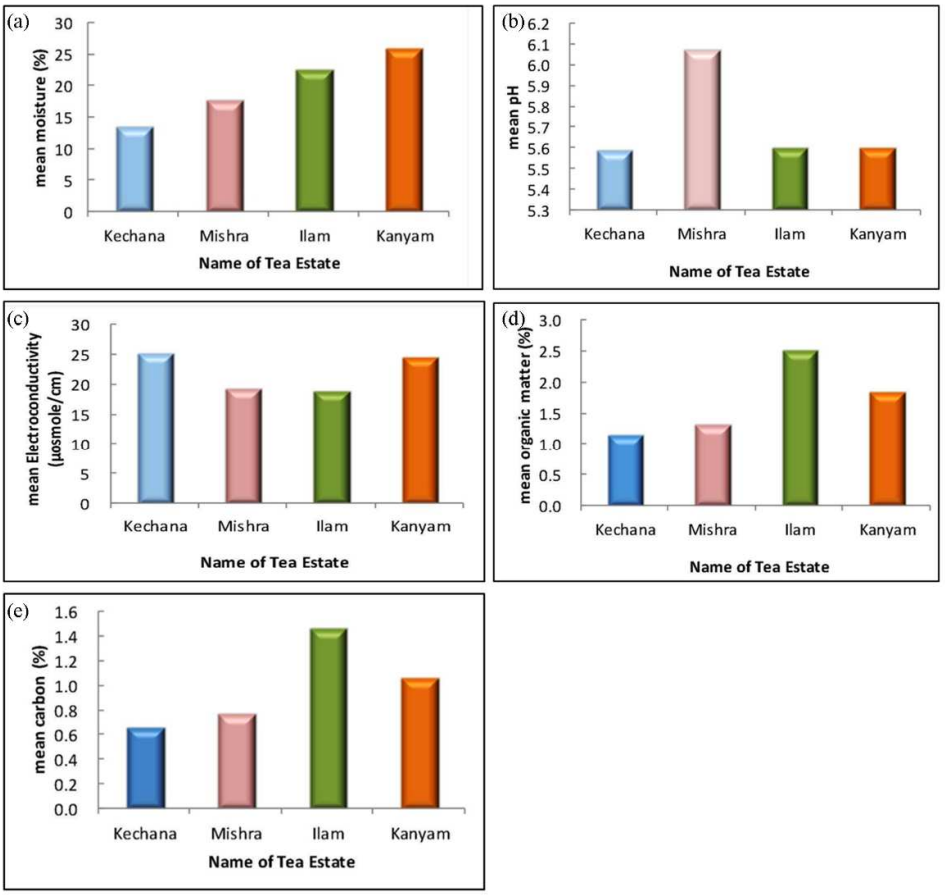

Fig. 2. Physiochemical Parameters of the Soil Samples (a) Mean Moisture, (b) Mean pH, (c) Mean Electrical Conductivity, (d) Mean Organic Matter, (e) Mean Carbon Stock

Soil Nutrient (NPK) Analysis: Analysis of the nutrient status showed that the soil sample from Mishra TE and Ilam TE had the highest amount of total Nitrogen and available Phosphorus/Potassium respectively. None of the soil sample showed deficient of nutrient status. Table 3 shows the status of nutrient in the soil samples collected from the study sIlam TEs.

Table 3: Status of the Nutrients in the Soil Sample Obtained from Different Study Ilam TEs

Name of Tea Estates	Total Nitrogen (%)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)
Kechana TE	0.21 (H)	30.6 (M)	113.2 (M)
MTE	1.14 (VH)	38.9 (M)	148.85 (M)
ILAM TE	0.34 (H)	88.85 (H)	355.1 (H)
Kanyam TE	0.28 (H)	45 (M)	223.6 (M)

Based upon classification given by NARC, 2015, Kathmandu
M=Medium; H=High; VH=Very High

Soil Quality Rating (SQR): The soil quality ranking of all the samples was analyzed based upon the assigned range of values for commonly used soil parameters in Nepal as described by Bajracharya et. al., 2007. Mean of 4 samples from each TE was calculated. Kechana TE had comparatively higher SQR score among the four; given in table 4 below.

Table 4: Soil Quality Rating (SQR)

Name of Tea Estate	SQR Score
Kechana	0.26
Mishra	0.24
Ilam	0.17
Kanyam	0.23

Table 5: Soil Quality Rating Guide Based on Assigned Range of Values for Commonly Used Soil Parameters in Nepal, 2007

Parameter	Ranking Value				
	0.2	0.4	0.6	0.8	1
Soil Texture Class	C, S	CL, SC, SiC	Si, LS	L, SiL, SL	SiCL, SCL
Soil pH	≤ 4, > 8.5	4.1 to 4.9	5 to 5.9	6 to 6.4; 7.6 to 8.5	6.5 to 7.5
Soil OM (%)	≤ 0.5	0.6 to 1.5	1.6 to 2.9	2.9 to 5.7	>5.8
Fertility (N+P+K)	Low	Mod. Low	Moderate	Mod. High	High
SQR	V. Poor	Poor	Fair	Good	Best

C=clay, S=sand, CL=clay loam, SC=sandy clay, SiC=silty clay, Si=silt, LS=loamy sand, L=loam, SiL=silt loam, SL=sandy loam, SiCL=silty clay loam, SCL=sandy clay loam, SQR=Soil Quality Rating

SQR = [(a*RSTC) + (b*RpH) + (c*ROM) + (d*RNPK)]

a=0.2 b=0.1 c=-0.4 d=0.3

Temperature Rainfall and Productivity Analysis: Daily analysis of temperature over a month during the study period shows that maximum and minimum temperatures recorded in the study areas during the month are 32.0 °C (Kechana TE) and 12.5 °C (Kanyam TE) respectively. Total rainfall recorded in the study areas during the month are 25.04 mm (Kechana TE), 246.5 mm (Mishra TE), 285.3 mm (Ilam TE) and 498.6 mm (Kanyam TE). Total green tea leaf production recorded in the study areas during the month are 472148 Kg (Kechana TE), 31442 Kg (Mishra TE), 59826 Kg (Ilam TE) and 57221 Kg (Kanyam TE) of green tea leaf.

Table. 6: Temperature, Rainfall and Tea Produced in Different Study Sites During Ashwin 2073.

Name of Tea Estates	Temperature (ºC)		Total Rainfall (mm)	Total Production (kg)
	Max	Min		
Kechana	32.0	18.5	25.04	472148
Mishra	31.0	17.0	246.50	31442
Ilam	27.2	17.0	285.30	59826
Kanyam	25.8	12.5	498.60	57221

Secondary Data Analysis:

Temperature Data: Result of analysis showed an increase in mean annual maximum temperature in both the districts, whereas increase in mean annual minimum temperature in Jhapa in contrary to decrease in mean annual minimum temperature in Ilam district.

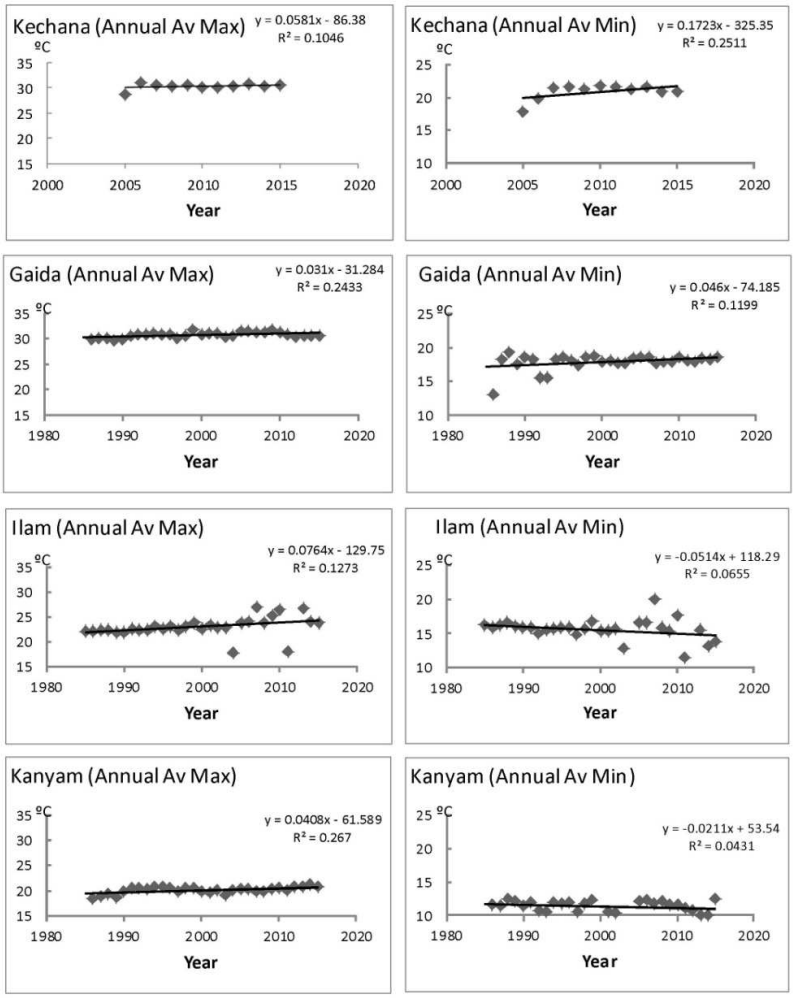

Fig 3: Maximum and minimum trend of temperature in different study sites

Rainfall Data: Result of analysis showed a decline in total yearly rainfall in both the district over a period of 30 years; given in the figure 4 below.

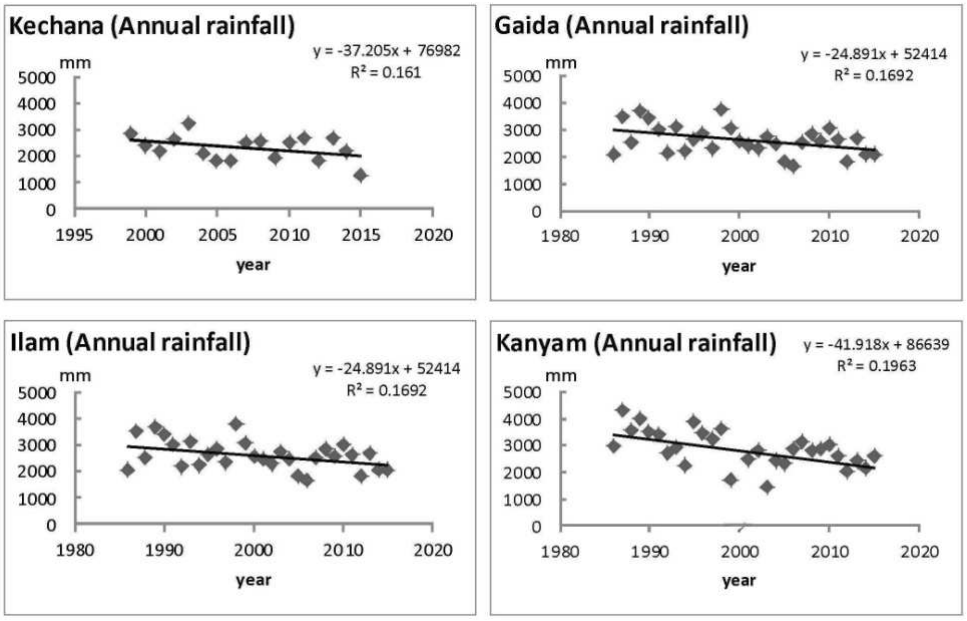

Fig 4: Rainfall Trend in Different Study Sites

Agricultural zones in Nepal consist of plains, hills, mid hills, high hills and mountains. Changes in agro-zones lead to the change in cropping pattern of the zone. Climatic parameters have potential impact to change the ecological distribution of agricultural crops. If shifting of climatic zones occurred rapidly due to climate change, impact on plant species might be severe. In this research, climatic factors, and the physiochemical parameters of the soil that may vary according to different locations are studied. The study sites ranged from 59 mtrs to 1580 mtrs in altitude and cover plain and hill areas among the agricultural zones of Nepal. Physicochemical properties of soil samples from different study sites differed to various extent. There was a gradual increase in soil moisture from Kechana to Kanyam, and was in consistent with the increase in altitude. The reason seems to be due to higher variation in altitude as we move into different agricultural zones. Soil texture was found to be similar from all the study sites. All the samples were classified as silt-loamy soil. pH of the soil of study area ranged from 5.5–7.3 and were close to normal. pH was highest in the sample obtained from Mishra TE. Soil sample from the study area contained 0.41% to 2.8% of organic matter and 0.23 and 1.63% soil organic carbon content. Earlier study has shown that the mean organic carbon in forest land top soil ranged from 0.1% to 4% and cultivation tends to reduce organic carbon content of the soil (Sitaula et al., 2004). The result of soil organic carbon content in this study was consistent with the earlier reports. In general, decreasing soil organic matter was observed with increasing pH. There was a clear inverse relationship between the soil organic matter and pH in the samples obtained from different study sites. Furthermore, there was decreasing organic matter content in the soil sample as the altitude of the study sites decreased. Increase in temperature may activate the microbial population in the soil, thereby, leading to reduction in the level of soil organic carbon, soil micronutrients and enhance decomposition (Malla, 2003). Nutrient analysis showed adequate amount of Nitrogen, Phosphorus and Potassium in the range of medium to high based upon the classification given by NARC, Kathmandu, Nepal, and was in consistent to the standard amount of

nutrition needed for agricultural land. Alteration in evapo-transpiration due to variability in climate and weather is major reason for change in moisture availability in the soil. All the factors govern the physiological active period and crop production. Various physical and chemical parameters of the soil were analyzed and soil quality rating (SQR) was performed based upon 4 variables namely texture, pH, organic matter and fertility. The ranking values for these parameters were based upon the assigned range of values for commonly used soil parameters in Nepal (Bajracharya et al., 2007). The result suggested that SQR value was highest and lowest for the samples from Kechana TE and Ilam TE respectively. Interestingly, tea production was highest in the Kechana TE suggesting that quality of soil has a great impact upon the growth and development of crop which ultimately determines the amount of production. However, the least amount of SQR in Ilam TE does not properly coincide with the comparative amount of tea production. The reason behind it may be the influence of other climatic parameters which were not considered in SQR analysis.

Analysis of the temperature over a period of 30 years showed an increase in mean annual maximum temperature in both the districts, whereas increase in mean annual minimum temperature in Jhapa in contrary to decrease in mean annual minimum temperature in Ilam district. Record of rainfall from the metrological department of the different study sites showed a decrease in annual rainfall in all the study sites over a period of 30 years. Past record showed that Kanyam TE received the highest amount of rainfall in the last 30 years which was consistent with the highest moisture content as observed in the soil samples from the same TE. A trend of decrease in rainfall and increase in mean annual maximum temperature could clearly justify the climate change in this region. Tea production is highly affected by climate change; however, its effect in tea production over a period could not be justified. The reason may be the impact of ambient temperature as explained by Wijeratne et. al. (Wijeratne et. al., 2007) in addition to the temperature ranging 12.5ºC to 30 ºC being the best for tea cultivation. Higher production was found in Kechana TE which had the highest temperature among the four estates, and in the range of 26.6ºC to 32ºC. The rising temperature and emission of CO_2 to some extent is beneficial for production of major crops by enhancing photosynthetic processes, water use efficiency, shortening physiological period and soil microbial activities. Combined effect of favorable environment and high SQR value which account for the highest amount of production in Kechana TE may effectively demonstrate the role of climatic variables on tea production. The lower yield in Mishra TE despite being higher temperature (25.6ºC to 3ºC) may owe to the physiochemical properties of soil with higher pH, lower organic matter, and lower amount of Phosphorus and Potassium as compared to other estates.

Conclusion

This study was done in the four different tea estates of Jhapa and Ilam district of southeastern part of Nepal. Current study was done to assess the impact of climatic factors upon tea production. The study was able to analyze important physicochemical parameters in the agricultural soil of these regions. We are able to demonstrate the role of various climatic factors and soil physicochemical parameters involved in tea production.

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Study on Water Sanitation and Hygiene Status in Government Schools and Impact due to Earthquake (An Assessment of Drinking Water Quality and Sanitation Status)

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Abstract

Clean, accessible water and adequate sanitation for everyone is important for better livelihood. Despite of sufficient fresh water, millions of people lose their life from disease associated with inadequate water supply and poor status of sanitation and hygiene, children to be mostly affected. According to UN, each day, 1,000 children die due to preventable water and sanitation related diarrhoeal diseases. Beside health, poor water quality and inadequate sanitation might negatively affect educational opportunity of a child. A universal and equitable access to safe and affordable drinking water and adequate sanitation and hygiene can be gained if the Sustainable Development Goals (SDGs) related to water and sanitation are achieved. Providing schools with safe drinking water and adequate sanitation and hygiene facility would help to complement this goal. Water Sanitation and Hygiene in school provides access to primary education, reduces child mortality, improves water and sanitation and promotes gender equality.

The study was conducted in 25 government schools of LSMC in December 2015. This study presents the WASH facility and their status in the schools. Mixed qualitative and quantitative methods were used in the study. Field visit was conducted in every school followed by questionnaire survey and interview. Water samples from each school were collected tested in laboratory.

The data shows that the building blocks of 60% schools and compound wall and gate of 12% schools were affected by earthquake. Further, water purification system in 8% schools and toilets in 24% schools were affected. 80% schools have drinking water facility and 88% schools have purification system. Drinking water of 88% schools were contaminated with coliforms. Based on analysis, the ratio of children per toilet is 1:55. 84% schools have hand washing stations with soap. 76% schools have the facility of Menstrual Hygiene in schools.

Keywords : *Water, Sanitation, Hygiene, Earthquake, Schools, LSMC, SDG*

Introduction

Water Sanitation and Hygiene (WASH) is a group of interrelated public health issues that are of particular interest to international development programs. Access to safe water, adequate sanitation, and proper hygiene can reduce illness and death. Epidemics such as outbreak of cholera are often associated with bacteriological pollution of water. The number of affected people can be reduced using purification method and good sanitation habit. Nepal earthquake 2015 also highly affected the WASH facilities. Providing schools with adequate access to water and sanitation facilities and supporting the implementation of hygiene promotion programs, including a disaster risk preparedness plan, can play significant roles for a sustainable recovery phase (Giardina, Prandini, & Sorlini, 2013). Schools need to demonstrate them as a role model place for sanitation so that it can influence the nearby communities for better sanitation and hygiene (SACOSAN-V, 2013). Water

quality parameters help to ensure the safety before it is used for drinking purpose. In this study, eight parameters are selected for the assessment of drinking water quality in schools. The sanitation and hygiene status in the school is studied. WASH education is important in schools.

Materials and Methods

Study Area

The study was carried in Lalitpur Sub-Metropolitan City (LSMC) of Lalitpur. It consists of 22 municipal wards with 54,581 households with 2.20.802 people (CBS, 2011).

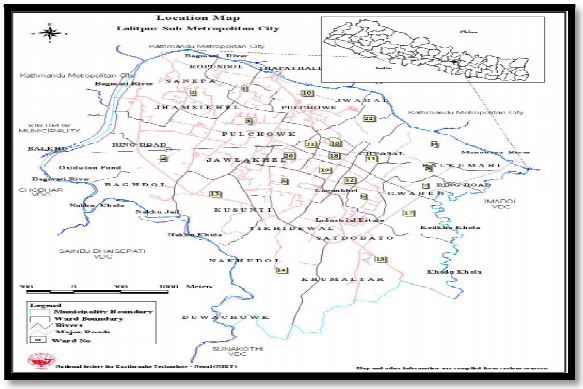


Figure 1: Map of Lalitpur Sub-Metropolitan City, Where the Study was Carried Out

Primary Data Collection

Water Sample Collection: Drinking water from the sample schools were taken for lab analysis in December, 2015. The samples are collected between 8am to 3pm. Physio-chemical analysis of drinking water was based on "General Experiments on Physio Chemical and Parameters of water" by Armila Raj Bhandari, 1st Edition.

Method of Water Quality Analysis

S. N.	Parameters	Unit	Methods	WHO GV	Nepali Standard	Sites
A	**Physical**					
1.	Temperature	^{0}C	Field thermometer			At the site
2.	pH		Field pH meter	6.5-8.5	6.5-8.5	At the site
3.	Conductivity	µg/cm	Conductivity meter (Instrumental)	-	1500	Laboratory
B	**Chemical**					
1.	Chloride	mg/l	Trimetric	250	250	Laboratory
2.	Total Hardness	mg/l	Trimetric	500	500	Laboratory
3.	Total Iron	mg/l	Phenate (Spectrophotometer)	0.3	0.3 (3)	Laboratory
4.	Total Ammonia	mg/l	Phenanthroline (Spectrophotometer)	1.5	1.5	Laboratory
C	**Microbiological**					
1.	Total Coliforms		Membrane Filter Method (MFM)	0	0 (in 95% sample)	Laboratory

() values in parenthesis refer to the acceptable values only in the absence of alternative

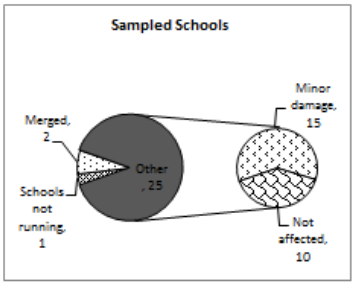
Questionnaire Survey: A set of structured questionnaires was prepared which includes WASH scenario of the school.

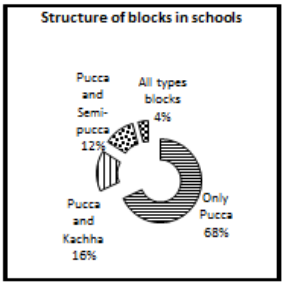
Secondary Data Collection

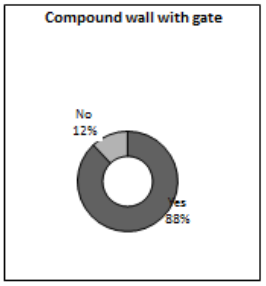
The data disaster events and its impact on WASH status were collected by intensive literature review through published and web-based online systems.

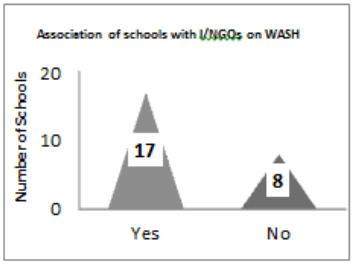
Results and Discussion

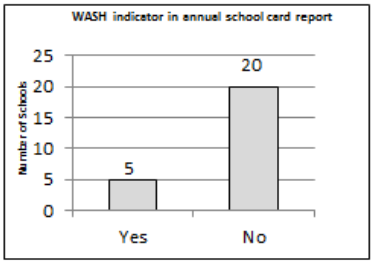
Section 1: School Detail









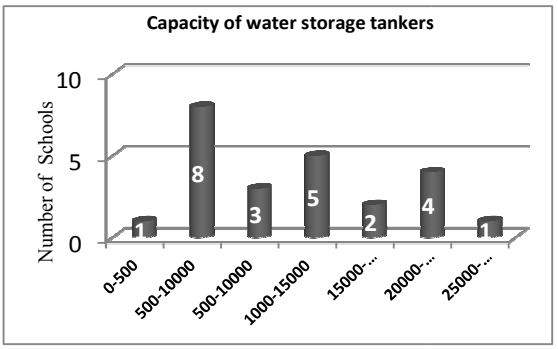


Section 2: Student Detail

According to the key informant questionnaire interview, 54% students in the sampled schools are girls and 46% are boys. The attendance ranged from 75% - 90%. The dropout ranges between 5% to 25% of the total students. Based on key informant interview, 28% of the schools have students with disabilities. 80% schools provided basic facilities differently- able students. Basic facilities like ramps, proper toilets have significant impact on dropout of differently- able students.

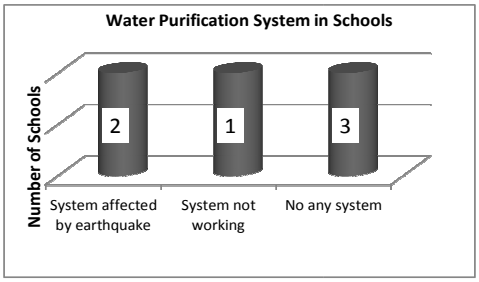
Section 3: Status in Water Supply in Schools

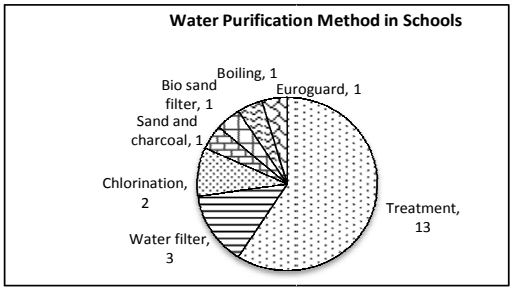
S.N.	Source of water	Number of schools
1	Tube well/Bore well	14
2	Public Tap	10
3	Private Tanker	5
4	Rainwater	5
5	Stone spouts	3
6	Others	1



In 80% schools water source is working properly. 16% schools have water supply source but these source is not functioning whereas 4% schools does not have their own water supply source. These schools are facing huge difficulty in water source management which has challenged the overall WASH in school. As per the Key Informant Questionnaire Interview, 80% water of school is clean while 20% does not have clean water. 80% schools have drinking water facility which means the water used for drinking water is either treated or filtered. 17 out of 25 schools are able to provide water to meet the demands like water for drinking purpose and sufficient to clean the toilets in schools.

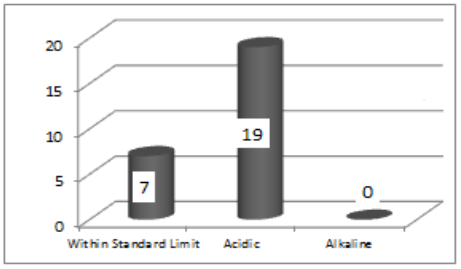
Water Purification in Schools

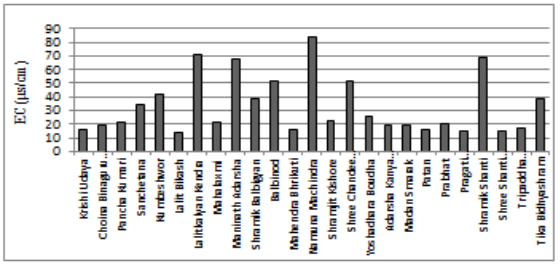




Water Quality of Government Schools

Physical Parameters: The physical parameter tested in this study was temperature, pH and electrical conductivity. The temperature in the various schools was found between 15℃ to 18℃. About 20% samples have least temperature which is 15°C. 36% samples have temperature of 16°C and 28% have17°C. 16% samples have highest temperature which is 18°C. The difference might be because of testing time of sample. NDWQS has no guideline for temperature hence we can say that all samples are in acceptable limits.





Chemical Parameters: Four chemical parameters were tested in the study. It includes: chloride, total hardness (calcium and magnesium), iron and ammonia.

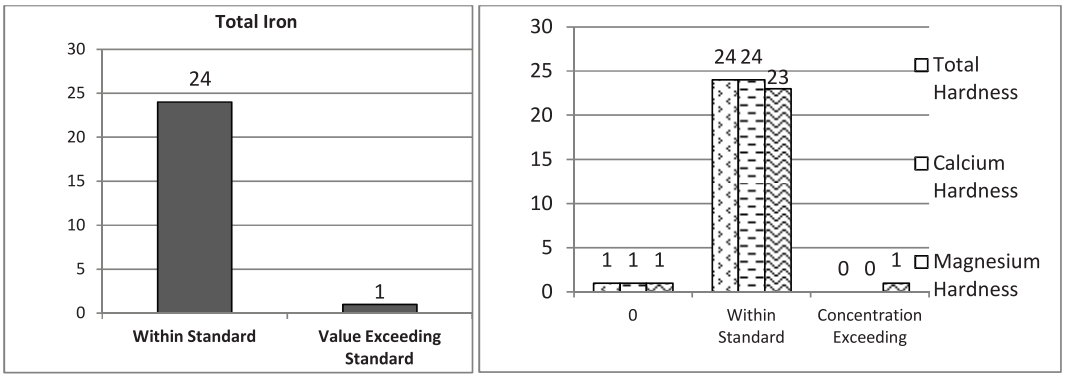
Chloride Concentration in Drinking Water Samples

SN	Chloride concentration (mg/l)	Number of schools
1	0-50	13
2	50-100	6
3	100-150	4
4	150-200	1
5	Above 200	1

Ammonia Concentration in Drinking Water Samples

SN	Ammonia Concentration	Number of Schools
1	0-0.01	20
2	1.01-0.02	0
3	0.02-0.03	4
4	0.03-0.04	0
5	0.04-0.05	0
6	0.05-0.06	1

Numbers of School



Microbiological Parameter

Presence of Total Coliform in Drinking Water		
S.N.	**Value**	**Number of School (in %)**
1	Below 4	12%
2	Above 4	44%
3	Too Many To Count (TMTC)	44%

Section 4: Toilet Facilities in Schools

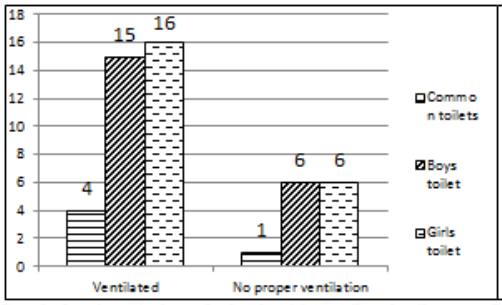
Where Does the Toilet Waste Go	
	Number of Schools (in %)
Underground Drainage	90%
Septic tank	5%
Soak pit	5%

Total Number of Toilet Facilities	
Common	9
Girls	77
Boys	72
Staff	40

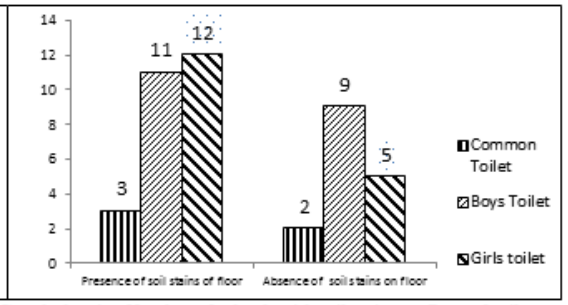
According to the key informant questionnaire interview, there are specific needs of additional toilet facilities. An additional need of 24 urinals and 41 toilets are needed in LSMC. However, 15 schools have enough space for construction of toilets (>=16'x16'). Among these schools, only 6 schools can manage water for construction purpose while only 7 schools can manage electricity for construction in case of power cut-off.

Impact of Earthquake in the Toilets			
Status	**Status**	**Status**	**Status**
Rebuild	Rebuild	Rebuild	Rebuild
Repair	Repair	Repair	Repair
Nothing	Nothing	Nothing	Nothing

Boys' toilet of 19 schools, girls' toilet of 19 schools and common toilet of 4 schools are in good condition (walls are not broken or peeling, floor is intact, walls are not leaking, no water logging). Most of toilets in schools lacked dustbins. Common toilets in 2 schools, boy's toilet in 5 schools and girl's toilet in 11 schools had dustbins. Presence of dustbins in toilets determines the cleanliness of the toilets. Common toilets in 1 school, boy's toilet in 7 schools and girl's toilet in 7 schools had visible faecal materials. It shows that the schools lacked sanitation. A clean hand washing station with a sanitizer/ soap is important in order to protect the student from pathogens. 84% schools are able to manage these facilities for student and staffs in school which maintained by cleaning staff regularly and is properly working.



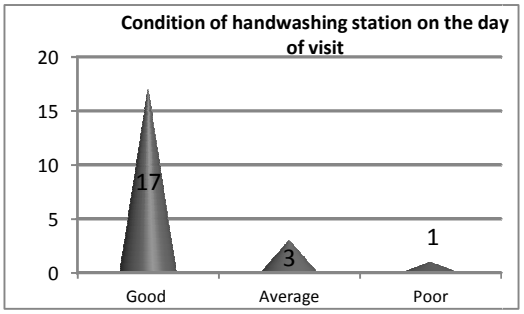
Graph showing number of schools with ventilated toilets



Graph showing Number of schools with soil stains on floor of toilets

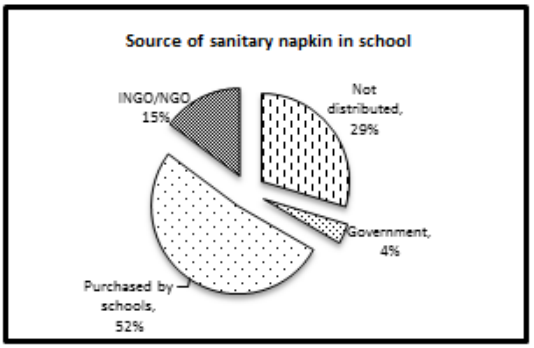
Section 5: Hand-Washing Facilities in Schools

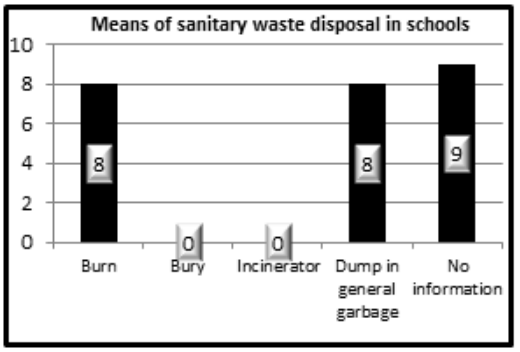
According to the key informant questionnaire interview, additional needs of 15 hand-washing stations are needed in LSMC.



Section 6: Menstrual Hygiene Facilities in Schools

On the basis of survey, it was found that 76% schools have menstrual hygiene facilities.





Section 7: Solid-Waste Facilities in Schools

Means of Solid-Waste Disposal in Schools		
S. No.	**Source of Waste Disposal**	**Number of Schools**
1	Collection everyday/week	21
2	Burning	7
3	Compost	1

Questionnaire Survey

Questionnaire survey was done with the people who are directly related to the school. A total of 25 schools participated in this survey. Most of the participants believe that WASH is an important component that needs to be considered in school. In schools, 20% of the students never carries their water bottles and totally depends upon the drinking waters from the school. Therefore it is essential to ensure that the drinking water provided to the students are safe and under drinking water quality standard.

Lalitpur District consists of a total of 456 schools including 190 public and of 273 private schools. LSMC consists of 28 government and 156 private schools. More than 12000 students study in the schools (Office D. E., 2071). Nepal earthquake 2015 also highly affected the WASH facilities. According to Government reports, the destruction of water system across 14 districts left 1.1 million people without access to protected water source. Significant damage to latrines has also left 1.1 million people without safe, hygienic and dignified access to sanitation facilities. In addition, among 190 schools, 157 were fully damaged due to earthquake. In schools, where many students study in the same environment with common source of water supply, the vulnerability towards diseases is high which can lead in high absentees. The study was carried out in the year 2015/16. As per the data provided by District Education Office there were 28 government schools in the year 2071 B. S. in Lalitpur Sub- Metropolitan City. Nepal Earthquake 2015 left only 25 schools to be totally functional. These schools were taken for the study.

Based on the survey, 60% schools were affected due to earthquake while compound walls of 12% schools were affected. The source of water for 14 schools is well. Public tap serves 10 schools, 3 schools uses water from nearby stone spout whereas 5 schools have to depend upon private tankers to fulfill the water demand. 5 schools have been using rain water to meet their water demand. In 8% schools, water purification filters are affected by earthquake. Vulnerability is seen in 32% schools where either water is not purified before drinking water or water purification systems have been damaged due to earthquake. 80% schools have facility of drinking water but only drinking water

in 12% schools is free from pathogens. The result may be due to inefficiency or absence of water purification system or lack of adequate sanitation in schools.

The average number of students using per toilet is 55. The sanitation standard for community schools in Nepal is 1 toilet for 50 students (Aid, 2015). The result shows additional need of toilet facilities. 76% schools had no damage on their toilets due to earthquake. 8% schools need to repair their toilets while 12% school needs to reconstruct their toilets.

On the basis of study, it was found that 84% schools have the facility of hand washing facilities which are differently-abled friendly. 11% schools have an additional need of hand washing stations The means of sanitary waste disposal in 32% schools is burning, 32% schools dump the waste in general garbage while in 36% schools, students themselves mange the disposal of the waste. In order to reduce girl child dropout in school, it is important to have menstrual hygiene facility at schools so that they would attend schools during time of menstruation.

Conclusion

This paper reviews the WASH status in the government schools on LSMC post Nepal earthquake 2015. As children spend most of their time in schools, integrated WASH facility in schools is vital. The study was carried out after the occurrence of earthquake on 25 April, 2015 regarding WASH facility at government schools of LSMC. The study shows most of the structural infrastructures being affected; increment in the risk of water borne diseases as water purification system being damaged. For the betterment of WASH facility in school, there should be further intervention in the schools regarding the structural and impact on WASH sector.

Seasonal variance can highly impact the occurrence of water borne disease thus proper seasonal intervention need to be carried out timely. WASH status in the schools needs to be monitored timely. Vessel that store drinking water should be cleaned in appropriate interval of time to preserve the filtered or treated water from getting contaminated as coliforms were detected in water which were purified.

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Instruction for the Submission of Articles to Journal of Environment Sciences (JoEnvSc)

Journal of Environment Sciences shall publish original research and review articles written in English language from Nepal and other interested scientist or experts across the world in the field of environmental science. Authors interested to publish their articles in Journal of Environment Sciences are requested to submit the articles written on A4 size (8.5 x11 inch), single space, Times New Roman, Font Size 12 in MS word with electronic copy in the prescribed address. Each manuscript submitted to the editorial board will be registered and reviewed. Manuscript that need improvements as suggested by reviewers and editorial committee will be returned to the respective author/s for correction and incorporation of the comments made. The corrected version of the manuscript with digital copy should be submitted promptly to the Department of Environment. The editorial Board can also make relevant edition of the manuscript.

Following are the basis for the review of articles:

- . Importance of the research problem and statement
- . Originality of the work
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- . Clarity of Presentation and organizations of the article
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All options about the papers published in the journal reflect the views of author/s and are not necessarily the views of DoEnv and its editorial board. The editorial board reserves the right to reject or accept the article/s for publication in the journal.

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The title should be informative and unique started with key word but concise and clear and should reflect the content of the paper. It should be in title case less than 15 words. Abbreviated and shortcut word/s should not be used in the title. Below the title, name/s and the address/es with indication by superscript figure of author/s should be given. Indicate current designation address with the email as footnote on the first page of the paper. The initials of the middle names and full form of first and family name/s, should be wiritten and indicate the corresponding author using superscript figure

Abstract

A concise and factual abstract is required (maximum 150 words). The abstract should state briefly the rational and purpose of the research, the principal results and major conclusions. Avoid using references and citations in this part, also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

Keywords

Immediately after the abstract provide a maximum of 5 keywords avoiding general and plural terms and multiple concepts. Write most frequently used words but not from the research title.

Abbreviations

Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Ensure consistency of abbreviations throughout the article. Considering alphabetic order.

Introduction

It should give appropriate background and explain the things that are proposed. It should include short introduction to justify the research and relevant reviews and state the objectives clearly (not more than 150 words).

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This should include description of experimental materials, procedures and statistical design used as well as method/s to analyze results. Methods should be described in detail; if methods are developed by earlier researcher/s, only reference may be cited. However we prefer detail methodology. Report the location, geo-references (altitude, latitude and longitude etc. and date of experiment conducted. Write scientific name with authority, common and local name of organism.

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Results and discussion will be either under separate or under combined headings (around 500 words. Table and figures should be illustrate-d before the text. Results should be presented in a concise manner avoiding data that are already given in tables. Discussion part should not repeat the results but should explain and interpret the data based on the published relevant studies. Analysis, compare and contradiction needs to be done. Insert graph/s and table/s wherever necessary and number them sequentially within each paper (article). The conclusion, recommendation and possible impact (if any) should be based on the supporting data in focused to research title and considered objectives.

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All units and measures should be in the metric system or in the International System Units (SI) and should be abbreviated for technical values. Currency exchange rates should be in US$ along with the local currency for the appropriate date for any prices cited. For statistical analysis use analysis of variance (ANOVA) to separate means. Authors are encouraged to use valid statistical tools/software to analyze the data.

Acknowledgements

Acknowledge the person/s and or institution/s, if necessary, who actually help to achieve the objectives of the research.

References

Only the papers closely related to the authors' work should be referred in the text by author's family name and the year of publication and be cited in an alphabetical order. The style of the reference citation should be as below:

Journal:

- *Upadhya TP, Sankhayan PL and Sloberg B. 2005. A review of carbon sequestration dynamics in the Himalayan region as a function of land-use change and forest/soil degradation with special reference to Nepal. Agriculture, Ecosystem & Environment 105:449-465.*

- *Jazen HH. 2004. Carbon Cycling in earth system- a soil science perspective. Agriculture, Ecosystem & Environment 104:399-417.*

Book:

- *Miller Jr. GT and Spoolman SE. 2012. Living in the environment. 17th ed.Thompson Steele, Inc., Canada. 446pp.*
- *Kormondy, JE. 2005. Concepts of Ecology. Prentice Hall of India, New Delhi.*

Contribution to Book/ Proceedings:

- *Karki, BS and Baskota, K.2006. Constraints Faced by Community Managed Forests in Qualifying Under the Kyoto Protocol. In: Conservation Biology in Asia (Eds. McNeely. JA, McCarthy TM, Smith A, Whittaker LO and Wikarmanayake ED), Society for conservation Biology Asia Section & Resource Himalaya Foundation, Nepal. Pp.401-412.*
- *Soule, ME. 1980. Thresholds for Survival: Maintaining fitness & Evolutionary potential. InL: Conservation Biology: The Science of Scarcity & diversity (Eds.) M.E. Soule & B.A. Wilcox) Sinauer Associates, Sunderland, MA., PP 151-169.*

Annual Report:

- *ACAP, 2013. Conservation Education & Extension Programme (CDP): Improved Sanitation Support. In: Annual Report-2013. National Trust for Nature Conservation, Khumaltar, Lalitpur, Nepal. PP.9-10.*

Web Material:

- *Pretty J. 2003, Genetic modification: Overview of benefits and risks. Accessed in 5 June, 2005 from http://www.essex.ac.uk/ces/. Downloaded on 20th Nov.2009.*

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Each table with a number and proper title heading (caption) should be prepared and stored appropriately. Use simple grid table without complex formatting structures. Use single(*) and double asterisks (**) to indicate statistical significance and have priority in this order to show 5 and 1 % levels of significance, respectively. Do not repeat information in the text presented in charts or graphs. Use 10 font size and bold table heading.

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Do not repeat data both in table and figures. Either use table, or graph or figure. Each Figure and/ or graph with a number and the proper title heading should be drawn or prepared below the graph/ figure.

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The page limit for the main research articles is not more than 10 page typed pages in single space including tables, figures and references.

Format for Review or Features Articles

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Special Attention:

- Use standard abbreviation such as **g** for gram and **cm** for centimeter and so on.
- Use realistic formatting not the artistic formatting without giving any jargons and complexity.
- For table, graph and figures use title case such as **Figure 1. Protected Areas in Nepal.**
- Do not merge unnecessary rows and column in the table to make more complex formatting.
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- Do scientifically whatever you want to do.
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