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About the Journal of Environment Sciences (JoEnvSc)

Department of Environment (DoEnv) is in very early stage of evolution with the mandate of planning, implementing, monitoring and enforcement of environment activities within the framework of Environment Protection Act-1996, Environment Protection Regulation-1997, standard, guidelines and Nepal Government's laws and rules. As we all know, environment does not have any political or physical boundaries, we need the knowledge about the natural science (environmental science, environmental management, environmental engineering, etc.) to fulfill the mandate given to DoEnv. To pile up scattered knowledge, information, technique, technologies that have been generated in different paradigms of environment, DoEnv has brought/published a journal "Journal of Environment Sciences (JoEnvSc)". The journal aims to share environmental information and also establishes relationship among professionals, researchers, academicians and policy makers in broad area. It is the second volume of journal that has got immense effort from environmental academicians, specialist and professionals.

The support that we have obtained from the professionals, experts and academicians, we are full with hope and confident to publish succeeding volumes of JoEnvSc in coming years and also hope for the spontaneous support from you all.

Journal of Environment Sciences- Volume 2

Spatial and Temporal Variation of Water Quality Parameters of Manahara River, Kathmandu.

Kashi Nath Nepal.[1], Bhupendra Sharma[2] , Subodh Sharma[3], Deepak Chhetry[4]

Abstract

River water is a vital water resource that is vulnerable to pollution. Anthropogenic activities and natural processes can easily degrade the quality of surface water and impair its usability. This study tries to observe the pattern of spatial and temporal variation of water quality parameters of Manahara River. The study was carried out between May to October in 2014. All together seven sampling sites were selected. The water samples were analyzed for physico-chemical parameters. Different water quality parameters showed the different pattern of variation along the river stretches and study period. The water quality was found to be deteriorating from upstream to downstream as it enters into the urban area.

Keywords*: manahara river, spatio-temporal variation, water quality.*

Introduction

The quality and quantity of surface water in a river basin is influenced by natural factors such as rainfall, temperature and weathering of rocks, and anthropogenic changes that curtail natural flow of the river, or alter its hydrochemistry (Eneji et al. 2012; Pejman et al. 2009; Raj and Azeez 2009) including hydrological features, climate change, precipitation, agricultural land use, and sewage discharge (Bu et al. 2010; Pejman et al. 2009). Rapid increases of industrialization, urbanization and population in the last few decades have caused a dramatic increase in the demand for river water, as well as significant deteriorations in water quality throughout the world (Ding-jiang et al. 2006). River hydrology is a complex system; water quality in river is always balanced with the pollution discharge, dilution and decontamination. However, over discharge pollutant will result in water quality deterioration. Rivers and streams are highly heterogeneous at spatial as well as temporal scales (Eneji et al. 2012; Raj and Azeez 2009). In addition, due to seasonality and regionality of river water, assessing spatio-temporal variations of river water quality at a watershed level has become an important aspect for the physical and chemical characterization of aquatic environments (Bu et al. 2010).

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Objective

The objective of the study was to determine the spatial (longitudinal) and temporal (monthly) variation of physico-chemical parameters of the river ecosystem.

Methodology

Study Area

The Manahara watershed is located in the east of the Kathmandu valley having the drainage area of 256 sq.km. The Manahara River originates from Manichud Lekh (ridge) at an elevation of 2352 m and having a length of 30 km. (DoS 1995). The drainage basin of the Manahara river contains three subwatersheds namely Upper Manahara, Hanumante and Kodku subwatershed.

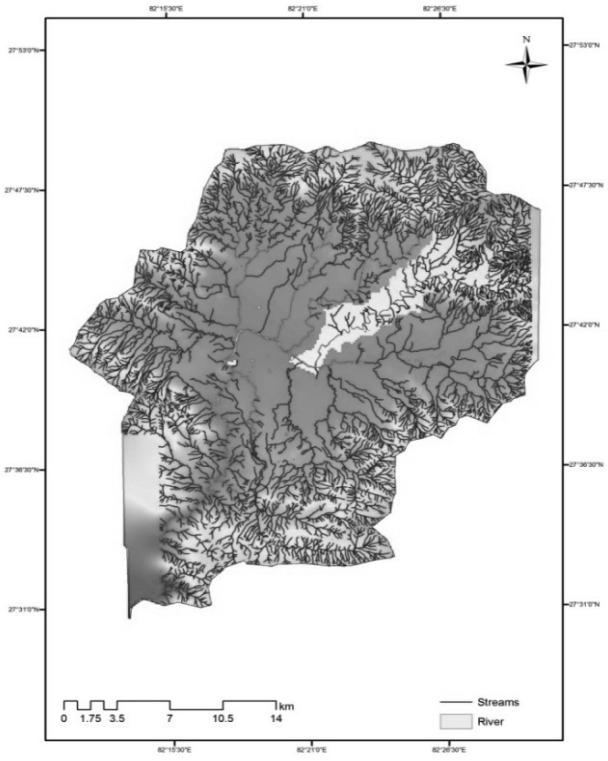

Figure 1: Location map of study area in relation to the Bagmati basin with Kathmandu valley

Sampling Stations

Seven sampling stations on the basis of reconnaissance survey throughout the length of the river were selected. The settlement area, confluence, wastewater discharge, substrate and water uses were considered in selecting the sampling stations. A reference station was selected in the headwaters, whereas other stations were considered immediately downstream of confluence or in the affected area in the immediate vicinity of each significant waste water discharge points (APHA 1995).

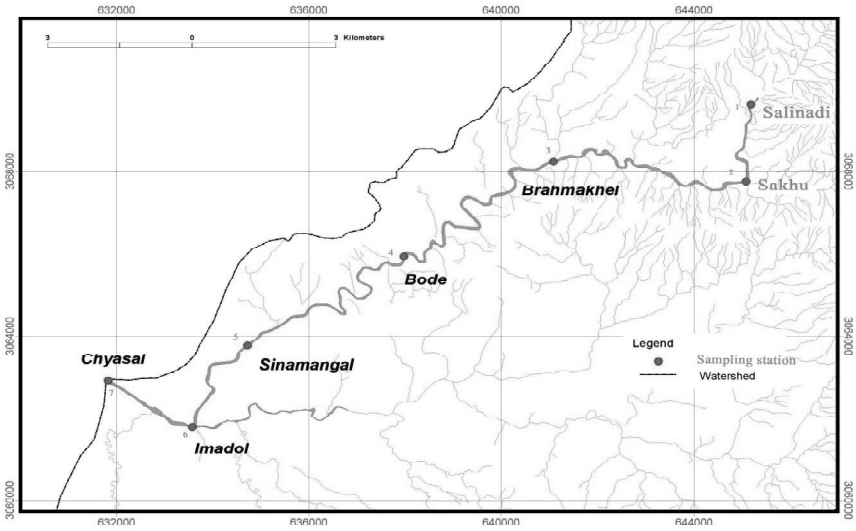

Figure 2: Map showing different sampling station

Station 1: Salinadi/Thulo khola

The sampling station 1 is located at Salinadi/Thulo khola, Sakhu at the headwater region of the Manahara river lying at 27° 44' 14.8" N latitude, 85° 28' 22.0" E longitude and 1500 metres altitude. There is a forest on the left side of the river with a patch of agricultural field in between the river and the forest. However, there is agricultural field on the right side of the river. The substrate consists of mainly cobbles, gravels, sands and boulders. There is a small patch of *Alnus nepalensis* as riparian vegetation at the right bank. There is little human interference in this area. Instream human activities like bathing, washing and fishing were common. Sewerage discharge direct into the river was not noticeable.

Station 2: Sakhu

The sampling station 2 is located at 27° 43' 14.0" N latitude, 85° 28' 17.4" E longitude and 1459.8 metres altidude at Sakhu. The station is just downstream of the confluence of Salinadi and Naldum Khola (Ghatte Khola). Its substrate mainly consists of gravels, cobbles and sands. The right and left flood plain is used for agricultural activities. Instream activities such as bathing, washing, cleansing and fishing as well as irrigation of agricultural land were common. Sewage discharge into the river was absent.

Station 3: Bramhakhel

The sampling station 3 is located at 27° 43' 32.0"N latitude, 85° 25' 51.8" E longitude and 1438.2 metres altitude at Brahmakhel. The station is just downstream of the confluence of Manahara river and Mahadev Khola. Its substrate mainly consists of gravels, cobbles, sands and silt. The right and left flood plain is used for agricultural activities whereas sparse settlement with some houses has been started in right flood plain. Instream activities such as bathing, washing and cleansing as well as irrigation of agricultural land were common. Sewerage discharge into the river was almost absent.

Station 4: Bode/Mulpani

The sampling station 4 is located at 27° 42' 17.1" N latitude, 85° 23' 56.4" E longitude and 1416.9 metres altitude with Bode town at left bank and Mulpani village at right bank. The station is just upstream of the water abstraction zone (dug wells) of Nepal Water Supply Corporation. Its substrate mainly consists of sands, silts and gravels. The right and left flood plain is used for agricultural activities. However, sparse settlement has been started in right and left flood plain. Instream activities such as bathing, washing and cleansing as well as irrigation of agricultural land were common. Sewerage discharge into the river was observed upstream and downstream of the sampling station.

Station 5: Oldsinamangal/ Pepsicola

The sampling station 5 is located at 27° 41' 07.9" N latitude, 85° 21' 59.3" E longitude and 1402.3 metres altitude at Sinamangal (Pepsi Cola). The station is just downstream of the Sinamangal-Sanothimi bridge. Its substrate mainly consists of sands and gravels. The right and left flood plain is used for agricultural activities with thin human settlement. Instream activities such as washing and cleansing, as well as irrigation of agricultural land were common. Discharge of sewage and industrial effluents into the river was observed in upstream of the sampling station.

Station 6: Imadol

The sampling station 6 is located at 27° 40' 03.8" N latitude, 85° 21' 15.2" E longitude and 1380.4 metres altitude at Imadol. The station is just downstream of the confluence of Manahara river and Hanumante river. Its substrate mainly consists of sands, silts, gravels and a patch of black clay as the river bottom. A patch of right flood plain is used for agricultural activities whereas the left flood plain has dense settlement just near to the river bank. Instream activities such as washing and cleansing were occasionally observed. Sewage discharge into the river was observed in this sampling station.

Station 7: Chyasal

The sampling station 7 is located at 27° 40' 41.0" latitude, 85° 20' 12.0"E longitude and 1384.5 metres altitude at Chyasal. The station is just before the confluence of the Manahara river and Bagmati river. Its substrate mainly consists of sands and gravels. There is dense settlement at right and left flood plain of the river being the core urban area. Instream activities such as bathing, washing and cleansing were not observed. Sewage discharge into the river was observed in this sampling station.

Sampling Period

The physico-chemical parameters were carried in each month from May 2014 to August 2014 for four months and in October 2014. During every sampling (for physico-chemical and microbiological study) at each sampling station, 3 samples of water were collected. Thus, altogether 105 water samples were studied.

Methods of Sample Collection, Preservation and Analysis

In each sampling station, three water samples: A (near left bank), B (at middle of the river) and C (near right bank) were taken (UNESCO/WHO/UNEP 1996). From each sampling point (site), water sample was collected in a clean sampling bottle (plastic). Most of the physico-chemical parameters such as temperature, pH, dissolved oxygen, free carbondioxide, total alkalinity, hardness, calcium, magnesium, chloride, conductivity and total dissolved solids (TDS) were measured in the sampling site (field measurement following APHA 1995). Water samples were collected and preserved for the analysis of BOD_5, NO_3-N, PO_4-P and NH_3-N. Water sample for analysis of NH_3-N was preserved by adding conc. H_2SO_4 to pH less than 2 whereas water samples for analysis of BOD_5, PO_4-P and NO_3 -N need no chemical preservation. All samples were brought to laboratory as fast as possible and refrigerated (< 4^oC but above freezing). The water samples for BOD_5 analysis were incubated on the same day whereas other parameters were analyzed within 48 hours (APHA 1995).

Methods of Analysis of Physico-chemical Parameters

The physico-chemical parameters of water samples of Manohara were analyzed with the method followed by (APHA 1995; Trivedi and Goel 1986).

Statistical Analysis

One way ANOVA was applied to test the significance of monthly variation of water quality of the Manahara River. It was also applied to know the significance of variation of water quality from upstream to downstream of the river (UNESCO/WHO/UNEP 1996).

Results and Discussion

The spatio-temporal variations of water quality parameters of Manahara River are presented in the Annex 1.

Total dissolved solid, electrical conductivity, biological oxygen demand (BOD), free CO_2 present, ammonium nitrogen, ortho-phosphate and nitrate nitrogen concentration were increased from upstream to downstream of the river. The point sources like sewage disposal and solid waste deposition might be the primary reason for the increase in concentration of physical and chemical parameters while moving downstream as the river enters the core urban area.

The concentration of TDS, EC, BOD, free CO_2 and chloride were observed in decreasing trend from May to August which might be the effect of increased runoff of river in monsoon so that dilution of physio-chemical parameters occurred and are again increased in October which might be due to reduced runoff than August observing the concentrating effect at low runoff (ENPHO 1997); (Pradhan 1998); (Shrestha 2005) (Poudel 2005).

The concentration ortho-phosphate increases from May to August in the sampling stations of the upstream of the river where agricultural runoff plays a major role as a non point source. The concentration of ortho-phosphate get diluted in the downstream in monsoon compared to the pre-monsoon (May).

Water quality of downstream was heavily polluted as it received the untreated sewage from urban area. Water quality at the middle section (stations 3 and 4) in monsoon showed the betterment than pre monsoon which might be due the high dissolved oxygen and subsequent lower biochemical oxygen demand. The water quality of river depend on the amount of pollutants received, water flow, river recovering capacity, parent materials of river basin, nature of tributaries, biological and chemical activities etc.

Since more of the stream parameters were observed to be affected by the precipitation event, this is thought to indicate that the streams reacted more strongly to the precipitation events (Maas 2010).

In nonpoint source pollution reaches, rainfall often "thickens" the pollutant concentration of the river water, which means that the pollutant concentration in river increased with the flow of rainfall increase. Hydrological variations of the river strongly influence temporal variations of river water quality, so it is necessary to analyze water quality variations in terms of different hydrological seasons. Rainfall would dilute the pollutant concentrations from point sources in the river. But for the point pollution reaches resulted from centralized town domestic sewage pipeline and/or from frequent shipping and digging sands, rainfall always increased the concentration of pollutant (Ding-jiang et al. 2006).

The range of chemical parameters in the downstream water profile is modified by the diluting and concentrating effects of tributary inflows, or due to the specific physico-chemical characteristics of an element or a group that determine their persistence in the water column (Sharma et al. 2005).

Conclusion

The physico-chemical parameters such as total dissolved solids, total solids, electrical conductivity, dissolved oxygen, percentage oxygen saturation, chloride, ortho-phosphate and total density/abundance of macroinvertebrates features vary significantly from stations 1 to 7, whereas the monthly variations of temperature, pH, biochemical oxygen demand, free CO_2, ammonia and nitrate- nitrogen were significant over the investigation period.

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Annex 1. Two way table showing the temporal and spatial observance of different water quality parameters.

	Stations	Salinadi		Sankhu		Bramhakhel		Bode		Pepsicola		Imadol		Chyasal		
	Months	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Temparature	May	19.97	0.15	24.33	1.45	29.87	0.15	27.8	0	25.07	0.12	27.37	0.21	22.43	0.21	b
	June	24.8	0.26	26.03	0.06	28	0.1	31.97	1.79	27.67	0.42	27.7	0.26	27.8	0.1	
	July	21.57	0.25	23.87	0.21	26.83	0.21	23.57	0.25	24.87	0.12	24.9	0.26	23.4	0.2	
	August	20.93	0.15	22.87	0.06	25.70	0.10	22.77	0.15	21.57	0.06	23.20	0.00	25.93	0.23	
	October	16.07	0.12	18.97	0.06	22.63	0.06	23.73	0.21	23.53	0.06	22.40	0.44	17.77	0.15	
		a														
pH	May	7.4	0.2	7.5	0.26	7.6	0.06	7.7	0.12	7.9	0.17	7.9	0.06	7.9	0.1	b
	June	7.37	0.12	7.47	0.06	7.67	0.12	7.7	0	7.93	0.06	7.97	0.06	7.83	0.06	
	July	6.35	0.03	6.4	0.1	6.4	0.12	6.39	0.15	6.35	0.07	6.48	0.03	6.49	0.05	
	August	6.95	0.15	6.98	0.08	6.96	0.04	6.99	0.05	6.99	0.08	7.10	0.09	7.13	0.06	
	October	7.01	0.11	7.03	0.12	7.01	0.08	7.03	0.03	6.63	0.05	6.88	0.07	6.81	0.02	
		a														
Electrical Conductivity	May	95.03	0.45	125.97	1.89	144.57	0.65	181.6	0	407.1	5.07	680.43	4.19	790.47	3.78	a
	June	93.53	0.45	125.7	1.59	144.23	0.75	135.43	0.21	409	6.08	679.33	4.16	717.33	5.03	

	July	42.43	0.47	62.13	4.71	74.3	1.65	82.9	1.35	118.2	0.1	189.27	38.85	277.67	3.79	
	August	41.33	1.11	52.67	1.12	68.27	4.79	75.23	1.25	120.43	0.72	181.93	34.43	244.00	1.73	
	October	49.33	1.91	65.77	10.69	84.57	1.01	93.57	0.60	179.43	4.34	340.00	19.00	484.00	2.65	
		b														
TDS	May	62.7	0.26	80.57	0.47	92.53	0.75	132.8	0	250.17	2.28	421.43	2.72	591.5	4.39	
	June	56.7	0.26	76.13	1.06	87.1	0.61	82.47	1.22	245.67	2.31	409.67	3.51	423	3.61	
	July	25.53	0.06	35.87	3.17	44.23	0.35	49.6	0.95	70.27	0.76	108	29.49	179.57	3.3	a
	August	24.17	0.59	31.73	0.61	41.20	2.85	45.03	0.55	72.60	1.65	107.23	19.90	127.03	1.29	
	October	28.80	0.17	38.80	7.30	50.20	0.40	56.37	0.29	107.00	2.62	202.47	12.69	281.67	3.21	
		b														
TS	May	73.03	0.84	91.23	1.85	109.2	0.66	168.8	0	281.83	4.66	467.77	1.33	650.5	6.05	
	June	61.03	0.45	83.13	1.85	97.7	1.58	97.8	1.83	261.67	1.53	426.33	4.5	445.67	3.51	
	July	30.2	0.61	42.2	3.96	56.9	2.86	66.27	1.96	88.6	3.47	143.67	28.04	216.73	5.31	a
	August	37.53	1.14	45.43	0.25	57.00	3.36	66.17	0.35	105.80	2.01	146.43	19.62	171.47	3.11	
	October	34.97	0.15	45.93	7.37	58.40	0.69	65.57	0.46	119.90	2.85	218.47	12.04	300.77	3.98	
		b														
DO	May	5.68	0.41	5.41	0.23	2.64	0.72	2.03	0	0.95	0.23	0	0	0	0	
	June	5.95	0.23	5.54	0.23	4.995	0.23	5.81	0.23	3.04	0.2	1.35	0.23	0.8	0.07	a

	July	6.55	0.31	6.14	0.31	5.2	0.42	6.14	0.12	5	0.31	4.79	0.12	2.12	0.21	
	August	7.24	0.84	6.30	0.24	6.03	0.23	5.69	0.95	2.03	0.41	1.76	0.24	1.22	0.17	
	October	6.61	0.12	6.41	0.23	5.74	0.12	5.40	0.23	3.92	0.12	2.16	0.12	1.15	0.12	
		b														
O_2	May	64.12	4.4	65.87	2.56	34.98	9.53	26.09	0	11.77	2.9	0	0	0	0	
	June	73.04	2.65	69.4	2.99	64.45	3.02	79.29	4.52	39	2.37	17.34	2.95	10.34	0.86	
	July	76.16	3.33	74.34	3.97	65.94	5.55	73.98	1.68	61.41	3.65	58.97	1.36	46.73	1.65	a
	August	83.32	9.69	74.93	2.84	75.11	2.86	67.57	11.37	23.57	4.68	21.01	2.83	15.26	2.14	
	October	69.27	1.30	71.13	2.61	68.00	1.35	65.24	2.96	47.11	1.36	25.54	1.49	12.46	1.31	
		b														
BOD	May	58.95	2.95	66.36	3.93	72.05	2.25	101.8	0	130.31	4.69	135.53	2.77	136.68	2.34	
	June	54.29	3.33	61.37	3.19	67.39	5.84	64.76	1.69	116.28	1.46	141.71	1.64	164.88	2.98	
	July	20.25	4.05	21.6	4.68	22.95	2.34	27	4.68	29.7	4.68	29.7	4.68	38.25	4	b
	August	13.60	1.22	15.35	0.13	18.35	0.45	30.47	0.49	44.03	1.88	60.53	1.40	82.33	1.78	
	October	16.27	0.12	16.80	0.69	23.07	2.31	27.73	1.15	39.73	3.06	59.73	2.31	64.80	1.39	
		a														
Free CO2	May	35.93	1.27	22.37	1.68	56.1	1.1	88	0	105.97	0.63	171.23	1.68	193.6	2.2	
	June	36.8	4.8	49.87	4.58	62.33	3.63	41.07	1.27	115.93	5.43	168.13	3.69	199.2	3.82	b

	July	22	2.2	24.6	1.68	31.2	1.68	27.5	1.1	31.2	0.64	23.8	2.29	33.47	1.68	
	August	4.77	0.64	9.53	1.27	9.90	1.10	12.47	1.27	23.40	1.22	25.67	1.27	35.23	1.56	
	October	9.17	0.64	10.27	0.64	13.93	1.27	18.70	1.91	26.77	1.68	38.13	1.27	47.80	1.35	
		a														
Chloride	May	7.09	1.42	8.51	2.46	9.45	2.17	19.85	0	62.86	4.56	106.35	2.46	178.36	4.34	
	June	6.23	0.75	8.74	3.9	9.36	0.75	15.83	1.08	46.56	1.48	103.99	2.17	158.46	2.7	
	July	1.89	0.82	2.37	0.82	6.15	0.82	1.18	0.41	5.2	1.64	10.65	0.72	16.5	0.66	a
	August	8.99	0.82	9.47	0.82	12.31	1.64	17.51	0.82	26.03	0.82	30.59	1.13	41.80	1.37	
	October	4.33	0.58	9.33	2.08	14.33	0.58	17.33	0.58	33.33	0.58	80.67	2.31	111.30	1.35	
		b														
$NO3^-$	May	7.56	0.3	6.24	0.28	5.9	0.7	4.52	0.36	9.92	0.31	6.79	0.31	7.83	0.32	
	June	5.26	0.84	6.14	0.35	6.29	0.3	7.02	0.1	8.33	0.34	8.97	0.04	9.35	0.31	
	July	1.01	0.13	2.53	0.63	3.88	0.76	5.44	2.07	5.61	0.18	6.16	0.96	6.86	0.04	b
	August	1.14	0.17	1.71	0.17	1.99	0.13	2.56	0.07	3.61	0.14	4.88	0.10	6.25	0.16	
	October	1.59	0.14	1.70	0.22	1.88	0.05	2.33	0.10	3.41	0.58	6.85	0.43	9.92	0.34	
		a														
$PO4^{--}$	May	0.352	0.01	0.361	0.02	0.384	0.02	0.422	0	2.183	0.07	2.325	0.09	2.723	0.08	
	June	6.07	0.7	4.52	0.32	5.17	0.06	6.12	0.06	6.41	0.02	6.85	0.18	7.24	0.35	a

	July	1.74	0.09	1.65	0.36	3.17	0.23	6.23	1.18	5.73	1.47	4.98	1.32	4.89	1.07	
	August	1.11	0.08	1.05	0.22	1.24	0.18	1.09	0.13	1.09	0.15	1.70	0.18	2.17	0.12	
	October	4.33	0.22	4.85	1.09	4.95	0.36	5.30	0.45	5.55	0.54	5.92	0.34	7.02	0.20	
		b														
Ammonia	May	0.194	0.15	0.163	0.09	0.104	0.03	0.206	0	0.877	0.47	1.263	0.05	1.564	0.09	
	June	2.2	0.54	2.27	0.49	2.39	0.34	1.58	0.04	2.46	0.58	2.65	0.33	3.01	0.31	
	July	1.51	0.58	2.3	1.37	1.78	0.55	1.94	1.02	3.94	1.01	4.28	0.93	4.98	0.2	b
	August	1.27	0.04	1.89	0.08	2.11	0.05	2.61	0.12	3.21	0.19	3.90	0.31	4.86	0.44	
	October	2.55	0.16	3.06	0.49	3.35	0.40	3.97	0.73	4.12	0.18	4.55	0.34	5.22	0.08	
		a														

Note: a means the statistical significance of the test at 0.05 probability level. b means the non significant variation of test.

Relevance of Water Pump as A Tool for Climate Change Adaptation

Khimananda Sharma[1], Man Kumar Dhamala[2], Sanjeet Kandel[1]

Abstract

The impacts of climate change have been observed on almost all parts of Nepal especially on freshwater resources, ecosystem, health status, industrial and social sector, and land use etc. with observed changes on pattern and intensity of temperature and precipitations. Livelihood of the people is seriously threatened due to lack of appropriate adaptive measures and this research was carried out to find out the relevance of drinking water pumps as tool for climate change adaptation. In this research, affordability and sustainability of the water pumps in technical, economical and environmental aspects were considered as basic principal of adaptation tool of drinking water supply system. The adaptive capacity of the local people was taken in reference to current socio-economic context. To link with climate change adaptation, different practices and strategies of the pumps, government policies and environmental measures were discussed. The study used 22 different proxy-parameters to determine the adaptive capacity of the each site from three different districts. These parameters were first normalized and then standardized. Affordability of projects was determined by the total cost benefit analysis of each project. The ratio of payoff money to the family income in percentage was adapted as an affordability index and economical sustainability was discussed on the basis of difference in affordability and current payment rate. Environmental sustainability was studied on source sustainability and system sustainability issue. The study evaluated the existing pumps as a good adaptation tool as pumps are pumping water to the uphill people from their nearest lowest water source thereby helping livelihood of the local people and this research tried to sight them as an adaptation tool but they have to be incorporated with economical sustainability and environmental measures. Further government support and coordination is recommended making such projects more effective.

Keywords: *adaptation, mitigation, water pump, affordability, livelihood*

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Introduction

Today whole globe has been facing a challenge of changing climate as an environmental management issue. There have been many changes in the world climate which can be tracked using many statistical and scientific tools. The changes in the different states of climate and its components which can be identified using different statistical analysis in climatic parameters with reference to temporal and spatial analysis is climate change (UNFCCC, 2011) which could be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2012). For Nepal Shrestha et. al. (1999) reported consistent and continuous warming in the period of 1977 to 1994 at an annual rate of 0.06^0 C with variable precipitation occurrence. Dixit (2013) analyzed Global Circulation Model (GCM) projections that the temperature over Nepal would increase at multi–model mean rate of 1.4ºC by the 2030s and 4.7^0C by the 2090s. Also GCM outputs suggest that extremely hot days are projected to increase by up to 55% by the 2060s and up to 70% by the 2090s. Overall climatic parameters and their statics are the reflections that show Nepal is a climate change victim.

National Adaptation Program of Action (NAPA) inception workshop identified agriculture and food security, water resources and energy, climate induced disasters, forest and biodiversity, public health and urban settlement and infrastructure as six major areas that are impacted by climate change (MoEnv, 2010). Depletion on the availability of drinking water resources is one among visible impacts of climate change in Nepal. Water is an important factor affecting livelihood, productivity, social dimension, risk, sensitiveness and capacity of human being. The interdependent relationship between water supply, energy used to supply those water and its share on climate change induction is being questionable today. Nepal being enlisted as 4th most climate change vulnerable country on globe, different initiative taken to cope with those climatic changes and adaptation practices are necessarily accountable. Both in energy production-energy consumption by different water pumps and their services to help to adapt climate change impacts-mitigate climate change are determinant of sustainable development on country. Local Adaptation Plans of Action (LAPA) framework (approved by the government of Nepal in November 2011) which aims to develop contents to engage nation effectively in the process of developing adaptation priorities has considered the role of renewable energy both for mitigation and adaptation.

The mitigation analysis done by center for energy studies (CES, 2013) also concludes solar water pumping reduces GHG and dependency on kerosene, wood fuel and diesel helping adaptation by reducing vulnerability to water shortage through providing access to water, reducing drudgery for women, improving food security, and improving water sanitation and health problem. It also creates the question behind water supply, renewable-non renewable energy supply to pumps and their role on climate change adaptation. This research is based on the study of different solar and hybrid (solar and electricity) run drinking water pumps being installed in three districts of Nepal in which NAPA has stated different level of climate change vulnerability viz. Ramechhap, Tanahu and Palpa with variability in pump size, water sources, social dimension and energy resource in order to find relationship between role of water pump to climate change adaptation and mitigation using indices developed on adaptive capacity, affordability and sustainability.

Methodology

This study analyzed the relevance of installed water pumps in terms of affordability of the people, their adaptive capacity measured with some proxy parameters and sustainability of the water pumps. The adaptive capacity index was measured using 22 different proxy parameters under social, economic and infrastructure and technology headings. The affordability was accessed under pumps economy and people's economy and sustainability under source sustainability and water system sustainability. Further under environmental implication watershed conservation and source of energy used are analyzed. All the scaling and standardization of adaptive capacity index follows UNDP procedure adapted for HDI (UNDP, 2004). Affordability is again presented in indices which are the percentage of annual project pay off charge to the annual income per household. The size of the family was considered ideal whereas the project period is 15 years following (AEPC, 2011). The interest rate for the solar projects is taken as 12.5% (CEDBL, 2014). The maintenance cost of the project period is average of worst and best situation. Finally annual pay off amount for the project was calculated using quarterly dividend compound interest formula.

Study Area

A wide range of area including three different districts with different overall vulnerability ranking and drought vulnerability ranking provided by national adaptation program of action 2010 (MoEnv,2010). The total number of household of the study area

was the population for the study and the sample size was 12.6% of total. This includes 85 households in Simple random sampling covering both beneficiaries and non-beneficiaries.

Datasets

Figure1: Location of the drinking water pump sites.

Table 1:Site details with vulnerability ranking

SN	**District**	**Overall Vulnerability ranking**	**Draught Vulnerability ranking**
1	Ramechhap	Very High	High
2	Tanahu	Moderate	Very low
3	Palpa	Very low	low

(Source: MoEnv, 2010)

Datasets

Table2: Adaptive capacity of different sites

District	Tanahu	Palpa	Ramechhap
Adaptive Capacity	0.370	0.566	0.498

Table3: Affordability of different sites

District	Tanahu	Palpa	Ramechhap
Affordability	2.79	3.74	21.60

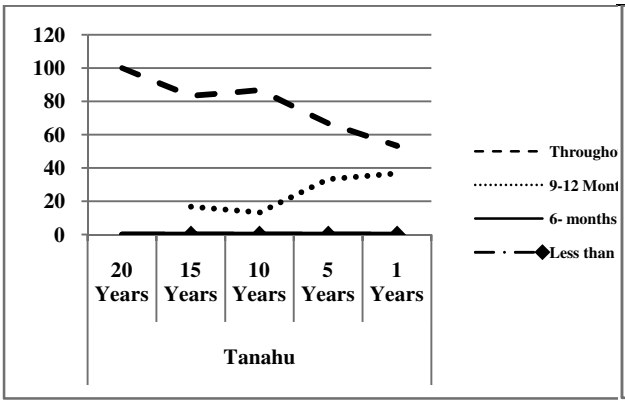

Figure2: Availability of water in Tanahu

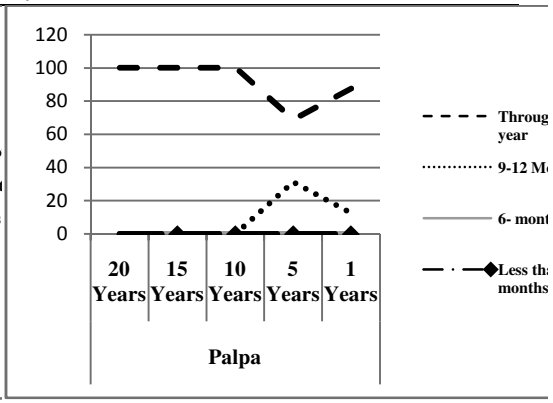

Figure3: Availability of water in Palpa

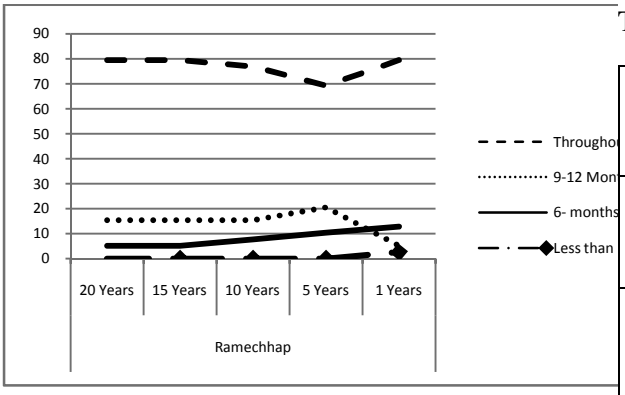

Figure 4:Availability of water in Ramechhap

Table 4 Correlation between parameters

District		Daily water demand (P- value)
Tanahu	Annual earning	0.309
	Total cattle	0.005
Palpa	Annual earning	0.095
	Total cattle	0.007
Ramechhap	Annual earning	0.484
	Total cattle	0.003

Results and Discussion

Adaptive capacity index versus affordability index

The overall research has found adaptive capacity of the Tanahu to be lowest and that of Palpa is highest, whereas looking at affordability index people at Tanahu has to bear lowest percentage of their earning to get pumped drinking water but in Ramechhap local people have to pay the highest (i.e. 21.6%). People at Palpa have highest capacity to cope with changing climate and adapt with the situation they are again subjected to pay lowest for their drinking water whereas people at Ramechhap are more stressed to pay for drinking water to survive even though they have the lowest adapting capacity and facilities around.

Table 5: Economic analysis of different pumps

District	Tanahu	Palpa	Ramechhap
Cost of water per litre (without subsidy) (Considering 15 years life time)	0.061	0.074	0.404
Cost of water per litre (with subsidy) (Considering 15 years life time)	0.038	0.0522	0.333
Current % share of income to payment to water	0.228	0.046	0.709
Percentage of annual payoff/ income	2.79	3.74	21.60
Ratio of operational cost and capital cost	0.424	0.88	1.569
Current Saving (NRs)	16,000	0	22,00,000

Sustainability of the water pumping system versus Sustainability of the water source

The economic sustainability of the pumps was not found to be in good condition as none of the pumping system was found to be economically sustainable despite provision and system of economic sustainability in project design and agreements. However, the pump at Ramechhap has been saving at highest amount among three, it is the one with highest charging system run by community and also implemented by community itself. The cost of per litre water has been calculated in two ways one including subsidy and another without subsidy during installation. The cost of water has been found to be lower than actual due to governments support. While analyzing current share of income

to payment to water and its annual pay off only to sustain those systems; we found a large imbalance. If these systems continue their operation at present modality they won't be able to sustain themselves economically. Technologically most of them are found to be viable in observed geological conditions. Solar pumps are the best practiced options observed in Palpa and Tanahu because of their non accessibility in electricity grid. The location of the sites is again not satisfactory as reservoir tanks are at unstable land and with personal land authority.

Observation about water source sustainability covers its geography, hydrological regime and watershed conservation strategies. This heading also covers mitigation for the

Table 6: Status detail on watershed with parameters discussed

District/Headings	Tanahu	Palpa	Ramechhap
Forestation on water shed	No additional effort	Plantation done	No additional effort
Vegetative measure	No additional effort	They have vegetative measure	No additional effort
Road side construction	Widened road above intake spring	Widened road below intake spring	Both side road development on intake river side

climate change consequences. The carelessness of the road construction above the water spring is objected in each site. Figures 2, 3 and 4 show that there is increasing availability of water only in Palpa which may due to vegetation on catchment area and no road construction above spring. Whereas to conserve the historic/ancient water springs except in Palpa district others are unaware. The knowledge behind climate change combating strategies with natural measures has to be given to the local community for the betterment of the technology driven strategies. The source of energy to pump water was another factor under study. The hybrid system in Ramechhap was found to be having higher operational cost in comparison to other cent percent solar driven systems. Solar system are one of the mitigation measure for lowering green house gas in one hand and on other hand the pay off cost ultimately goes down on other side because of free solar energy.

Practice, Policy and Possibility

Though different observations and analysis has been done in water pumping systems which are implemented, there is a high gap between policy and possibility. The issue of

affordability is serious, the issue of environment is neglected and policy hasn't been practiced. Water systems under study were found to be implemented just to address the water shortage issue rather than linking them with climate change adaptation and mitigation. We have concluded that these kinds of water supplying pumps can be considered as a climate change adaptation tool with some constraints. These pumps must be made more economically feasible to the local community, the environmental issues must be incorporated with their installation, water source conservation and technological viability must be concisely addressed. In Nepal such solar and hybrid pumps have huge potential and possibilities as national and local policies have been already drafted e.g. Climate Change Policy 2011 (Ministry of Science and Technology, 2011). NPC (2013) had identified 12 local programs out of 124 climate related programs whose budgetary sum is 6,121,582,000 NPR and all the 12 programs are related with water, irrigation, and watershed management. This further gives the possibility of budget support for the local people to install adaptation measures locally with the support of government of Nepal. GoN (2006) has clearly stated the development and arrangement of solar energy technology to operate at community and institutional level by integrating it with irrigation, drinking water and purification. This again previls replication of solar water pumps for the climate change adaptation tool.

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Use of Electric Vehicles for Mitigation of Environmental Emission in Urban Areas: A Case Study of Kathmandu Valley

Iswor Bajracharya[1], Nawraj Bhattarai[1]

Abstract

Growing number of vehicles is one of the major sources of air pollution in the Kathmandu valley. This study analyzes the future growth of fuel demand by passenger vehicles, associated environmental emissions and potential emissions reduction by introducing electric vehicles in the Kathmandu valley for the period 2016-2030. The bottom-up transportation model was developed in spreadsheet to estimate the energy demand and environmental emissions. Besides the reference scenario, three policy scenarios were developed. Both energy demand and environmental emissions will decrease significantly in the policy scenario. "Electric motorbike" scenario will reduce the petrol demand by 44% and CO_2 emission by 26%. "Electric Car" scenarios will reduce the petrol demand by 37%, diesel demand by 29% and CO_2 emission by 47%. "Electric Bus" scenario will reduce the petrol demand by 80%, diesel demand by 74 % and CO_2 emission by 79% during the analysis period. However, 2332 GWh of cumulative electric energy will be required in "Electric Motorbike" scenario, 1966 GWh in "Electric Car" scenario and 3670 GWh in "Electric Bus" scenario.

Keywords: *electric vehicles, environmental emissions, energy demand*

Introduction

Studies have shown that one of the major sources of environmental emission in the Kathmandu valley is the growing numbers of vehicles in the valley (Shrestha, 1996, Dhakal, 2003). Vehicular emission contributes to about 38% of PM10 emission in the valley (Gautam, 2006) and the concentration of this emission level is several times higher than WHO safer limit (WHO, 2014). Transport sector consumes about 63% of total imported petroleum fuel (WECS, 2010) in Nepal and the majority of this fuel is consumed by vehicles in the valley. The over reliance on fossil fuel has caused huge trade deficit with India. The electric vehicles have been used around the world to reduce the environmental emission. The objective of this study is to estimate the passenger vehicle energy demand and associated environmental emissions in the Kathmandu valley for the period 2016-2030 and to analyze the possible mitigation by introducing electric vehicles in the valley.

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Methodology

The spreadsheet was used to develop a bottom-up road transportation model and analyze the transportation policies. Four parameters are required to model the transportation energy demand and environmental emissions: present and future vehicle stock, vehicle-use intensity expressed in kilometers travelled by a vehicle per year (VKT), vehicle fuel-use intensity and emission factors. The passenger vehicles were classified as bus, minibus, light duty vehicles (LDVs) (car/jeep/van/taxi), microbus and motorbikes. The registered vehicle data for the Bagmati zone were collected from the Department of Transport Management and actual gasoline and diesel consumption data were taken from Nepal Oil Corporation. In this study, the base year is 2011 and the first scenario year is 2016. The study period is from 2016 to 2030. Figure 1 shows the methodological framework of this study.

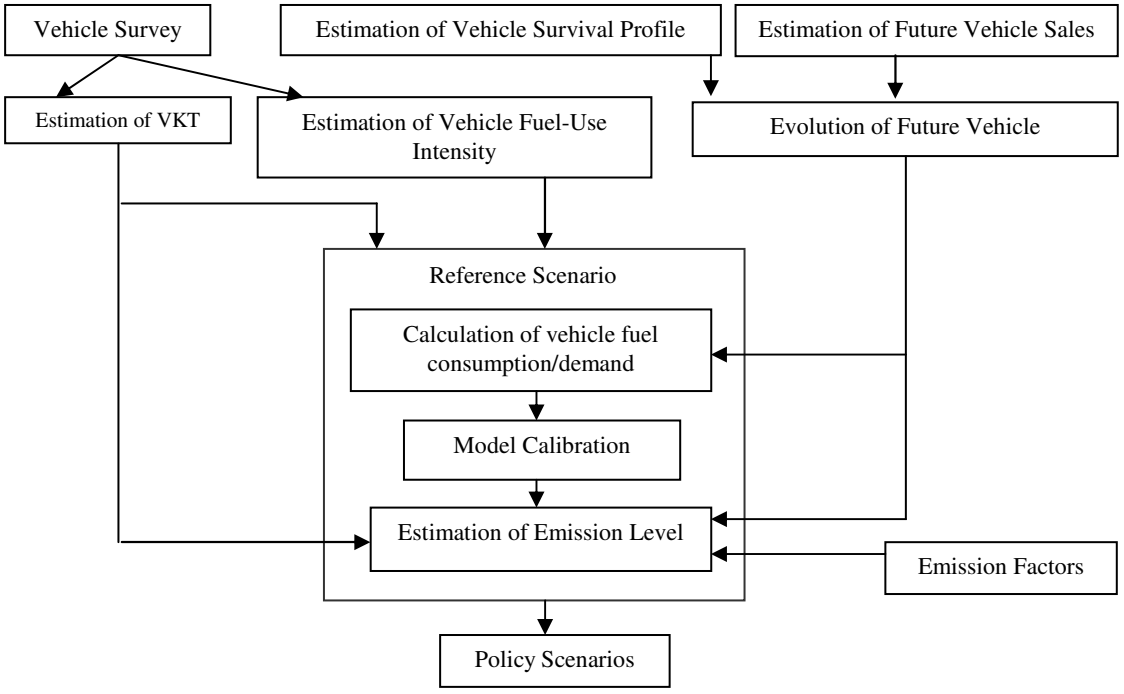

Figure 1. Framework of bottom-up transportation model

The first step in modeling the vehicle energy demand and environmental emission is to estimate the actual vehicle fleet moving on the road. The data provided by Department of Transport Management, Nepal is only the yearly registered number of vehicles. They do not represent the actual vehicle fleet existing and moving on the road. Each year a large number of vehicles are scrapped due to their age. The existing vehicle fleet can be

estimated, provided that the annual scrapping rate is known. Such data do not exist in Nepal. Therefore, it is necessary to estimate the evolution of vehicle stocks plying on the road each year. This can be described by a survival profile which shows the retirement of old vehicles and survival probability of existing vehicle stock in future. The vehicle survival profile follows a negative exponential function. Figure 2 shows the survival profile of different vehicles in Kathmandu valley. The existing vehicle stock in each year can be estimated from equation (1) (Lozada et al., 2010):

$$V_i(t) = V_i(t-1)e^{tk} \quad (1)$$

Where $V_i(t)$ is the number of vehicles of type i in time t, $V_i(t-1)$ is the number of vehicles of type i in time $(t-1)$. Likewise, the exponential function e^{tk} represents the survival profile of vehicle of type i in time t and k represents the decreasing rate of existing vehicle stock in time t and takes a negative value. The value of k can be estimated from equation (2) (Lozada et al., 2010)):

$$k = \frac{lnV_i(t) - lnV_i(t-1)}{t} \quad (2)$$

The values of k for the minibus and microbus were estimated from the vehicle survey in the Kathmandu valley and were found to be -0.017 and -0.015 respectively. The value of k for the bus was assumed to be the same as for the minibus. For the LDVs and motorbikes, due to their large number of presence on the road, the survey was not conducted; instead their values were assumed initially and adjusted during calibration to match with the actual gasoline consumption in the Kathmandu valley. The final adjusted values of k are -0.015 and 0.036 respectively for the LDVs and motorbikes.

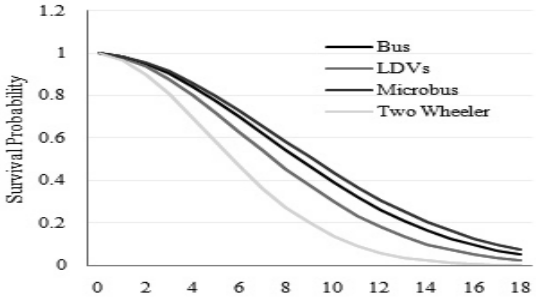

Figure 2. Vehicle survival profile

The future vehicle stock was projected using the historical annual average growth trend of each vehicle type. For bus and minibus, the future growth trend was taken 5% and for the LDVs and motorbikes, the values assumed were 10% and 12% respectively. Table 1 presents the estimated average annual VKT. Table 2 shows the average fuel

consumption for different vehicles types during the city drive in the Kathmandu valley. These values are based on the authors' vehicle survey in the Kathmandu valley in 2013.

Table 1. Average vehicle use intensity (VKT) in the Kathmandu Valley

Vehicle Type	Annual VKT
Bus	44,105
Minibus	43,307
LDVs	
Private (Car/Jeep/Vans)	12,310
Public (Taxi)	25,356
Microbus	38,520
Motorbike	8952

Table 2. Average fuel intensity of vehicles in the Kathmandu valley

Vehicle Type	Fuel Type	Fuel Intensity (km/l)	Fuel Intensity (Wh/km)
Bus	Diesel	3.5	
Minibus	Diesel	4	
Microbus	Diesel	6.2	
Car	Gasoline	13.5	
Jeep	Diesel	8.5	
Pick-up	Diesel	6.5	
Motorcycle	Gasoline	42.5	
Motorcycle (Saxena et al. 2014)	Electricity		40
LDVs (ibid)	Electricity		140
Bus (IEE, GCC)	Electricity		1300

Estimation of Energy Demand and Emission

The total annual energy demand by each vehicle type can be estimated from equation (3) and the total emissions can be estimated from equation (4) (Dhakal, 2003).

$$ED_{i,t} = N_{i,t} \times VKT_{i,t} \times F_i \quad (3)$$

$$E_{j,i,t} = ED_{t,i} \times EF_{j,i,t} \quad (4)$$

$ED_{i,t}$ is the total annual energy demand by vehicle type i in year t, $(N_{i,t})$ is the total number of existing vehicles of type i in year t, $VKT_{i,t}$ is the average annual use-intensity (km), F_i is the average fuel intensity (l/km or kg/km or MWh/km). Likewise, Ej,i,t is the emission type j made by vehicle type i in year t, $EF_{j,i,t}$ is the emission factor of type j by vehicle type i in year t (kg/GJ or g/km).

Due to the lack of the published emission data in Nepal, these data were taken from various existing literatures. The literatures reviewed are (ICAP, 2009; NVMES, 1999; Ramachandra et al., 2009; Bidya, 2009). The average emission factors are presented in Table 3.

Table 3. Emission factors by vehicle type

Vehicle Type	CO_2 (kg/GJ)	CO (g/km)	NO_x(g/km)	HC (g/km)	PM10 (g/km)
Bus	79.7	4.9	6.8	0.87	1.075
Minibus	79.7	4.9	6.8	0.87	1.075
Gasoline car	70.54	3.16	0.21	0.19	0.06
Diesel car	54.82	3.16	0.26	0.14	0.18
Jeep/Van	75.66	3.16	0.28	0.32	0.48
Motorbike	34.71	2.4	0.19	0.52	0.06

Construction of Policy Scenarios

In addition to the Reference Scenario (REF), three policy scenarios were developed to analyze the impact on energy demand and environmental emissions. The policy scenarios considered in this study are:

Electric Motorbike Scenario (EM): In this scenario, it was assumed that the electric motorbikes would replace the conventional petrol motorbike linearly by 10% in 2016 to 100% by 2025.

Electric Car Scenario (EC): In this scenario, it was assumed that the electric car would replace the conventional petrol and diesel LDVs linearly by 10% in 2016 to 100% by 2025.

Electric Bus Penetration Scenario (EB): Under this scenario, public bus would be used for mass transportation instead of personal and small vehicles. Therefore, it was assumed that the electric bus would replace the small vehicles linearly by 10% in 2016 to 100% by 2025.

Results and Discussion

Reference Scenario

Both the energy demand and environmental emission will increase tremendously in the reference scenario. Table 4 presents the diesel and petrol demand from the year 2011 to 2030. The total petrol demand which was 75 thousand kiloliters in 2011 would reach

361 thousand kiloliters by 2030. The total diesel demand which was 24 thousand kiloliters in 2011 would reach 46 thousand kiloliters by 2030.

Table 4. Diesel and petrol demand by passenger vehicle in the Kathmandu valley

Fuel Type	Year				
	2011	2015	2020	2025	2030
Diesel Demand (000' kL)	24	28	31	36	46
Petrol Demand (000' kL)	75	111	136	230	361

Table 5 presents the growth of environmental emissions in the reference scenario. This table shows that carbon dioxide (CO_2) emission will reach 707 thousand metric ton by 2030 which was just 187 metric ton in the base year. Likewise, carbon monoxide (CO), nitrogen oxide (NO_x), total hydro carbon (HC) and particulate matter (PM10) will increase significantly by 2030 compared to the base year.

Table 5. Environmental emissions by passenger vehicle in the Kathmandu valley

Emission Type	Year				
	2011	2015	2020	2025	2030
CO_2 (kton)	187	256	326	468	707
CO (kton)	6	9	11	18	28
NO_x (kton)	0.6	0.9	1.1	1.6	2.5
HC (kton)	1	1.5	2	3.2	4.9
PM10 (kton)	0.2	0.3	0.4	0.5	0.8

Policy Scenario

The results of the different policy scenarios were compared with the Reference scenario. Figure 3 presents the comparison of reference scenario energy demand with policy scenarios. This figure shows that the demand for both diesel and gasoline will reduce significantly in the policy scenarios. Table 6 presents the possible reduction of energy demand in policy scenarios. Table 7 pyxzresents the projected electricity demand in policy scenarios. Table 8 shows the environmental emission mitigation potential of policy scenarios during analysis period.

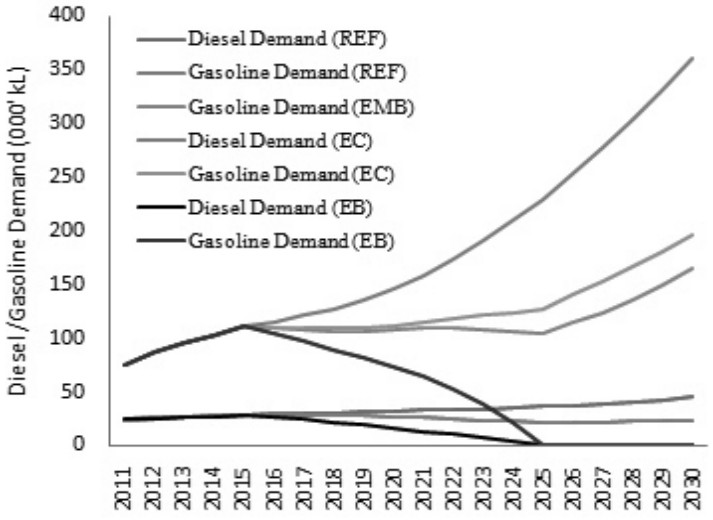

Figure 3. Comparison of energy demand in Reference and Policy scenarios

Table 6: Avoided energy demand (000' kiloliter) in policy scenario

Scenario	Cumulative energy demand (2016-2030)			
	Petrol	Diesel	% Reduction Petrol	% Reduction Diesel
REF	3,136	529		
EMB	1,765	529	-44	0
EC	1,990	374	-37	-29
EB	619	139	-80	-74

Table 7. Projected electricity (GWh) demand in policy scenario

Year	EMB	EC	EB
	Electricity	Electricity	Electricity
2011			
2016	11	9	21
2020	65	60	123
2025	215	180	337
2030	333	282	489

Table 8: Mitigation of environmental emission in policy scenarios (2016-2030)

Emission Type	REF	EMB		EC		PB	
	Emission	Emission	% Change	PBP	% Change	EMB	% Change
CO_2 (kton)	6,508	4,811	-26	3,436	-47	1,388	-79
CO (kton)	245	104	-58	191	-22	49	-80
HC (kton)	43	12	-72	40	-7	9	-79
NO_x (kton)	23	11	-52	19	-17	5	-78
PM10 (kton)	7	4	-43	6	-14	2	-71

The result showed that both the energy demand and environmental emissions, particularly from the small and personal vehicles would increase tremendously in the Kathmandu valley in the coming fifteen years if left uncontrolled. However, various policy scenarios shown in this study indicated that both energy demand and emission level could be reduced significantly. Use of electric vehicles is an option to mitigate the environmental emissions and energy demand by charging them by renewable resource generated electricity. Nepal is endowed with huge hydropower potential and therefore, by harnessing this hydro resource, 100% of the electricity can be generated from the hydropower plants which are renewable. The electric motorbikes and electric cars are more energy efficient and produce less environmental emissions compared to the conventional ones if they are charged by renewable resource generated electricity. Moreover, the penetration of electric buses for mass transportation can replace the small and personal vehicles thereby reducing both fuel demand and environmental emissions significantly. Therefore, an appropriate policy measures should be devised to encourage the use of electric vehicles in the Kathmandu valley and other cities of Nepal for urban transportation.

Conclusion

This study presented the energy demand and associated environmental emissions in the Kathmandu valley by the passenger vehicles in the coming 15 years and also presented the policy scenarios to mitigate the emissions. We used the spreadsheet to develop the bottom-up transportation model. The concept of vehicle survival profile was used to estimate the evolution of the actual vehicles moving on the road. These estimated vehicle numbers were used to project the future energy demand and emissions by vehicles. The policy scenarios discussed in this study showed a good mitigation result.

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Compliance Monitoring of the Industrial Effluents of the Industries in the Terai Region of Nepal.

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Abstract

Industrial effluents are resulting in different kinds of pollution to the water resources. Compliance monitoring of industrial effluents quality and its detail analysis is very significant to control environmental pollution and adverse health impacts. Compliance monitoring was carried out in Sugar, Paper and Brewery industries of Sarlahi, Dhanusa and Nawalparasi Districts of Nepal and effluents were analyzed for the desired physiochemical parameters like pH, Total Suspended Solids (TSS), Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) by applying the nationally valid standard methods. It was found that effluents quality is very poor with most of the parameters not complying with the industry specific national standards. The study suggests for the installation and upgrading of wastewater treatment plants in the monitored industries.

Keywords: *compliance monitoring, effluent water quality, physio-chemical parameter, treatment system.*

Introduction

Water pollution can be defined as any unfavorable change in the physical, chemical or biological characteristics of water that can affect the health, survival or activities of humans or other forms of life in an undesirable way (Miller, 2002). Industrial effluents are the point sources of water pollution discharging various categories of water pollutants like oxygen demanding wastes, inorganic chemicals, toxic organic chemicals, thermal discharges etc. The discharge of untreated or in-efficiently treated industrial effluents leads to the problem of surface and ground water pollution thereby affecting human health and overall environment.

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Industrialization is considered vital to nation's socio-economic development. The total no of industries registered till FY 2071/72 in Nepal are 5,646 ranging from small to large *(DoI, 2015)*. The different categories of industries registered are Food and Beverage, Paper/Pulp, Alcohol, Textile, Electronics, Leather, Cement, Brick etc. Industrial development has possibility to generate large number of employment in the country. Meantime, there is necessity to develop the industrial sector in planned way. The unregulated development especially in developing countries have led to surface water and ground water contamination by complex interacting chemicals and substances. *(Coros and Frische, 2011;)*. This may results in loss of habitat and aquatic species diversity.

Day by day the numbers of industries are increasing therefore a keen monitoring and research is required so their impact on human health and overall environment could be justified with the blind industrial development. A regular and thorough monitoring of industrial effluent quality is very essential to control pollution and its associated hazards.

Nepal government has formulated several generic and industry specific effluent standards under Environment Protection Act, 1996 and Environment Protection Regulation, 1997 to control the release of untreated industrial effluent into the nearby surface water. Department of Environment (DoEnv) under the Ministry of Population and Environment is an executing agency for the compliance monitoring of generic and industry specific effluent standards. This paper is an outcome of the monitoring work carried out by the team of officers of Department of Environment in the fiscal year of 2071/2072 B.S (2015 A.D.).

Objectives

The specific objectives of the monitoring are:

- To analyze the physio-chemical parameters of the industrial effluents.
- To know the status of compliance with the industry specific national standards.

Methodology

Study Site

Site visit and study was carried out to the following three industries in the year 2015 A.D. namely as:

1. Indu Shankar Sugar Industry Pvt.Ltd., Hariban Municipality-8, Sarlahi: It lies in the Eastern Terai Region of Sarlahi district, Nepal. It is one of the biggest sugar industry of

Nepal discharging huge amount of industrial effluent in to the nearby Chapini stream through 4 km cannal without any kind of treatment system.

2. Everest Paper Mill Pvt.Ltd., Chireswornath Municipality, Dhanusa: It also lies in the Eastern Terai Region of Dhanusa district, Nepal. It is one of the biggest Paper industry of Nepal. Facultative oxidation pond has been created for the treatment of wastewater. The effluent there after has been discharged to public drainage and often diverted to nearby agricultural field.

3. Gorkha Brewery Pvt.Ltd., Gaidakot Municipality- 10, Nawalparasi: It lies in the western terai region of Nawalparsi district. It is one of the biggest brewery industries of Nepal producing different brand of Beers. Secondary level waste water treatment plant has been constructed for the treatment of wastewater. The effluent thereafter has been discharged into Narayani River, which is one of the biggest and ecologically important river of Nepal.

Sample Collection

Water samples were collected in pre cleansed; acid washed 1000 ml capacity high density polypropylene bottle. Grab sampling technique was used for the sample collection. All the samples were collected at the exit point of the effluents from the industries that are assumed to be treated and ready for discharging into the nearby rivers/streams. The collected samples were stored in an icebox of 4°C and transported to the laboratory.

Sample Analysis

Samples were analyzed for the determination of pH, Total Suspended Solids (TSS), Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The parameters were selected based on the parameters included in the national industry specific effluent standard for the selected industries. The analysis was carried out by Nepal Government accredited laboratory with the standard methodology as prescribed in industrial effluent standards testing methodology.

Results and Discussion

The results of physio-chemical parameters analyzed of the monitored three industries are presented as below:

Table 1: Physiochemical parameters of Indu Shankar Sugar Industry effluent (Sugar Industry)

Parameters	**Units**	**Sugar Industry Specific standards of Nepal Government** (MoPE, 2058 B.S.)	**Results**	**Status of compliance**
pH		5.5-8.5	**3.4**	Noncompliance
COD	mg/l	250	**19600**	Noncompliance
BOD	mg/l	100	**6833**	Noncompliance
Total Suspended Solids	mg/l	100	**286**	Noncompliance

Table 2: Physiochemical parameters of Everest Paper Industry effluent (Paper Industry)

Parameters	**Units**	**Paper Industry Specific standards of Nepal Government**(MoEST, 2058 B.S.)	**Results**	**Status of compliance**
pH		5.5-9	6.7	Compliance
BOD	mg/l	100	**1005**	Noncompliance
COD	mg/l	Not set	3520	
Total Suspended Solids	mg/l	100	87	Compliance

Table 3: Physiochemical parameters of Gorkha Brewery Industry effluent (Beer Industry)

Parameters	**Units**	**Paper Industry Specific standards of Nepal Government** (MoEST, 2058 B.S.)	**Results**	**Status of compliance**
pH		5.5-9	5.6	Compliance
BOD	mg/l	30-100	**1003.0**	Noncompliance
Total Suspended Solids	mg/l	100	**262.2**	Noncompliance

pH value of all industries are acidic in nature ranging in between 3.4-6.7. Effluent from sugar industry is highly acidic (3.4) and does not comply with the national standard for sugar industry. The result of pH value of sugar industry is similar to the sugar mill effluent as given by *Samuel, S. and S.M. Muthukkaruppan, 2011.* The pH values of paper and brewery industry comply with respective national industry specific standard but the value of Brewery effluent is nearby the breaching point (5.6).

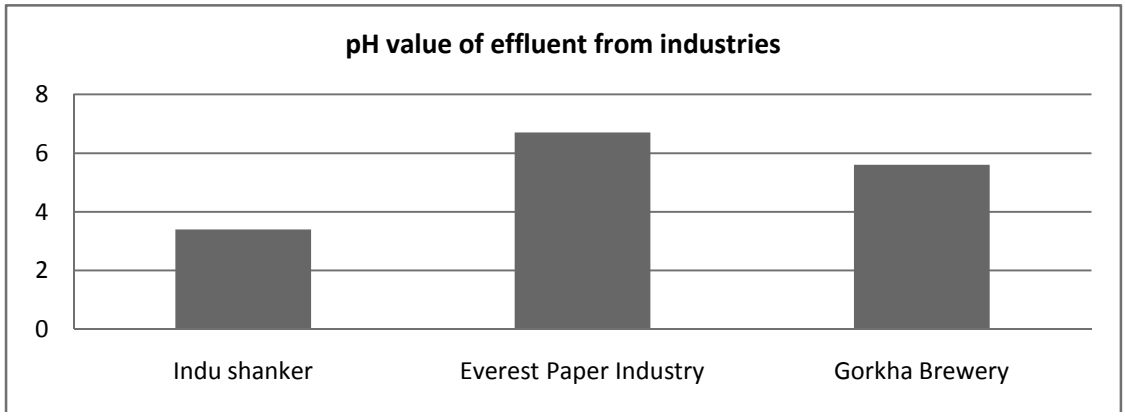

Figure 1: pH value of effluent from industries

Total Suspended Solids (TSS) represents the solid particulate matter in water that increases the turbidity of water their by reducing the light penetration and aquatic productivity. Water bodies receiving effluents with high TSS becomes turbid their by reducing aquatic productivity. TSS value of the monitored industries ranges in between 87 to 286 mg/L. except paper industry effluent (87 mg/L), sugar and brewery industry effluent does not comply with respective national industry specific standards.

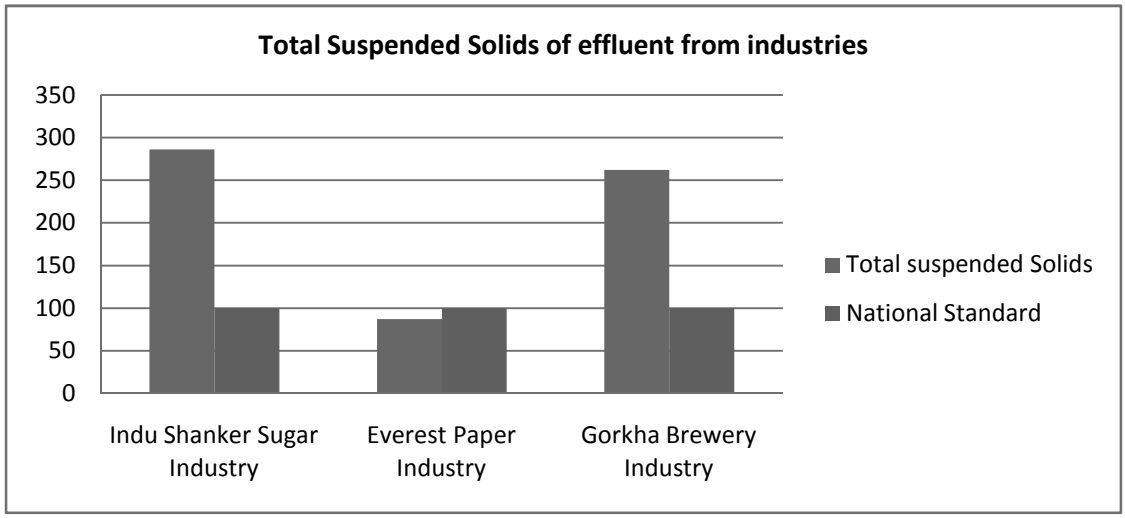

Figure 2: Total Suspended solids of Effluent from industries

Biological Oxygen Demand (BOD) represents the strength of bio-degradable organic matter and defined as the amount of oxygen required by the microorganisms for the

decomposition of organic matter (*Trivedy, R.K. and P.K. Goel. 1986).* Effluent containing high BOD value when discharged into water bodies depletes the dissolved oxygen thereby affecting the aquatic life. BOD value of the monitored industries ranges in between 1003 mg/L to 6833 mg/L and all three industries do not comply with respective national industry specific standards. All the water bodies receiving these industrial effluents have high chances of getting organically polluted. High BOD content in the effluent of Gorkha Brewery is may pose threat to ecologically important Narayani River. BOD value of Sugar industry is extremely high (6833 mg/L) about 69 times higher than national standard, as there is no treatment system.

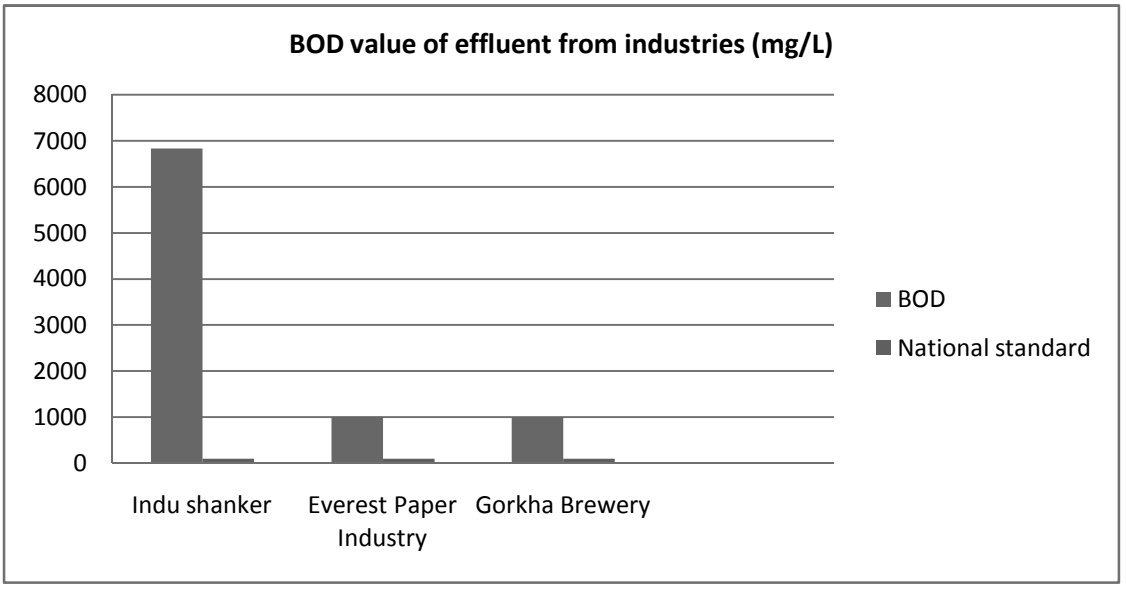

Figure 3: BOD value of effluent from industries (mg/L)

Chemical Oxygen Demand (COD) can be defined as the amount of oxygen required by strong chemicals for the decomposition of organic matter along with some inorganic chemicals (*Trivedy, R.K. and P.K. Goel. 1986).* It also measures the decomposable organic matter along with some inorganic chemicals in water. COD value of the Sugar and Paper industry was found to be 19600mg/L and 3520 mg/L respectively. Both the industries do not comply with the respective national industry specific standards of COD value. All the water bodies receiving these industrial effluents have high chances of getting organically polluted. The COD content of sugar industry was extremely high (19600mg/L) about 196 times higher than national standard, as there is no treatment system.

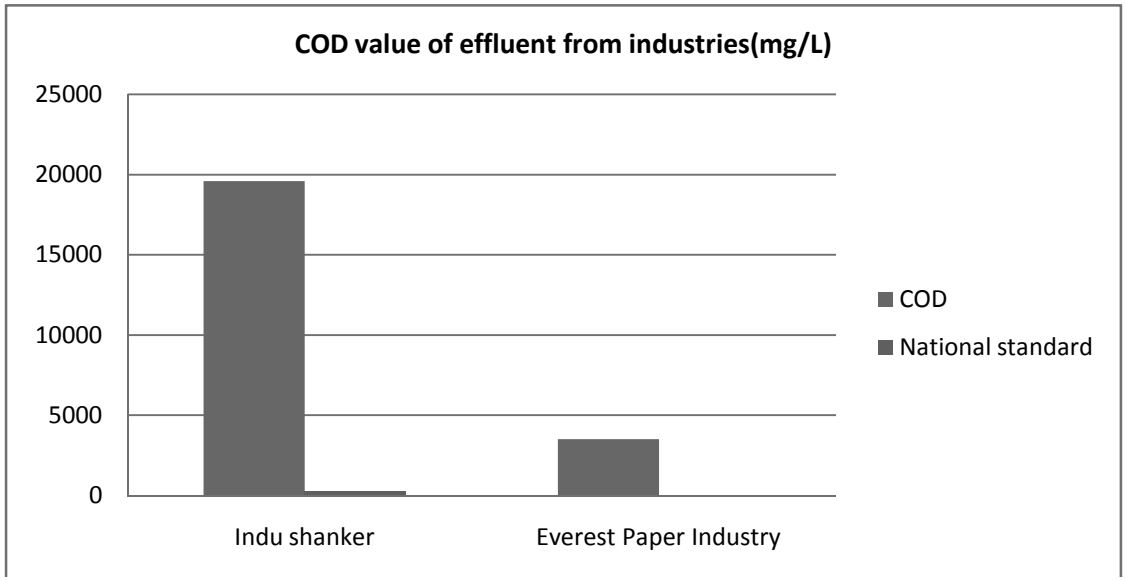

Figure 4: COD value of effluent from industries (mg/L)

Among these three industries sugar industry does not have any kind of treatment system. The value of all three parameters BOD, COD and Total suspended solids are highest for sugar Industry and all these parameters do not meet the national standard as well. In case of remaining two industries some parameters are within the national standard but these industries don not meet national standard for all parameters analyzed. The lower value of BOD, COD and Total suspended solids in these two industries may be due some sort of treatment but it may be due to different nature of industry. The higher value of BOD and COD indicates the inefficiency treatment systems in paper and brewery industry. BOD and COD value of monitored sugar, paper and brewery industries are found to be higher than such type of industrial effluent of India (*Samuel, S. and S.M. Muthukkaruppa,2011; Kuzhali S. S., N. Manikandan and R. Kumuthakalavalli, 2012 and Noorjahan, C.M. and S. Jamuna, 2012).*

Conclusion and Recommendations

Thus the industry specific standard parameters like pH, BOD, COD and TSS were analyzed for Sugar, Paper and Brewery industries. All the monitored industries do not meet the national standard showing the noncompliance status of the industries. The following recommendation can be made based on the monitoring results:

- Non compliance of the pH, TSS, BOD and COD value of Sugar industry indicates the need for installation of new treatment system.

- Non compliance of the BOD value of Paper industry indicates the need for upgrading of current treatment system.
- Similarly noncompliance of TSS and BOD value of Brewery also indicates the need for upgrading of current treatment system.

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Environmental Monitoring of Sand, Gravel and Stone Projects in Nepal: Practices, Gaps and Way Forward

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Abstract

Sand, gravel and stone (SGS) have been considered as an important source of revenue for the local bodies such as District Development Committees (DDCs), Village Development Committees (VDCs) and Municipalities, after enactment of Local Self Governance Act-1999 and Local Self Governance Regulations-2000. However, to use those natural resources proponents are required to carry out Initial Environment Examination (IEE) of the proposals mentioned in Schedule-1 and Environmental Impact Assessment (EIA) of the proposal mentioned in Schedule-2. Likewise, Schedule-1(C)- mining activities relating to other mines, mandates extraction of sand, gravel and stones. This paper has reviewed the number of IEE reports approved by Ministry of Federal Affairs and Local Development (MoFALD) till 2069 and analyzed the practices and policy gaps in implementations.

Keywords: *environmental assessment, initial environment examination, local level monitoring*

Introduction

In Nepal, SGS have been remained as an important source of revenue for the local bodies from 2000 AD, since when the Local Self Governance Act (LSGA, 1999) and Local Self Governance Regulations (LSGR, 2000) attributed ownership of the resources. The revenue in the form of tax is collected by the DDCs through private contractors by competitive bidding and DDCs share these resources with the VDCs, Municipalities, District Forest Offices and the Buffer Zone Committees- wherever applicable.

According to the EPR (1997), a proponent shall require to carry out Initial Environmental Examination (IEE) of the proposals listed in Schedule-1 and

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Environmental Impact Assessment (EIA) of the proposal listed in Schedule-2. The Schedule-1(C)- mining activities relating to other mines mandates extraction of sand, gravel and stones. Similarly, Parliamentary Committee on Natural Resources Management has also mandated the District Development Committees (DDCs) to carry out IEE or EIA of the rivers and preparation of the Environmental Management Plan based on the IEE/EIA findings before signing the contracts or issuing the extraction permit. The EPA (1996) and EPR (1997) authorize the MoFALD (then Ministry of Local Development, MoLD) to approve ToR of IEE and IEE reports for local bodies. The Environment Management Section of MoFALD is responsible for facilitating the ToR and IEE reports approval process.

Environmental Monitoring

Environmental monitoring is an important tool to ensure the implementation of Environment Management Plan (EMP) for minimizing adverse impacts and maximizing the beneficial impacts. In order to monitor the implementation and compliance of mitigation measures, as mentioned in the IEE report, independent third party monitoring has been recommended (EPR, 1997). The objectives of monitoring include examination of environmental baseline, compliance, and impacts of the project activities.

Parliamentary Committee on Natural Resources Management has monitored some parts of Dhading district and strictly recommended to close down the sand washing and sieving plants operated in the Prithvi Highway area with immediate effect and shift such plants beyond 500 meters from the Highway. The committee also recommended constructing sedimentation ponds to control turbidity in the river. Similarly, the report of the Office of the Prime Minister and Ministerial Council on extraction of sand, gravels and stones has also ordered to stop all the vehicles carrying wet-sands dropping water on the road (CDES/MoLD, 2011).

Central Department of Environmental Science, Tribhuvan University (CDES-TU), and the then MoLD- Environment Management Section (present MoFALD) signed Memorandum of Understanding (MoU) on April 18, 2011 and officially initiated the third-party monitoring of IEE approved SGS projects. Similarly, the Ministry signed MoU with Department of Environmental Science and Engineering, Kathmandu University (KU) in 2012. The purpose of MoU was to carry out independent and unbiased third-party monitoring, to enhance coordination between academia and government, to ensure the quality monitoring reports, and to strengthen the capacity of academic institutions.

For the local level monitoring and management of SGS extraction activities, there is a Monitoring and Coordination Committee at district level coordinated by the Chief District Officer (CDO) along with Local Development Officer (LDO) as a member secretary. CDES/MoLD (2011) has reported that this committee of Dhading district monitored collection/extraction of SGS projects and closed down 15 sand washing plants, shifted some crusher plants which had encroached the road. In addition, they were also compelled to refill the pits. Though, Monitoring and Coordination Committee in some districts has carried out the task effectively, still there seems need of further strengthening the committee for effective monitoring, evaluation and documentation.

Monitoring by Tribhuvan University

With the involvement of TU-CDES, the third-party monitoring of IEE approved SGS projects started from 2011, by monitoring SGS extraction from 10 rivers of Kavreplanchok and 9 rivers of Dhading, both belonging to Central Development Region of Nepal. During 2012, the monitoring was carried out in 58 rivers of the Eastern and Central Development Regions. From the Eastern Development Region, four districts (Udayapur, Jhapa, Morang and Sunsari) with 26 rivers; and from the Central Development Region, three districts (Chitwan, Makawanpur and Nuwakot) with 32 rivers were considered for monitoring. In 2013, the TU-CDES monitored 11 rivers of Eastern and Central Development Regions. Among them, six rivers were from Ilam and Jhapa districts of the Eastern Development Region, and five rivers were from Kavreplanchok and Sindhupalchok districts of the Central Development Region.

Monitoring by Kathmandu University

The involvement of KU in the third party monitoring started from 2012 by monitoring rivers of 8 districts. In 2013, KU accomplished the monitoring of SGS projects in 10 rivers of Sindhuli, Sarlahi, Kapilvastu and Arghakhanchi districts.

Table 1: SGS approved projects monitored by TU & KU in different years

Year	**2011**		**2012**		**2013**	
University	TU	KU	TU	KU	TU	KU
Districts	2	-	7	8	4	4
River	19	-	58	53	11	10

Source: MoFALD data base

Methodology

This paper reviews the IEE monitoring reports, assesses the relevance/significance of monitoring of various IEE reports, draws major achievements made so far, and find out gaps and suggest policy recommendations by reviewing the pertinent documents like IEE reports, compliance monitoring reports, existing acts/rules/regulation, and by consulting experts and stakeholders. In addition, outcomes of monitoring finding sharing workshop and policy workshop organized by MoFALD at Sukute Sindhupalchok dated 13-15 December, 2013; have also been incorporated in the present discussion paper.

Results and Discussion

Third party monitoring of SGS projects started from Kavreplanchok and Dhading districts of Central Development Regions of Nepal. Fourteen points directive was circulated (Annex I) by MoLD for all the DDCs on the basis of monitoring recommendations in 2011(www.mofald.gov.np). The environmental monitoring of SGS extraction/collection from the rivers of Jhapa, Sunsari, Morang, Udayapur, Makawanpur, Chitwan and Nuwakot districts, accomplished in 2012, has revealed that the baseline information comply with IEE reports. However, the summary report shows that site specific data on extraction sites are lacking. Similarly, the important parameters such as extraction depth, extraction location with respect to water course, extraction methods, extraction seasons, spoil management, and worker facilities, as recommended in the IEE reports, seems to be not complied. In all the rivers, the deposits were observed to be collected even from the river course, non-complying the IEE reports. In addition, neither daily nor annual amount of river deposits collected and transported seems to be recorded. As a result, the extraction limit of 300 m^3 per day, the threshold between IEE and EIA, could not be monitored by the monitoring teams. Similarly, alteration of river hydrology and morphology, change in river course, modification of erosion and depositional pattern of the river, increased turbidity of river water, degraded aquatic habitat, impact on aquatic life and loss of aesthetic value had been observed as the major impacts of extraction/collection. However, the extraction activities have also revealed the beneficial impacts like revenue collection, flood control, bridge protection and employment generation.

The review has obtained following major issues that are not complied in the field during the monitoring:

Issues Not Complied During Monitoring

1. Organization of environmental awareness program
2. Occupational health and safety measures
3. Installation of siren devices
4. Workers training
5. Untouched width between collection area and river bank
6. Water rescue devices
7. Pollution mitigation measures (soil, noise, water and air)
8. Health and sanitation facility to workers
9. Type of fuel provided to workers for cooking
10. Maintenance of embankment
11. Maintenance of prohibited area for collection (bridge, etc.)
12. Adequacy and appropriateness of implementation of mitigation measures
13. Excavation depth
14. Excavation area
15. Emergency vehicles
16. Spoil management
17. Relocation of affected structures
18. Collection/excavation amount

Highly Significant Adverse Impacts on Physical Environment

1. Change in land use (loss or degradation of productive land)
2. On sedimentation, soil erosion, bank cutting and flooding
3. Change in river hydrology and morphology and other water resources like water spring, well, etc

Highly Significant Beneficial Impacts

1. Control in flooding and haphazard deposit of spoils
2. Employment opportunities for local people involved in extraction and transportation
3. Revenue generation to DDC/VDC/Municipality (amount/year)

Issues with Significant Adverse Impacts on Physical, Biological and Aquatic Environment

1. Change in topography
2. Change in river hydrology and morphology and other water resources like water spring, well, etc.
3. Impact on aesthetic value and visual impact
4. Impact on aquatic habitat and life

Issues with Significant Adverse Impacts on Socio-Economic and Cultural Environment

1. Occupational health and safety gears
2. Sanitation and solid waste management in the project site
3. Impacts on the existing physical infrastructure facilities
4. Impacts due to the transportation vehicles to the nearby human settlements

Issues with Significant Beneficial Impacts on Social Environment

1. Control in flooding and haphazard deposit of spoils
2. Boost up of local economy
5. Increase in business opportunity to local people
6. Community development and improvement of public facilities

The monitoring findings of 2013, carried out by KU, have revealed that extraction from the rivers of Sindhuli district helped preventing water induced disaster. However, haphazard extraction, lack of safety gears for the workers, no sanitary facilities, inadequate record of the amount being extracted have been reported to be the issues not complying with IEE report. In addition, the maximum depth of extraction has not been mentioned in the IEE report (DESE-KU/MoFALD, 2013a). The use of heavy equipment like excavators and uneven extraction of the sediments from Bagmati River of Sarlahi leading to the change in river morphology affecting embankments and Bagmati Bridge has been reported (DESE-KU/MoFALD, 2013b). In the five rivers of Sarlahi district, the monitoring studies have revealed that most of the rivers have been reported not be complied with respective IEE reports. Other important parameters like extraction depth, extraction location, extraction methods, extraction season, spoil management and workers facilities as recommended by the respective IEE reports for the different rivers

have been observed not to be complied, particularly in the Bagmati River (DESE-KU/MoFALD, 2013c).

Policy Gaps

Methodological Gaps in National EIA Guideline (1993):
National EIA Guidelines (1993) has the provisions of scoring the impacts on the basis of magnitude, extent and duration of the impacts. However, the value of total score categorized is subjective and the final scores may vary with person to person. Consequently, the IEE reports have not adequately addressed the site specific environmental issues. This might have been the possible cause for excluding highly important parameters and including less important one.

Terms of References (ToR):
The issues that are to be addressed on ToR, which are the basis for preparing the IEE reports, should be site specific and relevant to the project, were found insufficient in addressing the relevant and site specific issues. In this regard, ToR review committee consisting of multidisciplinary team should be made responsible for addressing the issues sufficiently.

Lack of co-ordination with line-ministries and concerned agencies:
There seems lack of adequate coordination between line ministries during approval and implementation of IEE reports. Consequently, the rivers are claimed by various ministries; for instance MoFALD for extraction of SGS, Ministry of Energy (MoE) for hydropower development, Department of Road (DoR) for the bridge construction. These agencies therefore should have effective coordination. However, the lack of coordination between the line-agencies has resulted in approval of various IEE projects in the same river that uses the river materials for various purposes. This gap has led multiple jurisdictions for the same site for various purposes.

District Level Monitoring, Documentation and Reporting:
The IEE reports have the provision of the district level environmental monitoring of the projects. However, there is insufficient documentation and reporting in the district level offices. Meeting minutes of monitoring are only the documents available in various districts which are not enough to address the effective implementation of IEE recommendations. There seems no proper monitoring and documentation activities conducted in the district level.

Recommendations

The following suggestions and recommendations have been made during the policy workshop:

- The river channel should be buffered before extraction/collection of river deposits.
- The extraction boundary should be delineated in the field and the information should be shared with contractors and workers.
- In each extraction sites, a reference level should be left so that the depth of excavation could be assessed distinctly.
- Implementation of amended rules/regulations should be enforced from the date of amendment for new projects.
- Awareness program about the IEE implementation should be organized for the contractors, workers, security personals and other local level stakeholders.
- Hoarding boards should be displayed in the environmentally sensitive areas to make the local people aware about the major concerns of the IEE report.
- The IEE report should be documented in Nepali language also.
- LSGA (1999) tariff should be revised as per current market situation.

Recommendations from Monitoring Findings

Recommendations for Ministry of Federal Affairs and Local Development

i. Quantitative assessment of basic water quality parameters including turbidity, river discharge and aquatic environment need to be incorporated in IEE report.
ii. The report preparation team should be made responsible for the authenticity of data by making mandatory provision of declaration.
iii. The collection/extraction of deposits, from rivers of trans-boundary importance-like Mechi River of Jhapa and Mahakali of Kanchanpur, should be considered seriously, and proceed as per the integrated trans-boundary river management approach.
iv. As per EPA (1996) and EPR (1997), MoFALD should penalize the person/contractor that fails to comply environmental mitigation measures.
v. The Ministry should encourage DDC for EIA over several IEEs in a district.

Policy Recommendations

In order to have effective and quality monitoring the following policy interventions have been recommended;

- In the IEE, methodological uniformity, especially in total score/significance, should be maintained.
- Benchmark parameters for IEE study should be incorporated as per the field conditions.
- In order to maintain the quality of IEE report, provision of minimum qualification/license for IEE experts should be ensured.
- IEE related documents and reports should be properly documented and easy access of documents to the concerned stakeholders should be ensured.
- There should be proper coordination between line ministries /organizations /academic institutions and other concerned agencies.
- After finalizing the bidding process and before granting the permission of extraction, at least two consultation meetings and awareness programs with local stakeholders, contractors and workers in the working area, should be ensured by policy regulations.
- In each DDC, a separate environmental unit with at least one Environmental Expert/Inspector should be instituted.

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Air Pollution from Brick Kiln in Kathmandu Valley and its Management

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Abstract

Kathmandu valley is susceptible to air pollution due to its bowl-like topography, which creates poor dispersion mechanism and allows pollutants remain within the valley. Brick kilns operating in the valley, along with other sources, are major source of air pollution in Kathmandu valley. For this research review of publications, journals, books as well as field visit was carried out to visualize the current situation of the kiln. Stack emission from different types of kiln shows that the value of SPM from natural draught Brick kiln is the highest among the technologies used in Nepal. Similarly, brick kilns are not only deteriorating air quality but also degrading the health of people living nearby. Several studies on health impact of Kathmandu's air quality have also revealed that air pollution is a major public health risk for the citizen of the valley. Further, standards formulated from government of Nepal are ineffective in reducing the air pollution of the valley because of its weak implementation. Therefore development of strategic air quality management plan and its proper implementation is urgent to reduce the adverse health and environmental impact of air pollution in the Kathmandu valley.

Keywords: *environment, health impact, pollution, stack emission*

Introduction

Kathmandu valley, which has capital city Kathmandu along with some other municipal towns; Lalitpur, Bhaktapur, Kritipur etc. is the main economic as well as cultural centre of the country located between the Himalayas in the north and the Mahabharata Mountain in the south. It occupies an area of about 600 sq km and located at a plain about 1300 meter above sea level. As the major cities in the world, Kathmandu Valley is also facing the severe problem of air pollution. The valley is extremely vulnerable to air pollution due to an exploding population inflow, unplanned and rapid urbanization,

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and valley centric industrialization, significant increase of vehicle transport and excessive use of diesel generator. The bowl like topography of the valley restricts the wind movement and allows pollutants remains within the valley, which becomes worst during the winter season (Nov-Feb) due to the thermal inversion in late night and early morning (CANN/CEN, 2014).

According to WHO, Air pollution is the contamination of the indoor or outdoor environment by any chemical, physical and biological agent that modifies the natural characteristics of the atmosphere . Environmental protection agency (EPA) claimed that particulate matter (PM), atmospheric ozone (O_3), Oxides of sulphur (SO_x), Oxides of Nitrogen (NO_x), carbon monoxide (CO) and lead (Pb) are the major pollutants for the air pollutions. These pollutants harm the human health and the environment, and also cause property loss (EPA, 2012).

Brick kilns are one of the major source of air pollution in Kathmandu valley (Raut,2003).. These Brick kilns are deteriorating air quality and consequently degrading the health of people dwelling nearby the kiln. The operation of brick kiln in Kathmandu valley has caused significant environmental and health problem because the industry is using poor quality fuel and operating with conventional technology.. Brick production is a seasonal industry that generally runs in dry season from December to May (Joshi and Dudani 2008). Studies have found that the concentrations of Particulate Matter (PM) in air around the brick kiln zones are three times higher than the offseason of brick kiln (Raut, 2003). It is estimated that Brick Kiln contributes 11% of total PM_{10} in Kathmandu valley whereas 63% of total PM_{10} in Kathmandu valley comes from vehicles and re suspended road dust. (Gautam, 2006 as cited in CANN, 2014).

Methodology

Intensive review of publications, journals, books and web materials was carried on air pollution from brick kilns, its impact on health and environment and monitoring reports. The research findings relevant to Nepalese context were analyzed and reviewed carefully. Field visit and observation was carried out for the compliance monitoring of stack emission of Brick kiln and to visualize the overall environmental impact in the year 2014 and 2015.

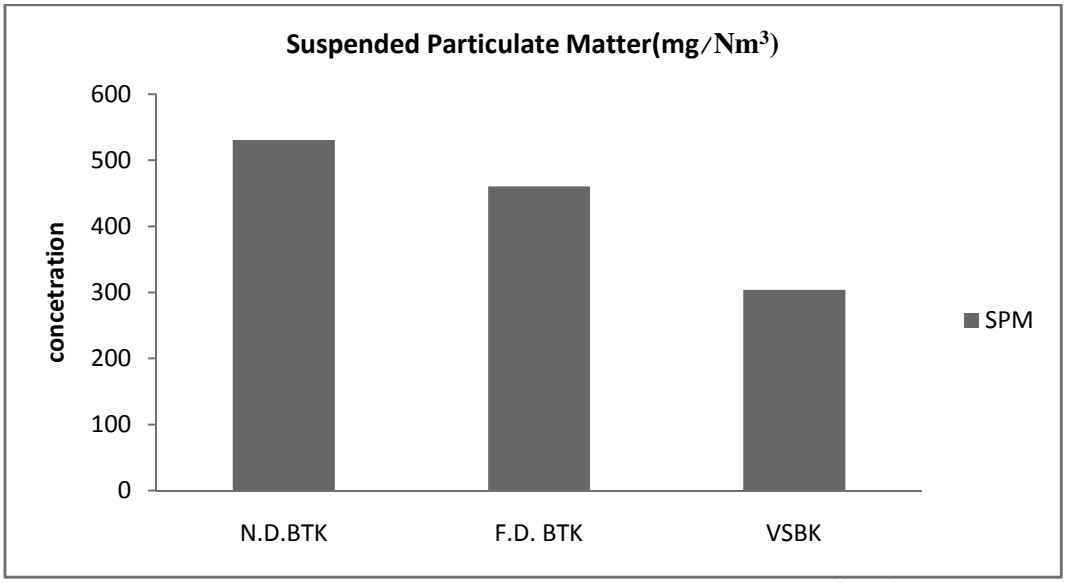
Results and Discussion

Status of Brick industry

During 1950s, Nepal faced the development of the brick manufacturing technology, later on improved to Clamp Kiln and Bull Trench Kiln for firing (Pokhrel and Lee 2014). According to 'All Nepal Brick Kiln Association there are around 104 brick kilns operating in Kathmandu valley. There are four main brick firing technologies prevalent in Nepal viz. Clamp Kiln MCBTK, Straight-line FCBTK with natural draught and forced draught, zig-zag FCBTK with normal and forced draught and VSBK. Hoffman technology was also introduced in Nepal in 1970s, but could not compete due to need for skilled manpower and high operating cost despite high quality product with bright feature and smooth surface (Pokhrel and Lee 2014). Government of Nepal has effectively banned MCBTK in the Kathmandu Valley since 2004 and out of the Valley in 2012 (MinErgy Initiatives, Nepal, 2013), providing FCBTK, VSBK and Tunnel Kilns as alternative options (Minergy, 2012). FCBTK with normal and forced draught are concentrated mostly in valley. The April earthquake and its aftershocks damaged more than 90% of the total brick kilns in the Valley. Most of them were built in traditional Bull Trench models that are inefficient, energy-intensive and polluting (DoEnv 2015, MinErgy Initiatives, Nepal. 2015). The demand for bricks is projected to increase over the coming months and years as the reconstruction following the earthquake adds to demand from an already booming construction industry (MinErgy Initiatives, Nepal. 2015*).* From the field visit it was observed that 100% of the 55 brick industry which was visited has reconstructed the Chimney and more than 90% industry had reduced the chimney height and changed the technology from natural draught to forced draught (DoEnv, 2015).

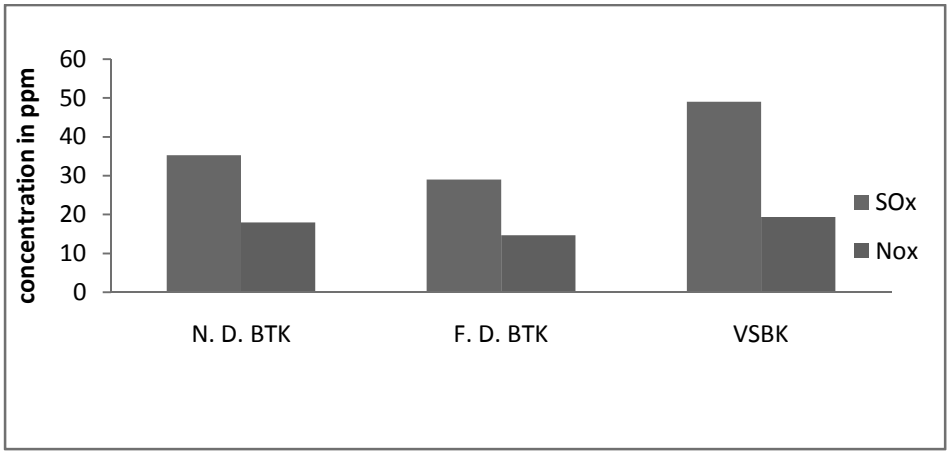
Emission from Brick Industry

Most of the brick kilns operated in Nepal use coal as a fuel for the burning of bricks. Burning of coal results emission of CO_2, CO, SO_X, NO_X and suspended particulate matter along with the flue gas from the chimney. It has been reported that brick kilns producing 350 million bricks annually are the major and single source of SO_2 and PM in the environment of Kathmandu valley (Maity, 2011). Monitoring of 15 different Brick kilns in Kathmandu valley and outside the valley showed the significant level of SPM in the stack emission. Average value of SPM, SO_x and NO_x from different types of kilns are shown as:



Source: Department of Environment (2014)

Figure1: Value of SPM from different types of kiln produced in 2014



Source: Department of Environment (2014)

Figure 2:Value of SOx and NOx from different types of Brick kiln in 2014

Emission of SPM from different types of kiln depicts that the pollution level of natural draught brick kiln is the highest whereas VSBK technology has the lowest of the three technologies. These values of SPM are within the emission standard of Government of Nepal. There is no standard for SO_X and NO_X; however these are the major pollutants

from the brick kiln. Several studies have shown that VSBK technology is the cleanest and energy efficient technology of the available technologies in Nepal. During monitoring of different kilns in Kathmandu valley, black smoke emission was observed which indicates high level of pollutants in the stack of the kiln.

Health and Environmental Impact of Brick kiln

Air pollution is a major environmental risk to public health. Exposure to air pollutants can break down natural defense mechanism in the body causing or contributing to respiratory diseases such as Lung cancer, Asthma, Chronic bronchitis and Emphysema. Air pollution can also have adverse impact on other important system such as cardiovascular system and central nervous system (Genc et al, 2012; Joshi and Dudani, 2008). Studies done on health impact of Kathmandu's air quality have also revealed that it is a major public health risk for the denizen of Kathmandu valley. MOPE in 2005 estimated that premature death of about 1,600 in Kathmandu valley is responsible for air pollution. Similarly a study conducted by NHRC/WHO based on the Environmental Burden of Disease (EBD) approach estimated 1926 cases of premature death per year (NHRC / WHO, 2009).

Air pollution has local as well as global impact. Acid rain, fog formation, bio diversity loss etc are the adverse impact of air pollution in environment. Industrialization is the major reason for acid rain because industries emit SO_X, NO_X, which form acid in combination with water. It causes extreme damage to plant lives, buildings, and contamination of lakes and rivers (EPA, 2012). Bio diversity of different areas can degrade due to air pollution because these entire chemical components affect the organism (WHO, 2011). As brick kilns use both the saw dust and coal, the study showed that brick kilns have both short and long term impact on Environment. Hamper in vegetation process, decrease in crop production, premature falling of plants fruits are short term effects whereas ozone depletion, global warming, photochemical smog, decrease in land fertility and decrease in water level are the long term effects (Pokhrel and Lee, 2011).

Top soil is the main raw material for the production of brick. Concentration of essential nutrients like Nitrogen (N), Phosphorus (P), and potassium (K) are very low in fields that have been used by the brick industry as the kiln use fertile topsoil (Tuladhar and Raut 2003). Burning of soil decreases the soil pH making it acidic, increase sand and decrease the clay content. It has serious impact on soil physical, biological and chemical

properties resulting sharp declination in soil fertility and productivity. To recover the production, farmers have been applying heavy doses of chemical fertilizers which have other harmful consequences (Thapa, 2011).

Legal Provisions

Environment protection Act-2053 and Environment protection regulation-2054 are the main umbrella laws to safeguard the environment and punish to the culprits for the noncompliance. Act emphasizes the protection of surrounding environment and control of any kind of pollution produced or emitted from the industries. Owing to its pollution level and impact in environment and human health, Nepal government has banned the establishment and operation of movable brick kilns in Kathmandu in 2003 and has been restricted throughout the country since 2012 (Minergy, 2012). Industrial promotion board, through its several decisions, has set some criteria and standards for the brick kilns emphasizing their sensitivity towards health and environmental degradation. Major decisions include operation of only fixed chimney, tunnel kiln or VSBK, compulsion of IEE or EIA prior to establishment of kiln, submission of soil use and reclamation plan before operation of kiln (191th meeting of Board), ban on use of wood, rubber, tire and plastics as fuel, maintain the minimum distance from the dense populated area; 1Km far for BTK and 500 m far from VSBK (169^{th} meeting of board) and maintaining the greenery around the kiln. Industrial enterprise Act, 1992 is the main act which governs all types of industries including brick kilns. Besides these rules and regulations, following emission standard has been enacted by Ministry of Population and Environment in 2006.

S.N.	Types of Kiln	SPM (Max Limit) mg /Nm3	Height of Chimney, Meter
1	BTK Natural Draught (Fixed Chimney)	700	30
2	BTK Forced Draught (Fixed Chimney)	600	17
3	VSBK	400	15

Source: Collection of Environmental Standards, Ministry of Science, Technology and Environment.

Despite the mentioned rules and regulation implementation of these laws is weak. Department of Environment under the Ministry of Population and Environment is main

regulatory authority for the compliance monitoring. Support from the governing ministry and relevant stakeholders are of prime importance for maintaining prescribed rules and regulation.

Conclusion and Recommendations

Brick industries are one of the major sources of air pollution in Kathmandu valley. SPM is the main culprit for the air pollution and Natural draught BTK technology is emitting comparatively high value of SPM. SO_X and NO_X emitting from the brick factories are also contributing for the ambient air pollution of Kathmandu valley. Hence several studies depict adverse health and environmental impact due to the pollution caused by brick kilns. Because of weak implementation of environmental standards related to brick, air pollution has become a severe problem of the Kathmandu valley. Based on the aforementioned conclusion following recommendation has been put forward.

1. Develop strategic air quality management plan by the concerned government authority (MoPE) to reduce air pollution in Kathmandu valley.
2. Promotion of cleaner and alternative technologies for the production of brick, thereby reducing the emission of SPM, SOx and NOx from kiln.
3. Strong Implementation of polluter pays principle also in brick sector and incentivize the entrepreneur who adopt environment friendly and cleaner technologies.
4. Introduction of stringent emission standards for the stack emission along with ambient standard limiting the value of SPM for brick industries and set the quality for fuel (coal) used in kilns.
5. Regular and effective monitoring of kilns for the control of pollution and to ensure the compliance of the stack emission standard as well as some other directives of promotion board.
6. Transform or replace the current BTK to energy efficient and cleaner technologies such as VSBK and Zig zag technologies for the brick production and also promote alternative of brick.
7. Conduct detailed study and extensive research on the health and environmental impact of pollution from brick kiln

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Water Quality and Sanitation of Dug Wells of Bara District, Nepal

Sadhana Pradhanang Kayastha[1]

Abtract

Groundwater is the main source of drinking water in the Tarai region of Nepal. The community depends on drinking water of dug wells and tube wells. The main of this study was to assess bacteriological water quality assessment of dug well and find out the status of risk of the well. A total of 3956 households are using dug wells. Altogether 12 dug wells are used by 230 households are selected randomly. The qualitative and quantitative faecal coliform analysis of water by Hydrogen Sulphide Paper Strip method in the field and membrane filter technique in Chromocult media in the laboratory. Sanitation status of the dug wells are analyzed by suing observation check list. The average risk score of ordinary well and sanitary well is found out 8 and 7 respectively indicating very high risk and urgent action needed to solve the problem.

Keywords: *ground water, water quality, risk, faecal coliform, checklist.*

Introduction

The majority of people living in the Terai region of Nepal depend on groundwater as their primary source of potable water. Access to safe water and adequate sanitation services has proven to be one of the most efficient ways of improving human health (Howard et al., 2003). Sustainable sanitation refers to economically viable, socially acceptable sanitation solutions that protect human health without contributing to environmental degradation (Cotton et al., 2010). Drinking water sources using by local communities in rural Nepal may be polluted due to several reasons. In Tarai region, the increment of poorly managed toilets is also one of the reasons of ground water contamination (MoPe 2001). In rural areas, more than half of the population has pit latrines (World Bank 1988). Nepal like other developing countries lacked adequate information on the levels of groundwater contamination from pit latrines. It is necessary to determine the extent of well water contamination in order to monitor likely danger to the public health (Amundson et al., 1998).

The supply of clean water is seen as the most fundamental strategy for controlling diarrheal morbidity (Gasana et al., 2002). In Terai region, water from dug wells and

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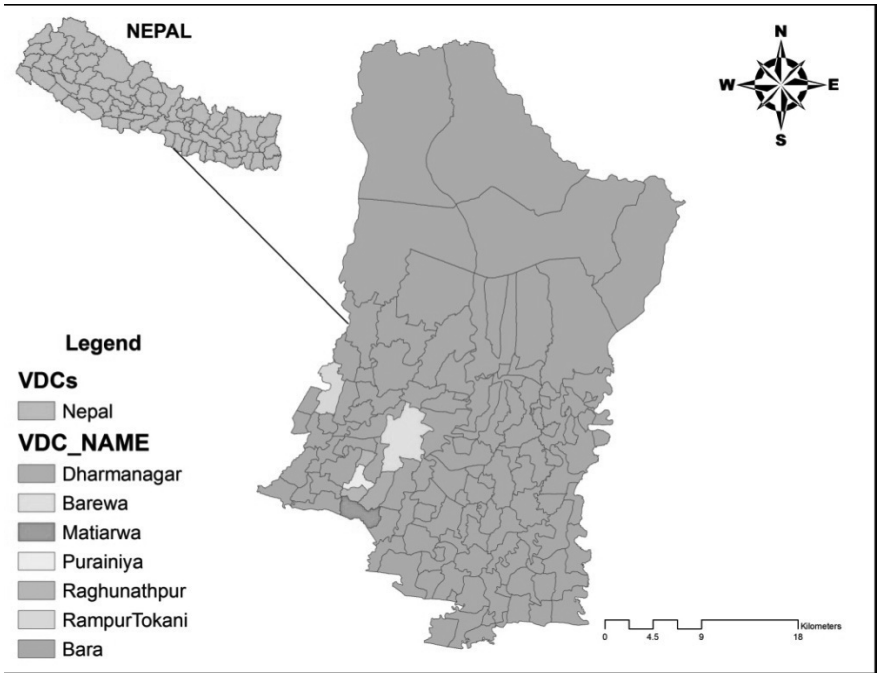
tube wells are contaminated with faecal indicator bacteria (DISVI 1990). This is one of the main causes of water borne disease increment trend (DoHS 1999).

There is widespread absence of piped drinking water in rural areas and as a result, the rural communities are using the most convenient sources of water such as spring, stream and tube-well in their areas irrespective of quality (MoPE 2001). Further, another reason of water pollution may be due to lack of proper conservation practice of water sources from human activities, animal grazing, among others. The contamination of drinking water may occur at their sources and consumption places due to ignorance or improper practice of storing water. Even if the drinking water sources are biologically clean, the collected water for domestic use may contaminate both outside and within the house environment through poor hygiene and sanitation practices (Pradhan and Pradhanang 2003). The main of this study was to assess bacteriological water quality assessment of dug well and find out the status of risk of the well.

Methodology

Study Area

Study district is Bara, which is surrounded by Rautahat district in east Makwanpur in North, Parsa in west and India in South. Bara district, one of the seventy-five districts of Nepal, is located in the south region of Terai (Figure1).



The majority of the people are using ground water as a source of drinking. The use of dug well had been replaced by tube well mainly due to the sanitary problem and people were able to install private tube well. The use of dug well has been increasing and people are renovating the old dug well for reuse even just for drinking and cooking purposes from the common well just to get rid of arsenicosis problem.

Research Method and Sample Design

A total of 3956 households are using dug wells. If assume 30-40 households are consuming water from one well then the total number of wells would be about 100 and the drinking water contamination is about 90% (ENPHO 2000) .More than 10 percent of the wells (12 wells) were chosen for the study.

Sample Selection

There are altogether 99 VDCs, out of those VDCs 9 VDCs are randomly selected, and if the VDCs does not have dug well then adjacent VDCs are taken. In an average 1-2 dug wells from each VDC are chosen randomly for the water sample collection. The sanitary status of the dug well was observed and recorded on the observation sheet prepared based on WHO (1996) criteria for dug well.

Water Analysis

The qualitative analysis of water was analyzed using bacteriological test kit of Hydrogen Sulphide Paper Strip Method (H_2S Method) in the field and for quantitative, membrane filter technique was used and analyzed in community medicine laboratory (APHA-AWWA-WEF1995). Chromocult media was used for bacteriological culture. For this analysis same day water sample was transported to the lab.

Observation Sheet

The information regarding the sanitation status of the dug well was filled in the observation sheet .It consists of overall physical state of dug well like crake, open/ closed, type of container, level of dug well (ground level or above ground) for water drawing/ from the also be filled and the status of risk of that well are to be found out

Results and Discussion

Altogether 12 sample dug wells were analyzed for the study (Table 1). There are about 220 households depended on these dug wells for water consumption. The drainage

system is very poor for all the study wells. Out of 12 dug wells four were newly improved dug wells, which were done by the initiation of Nepal Red Cross Society (NRCS) and community participation. This improved dug wells are mainly for the alternate option for the arsenic contaminated water consumed by the local community which is improved traditional dug well with cover, ventilation, well-plastered and about one meter raised from the ground level.

Water quality analysis showed that all the sample ordinary dug wells and 3 (75%) sanitary dug wells are contaminated with coliform bacterial (Table 2).

Quantitative Bacteriological Escherichia coli (E. coli) Water Test of Dug Well

Table 2 indicates that the number of E. coli per 100 ml water determines the quality of water. Higher the number of E. coli presents in the water the poorer the quality of water. This relation has been shown in the category and color code in Table 3. The water quality of the sample dug wells falls into category B – E showing that water of all the dug wells are contaminated and the risk level varies from low to very high (Table 3).

Sanitation Status of the Wells

For the evaluation of the sanitary status of the dug wells the observation checklist has been prepared. Two separate sets of check list one each for sanitary dug well and other for ordinary well has been used. Each question has risk score of one if yes as shown in table 5, 6 and 7. The question does not get mark if the answer is no. There are altogether 10 questions for risk assessment. The priority of action has been analyzed based on the risk scores as depicted in table 8, if the score is found out zero (0) which indicates no action required and the risk is low. Similarly if the score is 1-3, 4-5 and 6-10 then the priority action will be low, higher and urgent and the risk level will be low, medium and high respectively (Table 7). The average risk score of ordinary 8 wells and sanitary 3 wells have scored 8 and 7 respectively indicating very high risk and urgent action needed to solve the problem. One sanitary dug well has scored one indicating low risk and low action priority.

The Level of risk

Out of 12 dug wells analyzed, 11 dug wells with the average risk scores obtained by the specific diagnostic information for ordinary dug wells and improved dug wells are 8 and 7 respectively (Table 4 and 5). These scores are analyzed taking reference of color code

scheme for Escherichia coli in water samples and found out the risk is very high for both types of wells and its action should be considered urgent (Table 7). One dug well with no bacterial contamination (Table 2 and 3) and risk score of sanitation status of the dug well has been obtain by 1 (Table 7) which has been compared with risk level analysis from the color chart and shown low risk and low action priority.

Most of the dug wells are stopped using because of the unsanitary problems due to which epidemics of outbreaks of the water borne diseases occurred seasonally in many places. One fundamental problem in drinking water is how to make it potable so that mass general people would be healthy and can contribute to the productive work. Drinking water sources using by local communities in rural Nepal may be polluted due to several reasons such as unprotected source, unhygienic use of the source water, open defecation near the source, waste dumping nearby, washing and bathing above the reservoir etc. (Pradhan and Pradhanang 2003), In Tarai region, and the increment of poorly managed toilets are also one of the reasons of ground water contamination (MoPE 2001). In present study poor drainage and poor surrounding of the wells are the main cause of water quality deterioration. Generally, as the distance of water sources from human settlement localities increases, the amount of water required for household use decreases and thus the health condition of people deteriorates. There is widespread absence of piped drinking water in rural areas and as a result, the rural communities are using the most convenient sources of water such as spring, stream and tube-well in their areas irrespective of quality (MoPE 2001). In the present study not only the distance but also due to the arsenic contamination of hand pumps 20-30 households depends on one dug wells (Pradhan, 2000). More than 90% of dug well water is showing feacal contamination. But the community is not aware with the situation. This could be the reason that diarrheal disease in this district has occupied the second position which in contrary to the national context where it is the third position (DoHS 1999). SODIS method of disinfection is playing important role in treating water contaminated with faecal coliform bacteria (Pradhan and Pradhanang 2003 and ENPHO 2003). As the communities are not aware with the situation, the sharing of the result plays significant role to make them aware about the problem (Pradhan *et.al.*, 1995). The present study also shared the result with the communities and for intervention SODIS disinfection has been suggested.

Conclusion

People are using dug wells for drinking purposes and other domestic activities. All the water from dug wells is not advisable for drinking purposes except one. Even the wells which are provided as sanitary dug wells are contaminated. Most of the wells used by the communities for drinking and other activities have higher risk and required urgent action for further use. Only one well has shown no bacterial contamination with low risk with low action priority. There is the urgent need for the promotion of the delivery of sustainable water supply, sanitation and hygiene services by improving the water quality at the source through adequate protection of well water, treatment and provision of alternative sources such as improved pipe-borne water to the people. The potential remedial actions were also suggested in order to improve the source protection of such supplies.

Acknowledgments

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Table 1: Dug wells considered for the study

SN	Name VDC	Tole name	Number of HH user	Type of use	Remarks
1	Barewa	Barewa		All	O-DW
2	Barewa	Barewa		All	O-DW
3	Rangapur	-		All	O-DW
4	Parsa	-	15-20	All	O-DW
5	Parsa	Teliya Tol	>50	All	O-DW
6	Rampur		8-9	All	O-DW
7	Dharamnagar	Sitalpur	8-10	All	I-DW
9	Dharamnagar	Sitalpur	25-30	All	I-DW
10	Matiarwa	Matiarwa	20-25	Except drinking	I-DW
11	Raghunathpur	Jotpur	10-15	All	I-DW
12	Purainiya	Gamairiya	40-50	All	O-DW

O-DW = Ordinary Dug well, I-DW = Improved dug well, HH = House hold

Table 2: Qualitative Bacteriological (Coliform) water test of Dug well

Sample wells	Number	Coliform bacteria	
		Presence (+)	Absence (-)
Ordinary dug wells	8	8	
Sanitary dug wells	4	3	1
Total	12	11	1

Table 3: Classification and color code scheme for E. coli in water samples from the dug wells

Count/100 ml	Category and color code	Remarks	Water Samples
0	A (Blue)	No risk	1
1-10	B (Green)	Low risk	1
10-100	C(Yellow)	Intermediate risk	5
100-1000	D(Orange)	High risk	5
>1000	E (Red)	Very high risk	
		Total sample tested	12

Table 4: Risk Score for Sanitation Status of Ordinary Dug well (n = 8)

Specific diagnostic information for assessment	Risk	
	Yes	No
1. Is there latrine within 10m of the well?		
2. Is the nearest latrine on higher ground than the well?		
3. Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 m of the well?	8	
4. Is the drainage poor, causing stagnant water within 2 m of the well?	8	
5. Is the wall around the well inadequate, allowing surface water to enter the well	8	
6. Is the concrete floor less than 1 m wide around the well?	8	

7. Are the walls of the well inadequately sealed at any point for the 3 m below the ground?	8
8. Are there any cracks in the concrete floor around the well which could permit water to enter the well?	8
9. Are the rope and bucket left in such a position that they may become contaminated?	8
10. Does the installation require fencing?	8
Total risk score considered for the improvement of the dug wells	10
Average risk score obtained for improving the dug well	8

Table 5: Risk Score for Sanitation Status of Sanitary Dug well (n = 3)

Specific diagnostic information for assessment of Improved dug well	Risk Yes	No
1. Is there latrine within 10m of the well?		
2. Is the nearest latrine on higher ground than the well?		
3. Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 m of the well?	33	
4. Is the drainage poor, causing stagnant water within 2 m of the well?	3	
5. Is the wall around the well inadequate, allowing surface water to enter the well	3	
6. Is the concrete floor less than 1 m wide around the well?	3	
7. Is there any ponding on the concrete floor around the hand-pump?	3	
8. Is there a faulty drainage channel? Is it broken, permitting ponding?	3	
9.Is the hand pump loose at the point of attachment to the base?	3	
10. Is the cover of the well unsanitary?		
Total score points considered for the improvement of the dug wells	10	
Average Score obtained for improving the dug well	7	

Table 6: Sanitation Status of Sanitary Dug well with no Bacterial Contamination (n = 1)

Specific diagnostic information for assessment of Improved dug well	Risk Yes	No

11. Is there latrine within 10m of the well?	
12. Is the nearest latrine on higher ground than the well?	
13. Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 m of the well?	
14. Is the drainage poor, causing stagnant water within 2 m of the well?	1
15. Is the wall around the well inadequate, allowing surface water to enter the well	
16. Is the concrete floor less than 1 m wide around the well?	
17. Is there any ponding on the concrete floor around the hand-pump?	
18. Is there a faulty drainage channel? Is it broken, permitting ponding?	
19. Is the hand pump loose at the point of attachment to the base?	
20. Is the cover of the well unsanitary?	
Total risk score points considered for the improvement of the dug wells	10
Average risk score obtained for improving the dug well	1

Table 7: Level of Risk Analysis

CD	0	1	2	3	4	5	6	7	8	9	10
E											
D											
C											
B											
A											
	No action required	Low risk Low action priority			Intermediate to high risk Higher action priority			Very high risk Urgent action			

CD = Color code

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Comparative Study of Indigenous Communities Traditional Knowledge in Agricultural Practices to Combat Climate Change

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Abstract

This paper deals with the role of Indigenous Traditional Knowledge in an agricultural system of locally evolved practices that are used by the Indigenous communities in three climatic zones in Western region of Nepal. The intent of the paper is to highlight the importance of Indigenous Traditional Knowledge in agriculture and its role in adaptation to Climate Change.

All primary and secondary data were collected and verified. Data and information were collected using PRA tools application in field. Dunnai, Bhallacha and Shivapur of Dolpa, Rukum and Bardia district respectively were selected as the survey site because these represent (i) different agricultural activities, (ii) the demographic and social settings are very different iii) presence of indigenous community and iv) ranked as vulnerable to Climate Change. During interaction with people, government authorities and stakeholders who compared their traditional agricultural practices with modern farming while most of the farmers agreed Indigenous Traditional Knowledge is the best way to adopt. It is farmer oriented and evolved by the farmers. Modern technologies are developed by researchers and often not suited to the local environment.

Aiming to promote through mainstreaming media, few articles were published, promoted through social media and documentary was made out of the basic concept from three regions. The training programs for extension workers, regional research, awareness among the farmers on the role of Indigenous Traditional Knowledge in agricultural for adaptation is very necessary in the context of Nepal.

Keywords: *climate change, indigenous traditional knowledge*

Introduction

The impacts of Climate Change are more pronounced in agricultural systems. Erratic climatic pattern, rainfall, unprecedented fluctuations in annual temperature and pest outbreaks affects agricultural productivity. Stopping the cause of Climate Change in beyond the scope of farmers they nevertheless can adapt to farming practices to an

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extent that minimizes the potential productivity losses in Nepal. Climate Change impacts have affected the livelihood of rural farmers. To some extent rural farmers have leveraged their indigenous knowledge to adapt to the changes. Indigenous Traditional Knowledge is the acquired knowledge of indigenous peoples through time and space. The two types of Indigenous Tradition Knowledge, namely Indigenous Traditional Knowledge as technology and indigenous traditional knowledge as cognitive facilitator of development (Varte, 2012).

Indigenous practices though have contributed to limit the impact of changing climate, lack of proper documentation and promotion of these practices hinders in evaluating their effectiveness and transferring the knowledge.

Objectives of the Study

- To explore, understand and identify the effects of Climate Change and Indigenous Traditional Knowledge used in agricultural practices to combat Climate Change effects in the three climatic zones of Nepal.
- To document identified issues, knowledge, skills and ways to sustain ITK within the community.
- To promote Indigenous Traditional Knowledge as solution to Climate Change on agricultural practices through mainstreaming media

Methodology

Qualitative research methods focus on discovering and understanding the experiences, perspectives, and thoughts of participants—that is, qualitative research explores meaning, purpose, or reality (Denzin & Lincoln, 2005). For primary qualitative data collection PRA tools was used during the research period.

Sampling frame: The households containing Indigenous communities in the wards of VDC's were the sampling sites.

Inclusion criteria: The households out of total within the wards of VDC's which contained indigenous people who are involved in agriculture were included.

Sampling method: A simple random sampling of the total household was done to select the households to be surveyed because the population was homogenous.

Sample size: The sample size was taken from 15% (20 households in Dunnai), 26 % (20 household in Bhallacha and 11% (20 household in Shivapur) of the total number of households. Here, n= 20 households and the Total household, N= 130 (wards of Dunnai), 75(wards of Bhallacha), 182 (wards Shivapur). Following equation was applied to obtain an estimated sample size.

$p = 1- N-1 / N\times N-2 / N-1.....N-n/N- (n-1)$

p = 1- N-n/N

P = n/N

Primary Data Collection

Primary data and information was collected through field visit, questionnaire survey and key informants interview (KII), Focal Group Discussions (FGDs).

- **Mapping and modeling**- The first step in the research was mapping and modeling. It was used to obtain spatial information of the area. Information gathered helped to verify the information on the sketch map. A transect through an area with local informants helped to learn different condition, problems of the area, environment, agriculture, social and economic condition, changes in environment.
- **Questionnaire Survey**
  Based on the no of households in the VDC's, sample size was determined. In order to generate reliable and valid data and minimize errors, a probability technique was applied to determine the sample size.
- **Semi Structured interview-** The individual interview-representative information about the Climate Change and Indigenous Traditional Knowledge from individual informants including people from CBO"s NGO's and VDC's was collected from all three places.
- **The key informant interview**- specialized information from one or group of persons about the Climate Change and ITK. The interviews were carried out with government authorities for depth knowledge about the place and practices.
- **Focus Group Discussion** -It was useful for obtaining general information about the past and present situation, the different in climatic condition and method used for adapting it during FGD's.
- **Seasonal calendar**- A seasonal calendar helped present large quantities of diverse information in a common time frame. These yearly cycles are important in determining the change in the situation, impact due to Climate Change and their adaptation techniques. Information collected during the drawing of the seasonal calendar is very rich, not only in terms of what is put down by the community, but also in what comes out from the discussions during the process.

Secondary Data

Secondary data was collected from the relevant journals, magazine articles, books, web site, thesis reports, and official records.

Results and Discussion

Comparative study

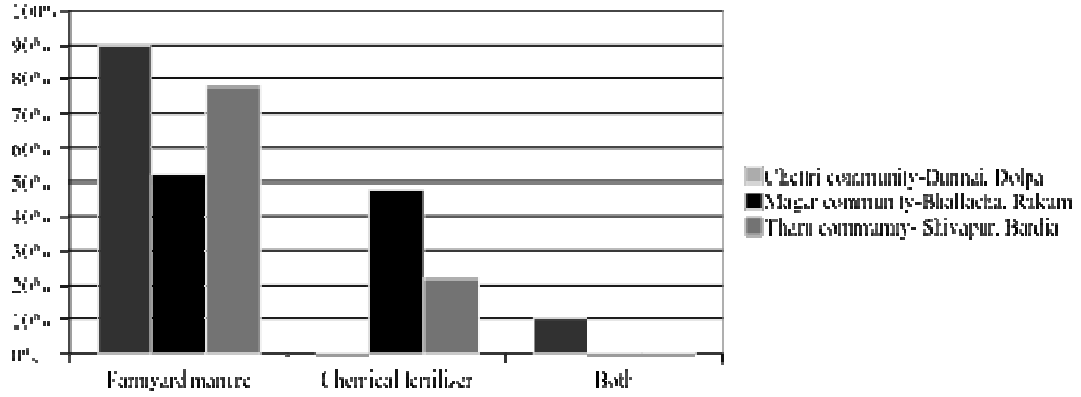

Figure 1: Use of fertilizer in three climatic zones of three indigenous communities

According to figure 1, in all three places people are still using farmyard manure. Chemical fertilizer has been introduced and people are experimenting it. While experimenting in Dunnai people have now either stopped using chemical fertilizer or started using both according to situation and crops, realizing that it gives less production after few years. In Bhallacha, some people have started using chemical fertilizer and have observed higher production but most of them still prefer farmyard manure. In Shivapur, they have already observed how chemical fertilizer destroyed their soil quality along with giving less production after some years, so people prefer to use farmyard manure.

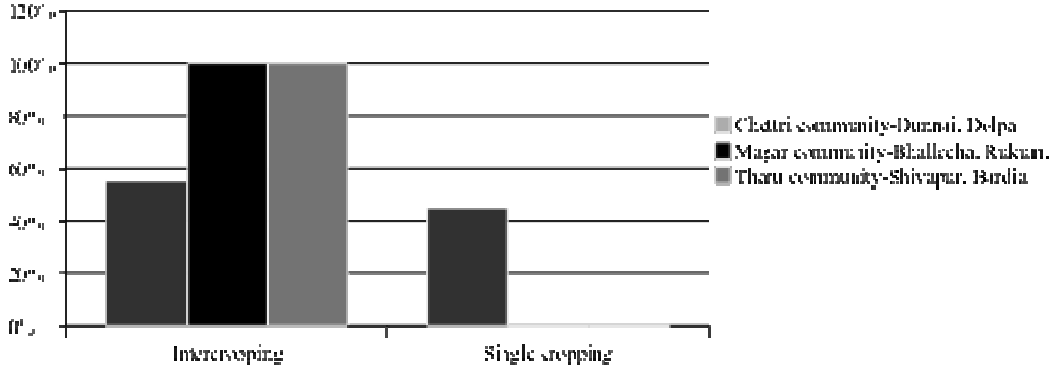

Figure 2: Agriculture practice in three climatic zones of three indigenous communities

According to above figure 2, in all three places people are practicing intercropping. In some of the higher altitude of Dunnai some people practice single cropping.

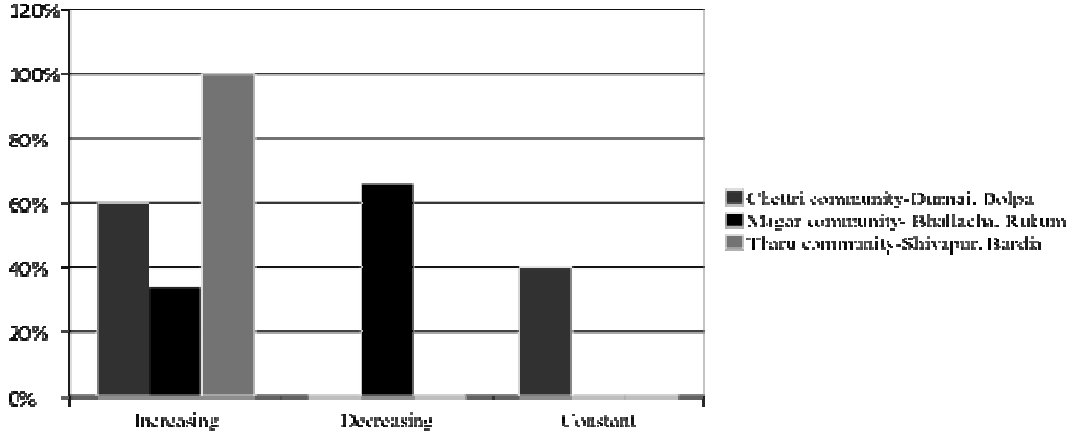

Figure 3: Pest attack in crops in three climatic zones of three indigenous communities

According to above figure 3**,** in Dunnai and Shivapur, pest attack in crops is increasing as result of rise in temperature, less and irregular rainfall but in Bhalllacha this change has resulted in decreasing pest attack in crops.

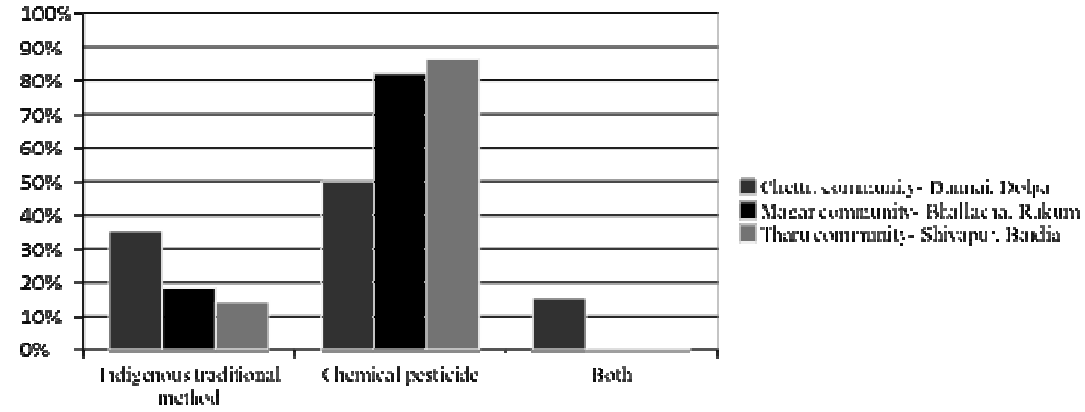

Figure 4 : Use of pesticide in crops in three climatic zones of three indigenous communities

According to above figure 4, in all three places people are using chemical pesticide knowing the fact that homemade pesticide is good. They are using it because homemade pesticide is not possible to manufacture for large scale agriculture.

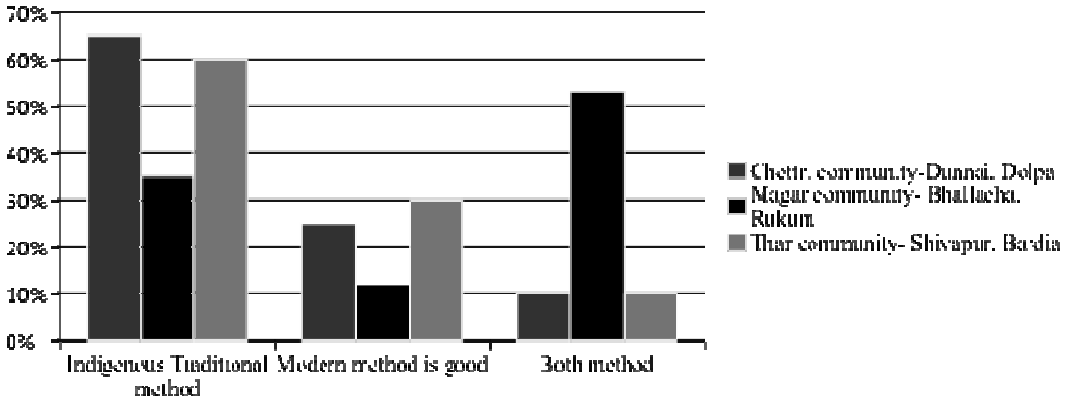

Figure 5: Indigenous Traditional Knowledge and its adaptation to Climate Change in three climatic zones of three indigenous communities

According to figure 5, in all three places people agree on fact that indigenous method in agriculture practices are more sustainable, cost-effective, environment friendly and adaptive to changing climate.

Precipitation and Temperature Data
Test interpretation
H_0: There is no trend in the series
H_a: There is trend in the series

The data was taken from DHM (Department of Hydrology and Meteorology) of nearest place to survey site. Analysis of precipitation data was carried out by using Mann Kendal Test, the value of p-value (Two-tailed) is calculated using exact method. As the computed p-value is lower than the significance level alpha=0.95, one should reject the null hypothesis H_o, and accept the alternative hypothesis H_a. The risk to reject null hypothesis H_o while it is true is lower than 64.24%. According to the test, there is trend in the series of rainfall data of Rukum from 1984 to 2012. The trend of Average precipitation is decreasing by 0.443mm Sen's Slope every year, which is a sign of climate variability.

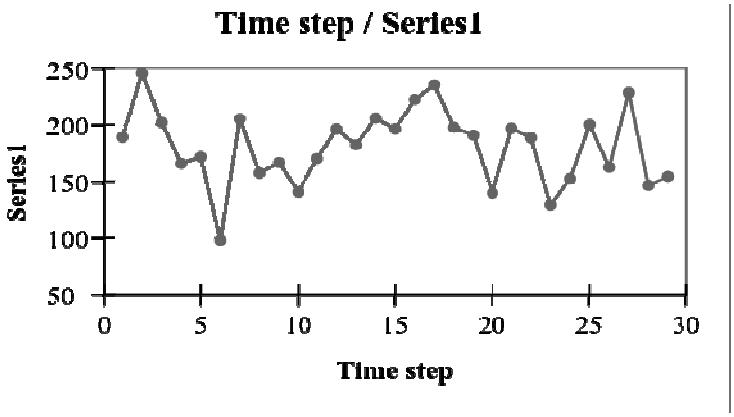

Figure 6: Rainfall data of Musikot, Rukum

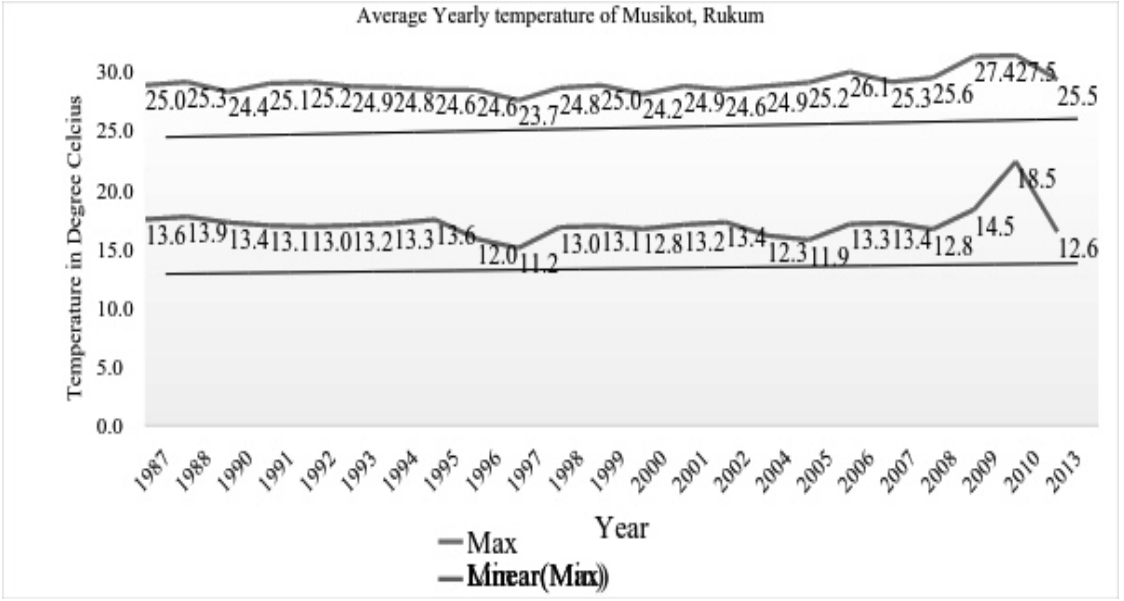

Figure 7: Average max and min temperature of Musikot, Rukum

Test interpretation

H_0: There is no trend in the series

H_a: There is trend in the series

The data was taken from DHM of survey site. Analysis of precipitation data was carried out by using Mann Kendal Test, the value of p-value (Two-tailed) is calculated using exact method As the computed p-value is lower than the significance level

alpha=0.95, one should reject the null hypothesis H_o, and accept the alternative hypothesis H_a. The risk to reject null hypothesis H_o while it is true is lower than 0.01%. According to the test, there is trend in the series of rainfall data of Dunnai from 1984 to 2012. The trend of precipitation is decreasing by 1.254mm Sen's Slope every year, which is sign of climate variability.

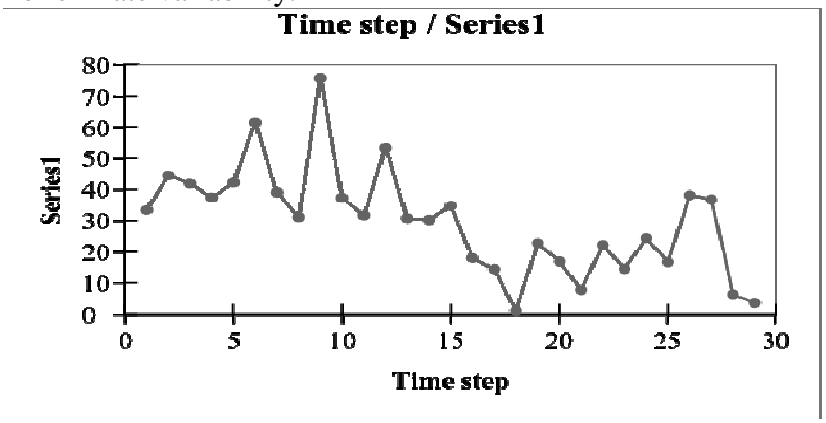

Figure 8: Rainfall data of Dunnai, Dolpa

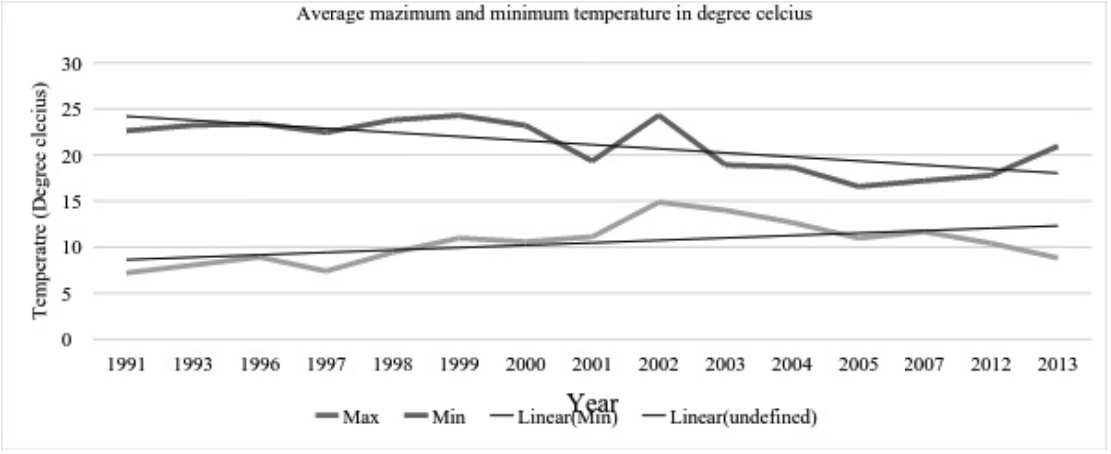

Figure 9: Average max and min temperature of Dunnai

Test interpretation

H_0: There is no trend in the series

H_a: There is trend in the series

The data was taken from DHM of nearest place to survey site. Analysis of precipitation data was carried out by using Mann Kendal Test, the value of p-value (Two-tailed) is calculated using exact method. As the computed p-value is lower than the significance level alpha=0.95, one should reject the null hypothesis H_o, and accept the alternative hypothesis H_a. The risk to reject null hypothesis H_o while it is true is lower than 7.49%. According to the test, there is trend in the series of rainfall data of Bardiya from 1984 to 2012. The trend of precipitation is decreasing by 1.417mm Sen's Slope every year, which is sign of climate variability.

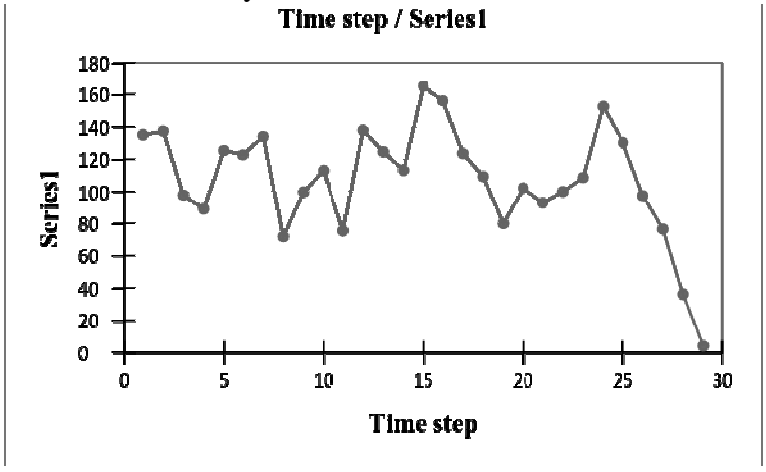

Figure 10: Rainfall data of Gulariya

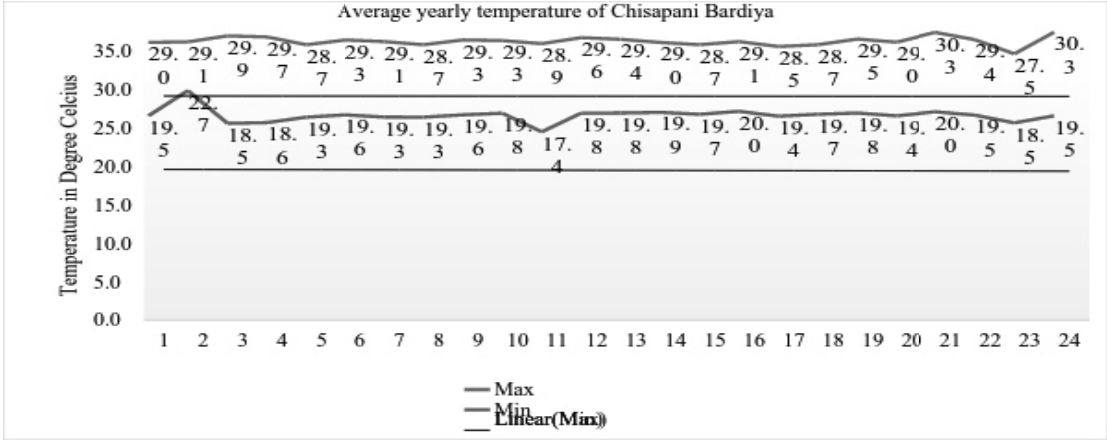

Figure 11: Average yearly data of max and min temperature of glulariya

Indigenous Traditional Knowledge and its adaptation to Climate Change

According to people in three places Indigenous Traditional Knowledge in intercropping of *Glycine max*(soya beans), *Solanum tuberosum* (potato) with *Zea mays*(maize) and *Pisum sativum* (pea) with *Avena sativa* (oats) are practiced because the beans are well grown while cultivating in-between the maize, support (local name: ***Thakra***) is also not required and attracts parasitic wasps that control corn earworm and at the same time serves as weed cover. Scientifically, intercropping crops with legumes may be an important food security strategy in the context of Climate Change (IDRC, 1996). According to Scheidegger(2008), intercropping has a higher biological efficiency than sole cropping because of better buffering against climate extremes, more efficient use of resources(light, nutrients and water), less problems with pest and diseases.

In Dunnai, Soyabean are grown at the ditch of land with paddy and *Cannabis sativa* (local name: ***Bhango***) plant is planted at the edge of agricultural land so that they can produce oil from it though it has scientific benefit, it lays a branch primary root that reaches a depth of 2 to 2.5m and a branch of secondary nodes that grows between 60to 80cm below ground. It is versatile crop that will grow and adapt to any soil and climatic condition with the minimum requirement of abundant irrigation or moisture (Adnan M. Esmail, 2010).

In Bhallcha and shivapur, they practice mulching in ginger to control weeds. They use ***Ausuro*** and ***Khirro*** for mulching purpose as these works as a pest control which is an Indigenous Traditional method. According to Scheidegger (2008), mulching helps for better water balance, sustained soil fertility, higher soil organic matter content, it can offset reduced rainfall, buffer erratic rainfall distribution, reduce soil temperature and store more carbon.

Most of the people in village in three places use the farmyard manure in Indigenous Traditional way. Farmyard manure helps to cope with this changing situation because it demands less water. It increases organic matter in soil which in cropping system will be critical to retain water, increase yields and reduce risk in rain fed agriculture while sequestering carbon, it helps to repair ecosystem and increases the resilience of both people and landscapes to Climate Change. Reduces agriculture's greenhouse gas emissions and increases carbon sequestration, it strengthens food security and delivers environmental benefit (Climate Smart Agriculture, The World Bank).

Homemade pesticides like liquid obtained from boiling of cow bone, cattle urine, ash application, dipping *Urtica plaviflora* (***Sisno***) in water for 12 hours; mixing *Juniperus indica* (***Dhupi***) in cow urine etc. is used to control pests in crops. According to Khanal(2010), organic agriculture provides better result in many aspects of environmental issues compared to conventional agriculture. So, Indigenous Traditional

method might be the best way to control pest without any side effects on environment, soil and plant production itself.

Conclusion

In initial days of our research, we were under belief that Indigenous Traditional farming practices and its related properties would have been totally lost. The research work was frequently attacked by people favoring modern technologies and Chemicalization of agriculture. For some time, during meetings with Government authorities in Rukum, some of the times we felt we were treated to be anti-development and advocates of old traditional methods. When we went into discussion with staff of agriculture development agencies about validity of indigenous methods of subsistence that were still under use of majority of farmers, the initial response was less towards indigenous practices in Rukum and Bardia but authorities of Dolpa were more agreed on fact Indigenous Traditional Knowledge and its effectiveness and said integrating best of Indigenous Traditional Knowledge and modern technologies would give good result to combat Climate Change. While visiting all three places, interacting with people and according to analysis of DHM data, changes in precipitation and temperature within last thirty years was found which is affecting agricultural system.

Indigenous Traditional Knowledge is passed on and modified from generation to generation and from farmer to farmer, whereas modern technologies are communicated from researchers via extension personnel and/or farmers. Different Indigenous Traditional Knowledge practiced by these three indigenous communities which helps in combating Climate Change are: intercropping, crop Rotation, crop shifting, mulching, use of farmyard manure, homemade pesticides, use of local tools in field, irrigation, storage of local seeds and grains, landraces which are more resistant to changing environment and other traditional way of agriculture practice.

Some of the problem that has made people shifts towards modern practices:

Lack of understanding of traditional agriculture which further leads to a communication gap between promoters and practioners giving rise to myths such as local seed gives less production, it takes long time for preparation of Farmyard manure. 2. The accomplishments of farmers by using their own ITK often are not recognized, because they are not recorded in writing or made known; and 3. Poor involvement of farmers and their organizations in integrating, consolidating, and disseminating what is already known.

The motives were to highlight, document and promote Indigenous Traditional methods under use by farmers which are in verge of lost. Promotion of the Indigenous Traditional Knowledge documented was done through social media, articles and documentary (.https://www.youtube.com/watch?v=KMEKNshBqcs). Here,

documentation and screening of Indigenous Traditional Knowledge is necessary before the valuable information is lost forever. It may be an alternative, a substitute or a complement to modern technology; it may generate ideas for future research.

Acknowledgements

At the outset, we Authors would like to express our gratitude and also acknowledge Korean Green Foundation for the financial support, Youth Engagement in Sustainability (YES Nepal) and Tourism Development Endeavors (TUDE) for supporting concept and believing me without which my purpose would be countless. We are grateful to Mr. Niraj Tamrakar and Ms. Sabina Karki for support in documentary making and assisting during entire thesis period.

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Feasibility Study of Waste to Energy Potential with the Focus on Bio Digester Optimization

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Abstract

Increasing amount of municipal solid waste (MSW) is becoming an issue for municipalities Nepal. The best method for dealing with MSW is converting it into energy using efficient anaerobic digestion technology. Temperature enhancement is necessary especially in hilly areas where temperature is low. The average waste generation in 2015 was 0.31kg/day/capita of ward no. 8 Chyasal of Lalitpur Sub Metropolitan City (LSMC) with the organic fraction of waste 70.3%. The bio-digester can be optimised using solar heated system and sawdust as insulation for the effective temperature maintenance. The feeding of waste per day was 266 kg for 35 m^3 of digester with same amount of water. The amount of energy production increases by 35 MJ using sawdust along with heated water. The solar heated system was designed for 35m^3 of bio digester. Total amount of heat required by the digester for the mesophilic range was determined to be 18918 KJ .The total yield of methane from 35m^3 is 6.72m^3.The payback period was 6.2 years and IRR was 10% for digester using sawdust as insulation and 3.4 years and 21% for digester using solar heating technology. Solar heating technology was seen to be more effective with comparison to insulation method.

Keywords: *municipal solid waste, anaerobic digestion, solar technology, sustainable waste management*

Introduction

The proper management of increasing amount of solid waste has become a serious issue in Lalitpur Sub Metropolitan City (LSMC) of Nepal (CBS, 2011). With its limited resources and capabilities, LSMC at present has been able to collect nearly 60 tons/day, while the remaining 15 tons are somehow managed by private sectors and at individual levels according to baseline study (SWM, 2012). The best solution is design of efficient anaerobic digestion technology (Jha et al, 2010). Different heating technologies are also under research and in practice (MinErgy, 2014).

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Some organisations and private sectors are working in small sector only but there is no best practice of any technology for proper disposal of waste all along the valley.

This paper reviews the present waste generation pattern of Chyasal, wards no. 8 of LSMC of Nepal and presents the efficient heating and insulating technology to get the maximum efficiency of biogas digester.

Methodology

This study was conducted in Chyasal of LSMC by surveying, visiting collection points, transfer points and transfer stations .For the survey and investigation, relevant data was collected from 111 houses, municipality office, government organizations, NGOs, internet and literature reviews. The cost for installation of biogas, the subsidy provided by the government for installation of the biogas plants, the materials required for construction of the biogas plant and other data was collected by visiting in these organizations.

The total numbers of 50 houses were surveyed for the collection of amount of waste. The separate plastic was distributed among the houses and was informed to use them for waste collection of organic and inorganic separately. The waste detail is taken from waste of two different days separately and average was done.

The details of temperature (average high temperature and average low temperature) of every month were received from the Department of Meteorology, Lalitpur.

The technical analysis and design of digester heating technology was carried out through desk study of different journals from science direct, national and international reports and consultation from experts. The detail design consists of design of solar water heater, design of heat exchangers and pump in solar heating technology and design of outer wall, design of slab and calculation of amount of sawdust in insulation technology.

Working with Insulation

The second wall was built to ensure maximum insulation of the biogas digester with sawdust (MinErgy, 2014).
It was at same level to the main digester to keep the insulating material within the gap of the two walls. After plastering of the second wall, dry sawdust was put between the two walls. The insulated bio-gas digester was fed with organic waste. The required amount of saw dust was also calculated. The number of slab was put above the level of sawdust to seal or to avoid percolation of water and to avoid the entry of soil. The hot water is used by heating with the electricity and passed through the digester to increase the temperature to reach the optimum temperature.
The heat loss from the biodigester wall before insulation was calculated using the following formula.
The Total digester heating requirement is given by,

$$Q_{Total} = Q_T + Q_L$$

(Source: Engineering Thermodynamics, 2008)

Q_T= Rate of heat transfer to raw manure influent
Q_L= Rate of heat loss through digester walls, floor and roof

$$Q_T = m \times c \times (T_2 - T_1)$$

$$Q_L = \frac{T_2 - T_1}{R_{th}}$$

Resistance to heat flow is given by

$$R_{th} = \frac{L}{K \times A}$$

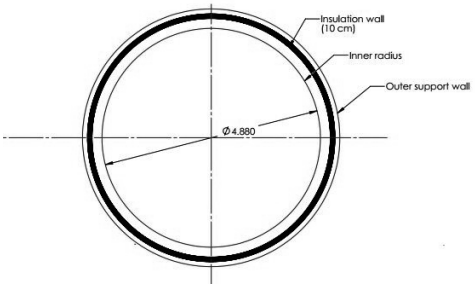

Figure 1: Plan of digester using sawdust

Working with Solar

The solar water heater is used in this method to heat the water. The heated water is circulated through the heat exchanger through the heat exchanger inside the bio digester. The water is used only to increase to increase the temperature of the digester to reach the optimum temperature. The pump is used to circulate the water in the entire system. The temperature sensor is used to notify when the required temperature of the water is gained. In the sunlight the collective array absorbs the solar energy and converts it into heat energy to heat the water (Prajapati, 2002). Total water required temperature of the water, total energy required by the digester, power of the pump and the design for the heat exchanger is to be determined for the system.

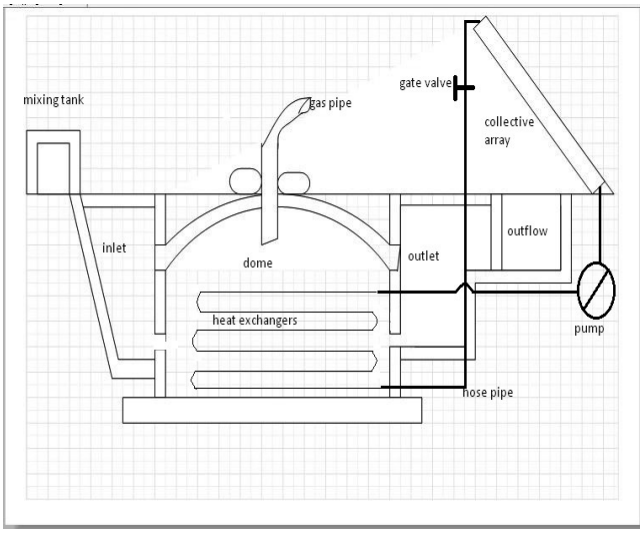

Figure 2 : Digester using solar technology (Tiwari et al 1996)

The data collected was processed, reviewed and edited. The data was analyzed and manipulated using relevant statistical tools and computer software.

Results and Discussion

The total potential of waste the from ward no. 8 Chyasal has been projected by surveying 50 houses with the population of 738. The per capita waste generation was 0.31 kg/day. The total population of this area was 12639 (CBS, 2011) and the waste production was 2763 kg. The total waste collection in ward 8 of LSMC is estimated to

be 2.763 MT/day .However the value may differ 10% - 20% because of estimation based on the quantification technique. Assuming 65% of the waste has been collected (SWM, 2012) 1800 kg/day was collected. The digester volume required for this waste accounts 148.4 m^3 .So, four no. of bio-digester of 35 m^3 can be proposed for this site with the biogas yield of 69 m^3. The total energy production per day was 1518MJ/m^3 from the biogas technology.

The average temperature of Lalitpur district was around 20 ^{o} C but the temperature inside the digester is more than this. So we have taken the average temperature as 22°C (Dhakal, 2012) and the required temperature for digester was around 30 ^{o} C - 35 ^{o} C (Boissevain, 2012). The total loss of the digester is also considered with the energy required by the manure to reach the required temperature.

The heat required to raw manure influent and heat lost was calculated as 18916 KJ and 1826.89 KJ respectively.

Contribution in GHG Emission Reduction

The biogas plant has been contributing for mitigating the climate change by reducing the green house gases as methane which is the second most important greenhouse gas. From 35 m^3 biodigester, the production of methane was 6.72 m^3/ day which is equivalent to 32.42 tonnes of CO_2. So, the total cost saving from GHG emission reduction is Rs. 22692.

Solar Water Heater

Taking the water temperature for bio digester, 40^0C the volume of water to be used is 225 litres 0.225$m^{3.}$ Then the length of pipe is calculated as 106 m. The density of copper is 8960 kg/m^3. So, the required mass is 7.5 kg of copper. The spacing for the coil is 3.91 cm. The temperature of water inside the solar water heater should be 40.5 ^{0}C which is controlled by the controlled valve used in the system. Hence the total number of panels on the solar panel is 1 for the efficient production of the biogas at the average temperature of 20^o C. The 120W circulatory pump of "lonkey" company has been used in this project.

Insulation Using Sawdust

This includes two walls with dry sawdust intermediate between them. The second wall was maintained at same level as first digester. The quantity of water circulated was 266 litres. The electricity required to heat this water is 6.2 units. Annual cost of electricity was Rs.27156.

The outer radius of digester was calculated as 2.66 m with height of 2.66m.The critical thickness of calculation was 0.06 m and for ease it has been taken as 0.1 m.

The volume for insulation was 1.99 m^3 with the mass of sawdust 418.15 kg taking density of sawdust as 210 kg/m^3. The total cost has been estimated as Rs. 8353 considering unit kg cost as Rs. 20.

The design criteria for the slab has been adopted on the basis of ease of handling .The no. of slab required was 41 with 0.11 m thickness and the outer wall volume accounts of 2.28 m^3.

Financial Analysis

As per this place the cost of installation of Biogas plant costs NRs. 20,000 per m^3 (Anon, 2014). So for constructing 35 m^3biogas plant the total average cost would be NRs. 7, 00,000. There also include the cost of insulating material, outer support wall and slab material. The total installation cost is NRs.827199. For sawdust, changing interval is 5 years. For ease of calculation the future worth of sawdust is converted into pw and added in installation cost.

Table 1: Financial analysis of insulation method including GHG

Discount rate	8%	
NPV (NRs.)	1384982	
B/C ratio	1.9	
Payback period	6.2	Years
IRR	10%	

For constructing 35 m^3 biogas plant the total average cost would be NRs. 7, 00,000. The total installation cost of bio digester using solar technology is NRs. 758720.

Table 2: Financial analysis of solar method including GHG

Discount rate	8%	
NPV (NRs.)	2672054	
B/C ratio	3.3	
Payback period	3.4	Years
IRR	21%	

Conclusion

Solid waste management, being a challenge, became one of the most efficient methods for the energy production. Sawdust has been used as insulating material because of its low thermal conductivity of 0.08 W/ m.K. Techno economic analysis was done for the both method and the payback period were determined taking 8% discount rate and solar water heater technology was found as the best method for the heating of the manure inside the digester. The biogas produced can be distributed to the nearby household for cooking purpose through piping at a lower rate than the LPG, so that the use of LPG can be reduced by locally generated biogas.

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Potential of Eco-friendly Vehicles in Kathmandu Valley

Bhupendra Sharma[1] , Amar Shrestha[2] , Prakash Sigdel[1]

Abstract

Air pollution is the major concern mainly in Urban areas so, government has forwarded a new policy on eco-friendly vehicle which aims at increasing the number of eco-friendly vehicles either by introducing new or by conversion of conventional vehicles to eco-friendly vehicles. With extreme air pollution covering up the sky, need of eco-friendly vehicles has been realized. Scarcity of petroleum products has triggered the importance of ecofriendly vehicles. On top of this, eco-friendly vehicles have been around since 1975, still showing no improvement in share of vehicular fleet. In Nepal, eco-friendly vehicles model like SAFA tempo (three-wheeler), Mahindra Reva (four wheeler), Danphe (a three wheeler electric powered vehicle) and others have been in operation since a decade now. Vehicle companies of Kathmandu valley and key informants were consulted in depth to collect quantitative data on fact about the current market potential of such eco-friendly vehicles that has been here for past few decades. But moving into deep, the study shows that previously running eco-vehicles are also in verge of collapse due to a common problem of load shedding and discouraged entrepreneurs.

Keywords: *eco-friendly, fuel, transportation system*

Introduction

A vehicle (from Latin: *vehiculum*) is a mobile machine that transports passengers or cargo (Merriam-Webster, 2014). Eco-friendly vehicle or environmentally friendly vehicle or green vehicle is a vehicle that uses alternative fuel sources to run (Joshy, 2013). Eco-friendly vehicles or eco-friendly vehicles have been realized as the alternative for conventional ICE vehicles which will help reestablish our natural beauty again with a friendly environment to live in. Eco-friendly vehicle (also known as the green car or environmentally friendly vehicle) is a vehicle that emits less pollutants or harmful gases when it runs. A program has also been proposed by the Ministry of Finance to introduce bio-fuels to run government owned vehicles by the fiscal year 072/073. The low emission makes the environment safe as the changes in climate and health hazards that result from the inhalation of harmful matters are greatly reduced, at

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the same time it can be of similar or more advanced technical functionality in comparison to the ICE vehicles. Eco-friendly vehicles use less toxic fuels such as ethanol, biodiesel and natural gas. From time to time different models of eco-friendly vehicles have been introduced in the market yet they are in trauma. **Eco-Friendly Vehicles** types include *Hybrid vehicles* (Full hybrids, Mild hybrids, Plug-in hybrids) (Cobb, 2014); *Battery electric vehicles*; *Compressed-air vehicles*, *Hydrogen fuel-cell vehicles, Neat ethanol vehicles/ E100, Flexible-fuel vehicles (FFVs), Natural gas vehicles(NGV),*

Methodology

Research Plan and Study Area

The study area of this research is Kathmandu city which lies in Bagmati zone of Central Development region. This city is the capital and largest municipality of a small nation of Nepal. This city is accompanied by Lalitpur, Kirtipur, Madhyapur Thimi and Bhaktapur. According to the 2011 census, Kathmandu valley has a population of 2.51 million people (Sharma, 2011). Major economical activity is conducted in this city where almost all different castes people inhabit. The geographical co-ordinates is 27°42'N 85°20'E. About 50 different vehicle brands exist according to various sources. 1,000 kilometers length of road extension exists with 500,000 vehicle plying every day (Unknown, Centre for Inclusive Growth, 2012).

Research Design

This research was carried out on the basis of a descriptive or exploratory research design because the objective of this research was to identify or investigate the status of potential of eco-friendly vehicles for pollution control and environmental conservation of Kathmandu valley.

Nature and Source of Data

The research work was carried out through primary and secondary data collection techniques. For the primary data collection, field visit to the vehicle showrooms, local vehicle manufacturer and concerned stakeholders was carried out. Likewise, secondary data were collected from Department of Transport Management and other related literatures. Structured and unstructured set of questions, field observation, personal interviews, and stakeholder's consultation methods was applied for that purpose. Besides, some other useful data was collected from the relevant sources. All the data and information was analyzed and presented carefully to fulfill the objective.

Method of Sampling

The samples were randomly selected using simple random sampling method. Simple random sampling is a method of selecting a sample from a statistical population in such a way that every possible sample that could be selected has a predetermined probability of being selected. The total population was 50 out of which 20% sample size was chosen randomly. And for the key informant interview, concerned persons of DoTM and other organizations were chosen.

Data Collection

Data was collected from various sources depending on their availability. Depending on the source of information or data, they are categorized in two types:

i. Primary data
ii. Secondary data

Primary Data Collection

Primary data were collected through key informant interviews and questionnaires, direct observation and consultation with stakeholders.

i. Questionnaire survey: Mostly structured and few unstructured questionnaires were used for the survey. Structured questionnaires were used for vehicle companies whereas unstructured questionnaire were used for DoTM officials and stakeholders. Both qualitative and quantitative information were collected from the respondents.
ii. Key informant interviews: It was conducted by selecting the experts on the related field who have knowledge about the subject matter. Some organizational personalities, entrepreneurs and stakeholders were chosen for the interview.

Secondary Data Collection

Various literatures from national and international experts and authors were collected from different organizations. Data on the status of regions vehicular fleet was collected from DoTM. Many other literatures from various sources like internet, articles, reports, journals and projects reports were used.

Results and Discussion

Status of Eco-friendly Vehicles in Kathmandu Valley

There are 2,200-plus eco-friendly vehicles in operation at present, including around 1,500 two-wheelers, 600 Safa Tempos and 100 four-wheelers (Shrestha R. , 2014).

Nepal, especially Kathmandu valley has seen few eco-friendly vehicles in its short history of transportation, including the use of zero emission vehicles combating the air pollution in Kathmandu valley. The Trolley bus service was started in Kathmandu in 28 Dec 1975. Starting from Tripureswor and ending at Surya Binayak, the Chinese gifted buses served the valley silently and smokelessly for more than three decades for 15 paisa per ride, later increased to Rs 5 (Shrestha D. K., 2012). It ran from Kathmandu to Suryabinayak in Bhaktapur within the valley. The service was stopped due to loss in revenue in 2001. A limited trolleybus service was restarted in 2003, and there were plans to expand it, but they did not come to function. The service was permanently suspended in 2009 and today remains as a legacy.

The group called the Electric Vehicle Development Group converted an old car into an EV in 1992. In 1993, the Global Resources Institute, with assistance from USAID, began a program to develop EVs as a profitable industry. The project converted 7 polluting diesel operated three-wheelers known as 'Vikram tempo' into EVs (Safa Tempos), and successfully operated them as public vehicles for six months. At the end of the pilot project in early 1996, a group of Nepali professionals and entrepreneurs bought the 7 EVs and started the first EV Company, Nepal Electrical Vehicle Industry (NEVI), in Kathmandu.

In Kathmandu, Toyota Prius and Honda Insight hybrid were introduced in 2012 and 2009. Battery powered vehicles like Reva in Kathmandu valley and danphe in Hetauda and Chitwan are gaining popularity. They provide a 0% to 99.9% reduction in CO_2 emissions compared to an ICE (gasoline, diesel) vehicle, depending on the source of electricity. Government of Nepal has recently declared the use of ethanol (E15) in the government owned vehicles from the FY 2072/073.The higher operating cost of the electric vehicles (NRs. 11.62/km) in comparison with the Liquid Petroleum Gas operated three wheelers (NRs. 6.17/km) and petrol vehicles (7.06/km) have made the entrepreneurs difficult to survive (Energy Himalaya, n.d.). The high tariff rate and the high cost of battery are the main reasons of its high cost. Despite of the high cost of the SAFA tempo the Kathmandu valley provides technical feasibility for the promotion of these vehicles. A study has shown that the present electricity generation capacity is enough to charge 70 thousand electric vehicles (Energy Himalaya, n.d.). Another EV famous as Reva, a tiny car, was introduced in 2002 by a private company Eco Vision. Now the car is available as Reva e2O under the company brand of Mahindra. About 25 units of car have been sold so far except Reva i. The common site of face masks and dense smog that often envelopes the capital city should have been enough cause for concern and for the government to actively promote eco-friendly vehicles. However, the

government, which collects the second largest amount of revenue through custom charges on vehicles, has so far failed to promote EVs in the Nepali market. .On top of this different studies show that existing EVs are preventing more than eight tonnes of carbon from being emitted every year (Ghimire, 2012).

Vehicle Company Status

Reviewing the various literatures and stakeholders information, about 50 different brand's vehicle company exist within Kathmandu valley. Some of those firms are in idle stage in present. Five of those are local vehicle companies which has been manufacturing EV since 1996. There are more than 600 of these companies' product vehicles which are a kind of popular in valley's transportation system. Rests of other eco-friendly vehicle company are foreign based enterprises operating in the valley.

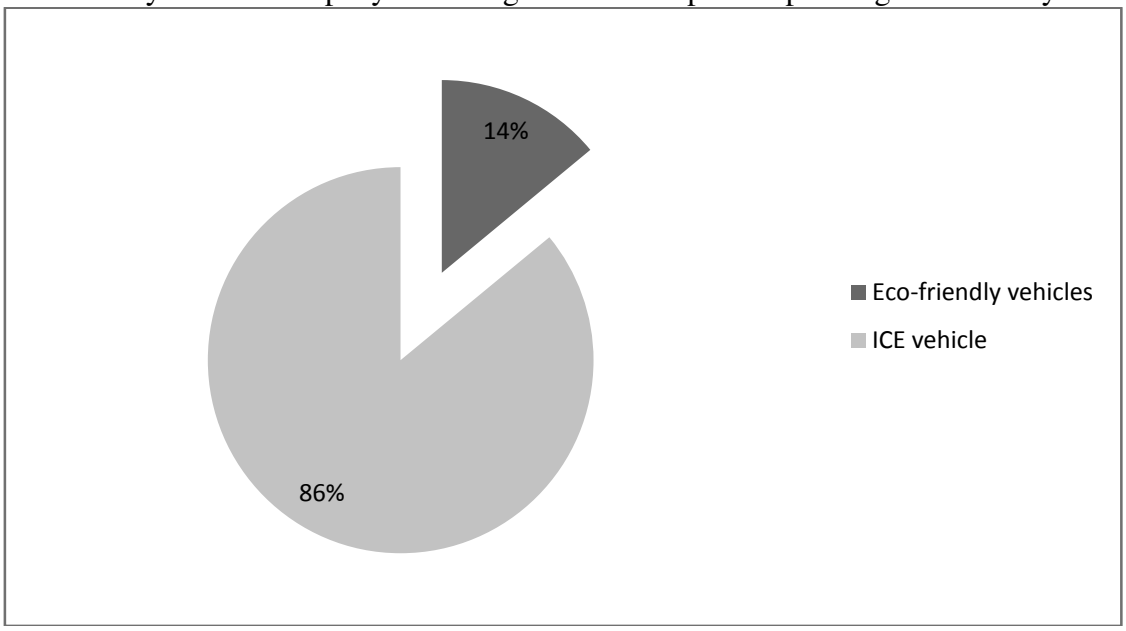
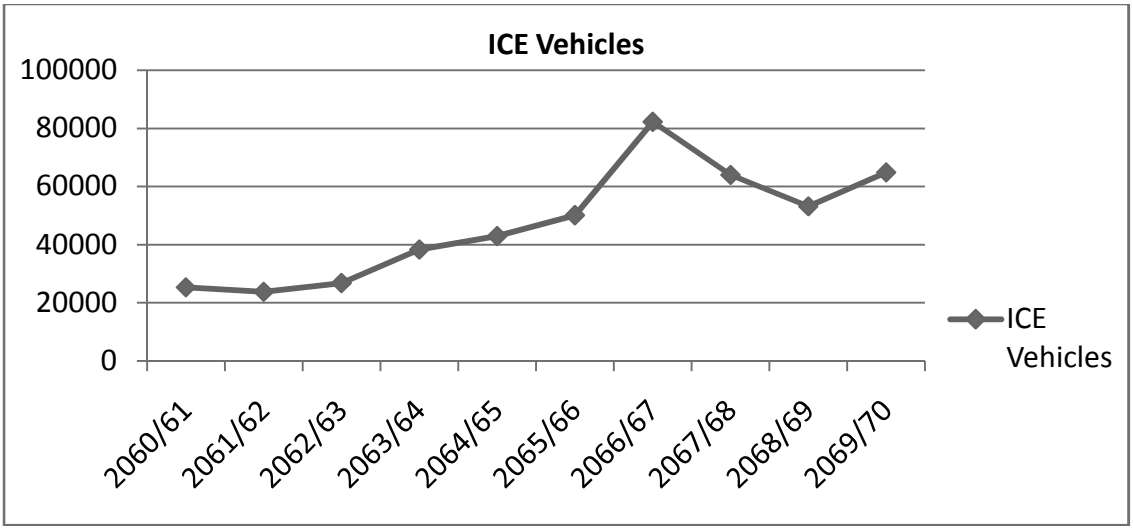


Figure1: Percentage of Eco-friendly and ICE Vehicle Company in Kathmandu valley

Trend over Vehicular Growth in Bagmati Zone

Analysis of data shows that trend on vehicular growth in Bagmati zone is much higher than other parts of the country. Within the short history of its transportation facility, the number of registered vehicle in Bagmati zone has increased 30 times within a decade time period of FY060/61 to FY 070/71. Although the increase in the vehicle number is huge, total registration of eco-friendly vehicles seems pity. There are 2,200-plus eco-

friendly vehicles in operation at present, including around 1,500 two-wheelers, 600 Safa Tempos and 100 four-wheelers (Shrestha R. , 2014). For the last three fiscal years, not even a single new valley's iconic Safa Tempo has been registered. Other eco-friendly vehicles registration and sales in the valley is also depressing.



Source: DoTM

Figure 2: Trend of ICE vehicles growth in KV

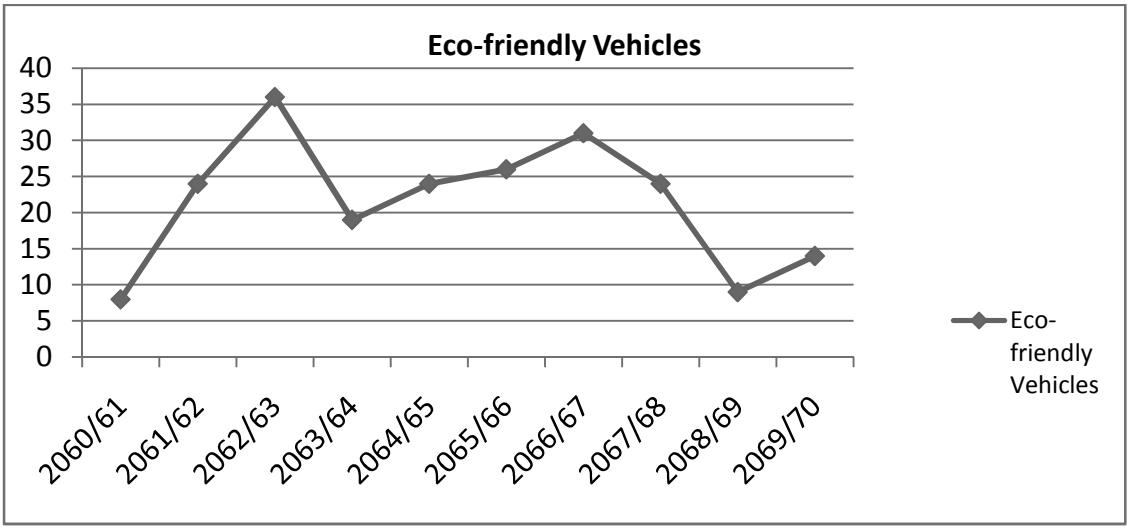


Figure3: Trend of Eco-friendly vehicles growth in KV

Eco-friendly Vehicles: Cheap or Expensive?

Comparison between local and imported eco-friendly vehicles shows that locally manufactured EV are cheaper than the imported eco-friendly vehicles. Government provides 50% subsidy i.e.,112% tax off, while importing eco-friendly vehicles. But even the 50% imposed tax is too much burden for imported eco-friendly vehicle's cost making it far too expensive for most Nepalese. Various factors makes the imported vehicles expensive than the locally manufactured eco-vehicles. As the technology is new and advanced to the global industry itself, the cost for such eco-friendly vehicles is higher in the international market too. During the study, 78% of eco-friendly vehicle companies agree the cost of eco-friendly vehicles are expensive than the ICE vehicles although its benefits for the environment is huge.

Table 1: Price Comparison of Local and Imported Eco-friendly Vehicles

Eco-friendly vehicles- Local	**Eco-friendly vehicles- Imported**
Less tax (1%)	112% tax
No transportation cost	Transportation cost added
Low performance	Higher performance
Less comfort and simple technology	Comfortable and technological advancement

Table 2: Price Comparison of Eco-friendly and ICE Vehicles

Eco-friendly vehicles	**ICE vehicles**
50% tax subsidy	No tax subsidy offered
New technology	Common technical advancement
Expensive (than similar performance conventional vehicles)	Cheaper

Environmental Awareness Among Vehicle Costumers

Study on the demand of eco-friendly vehicles shows that there is very limited demand for eco-friendly vehicles in the valley. Received data clarifies that the market potential for eco-friendly vehicles is much less. With global warming becoming more of a reality and air pollution increasing every day, the government must do whatever it takes to reduce the amount of carbon emissions and the promotion of eco-friendly vehicle for personal and public use.

Table 3: Market Demand for Eco-friendly Vehicles in KV

No demand	Very limited	Limited	Huge demand
55.56%	33.33%	11.11%	0%

Policies and Strategies of Nepal

Expansion of the trolley bus system has been mentioned in all the Five -Year plans since the 6th Plan. The National Transport Policy, 2058 has also mentioned that eco-friendly electric vehicles will be promoted. The government does not charge any Value Added Tax (VAT) and only one percent custom duty for import of Safa Tempo's chasis, engine, motor, battery, and battery charger. Similarly electric vehicles are not required to pay annual vehicle tax. The government had also included some policies favorable to EVs in its budget for 2003/4. These include exemption of custom duty for the import of trolley buses and parts and reduction of electricity tariff (Tuladhar, Electric Vehicles in Kathmandu, CEN's Fact Sheet 3, 2003).

Some strategies adopted by the national government are as below:

- Motor Vehicles and Transport Management Rules, 2054 (1997) in exercise of the powers conferred by Section 179 of the Motor Vehicles and Transport Management Act, 2049 (1993), Government of Nepal has framed the vehicular and transportation rules.
- NEPAP - Vehicle emission control in Kathmandu Valley in 1993.
- The Government introduced a vehicular pollution control program in 1996.
- The Environmental Protection Act and the Environment Protection Regulation 1997:
    i. Standard for inspection of used vehicles
    ii. Standard for import of vehicles
    iii. Compliance plans
    iv. Enforcement plans
    v. Compensation plans
    vi. Vehicle Inspection Strategy of the Country
    vii. Regular Inspection of the Vehicles
    viii. Inspection at the time of Import of Vehicles

The Ministry of Physical Infrastructure and Transport (MoPIT) is doing final preparations to introduce a policy which aims to promote the operation of electric

vehicles. The government has introduced a policy that has targeted to promote environment-friendly vehicles and increase the use of such vehicles to 20 per cent in the country by 2020. To start with, it plans operating clean vehicles in selected routes within Ring Road of the Kathmandu Valley (Shrestha R. , 2014). 'Environment Friendly Vehicles and Transport Policy 2014' has focused on promoting the use of electric and other vehicles that run on solar power and gas. In a bid to produce eco-friendly vehicles, the government in the policy has also encouraged registration of industry for assembling clean vehicles and conversion of old fuel-run vehicles to electric. Similarly, the policy has mentioned providing incentives in income tax, customs duty, VAT, and excise duty for production, conversion of old vehicles and operation of green vehicles. The government, in initial phase, plans to operate environment-friendly public vehicles on some routes in Kathmandu Valley and gradually expand the practice outside the Valley.

Some facts

- → The trolley bus system was never expanded though the expansion of the trolley bus system has been mentioned in all Five Year plans since 6th plan.
- → New registration of the SAFA tempos in Kathmandu has been stopped even though it has been mentioned that environmentally-friendly electric vehicles will be promoted in the National Transport Policy, 2058. Instead data shows hundreds of diesel vehicles and other vehicles continue to be added every day. Government is also creating unnecessary problem to private entrepreneurs who are willing to introduce four wheeler EVs.
- → The government does not charge any Value Added Tax (VAT) and only one percent custom duty for import of SAFA Tempo's chassis, engine, motor, battery, and battery charger. Similarly, electric vehicles are not required to pay annual vehicle tax. Imposition of 10% VAT on locally manufactured EV is still a matter of dispute between stakeholders and the Government (Department of Revenue) (Energy Himalaya, n.d.).
- → The Ministry of Population and Environment (MoPE), with the assistance of DANIDA has established a Clean Vehicle Fund, under a project to support the EV sector, to support R&D and promotion of EVs. In the past, MoPE with the support of DANIDA also provided some easy loan plans (up to 70%) to

establish two battery charging stations in Lalitpur and to procure 48 EVs for private owners (Unknown, Joomla).

→ The green vehicle policy 2014, has said that the government will establish 'Environment-Friendly Vehicle and Transport Development Fund'. Its resources will be utilised for research and development, human resources development, skill training and protection and promotion of domestic industry to be involved in manufacturing of environment-friendly vehicles.

Conclusion and Recommendations

Due to various reasons especially vehicular emission, once famous as the pristine environment Kathmandu valley is now a most polluted city where smog is a common site. Rapidly increasing number of vehicles and road extensions throughout the valley has triggered the problem to be worst. A decade ago, air polluting three-wheelers operating within the valley were banned from the city and were replaced by EVs. At the same time, a movement of removing old vehicles was initiated by the government but was widely protested making the government unable to implement the decision. But instead, eco-friendly trolley buses are now expired and are out of order. Whereas, huge tax amount imposed on the import of vehicles of either kind has led to make eco-friendly vehicles out of status for major population. The city has shown some response to the degrading environmental condition and is acting on it. But in case of transportation system, until and unless the government decides to completely remove tax imposed on eco-friendly vehicles, in order to minimize the vehicular emission, they will be out of affordability range, thus lowering the potential of eco-friendly vehicles in the valley.

Studies show that the pollutants are much dense around the road areas of the valley. Poor performance on the side of giant leading team of government body has already pushed the country far down than any other countries in the list of worst air quality of the world. On the part of laws and policies, the guidelines and laws that were supposed to control degradation of air quality by checking on vehicular emissions are not strictly followed. Strategic weakness of government has even pushed new eco-friendly vehicles to be out of choice from medium class people. Whereas the facts is; in any country, it is the middle class that is the biggest consumer and which decides the consumption patterns that has direct effect to its environment.

i. Vehicular emission is the leading contributor on the share of air pollutants which has impact on all life within valley. Thus transportation system must be eco-friendly.
ii. Encourage many people to choose eco-friendly vehicles by removing the tax amount levied on the eco-friendly vehicles, the cost of those vehicles will be removed heavily.
iii. Also, the government must take initiative on conversion of conventional ICE vehicles to make them more effective and environment friendly.

Acknowledgements

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Use of Pesticides in Nepal and Its Environmental Concern

Keshab Raj Joshi[1]

Abstract

Pesticides are used to protect human health and increase the agricultural production. Use of pesticides is continuously increasing in Nepal. In order to regulate the import, export, production, purchase, sale and use including the effect on human and environment, registration and banning of pesticide is carried out. However, studies show the use of unregistered and banned pesticides. Overuse, misuse, lack of environmentally sound disposal and the residual effect of pesticides have caused the serious health hazards and is a matter of environmental concern. Legal measures for regulating the pesticides are not effectively implemented and are not time specific. Special focus is necessary towards the minimum or no use of pesticides and promoting the use of bio-pesticides. As Nepal has also shown its commitment towards Basel, Stockholm and Rotterdam Conventions, there should be proper care on protection of human health and environment from hazardous and obsolete pesticides.

Keywords: *consumption, obsolete, legal measures, residue, safe use*

Introduction

Pesticides are the chemicals designed to kill or inhibit the growth of an undesirable organism (Miller, 1994). Since the late eighteen hundreds, pesticides have been in existence. However, around Second World War and during the green revolution, their use started to pick up and pesticides have become a part of farming for many people since then (Rottenberg, 2004). Pesticides are used for increasing the agricultural productivity and the public health protection (Sharma et al., 2015). Therefore, these are playing a crucial role in meeting the food demand of growing population and controlling the vector-borne diseases. However, most of the applied pesticides get dispersed in the environment and thus affect the health of un-protected agricultural and industrial workers (Hashmi and Khan, 2011).

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Nepal also started using the pesticide for the public health purpose and is now widely used in agriculture. Overuse and misuse of pesticides is in practice causing environmental and health hazards. Nepalese farmers as well as pesticide dealers are not sufficiently aware regarding adverse effect of pesticide use (Giri et al., 2006). Farmers even apply pesticides in a regular manner and send them to market without considering the waiting period required for the pesticide to breakdown.

Published literatures and few case studies documented from Nepal have been used for this study. This study describes the history and types of pesticide used in Nepal. Pesticides banned in Nepal have been identified. Environmental and health effects of pesticides have been described based on previous studies conducted. Legal measures and standards related to environmental aspects of pesticides in Nepal have also been analyzed.

Methodology

For this study, review of literature on pesticides in Nepal was carried out. Various information, data and status of pesticides use in Nepal were collected from desktop review including review of literature (e-literature) and review of cases. Review of pamphlet, brochure from GoN/NGOs/INGOs was also conducted. Subjective analysis of collected information has also been carried out.

Results and Discussion

Chronology and Types of Pesticide Use

Nepalese were unaware of modern chemical pesticides until 1950s and were practicing the traditional pest control methods. DDT and Pyrethrum were the first pesticides introduced from USA in 1950 for Malaria control for Gandaki hydropower project. In November 1952, for the first time, 800 houses were spread with pesticides to protect people from malaria in Nepal (Kandel and Mainali, 1993). This was introduced by the Ministry of Health. Similarly, Paris green, Gamaxene and Nicotine sulphates were imported in 1955 from the United States for malaria control. Ministry of Agriculture imported DDT in 1956 for pest control purposes that encouraged the use of the pesticide in agriculture sector (SHELGA, 2006). DDT was soon followed by a variety of other organochlorines (in 1950s), organophosphates (in 1960s), carbamates (in 1970s), and

synthetic pyrethroids (in 1980s) (Dahal, 1995). Department of Agriculture initiated the application of chemical pesticides for crop protection since 1960s (Aryal, 2006).

Nine major pesticides groups are in use in Nepal. Those pesticide groups include insecticides, herbicides, fungicides, acaricides, rodenticides, bio-pesticides, bactericides, molluscicides and others. Insecticides are the highest among the registered pesticide groups. Pesticide registration trend in different years from 1997 to 2014 shows continuous increase in their numbers (Table 1). Out of 1561 registered pesticides during 2014, there are no extremely hazardous pesticides and 62 of them are in highly hazardous category (Table 2).

Table 1: Pesticides Registered in Nepal

S. N.	**Pesticide**	**Number of Trade Names in Different Years**							
		1997	**2002**	**2003**	**2004**	**2009**	**2010**	**2013**	**2014**
1	Insecticides	46	207	213	213	210	391	613	889
2	Herbicides	9	22	23	23	24	63	120	168
3	Fungicides	17	71	71	71	62	170	304	408
4	Acaricides	1	2	2	2	-	-	12	19
5	Rodenticides	-	8	8	8	9	7	18	23
6	Bio-Pesticides	-	-	-	-	13	16	23	42
7	Bactericides	-	-	-	-	-	4	7	11
8	Molluscicides	-	-	-	-	-	-	1	1
9	Others	5	2	2	2	8	-	-	-
Total		**78**	**312**	**319**	**319**	**326**	**651**	**1098**	**1561**

Source: CBS, 2014 & PRMD, 2014

Table 2: Situation of Registered Pesticides 2070/071 BS (2013/014 AD) According to WHO Hazard Category

S.N.	**Hazard Level**	**Group**	**No. of Pesticides**
1	Extremely Hazardous	IA	0
2	Highly Hazardous	IB	62
3	Moderately Hazardous	II	793
4	Slightly Hazardous	III	282
5	Unlikely to present acute hazard in normal use	NH	394
6	Not Calculated	NC	30

	Total		**1561**

Source: PRMD, 2014

Banned Pesticides

Nepal has banned 15 pesticides till 2015. Many of them belong to persistent organic pollutants (POPs). Chlordane, DDT, Dieldrin, Endrin, Aldrin, Heptachlor, Mirex, Toxaphene, BHC, Lindane, Phosphamidon and Organo Mercury Fungicides have been banned since 2001. Methyle parathion and Monocrotophos were banned in 2007. Banning the import of Endosulfan was started since 2012 and banning on its use, sale and distribution was effective only after 2 years in 2014 (PRMD, 2013).

Out of 15 banned pesticides in Nepal, 10 belong to the listed POPs under the Stockholm Convention. Those listed POPs are Chlordane, DDT, Dieldrin, Endrin, Aldrin, Heptachlor, Mirex, Toxaphene, Lindane, and Endosulfan. Chemicals recognized as persistent with greater bioaccumulation or bio-concentration factor having potential for long-range environmental transport causing the adverse effects on human health or to the environment are listed on the Stockholm Convention Text (Sah and Joshi, 2011).

Illegal import banned pesticides over Nepal's boarder are found into local markets (Palikhe, 2002). Shrestha et al. (2010) in their study of use of pesticides among commercial vegetable growers of Jiwanpur and Kewalpur VDCs in Dhading district observed the use of extremely hazardous pesticides in vegetables which are banned for normal agriculture use by Government of Nepal.

Environmental Effects

Injudicious and indiscriminate use of pesticides and presence of pesticide residues in food, fruits, vegetables and environment is a matter of grave-concerns (Sharma et al., 2012). Negative externalities have also increased along with the increase in the agricultural production and productivity due to the use of chemical inputs such as pesticides (Wilson and Tisdell, 2001). Pesticide pollution in the environment results disturbance of agri-environment system, residues in food and loss of biodiversity, develops pest resistance, secondary pest outbreak and economic loss to the users (Koirala, 2011). Often highly persistent and mobile in the environment, many pesticides have moved through air, water, and soil, and bioaccumulated or bioconcentrated in food chains, nearly exterminating several top predators (Cunningham and Cunningham, 2003). Pesticides affect man, animal, plants, soil as well as aquatic biota (Pandey et al., 2005).

Pesticide residues analysis of tea in Nepal during 2011 detected residues of Carbamates, Pyrethroids, and Oxygenated hydrocarbons in the samples including the organic claimed tea and the Fenobucarb was the most common insecticide detected (Shrestha, 2014). Giri (2010) also found pesticides in tea, vegetable and fruit samples and recorded soil samples contaminated with pesticides at different concentrations in Kathmandu valley. Pesticide contamination study in Ansikhola watershed of Kavre District detected Endosulfan, Iprobenfos, Monochrotofos, Mevinphos and Butamifos in water samples and Cypermethrin, Dichlorvos, and Cyafluthrin were detected in soil samples (Kafle et al., 2015).

There are no facilities for the disposal of obsolete pesticides in an environmental sound manner in Nepal (Aryal, 2006). Therefore, 74.5 metric tonnes of obsolete pesticides (majority of which belonging to POPs) were being stored in many places of the country. Many of stocks were located near farm fields, human settlements, schools or water sources (Shah and Devkota, 2009). The GIZ completed their collection from Nepal and disposal in Germany (Sharma et al., 2012). However, their residues might be present in nearby environment and therefore continuous monitoring is a matter of concern.

Health Effects

Pesticides are the potential health hazards drawing attention to everyone (Koirala et al., 2009). Pesticide pollution not only affects short-run health effects, but can also result in chronic diseases (Atreya, 2007). Farmers applying pesticides for agriculture are always at risk to their health hazards. Many farmers do not care about the safe handling of pesticides (Pandit & Paudel, 2013). Farmers are likely to expose themselves to unsafe concentration of pesticides because they rarely use any kind of protection gear during spray operations (Atreya & Sitaula, 2010). The predicted probability of falling sick from pesticide related symptoms is 133% higher among individuals who apply pesticides compared to individuals in the same household who are not directly exposed (Atreya, 2007).

There is a threat of pesticide residues in foods and may endanger to public health (Koirala et al., 2009). Shah and Devkota (2009) observed different health effects of pesticide residue level in soil samples of a nearby school-ground Amlekhgunj, Bara district, Nepal. Those health effects included headache, vomiting, heart complaint, foul smell, unconsciousness, drowsiness, irritation, eye problem, skin problem and loss of concentration. Study showed that 95% of pupil of the school claimed the problem to be due to the storage of obsolete pesticides in the adjoining warehouse. Long-term effects of the pesticide have not yet been studied in Nepal (Atreya and Sitaula, 2010).

Suicide cases using the pesticides are also common. Gupta and Joshi (2002) in their study of pesticide poisoning cases attending 5 major hospitals of Nepal found that almost all the cases of poisoning were intentional. Only a few were reported to be accidental and poisonings due to agricultural exposure were not found.

These evidences show the health effects of the pesticides in Nepal. Therefore, Farmers and policy makers need to become aware of the health impacts of pesticide use as they continue to promote its use in Nepal (Atreya, 2007). Due to the growing health concern of pesticide used in vegetables, vegetables at Kalimati vegetable market in Kathmandu are tested appropriate for consumption after analyzing pesticide residue sample test using Rapid Bioassay of Pesticide Residues (RBPR) method (MoF, 2014). This is a good initiation and should be carried out in every major vegetable markets for all types of pesticides in use. There is an urgent need to establish a national pesticide residue monitoring programme (Koirala et al., 2009).

Legislation and Standards

Basel, Rotterdam and Stockholm conventions are three multilateral environmental agreements which have the common objective of protecting human health and environment from hazardous chemicals and wastes. Nepal has also shown its commitment towards these international efforts. According to the Constitution of Nepal, 2072 (2015), right to clean environment is a fundamental right. Therefore, every person shall have the right to live in a clean and healthy environment and victim of environmental pollution or degradation shall be entitled the right to compensation from the polluter. The Pesticides Act 2048 (1991) and the Pesticide Rules 2050 (1994) are the legal measures of Nepal directly related to pesticide. The Pesticide Act 2048 (1991) was enacted for making provisions on the import, export, production, purchase, sale and use of the pesticides. According to the Pesticides Rules 2050 (1994), the effect to be caused from pesticides to the human beings, animals, birds and environment is necessary to be considered before carrying out the registration of pesticides**.** However, these do not deal with the obsolete pesticides.

Other sectoral Acts and Rules also have the provisions for its control, safe use and disposal. Water Resources Act, 2049 (1992), Solid Waste Management Act, 2068 (2011), Food Act, 2023 (1967), Customs Act, 2064 (2007), Plant Protection Act, 2064 (2007), Environment Protection Act, 2053 (1997), Consumer Protection Act, 2054 (1998), Seed Act, 2045 (1988), Aquatic Animal Protection Act, 2017 (1960) and their associated Rules are also associated with pesticides though not directly related.

Nepal has also set the Maximum Residue Limit (MRL) of pesticides for foodstuffs publishing on Nepal Gazette of February 5, 2001 (2057/10/23 B S) according to the provision made under the Food Act, 2023 (1967). Therefore, the pesticide MRL for whole milk powder and skimmed milk powder has been set. MRL of pesticide for food grain, whole green gram, split green gram, dehusked split green gram, red gram, whole black gram, split black gram, whole bengal gram, split bengal gram, whole lentil, dehusked lentil, bengal gram flour, wheat, maize and corn flakes has also been prescribed. Processed drinking water (mineral water) has also the Pesticide MRL. Regular monitoring by concerned agency to ensure the compliance with these standards is necessary.

Conclusion and Recommendations

Various types of pesticides are used in Nepal. Chemical pesticide was entered in Nepal for malaria control. Since then, there is continual use of pesticides with different commercial names. There is the provision of pesticide registration in Nepal. However, various kinds of unregistered pesticides are in use. Some pesticides have been banned in Nepal and most of them are POPs. Use of bio-pesticides is still in minute amount. In present situation, due to the hazardous effect of pesticides, people are trying to use traditional bio- pesticides but their low efficiency is causing problems to their use.

Therefore, now it is the time to adopt Integrated Pest Management (IPM) and scientists should develop the pesticides that are safer to health. There is a need for the behaviors change of farmers to produce healthy food rather than producing high yield. There should be the minimum or no use of chemical pesticides and application of traditional practices of pest control or the bio-pesticides must be there. Scientific management of obsolete pesticides is necessary. Regular monitoring of pesticide residues in food, water and environment will identify the severity of pesticide pollution. Strict monitoring and checking on pesticide import will ensure the use of registered pesticide only. Effective implementation of legislation concerned to pesticides is needed. Cumulative impacts of pesticide use and effects on ecosystem must be considered.

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Plastic Bags and Control Initiatives in Nepal

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Abstract

Plastics are incredibly versatile non-biodegradable, synthetic polymers consisting of repeating units called monomers. The repeating unit as ethylene or ethene yield plastic bags. History of plastic bag use does not go long in Nepal but its use is increasing tremendously which is revealed by the significant percentage of plastic in municipal waste. Indiscriminate littering and burning of plastic waste raises many environmental issues. Government of Nepal came up with the Plastic Bags Regulation and Control Directive which prohibits the use, import, storage and sale of plastic bags less than 30 microns. As a more stringent endeavor, Government of Nepal has banned on the use, distribution, and import of plastic bags less than 20X35 cm and below 40 µm in Kathmandu Valley. Department of Environment has now stepped up monitoring and action against those found selling or using plastic bags instead of other environment-friendly alternatives, such as jute or cloth bags. However, a combination of legislation and the enhancement of ecological consciousness through education would be the best way to solve such environmental problems. All sectors of the community should take their individual steps in prohibiting the use of plastic bag. The general public as well has the responsibility of changing their attitudes towards the problem. It is nevertheless certain that the polythene bags that threaten the environment as a whole must be urgently addressed.

Keywords: *plastic bags, polythene, GoN, solid waste*

Introduction

What are Plastics?

Plastics are non-biodegradable, synthetic polymers derived primarily from petro-fossil feedstock and made-up of long chain hydrocarbons with additives and can be moulded into finished products (Brydson 1999). Plastics are incredibly versatile materials; they are inexpensive, lightweight, strong, durable, corrosion-resistant, with high thermal and electrical insulation properties. The diversity of polymers and the versatility of their properties facilitate the production of a vast array of plastic products that bring technological advances, energy savings and numerous other societal benefits (Andrady & Neal 2009). There are currently some 20 different groups of plastics, each with

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numerous grades and varieties (APME 2006). Almost all aspects of daily life involve plastics, in transport, telecommunications, clothing, footwear and as packaging materials that facilitate the transport of a wide range of foods, drink and other goods (Andrady & Neal 2009).

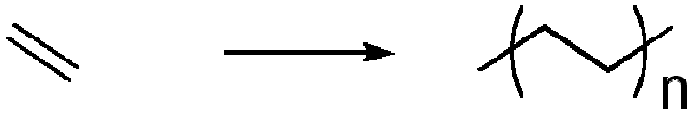
History of Plastics

The plastics we use today have come a long way since Alexander Parkes first introduced them to the world at London's Great International Exhibition in 1862. Parkes's material was an organic derivative of cellulose that could be molded when heated and then maintained its shape upon cooling (Lajeunesse, 2004). But it wasn't until 1907 that the word "plastic" was coined. The first truly synthetic polymer, *Bakelite*, was developed by Belgian chemist Leo Baekeland in 1907, and many other plastics were subsequently developed over the next few decades (Brydson 1999).The booming of the plastic industry dates back to world war II. However, the development of the petrochemical industry is probably the greatest contributing factor in the growth of plastic industry, the two industry today having remarkable degree of interdependence (Brydson 1999).

Polymers and Plastic Bags

Plastics are composed of polymers, large molecules consisting of repeating units called monomers. Oil and natural gas are the major raw materials used to manufacture plastics. The plastics production process often begins by treating components of crude oil or natural gas in a cracking process. This process results in the conversion of these components into hydrocarbon monomers such as ethylene and propylene. Further processing leads to a wider range of monomers such as styrene, vinyl chloride, ethylene glycol, terephthalic acid and many others. These monomers are then chemically bonded into chains called polymers. The different combinations of monomers yield plastics with a wide range of properties and characteristics.

In the case of plastic bags, the repeating units are ethylene, or ethene. When ethylene molecules are polymerized to form polyethylene, they form long chains of carbon atoms in which each carbon also is bonded to two hydrogen atoms (Lajeunesse, 2004). Simple process of formation of polyethylene from its n number of monomer ethylene can be shown as:



source: American Institute of Chemical Engineers (AIChE), 2015

Figure 1: Process polythelyne formation

Plastics are incredibly versatile non-biodegradable, synthetic polymers consisting of repeating units called monomers. The repeating unit as ethylene or ethene yield plastic bags. History of plastic bag use does not go long in Nepal but its use is increasing tremendously which is revealed by the significant percentage of plastic in municipal waste. Indiscriminate littering and burning of plastic waste raises many environmental issues. Government of Nepal came up with the Plastic Bags Regulation and Control Directive which prohibits the use, import, storage and sale of plastic bags less than 30 microns. As a more stringent endeavor, Government of Nepal has banned on the use, distribution, and import of plastic bags less than 20X35 cm and below 40 µm in Kathmandu Valley. Department of Environment has now stepped up monitoring and action against those found selling or using plastic bags instead of other environment-friendly alternatives, such as jute or cloth bags. However, a combination of legislation and the enhancement of ecological consciousness through education would be the best way to solve such environmental problems. All sectors of the community should take their individual steps in prohibiting the use of plastic bag. The general public as well has the responsibility of changing their attitudes towards the problem. It is nevertheless certain that the polythene bags that threaten the environment as a whole must be urgently addressed.

Many kinds of polyethylene can be made from ethylene. Plastic bags typically are made from one of three basic types: high-density polyethylene (HDPE), low-density polyethylene (LDPE), or linear low-density polyethylene (LLDPE). Those thick, glossy shopping bags from the mall are LLDPE, while grocery bags are HDPE, and garment bags from the dry cleaner are LDPE. The major difference between these three materials is the degree of branching of the polymer chain. HDPE and LLDPE are composed of linear, unbranched chains, while LDPE chains are branched. Branching can influence a number of physical properties including tensile strength and crystallinity. The more branched a molecule is, the lower is its tensile strength and crystallinity (Lajeunesse, 2004).

Plastic Bag Control and Regulation Directive 2068 has defined Plastic bag as " A bag of any shape or size made up of the high molecular high density polyethylene (Film grade) granules, with the addition of master batch (to develop colour), Titanium dioxide to make opaque, calcium carbonate as filler. There are two major categories of plastic namely Virgin Food Grade Plastic granules for packaging food, water and medicine and Virgin Plastic Granules for non food items (Plastic Bag Control and Regulation Directive 2068).

Process of Making Plastic Bags

An extruder heats polyethylene plastic resin pellets to around 500 ºF to melt the pellets. A screw inside the extruder forces the molten plastic through the machine and pushes the material through a dye that controls the thickness of the product. Air forces the emerging plastic film into a bubble that travels upward about three stories in a cooling process. After pinching out the air and flattening the bubble, the film is cut to size and wrapped on a spindle. The film rolls are unwrapped sliced with a heated knife that both seals the sides of the bag and cuts it to size.

Virgin plastic polymers are rarely used by themselves and typically the polymer resins are mixed with various additives to improve performance. These additives include inorganic fillers such as carbon and silica that reinforce the material, plasticizers to render the material pliable, thermal and ultraviolet stabilizers, flame retardants and colourings. Many such additives are used in substantial quantities and in a wide range of products (Meeker et al. 2009).

Methodology

The study is the recompilation of the previous studies and researches. Methodology involved the desk study of different journal, newspaper, books, reports and legislations.

Results and Discussion

Scenario of Polythene Bags in Nepal

History of plastic bag use does not go long in Nepal but its use is increasing tremendously. The significant percentage of plastic in municipal waste reveals its uncontrolled use. The environmental audit report of the Kathmandu metropolitan city

showed that plastic and paper comprise major portion of inorganic waste (Fig 1). Several attempts have been carried out to control and regulate plastic bags in Nepal. Many municipalities such as Ilam, Dharan, Itahari have initiated to ban the use of plastic bags. Owing to its adverse impact to human health and environment, Government of Nepal (GoN) has promulgated rules and regulations to control and regulate the use of plastic bags.

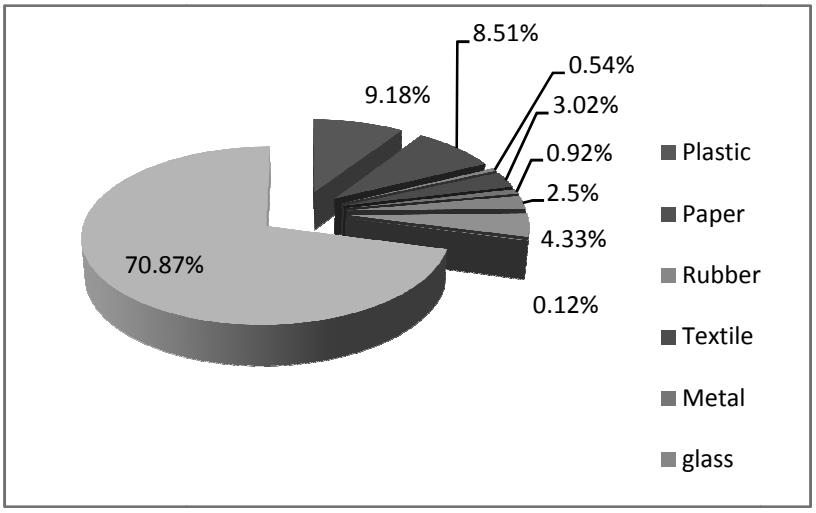


Figure 2: Waste composition of Kathmandu Metropolitan City

Source: Environment Audit Report, 2015

Environmental Implications

With increasing global consumption and their natural resistance to degradation, plastic materials and their accumulation in the environment is of increasing concern (Webb et al 2012).While polythene bag is recyclable, it cannot be remade into an organic state, and once created must stay as a synthetic substance for the rest of its life. In general, plastic bags are the preferred environmental choice, not because of their recyclable qualities but because of their manufacturing process, which uses around 70 percent less energy and releases 50 percent fewer greenhouse gas particles than alternatives like paper bags. However, Indiscriminate littering of unskilled recycling/reprocessing and non-biodegradability of plastic waste raises many environmental issues (CPCB 2012). During polymerization and product manufacturing process fugitive emissions are released. Indiscriminate plastic waste disposal on land makes the land infertile due to its impervious nature. Burning of plastics generates toxic emissions such as Carbon Monoxide, Chlorine, Hydrochloric Acid, Dioxin, Furans, Amines, Nitrides, Styrene,

Benzene, 1, 3- butadiene, CCl_4, and Acetaldehyde. Lead and Cadmium pigments, commonly used in LDPE, HDPE and PP as additives are toxic and are known to leach out (CPCB 2012). Over 260 species, including invertebrates, turtles, fish, seabirds and mammals, have been reported to ingest or become entangled in plastic debris, resulting in impaired movement and feeding, reduced reproductive output, lacerations, ulcers and death (as cited in Thompson et al 2009).Plastic ingested by animals persists in the digestive system and can lead to decreased feeding stimuli, gastrointestinal blockage, decreased secretion of gastric enzymes and decreased levels of steroid hormones, leading to reproduction problems (as cites in Derraik 2002).Plastics also complicate waste management processes, causing contamination in composting operations, and having poor recovery rates through recycling. Plastics that are not as biologically recalcitrant, that decompose when use is done, have been perceived as solutions to at least some of these problems (Tonjes and greene 2013). Sub-standard plastic bags, films etc. pose problem in collection and recycling. Littered plastics give unaesthetic look and choke the drain. Garbage mixed with plastics interferes in waste processing facilities and also cause problems in landfill operations.

Plastic Prohibition in Nepal

In 2002, when the Supreme Court directed the government to enforce the decision to ban the use of plastic bags, the government dithered (The Kathmandu post 2015). In 2011, the GoN came up with the Plastic Bags Regulation and Control Directive which prohibits the use, import, storage, sale and use of plastic bags less than 30 microns and imposed a fine of Rs. upto 50,000 for non compliance. The Bagmati cleanup campaign which was conducted for long time, collecting tons of plastic bags from the river revealed the plastic being the major culprit to pollute the river. Following directives from Parliament over the threat of the use of plastic bags, the Ministry of Science, Technology and Environment (MoSTE) had imposed a ban on import, production and use of polythene bags less than 40 microns in thickness at Kathmandu valley with effect from April 14, 2015. However, the ban could not be monitored effectively as the country was hit by the earthquake less than two weeks after the government move. The Department of Environment has now stepped up monitoring and action against those found selling or using plastic bags instead of other environment-friendly alternatives, such as jute or cloth bags.

Legal Provision

- Constitution 2015 , article 30(1) secures right regarding clean environment and states every person shall have the right to live in a clean and healthy environment.

- Plastic bag control and regulation directive 2068 is the major legal tool that directly addresses plastic. It provides the direction for the type of plastic to be manufactured, stored, retailed and used. Production, storage, retail and use the plastic against the standard size, thickness and quality as mentioned in the directive is deemed punishable (Plastic bag control and regulation directive 2068) as per EPA which has provisioned fines ranging up to Rs. 50,000 for the production and use of such bags.

- GoN has banned on the use, distribution, and import of plastic bags less than 20X35 cm and below 40 µm in Kathmandu Valley as The Parliamentary Committee on Environment Protection directed the government to ban the plastic bag in Kathmandu valley. Which has come into force since 1st Baisakh 2072 after publication the notice in Nepal gazette.

- The Environment Protection Act, 1996 and Environmental Protection Rules, 1997 have made provisions on pollution control, Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA), conservation of national heritage etc. Section 7 of Act refers to pollution control, which states "A person shall not cause pollution or allow pollution to be caused in a manner which is likely to have significant adverse impact on the environment or harm human life or public health or shall not emits, discharge sound, heat, radioactive from any machine, industrial enterprises or any other place above the prescribed standard." The Chapter 3 of Regulation has provided various provisions under rules 15 to 29 for preventing and controlling pollution (The EPA, 1996 and EPR, 1997)

- Industrial Enterprise Act, 1992 has provision with GoN to issue directives to any industry in the matters relating to the pollution of environment and it shall be the duty of the concerned industry to follow such directives. Section 25 (2) empowers GoN to punish those who don't comply with the conditions mentioned in the license or registration certificate (Industrial Enterprise Act, 1992).

- Solid Waste Management Act, 2011, outlines the duties of local government to take action to control haphazard waste generation, disposal or collection (Solid waste management Act, 2011).

Way Forward

- Strong implementation of the government rules, regulations and directives is inevitable to check the uncontrolled use of plastics bag. Environment Inspectors shall be empowered and capacitate to seize the plastic beyond standard size and they should authorized to penalize those who don't comply with the conditions mentioned in the directive.

- Sooner or later, all components in a polymer material will be returned to the environment, with the degradation, so it is very important to use pigments, fillers and additives that are not toxic in nature.

- Prohibition of plastic waste burning can prevent the release of toxic gases viz. dioxins and furans to the environment.

- Plastics have been around for more than 100 years, and they will be around for many more. Without a doubt, they are useful to mankind. Frequent campaigns are required to make the people aware in discouraging use of the plastic bags.

- Reduce, reuse, and recycle (3R) should be promoted. Proper management of plastic waste and endeavor to promote alternative and biodegradable bag will be imperative to reduce the adverse impact of plastics to environment and human health.

- One solution to this problem is to make degradable bags, such as those from starch which can be polymerized to the biodegradable plastic known as polylactide. Comprehensive research is requisite for the promotion of degradable plastic bags. Government should encourage the scientific society to discover the alternatives.

Conclusion

Ultimately, all sectors of the community should take their individual steps. A combination of legislation and the enhancement of ecological consciousness through education would be the best way to solve such environmental problems. The general public also has the responsibility of changing their attitudes towards the problem. It is nevertheless certain that the polythene bags that threaten the environment as a whole must be urgently addressed.

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Current Status and Management Practice of Clubroot (*Plasmodiophora brassicae*) Disease in Eastern Hills of Nepal.

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Abstract

Cruciferous vegetable is the most important crops of the eastern hills, being grown commercially in normal as well as off-season. Severe infestation of clubroot diseases caused by the fungus Plasmodiophora brassicae appeared to be a major threat to the farmers for the cultivation cruciferous vegetables in Dhankuta and Terathum since few years. This study is carried out to explore the present status and management practice of the disease at farmer's level in Terathum and Dhankuta district. Fifteen cabbage/cauliflower growing households each from Marekatare, Tankhuwa and Parewadhin VDCs of Dhankuta district and Chitre and Basantapur VDCs of Terathum district, were surveyed during 2015. Diseases were firstly noticed by farmers from Parewadin VDC of Dhankuta district from about 5 years ago found highest disease incidence (82.2 %) with 76.78 % yield loss. Out of total respondent, only 19.7 % farmers got information about the clubroot diseases and its management practices from different source. Only 32.96 % farmers have knowledge about the medium for disease transmission or spread in which, 14.5 % farmers responded to transmit the diseases through soil where as 5.3 % and 13.16 % farmers by seedlings and by both soil and seedlings respectively. Only 22.44 % farmers of the surveyed district adopt different practice for the management of the clubroot diseases locally. Intensive effort may require for integrated diseases management practices such as dissemination of available technology for the diseases management, effective domestic quarantine system, appropriate research and sufficient awareness programme should be instantly launched by the concerned stakeholders.

Keywords: *clubroot, crucifers, management*

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Introduction

Cruciferous vegetable is *grown commercially in normal as well as off-season. It has the major source of income for the livelihood of the farmers.* Among cruciferous vegetables, the most important ones are cauliflower and cabbage. Although clubroot disease, caused by *Plasmodiophora brassicae* Wallenhammar, 1996, Agrios, 2005), has been observed in Nepal since 1993 (Timila *et al.*, 2008), severe and widespread epidemics have been observed since 2012 in some VDCs of Dhankuta and Terathum district. Typical disease symptoms are widespread, and disease severity has been particularly severe in Murtidhunga, Parewadhin and Tankhuwa VDC of Dhankuta district (DADO Dhankuta, 2069/70) and Chitre VDC of Terathum district (DADO Terathum, 2070/71). Clubroot is a destructive soil-borne disease which affects nearly all cultivated as well as many wild and weed members of the cabbage family. These roots often decay before the crops matured, releasing many resting spores, which can survive for a decade in the absence of a susceptible host plant (Agrios, 2005).

Methodology

Survey was carried out in Marekatare, Tankhuwa and Parewadhin VDCs of Dhankuta district and Chitre and Basantapur VDCs of Terathum district. These VDCs are the pocket area for commercial vegetable cultivation especially cabbage and cauliflower. These are the VDCs which lie on the road corridor of Dhankuta-Terathum highway. A semi structured questionnaire was prepared for the survey purpose and the total of 75 farmers (15 farmers growing cabbage/cauliflower from each VDCs) were selected by simple random sampling approach. Data processing was carried out in MS Excel and SPSS v. 20.

Results and Discussion

Present Status

Among cruciferous vegetables grown in Dhankuta and Terathum district, the most important are cauliflower (*Brassica oleracea* var. botrytis L.) and cabbage (*B. oleracea* var. capitata L.). Survey in the 5 VDCs of these districts revealed that commercial cultivation of cabbage and cauliflower was started in Basantapur and Parewadhin VDCs about 19 years ago followed by Tankhuwa VDC (14 years ago), Chitrre VDC (11 years ago) and Marekatare VDC (10 years ago). Among the surveyed farmers in both districts, farmers are cultivating cabbage/cauliflower in 18.7 ropani of land per household. Among them, highest

cultivation area was found in Basantapur and Chitre VDCs of Terathum district. It was about 25 ropani of land followed by Tankhuwa (24 ropani), Marekatare (11 ropani) and Parewadhin (8.5 ropani) VDCs of Dhankuta district. Disease symptoms first were seen from the farmers field of Parewadhin VDC of Dhankuta district about 5 years ago while Chitre (4 years ago), Basantapur (3 years ago), Marekatare (2.5 years ago) and Tankhuwa (2 years ago). Among the surveyed VDCs, diseases incidence was found highest in Parewadhin VDC (82.2 %) which is followed by Marekatare VDC (75 %), Chitre VDC (40.25 %), Tankhuwa VDC (35.33 %) and Basantapur VDC (23 %). Maximum yield loss was found in Parewadhing VDC (76.78 %) which is followed by Marekatare VDC (44 %), Chitre VDC (20.71 %), Tankhuwa VDC (9 %) and Basantapur VDC (6.83 %). Farmers have started to grow alternative crop for cabbage/cauliflower in some VDCs due to the higher infestation of the diseases and yield loss. Thirty Percent farmers in Tankhuwa VDC and 25 % farmers in Marekatare VDC have started to cultivate other crops in place of cabbage and cauliflower due to the heavy economic loss from the diseases (Table 1).

Table 1: Number of respondent, Cabbage /cauliflower cultivation starting year, area of cultivation per household, diseases appearance year, club root diseases intensity and yield loss and percentage of farmers start to cultivate other crops in place of cruciferous vegetables in surveyed district and VDC in 2015.

District	VDC	No of respondent	Cabbage/cauliflower cultivation starting year (Years ago)	Area of cultivation (ropani)	Diseases appear year(Years ago)	Diseases incidence %	Yield loss %	Start to cultivate other crops
Dhnakuta	Parewadhin	15	19	8.5	4	82.22	76.78	30%
	Marekatare	15	10	11	2.25	75	44	25%
	Tankhuwa	15	14.66	25.66	1.67	35.33	9	0
Terathum	Basantapur	15	19.33	25	2.42	23	6.83	0
	Chitre	15	11.5	25	3.25	40.25	20.71	0

Information About the Diseases Management

Out of total 75 farmers surveyed in Dhankuta and Terathum district, only 19.7 % farmers got a information about the clubroot diseases and its management from different sources. In the surveyed VDCs, 26.6 % in Chitre, 50 % in Basantapur, 6.7 % in Marekatare, 13.3 % in Parewadhin and non of the respondent in Tankhuwa VDC got information about the clubroot diseases and its management practice. In the surveyed VDCs, NARC, DADO and Agro-vet were the major source of information to the farmers for the diseases and its management practices. Among these sources, 11.84 % farmers got information from NARC through different workshop, trainings and meeting where as, 5.26 % farmers got information from DADO and 2.64 % farmers

got information from the local agro-vets. Among the surveyed VDC, NARC is the major source of information in Chitre (26.7 %) and Parewadhin (13.33 %) where as, DADO is the major source of information in Basantapur (25 %) and Local agrovet is the major source of information in Marekatare (6.67 %) (Figure-1).

Soil samples from the production areas of Dhankuta district indicated acidic (pH range of 4.2 to 7.2 with >90% below 6.0) (Soil testing report, DADO Dhankuta). The diseases development is generally favored by acidic soils, amendments which increase the soil pH may serve to reduce symptoms of the disease (Karling, 1968). Application of agricultural lime to raise the soil pH to a value of 7.2 or greater is considered optimal for clubroot control (Timila, 2012, Timila and Neupane. 2009; Strelkov *et al.*, 2011)**.** The use of lime and Nebijin is only the available technologies to manage this disease in Nepal (Timila, 2012). Rotation out of susceptible crops represents an important cultural strategy for mitigating the impact of clubroot in fields where the disease is already present (Strelkov *et al.*, 2011). Among the surveyed farmers in Dhankuta and Terathum district, only 9.21 % farmers got information about the application of Nebijin (flusulfamide) for the management of the clubroot diseases where as 6.58 % farmers got information about the management of the diseases through the improvement of soil pH by the application of agricultural lime in the field and about 3.95 % people got information about the crop rotation other then cruciferous crops for the management of the diseases (Figure-2).

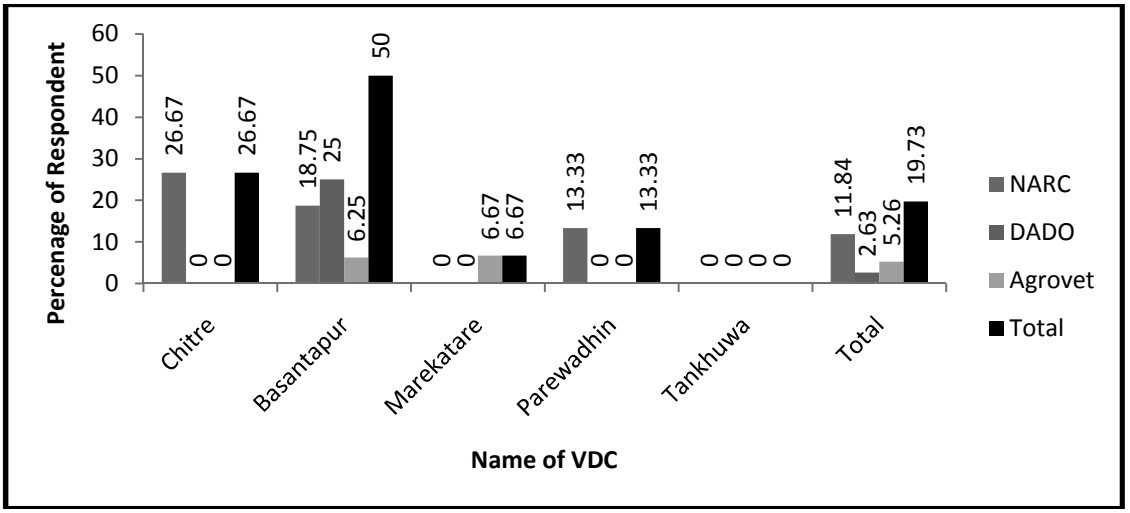

Figure 1: Percentage of farmer's information about diseases management from different sources.

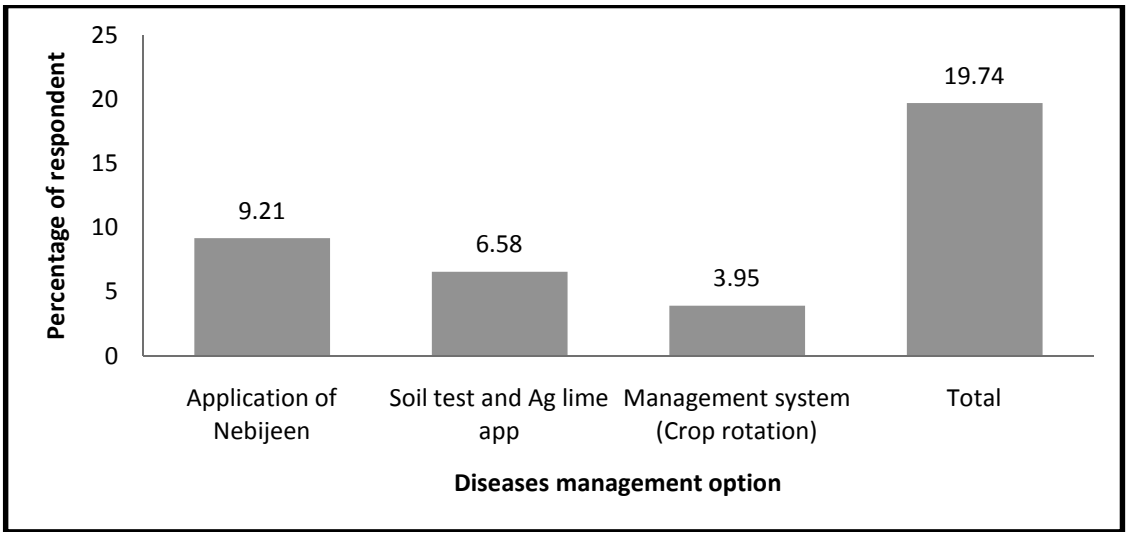

Figure 2: Percentage of farmer's information about the diseases management practice.

Knowledge on Diseases Dissemination

As a soil borne pathogen, the intra- and inter-field spread of *P. brassicae* has generally been regarded as slow (Strelkov *et al.*, 2011). The disease is usually monocyclic, and zoospore movement in the soil is limited (Howard *et al.*, 2010). However, any activity that transport contaminated soil from one point to another has the potential to disseminate clubroot (Timila, 2012; Strelkov *et al.*, 2011)**.** This disease has been spreading in new area mainly through the soil and the movement of seedlings grown in infested fields (Timila, 2012). In addition, *P. brassicae* resting spores have been detected as external contaminants of seeds and tubers of various field crops grown in clubroot infested fields (Rennie, *et al*, 2011). Hence, the dissemination of clubroot on propagative materials may represent another secondary mechanism of field-to-field spread (Strelkov *et al.*, 2011).

Out of 76 farmers surveyed in Dhankuta and Terathum district, only 32.96 % farmers have knowledge about the medium for diseases transmission in which, 14.5 % farmers responded to transmit the diseases through soil where as 5.3 % and 13.16 % farmers by seedlings and by both soil and seedlings respectively. Among the surveyed VDCs, 13.34 %, 25 % and 33.34 % farmers in Chitre, Basantapur and Marekatare respectively responded to transmit the disease by soil where as 6.67 % in Chitre, 12.5% in Basantapur, 6.67% in Parewadhin and 13.34 % in Tankhuwa VDC, farmers think that

the disease was transmitted by seedlings. But, 13.34 % farmers in Chitre, 25 % farmers in Basantapur, 13.34 % farmers in Parewadhin and 13.34 % farmers in Tankhuwa VDC think that the diseases was transmitted by both soil and seedlings (Figure 3). Farmers use seed potato which is grown in the infested field.

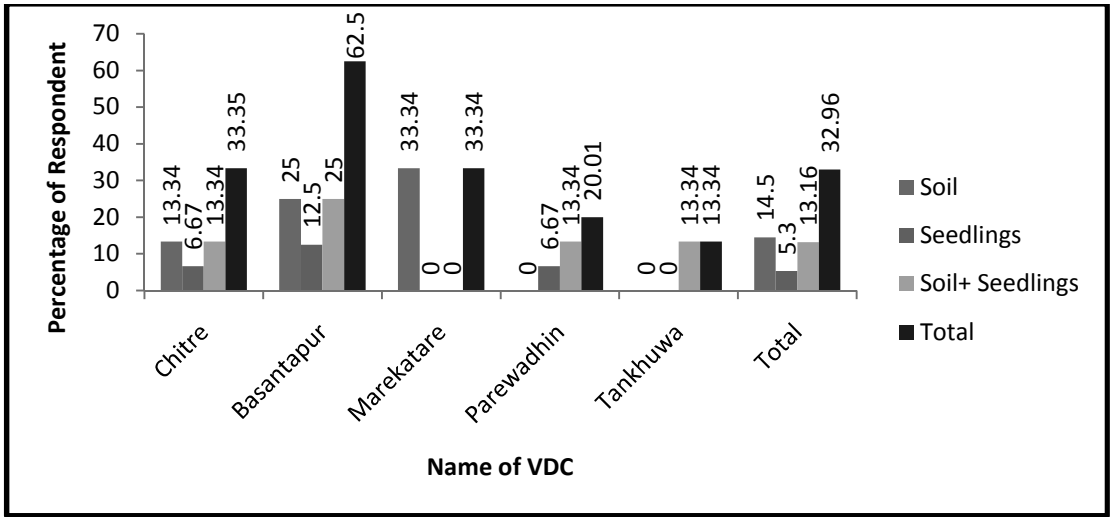

Figure 3: Percentage of farmers have knowledge about the medium for diseases transmission in surveyed VDCs.

Management Option Practiced by the Farmers

Some technology for the management of clubroot is available in Nepal. Research conducted by the Plant Pathology Division (PPD) Khumaltar has found that the application of copper oxychloride and Nebijin reduced the diseases incidence by 45.1 % and 63.65 % respectively (PPD, 2014). Amendments of lime @ 300 kg per ropani (500 m^2) significantly reduced clubroot severity compared to control in the field conditions (Timila, 2008). Effectiveness of liming thereby increased pH level that suppresses the zoospores germination, but the effectiveness could be affected by virulence of the pathogen, inoculums density in the soil and types of liming materials (Murakami *et. al.*, 2002).

Out of total 76 farmers surveyed in Dhankuta and Terathum district, 22.44 % adopt different practice for the management of the clubroot diseases in which 11.84% farmers applied agricultural lime and Nebijin as well as soil treatment by solarization, 6.7 % farmers uprooted clubbed plants and feed to the animals where as 3.9 % farmers practice firing of weeds in the field as a disease management option. Among the

surveyed VDC, 26.7 %, 8.7 % and 13.3 % farmers in Chitre VDC, Basantapur VDC and Marekatare VDC respectively applied agricultural lime and Nebijin as well as soil treatment by solarization, whereas 6.7 % in Chitre, 12.5% in Basantapur, 13.3% in Marekatare and 6.7 % in Tankhuwa VDC, farmers uprooted clubbed plants and feed to the animals. But, 13.3 % farmers in Chitre, 13.33 % farmers in Parewadhin and 6.7 % farmers in Tankhuwa farmers practice firing of weeds in the field as a disease management option.

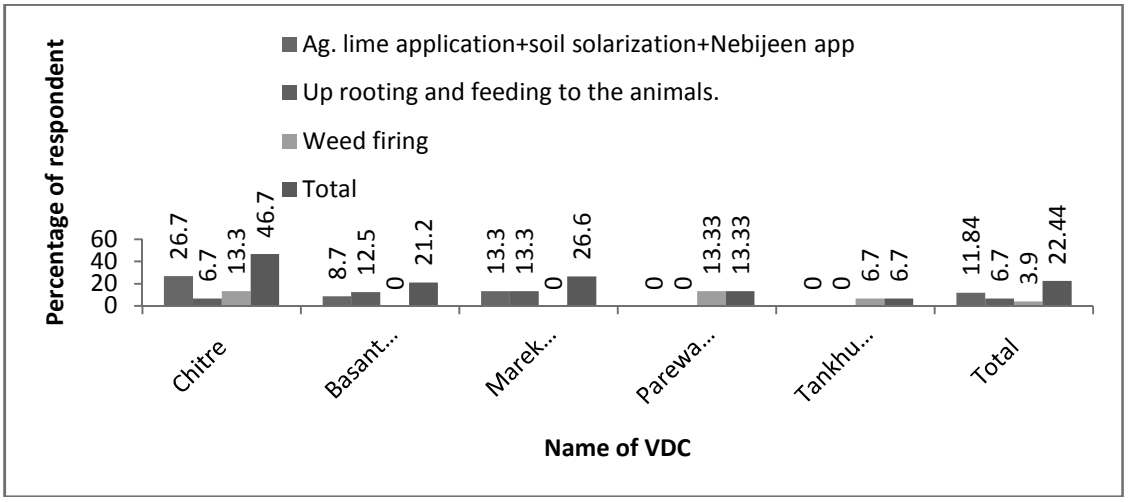

Figure 4: Percentage of farmers that practice different method for the diseases management.

Alternative for the Cabbage/Cauliflower Cultivation

Plasmodiophora brassicae is an obligate parasite (Agrios, 2005), in the absence of a host plant, pathogens are unable to complete life cycle. Therefore, for the management of the disease, avoid growing cruciferous crops in fields for 3-5 years (PPD, 2014). Farmers need to choose alternative of cruciferous vegetables for crop rotation which is very difficult to the farmers in this region because cultivation of cabbage/cauliflower is a major source of income for their livelihood. Out of total 76 farmers surveyed in Dhankuta and Terathum district, 89 % farmers choose to cultivate maize/potato/peas, if the diseases infestation and yield loss increase in future and have no any management option available for the diseases management. Likewise, 3 % farmers were choose to cultivate Chiraito, 4 % farmers choose fodder cultivation as an alternative to the

vegetable crops where as about 4 % farmers choose to cultivate agricultural crop by the consultation with agricultural technicians (Figure 5).

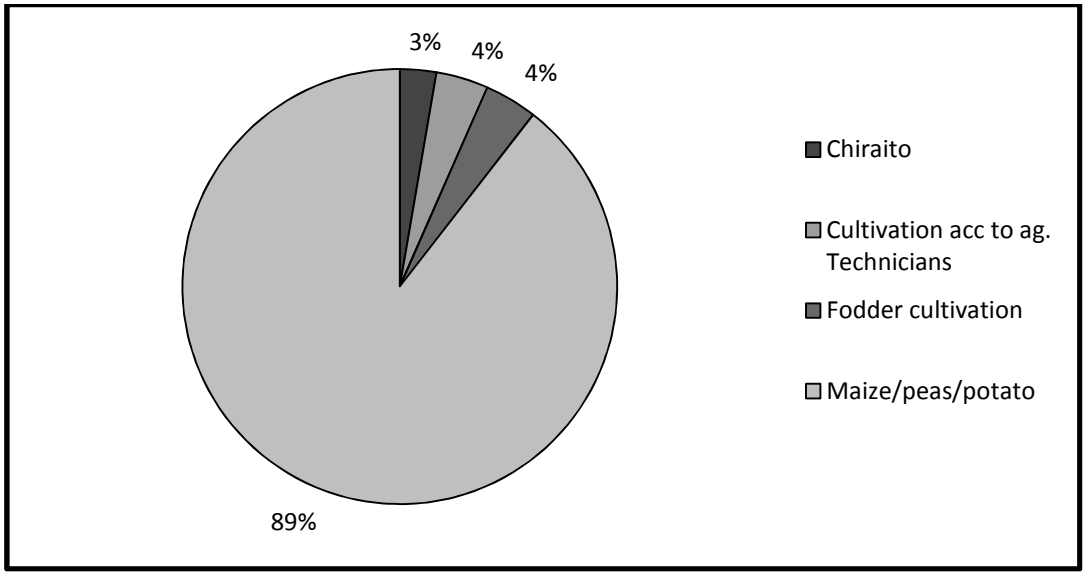

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Figure 5: Percentage of farmers that take alternative option for the cultivation of cabbage/cauliflower among surveyed farmers.

Conclusion

Within five years, clubroot has emerged as one of the most important diseases of cabbage and cauliflower in the eastern hills of Nepal. The disease is now endemic to this region and also it will likely continue to spread to nearby field due to wrong practices and lack of knowledge to the farmers such as sanitation of equipment, use of diseases free seedlings may help to slow the spread of clubroot diseases. Survey also revealed that available technology for the management of the diseases was not extended to the farmer's level in this region. So, we need to verify and disseminate the available diseases management technology in the farmer's field and extend at the farmers level. As such, sustainable vegetable production on these regions will depend on effective disease management approaches such as improvement of soil pH by the application of agricultural lime, application of Nebijin, crop rotation etc. For this, intensive effort may require to manage the diseases by the concerned stakeholders of the region. Awareness to the farmers on disease nature and its integrated management options should be emphasized.

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Evaluation of Potato Cultivars for Eastern High Hills of Nepal

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Abstract

Tubers of seven potato (Solanum tuberosum L.) cultivars; 2 released check cultivars, 1 widely adopted local cultivar and 4 improved cultivars were evaluated at the farmer's field at Basantapur, Tehrathum (2300 masl) during summer season of 2015 with an objective to identify and recommend the suitable cultivars. The experiment was conducted in randomize complete block design (RCBD) with four replications, each farmer as one replication. Tubers were planted in ridges in 60 X 25 cm spacing fertilized with 100:100:60 NPK and 15 t farm yard manure per hectare. The vegetative characters, yield and yield attributes were the parameters taken during the evaluation. The result of the study showed that the maximum plant height (61.60 cm) and number of stems per hill (4.80) was attained from the variety CIP 393385.39. While, the highest tuber yield per plot was from Kufri Jyoti. Similarly, the highest yield (18.92 t/ha) was from Kufri Jyoti among all the seven evaluated cultivars. It could be concluded that Kufri Jyoti followed by CIP 393385.39 and CIP 385499.11 could successfully be grown during summer season for eastern high hills of Nepal.

Keywords: *attribute, character, cultivar, parameter, ridge*

Introduction

Potato (*Solanum tuberosum* L.) is one of the world's major non-cereal food crop grown in more than 148 countries in a wide variety of soils and climates surpassed only by wheat, rice and maize in total production (FAO, 1995). It occupies the 5th position in area coverage, 2nd in total production and 1st in the productivity among the food crops (rice, maize, wheat, millet and potato) grown in Nepal (NPRP 2013). According to ABPSD (2012/2013) the area under potato is 1,97,234 ha. and total production is 26,90,421 mt. with an average productivity of 13.64 mt/ha. which is very less as compared to other countries. Out of the total area under potato, 19% is in the high hills and mountains, 44% in the mid-hills and 37% in terai (NPRP, 2012/13).

Potato can make a major contribution in improving world health and productivity and meets the nutritional requirement of the fast growing population particularly in the developing country like Nepal (CIP, 1995). Demand of high yielding varieties with

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resistance to major disease and pests has remained always very high since, long time in Nepal (Khatri *et. al.*, 2010). To address the farmer's basic need on potato crops, there should be a continuous research process in selection, evaluation and recommendations on the improved potato cultivars for the area and problem specific.

Methodology

This experiment was conducted at the farmer's field at Basantapur, Tehrathum, the research command area of ARS, Pakhribas during the year 2015. The treatments consisted of seven cultivars namely; CIP 388676.1, CIP 385499.11, CIP 393385.39, PRP 25861.1, Desiree, Kufri Jyoti and Local. The experiment was conducted in the Randomized Complete Block Design with four replications. The four replications signified the four farmers within the area itself. The tubers were planted with the spacing of 60 cm within the rows and 25 cm between the plants. A total of 48 tubers were planted in a plot of 7.2 m^2 area. Vegetative parameters, yield and yield attributes were collected during the experiment and were tabulated. The Genstat Software Edition 4 was used to analyse the data.

Results and Discussion

Vegetative parameters

Highly significant variation was recorded on uniformity of plants (Table 1). The maximum uniformity of plants (5.00) was recorded in the varieties CIP 393385.39 and PRP 25861.1 while, the minimum uniformity of plant (3.50) was recorded in Desiree.

Table 1. Vegetative parameters of potato cultivars at eastern high hills of Nepal (2015)

Treatments	Vegetative parameters at 90 days after planting		
	Uniformity	Plant height (cm)	Number of stems/hill
CIP 388676.1	4.00	31.20	4.40
CIP 385499.11	4.75	49.60	4.40
CIP 393385.39	5.00	61.60	4.80
PRP 25861.1	5.00	51.50	3.80
Desiree (Ch)	3.50	30.50	2.05
Kufri Jyoti (Ch)	4.00	38.80	3.65
Local (Ch)	4.75	53.30	2.55

Treatments	Vegetative parameters at 90 days after planting		
	Uniformity	Plant height (cm)	Number of stems/hill
Mean	4.42	45.20	3.66
F-test	**	**	*
LSD	0.52	11.84	1.55
CV%	7.90	17.60	28.60

*, significant at P ≤ 0.05. **, P≤0.01, SEM, standard error of mean. LSD, least significant difference. CV, coefficient of variance

The analysis of variance showed significant effect on plant height. The mean table shows that the highest plant height (61.60 cm) was from cultivar CIP 393385.39 followed by Local cultivar with (53.30 cm) and the lowest plant height (30.50 cm) from Desiree. Plant height is a desirable character which contributes to the increment of plant canopy and biomass. The higher biomass has the capacity for higher photosynthetic rates and its translocation to sink (tuber) resulting into higher yield. In case of number of stems per hill, the result showed significant. At full vegetative growth phase the highest number of stems per hill (4.80) was from the cultivar CIP 393385.39 while, the lowest (2.05) was obtained from Desiree. The number of main stems arising from a seed is important because it influences the number and size of tubers at harvest.

Yield and Yield Parameters

The data regarding number of tubers per plant revealed that differences were highly significant to potato cultivars (Table 2). The numbers of tuber per plant are most important components of yield. The highest number of tubers (10.60) per plant was observed from the cultivar Kufri Jyoti followed by CIP 393385.39 and Local with (10.35) while the lowest number of tubers (5.00) per plant was obtained from Desiree.

Table 2. Yield and yield parameters of potato cultivars at eastern high hills of Nepal (2015)

Treatments	Yield and Yield Parameters				
	Number of tuber/plant	Tuber yield/plot by size (kg)			Tuber yield (mt/ha)
		<25 g	25-50 g	>50 g	
CIP 388676.1	8.10	2.08	4.25	3.4	10.42

Treatments	Yield and Yield Parameters				
	Number of tuber/plant	Tuber yield/plot by size (kg)			Tuber yield (mt/ha)
		<25 g	25-50 g	>50 g	
CIP 385499.11	7.80	2.02	4.41	4.81	15.79
CIP 393385.39	10.35	2.52	4.03	5.97	16.64
PRP 25861.1	6.95	4.12	3.13	3.67	11.63
Desiree (Ch)	5.00	3.59	1.84	1.41	8.55
Kufri Jyoti (Ch)	10.60	3.31	5.16	6.26	18.92
Local (Ch)	10.35	4.4	3.34	3.37	11.93
Mean	8.45	3.15	3.74	4.41	13.41
F-test	**	**	**	*	**
LSD	1.56	0.81	1.23	3.24	3.65
CV%	12.5	17.4	22.20	49.5	18.30

*, significant at P ≤ 0.05. **, P≤0.01, SEM, standard error of mean. LSD, least significant difference. CV, coefficient of variance

Similarly, the production of small size tubers (<25 g) and medium size tuber (25-50 g) per plot by size were found highly significant while large size tubers (>50 g) was found to be significant (Table 2). However, small size tubers (<25 g) was found high from Local cultivar (4.4 kg) per plot and in case of medium size tubers (25-50 g) was found to be higher from Kufri Jyoti (5.16 kg) per plot. On the other hand large size tubers (>50 g) was found to be the highest (6.26 kg) per plot from Kufri Jyoti. The total tuber yield was found highly significant among the cultivars (Table 2). The highest total tuber yield (18.92 mt/ha) was recorded from the cultivar Kufri Jyoti followed by CIP 393385.39 (16.64 mt/ha) while the lowest total tuber yield (8.55 mt/ha) was recorded from Desiree.

Conclusion

Generally, all the evaluated cultivars showed highly significant result in plant uniformity, plant height and number of stems per hill. The weight of tuber per plot also showed the similar type of result as significantly different among the cultivars. Similarly, the highest yield per hectare (18.92 mt/ha) was obtained from the clone Kufri Jyoti followed by CIP 393385.39 (16.64 mt/ha). In other words, Kufri Jyoti seems to be the best clone among all seven evaluated ones for the higher productivity for ware

potato production under eastern high hills of Nepal. Beside this, cultivars CIP 393385.39 and CIP 385499.11 should be further evaluated.

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Livestock Depredation and Human Casualties by Leopard *Panthera Pardus* in Bhaktapur

Naresh Kusi[1] and Manoj Aryal[2]

Abstract

Leopard Panthera pardus is the largest mammalian predator in the mid hills of Nepal. It enters into conflict with humans through livestock depredation and human casualties. In Sipadol area of Bhaktapur, the conflict was significant in Aasapuri, Patibhanjyang, Thulogaon, Maligaon and Taudol. Livestock depredation occurred throughout the year with maximum cases during spring season. Goats were the most depredated livestock. Leopards killed three small children and an adult man was injured from 2001-2014. Primary data were collected by transect surveys, questionnaire surveys, key informant interviews and focus group discussion. Families that have suffered a loss to leopard have a negative attitude towards it. However, educated people and old people with religious faiths favor leopard conservation. The practice of stall feeding and proper guarding while grazing may lessen depredation problem while initiations of capturing human-killing leopards may properly address the problem of human casualties.

Keywords: *attitude, conflict, leopard conservation, primary data*

Introduction

Of all big cats, leopard *Panthera pardus* is the most widely distributed (Bailey 1993). Its highly adaptable hunting and feeding practices enable it to easily survive in human dominated areas through a change in its dietary habits (Seidensticker *et al.* 1990; Chauhan and Goyal 2001).

The success of community forestry has restored suitable habitat for many wildlife species including the leopards in Nepal. At the same time, human population growth rate is also high. In a situation where the predator and the humans share resources, conflicts are evident (Bhattarai, 2009).

Most studies on human-wildlife conflicts are made in the protected areas and very little is known about them beyond the protected areas. This study was conducted to find out

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the status of human-leopard conflict in Sipadol, Bhaktapur and to figure out the perceptions of the local community towards leopard conservation.

Methodology

Study Area

Sipadol lies in the southern part of Bhaktapur district with an area of 8.43 km^2. Hills and valleys are the dominant topographical features here. The climate is subtropical with *Schima wallichi* and *Castonopsis indica* as dominant trees. The elevation ranges from 1340 to 1980m (GoN 1999).

There are six Community Forests (CFs) which comprise an area of 3.40 km^2. According to DDC Bhaktapur (2006), the total households in the area were 1,127 of which 536 households were involved in Community Forest User Groups (CFUGs). Leopard *Panthera pardus* is the major predator in the area and Barking deer *Muntiacus vaginalis* is its important natural prey.

Agriculture and animal husbandry are the important economic activities in the area. Collection of firewood, fodder and other forest products is an important human activity.

Preliminary information on presence and extent of human-leopard conflict were gathered through discussions with the government officials, forest rangers and villagers. Strip transects of 10m width were conducted along river side, forests, dirt roads, trails and ridges to look for leopard signs in the potential sites identified during reconnaissance survey (Laing *et al.* 2003). Length of transects varied from 800m to 1200m. Geographical positions were obtained with a handheld Geographical Positioning System (GPS) device and other relevant attributes like elevation and forest type were noted.

A total of 40 households were selected purposively and a structured questionnaire was asked to the respondents. Similarly, five key informant interviews were made with forest rangers, CFUG members and VDC staffs. An informal Focus Group Discussion (FGD) was done by inviting the members of the households most affected by the conflict.

Results and Discussion

Livestock Losses

Livestock losses were significant in Patibhanjyang, Thulogaun, Maligaun and Taudol whereas Suryabinayak and Bibicha had no incidence of livestock depredation. Goats were the most depredated livestock followed by dogs. (Figure 1)

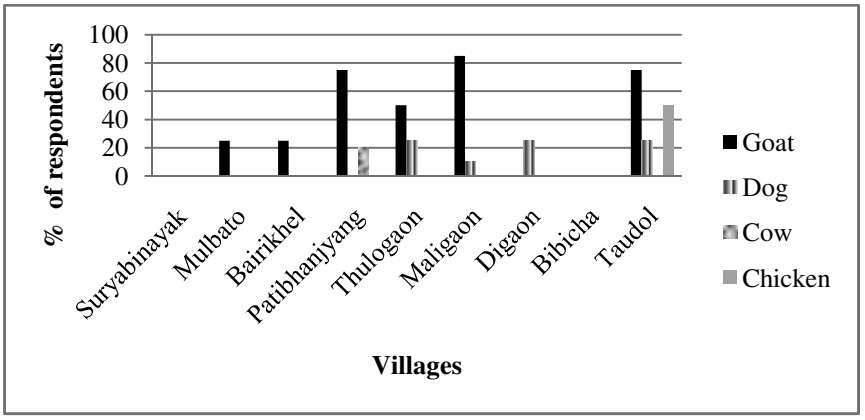

Figure 1: Livestock lost to leopard in different areas

The loss is estimated at USD 47 (NPR 5000.00) per household. The highest loss amounted up to an estimated USD 282 (NPR 30,000.00) where six goats were killed by a leopard in a single attack at a household in Darlang area.

Most incidences of livestock predation occurred in the forest edges. A few cases were reported from the courtyard and sheds of households. Leopard attacks on livestock were maximum during spring (50%) followed by rainy and autumn seasons (25% each).

Human Casualties

Leopards killed three children (aged between 5-10 years) and one adult man was injured from 2001-2014. Details of the human casualties are given in table 1. Differences in the season of attacks show that the conflict is not seasonal.

Table 1: List of human casualties due to leopard attack

S.N.	Village	Gender	Age	Time of attack	Date	Place of attack	Remarks
1.	Taudol	M	36	Evening	NA	Pipalbot	Minor injury
2.	Thulogaon	F	9	Evening	Nov-2008	Thulogaun	Death
3.	Maligaon	M	8	Morning	Oct-2002	Maligaun	Death
4.	Digaon	M	5	Morning	July-2001	Digaun	Death

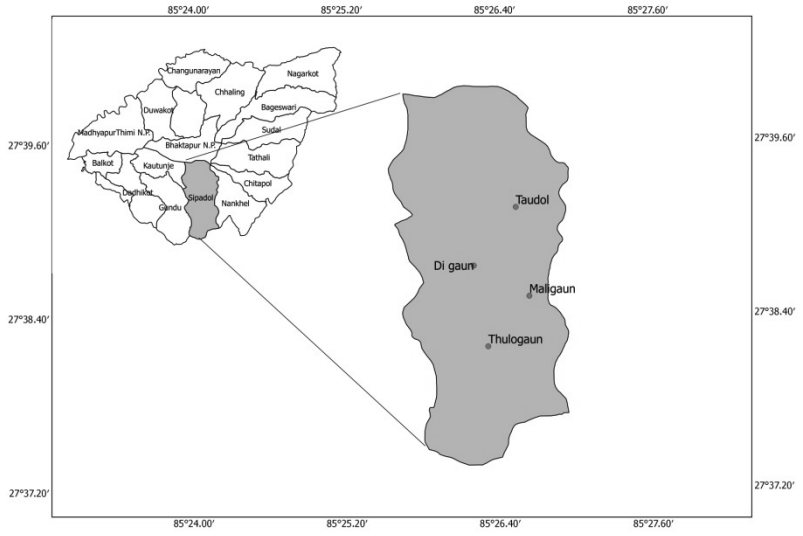

Figure 2: Location of human casualties

Leopard Signs

A total of four transects with a total length of 4.4km (mean length of 1.1km, ranging from 800m to 1400m) were surveyed. During these surveys, a total of 13 signs were recorded consistitng of eight scats (61.53%), three pugmarks (23.08%), one track (7.69%) and one vocalisation (7.69%). The overall sign encounter rate was 2.95 signs/km. The individual sign encounter rate were 1.82/km for scat, 0.68/km for pugmark, 0.23/km for track and 0.23/km for vocalisation.

Attitude Towards Leopard

The people from Aasapuri, Darlang, Patibhanjyang, Thulogaon, Maligaun and Taudol had negative attitude towards leopard whereas people from Suryabinayak, Bairikhel, Digaon and Bibicha were neutral. In general people liked leopard for its beauty. Old people from the area considered leopard as a protector of their forest. They believed that leopards keep them safe from various disasters, prevent diseases from spreading into their community and thought that *Bandevi* (the goddess of forest) will harm them if they killed leopards.

Majority of the respondents (65%) said the government should be responsible for leopard conservation. While 20% of the respondents said that the government and the locals should be jointly responsible, 10% suggested that the government, local communities and forest officials should work together and the remaining 5% said that the local community should be solely responsible.

Goats are medium size prey for leopards. Goats were the most depredated of all livestock types because leopards select prey based on their body size and prefer smaller and medium sized prey (Hayward *et al.* 2006). Involvements of small children aged between 5-10 years in the three incidences of human death also support this.

In Patibhanjyang a cow was killed by leopard but was left at the shed. It suggests that leopards may also take up larger livestock when opportunity arises but they are generally unable to drag them to a safe feeding site. Aasapuri, Thulogaun, Maligaun and Taudol are located in proximity with the community forests. So they suffered the highest loss of livestock. On the other hand, absence of livestock depredation in Suryabinayak and Bibicha is explained by their far off locations from the forests.

Most livestock depredation occurred near forest edges because most people in the villages grazed livestock near the forest edges. Near the forest edges, the predator has a good cover and the livestock are easier to prey on. Our observations were comparable with that of Kabir (2010) in Pakistan where majority of livestock depredaton by leopard occurred in open places near forests.

A considerable number of livestock were depredated near human settlements since leopards frequented human settlements throughout the year. A similar trend was observed in Bardia National Park by Odden and Wegge (2005). Livestock depredation

were more during spring season than during other seasons of the year since livestock were grazed for a maximum time during spring season.

For subsistence farmers, even a small loss holds important economic significance. Be it an elusive snow leopard (*Panthera uncia*) in the Annapurna Conservation Area (Oli *et al.*1994) or the more common leopard, people develop negative attitude towards the predators when their livestock are depredated. The prevalence of positive attitude towards leopard conservation in the educated people is due to their knowledge of its ecological role. At the same time, a positive attitude in the old people is influenced by the the fact that tiger *Panthera tigris* is considered the vehicle of Goddess Bhagwati in the Hindu religion and that in the mid-hills of Nepal people call leopard by the same name '*Bagh*' as they have it for the tiger in the terai. But old people in the families that have lost their children to leopard had negative attitude towards it since a bond with family relatives is always bigger than religious faith.

Use of guard dogs did not help in mitigating leopard attacks. In many cases the dogs were killed leopards. Incidents even indicated that the dogs actually attract leopards because leopards see dogs as their prey rather than as guards.

To lessen livestock depredation by leopards, the villagers need to be encouraged to adopt the practice of stall feeding around their homes rather than leaving them to graze near or in forests. If the livestock are taken for grazing, a herder should always be present as a guard. Identification of human-killing leopards is an important step to address the problem of human casualties. Actions should be put in taking them into captivity. Once an area is identified to be frequetly used by such animals, it can be declared a 'No go zone' and the villagers should be encouraged to go in group if they strictly required going to such places.

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Comparative Economic Analysis of Locally Adapted and Drought Tolerant Rice Varieties in Nawalparasi District of Nepal

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Abstract

Rice is the most important cereal crop grown mainly by small scale farmers as a food crop in Nepal. Rice production is however low resulting in imports amounting to billions annually. Climate change is a great threat of today to the farming community. Drought is one of the major problem induced by the climate change. Data for was obtained from rice adaptability trials at two V.D.Cs (Dobadi and Rakachuli) of Nawalparasi Districts and was analyzed using Excel and SPSS 16. Adpatability trial consists of Sukha varieties 1,2,&3 which was compared with the locally adapted rice variety Radha 4. For comparison Gross margin, Dominance Analysis and Marginal Rate of Return was calculated.Net Benefit from the Sukha varieties is higher. If farmers changed from locally adapted rice variety to improved drought resistant rice varieties Sukha 1,2&3 they would earn a marginal rate of return 170%, 40% and 8% respectively. Dominance Analysis showed that all the varieties were Undominated. The marginal Rate of Return of the cultivation of Sukha 1 variety is above minimum acceptable rate of return that is 100%. This implies that farmers in rainfed rice growing areas in Nawalparsi District of Nepal are encouraged to plant improved variety Sukha varieties. These results are compelling and speak of the need for reorientation of the agricultural research agenda taking into consideration the existing and emerging abiotic stresses, and the development and dissemination of improved drought-tolerant technologies.

Keywords: *drought, rice, economic analysis, gross margin, dominance analysis, marginal rate of return*

Introduction

Rice ranks the first among cereal crops in terms of Area, production and livelihood of the people. As the most important staple food of Nepalese people, rice contributes nearly 20% to the agricultural gross domestic product and almost 7% to GDP (MOAD, 2013). The growth of imports has outpaced exports and the agricultural trade deficit has increased over the years from $124 million to $373 million (TEPC, 2013). Drought is

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one of the most important abiotic stresses resulted due to climate change causing significant yield losses across the country especially in the rainfed rice environments. In Nepal 30% of total rice cultivated areas are prone to drought (Gumma, et.al, 2011). National Rice Research Program has developed and released drought tolerant varieties like Sukha-1, Sukha-2, Sukha-3, Sukha-4, Sukha-5, and Sukha-6 to address the problem of drought (NARC, 2012). The overall objective of this study was to recommend profitable and appropriate rice variety for small scale farmers facing the problem of Drought.

Methodology

Study Area

The study was undertaken on drought tolerant rice varieties (Sukha1, Sukha2, and Sukha3) adaptability trial at Dhobadi and Rakchuli V.D.Cs Nawalparasi for two years from 2010 to 2011. Locally adapted variety Radha-4 was used as a check. Dobadi and Rakachuli V.D.Cs lies at an elevation of 300 masl. Average minimum and maximum temperature of the study sites is 5^{o}C and 38^{o}C respectively. The district spreads from 27°21' to 27°47' north latitude and 83°36' to 84°25' longitude in east. Mean precipitation of the area is 2145 mm per year. The soil in the District is heavy loamy soils. Farming in these V.D.Cs is rainfed type. In recent years Drought has been the major problem in these areas. The production is decreasing every year. To address the problem of drought brought by the changing climate adaptability trial had been set at these two V.D.Cs. Whether these drought tolerant varieties were economically viable for farmers or not, Economic Analysis for these varieties is performed.

Data Collection

Primary data on input and output were obtained from the operations carried out during the implementation of the rainfed rice adaptability trials. Data of two years from two V.D.Cs were collected and mean of the cost and yield were calculated. Quantities of purchased inputs from local markets were recorded.

Data Analysis

Data was analyzed using MS-Excel and SPSS. CIMMYT approach was used as a tool for Economic Analysis for collected data. Various analyses include calculation of gross margin, Dominance Analysis and Marginal Rate of Return (MRR). Gross margin was calculated as the difference between the total revenue and Total variable costs for each variety. Total revenue was computed as the product of adjusted average rice yield by the

market price. Adjusted rice yield is calculated by deducting 10% from the Yield of the crop. The cost components include the Human labour, Bullock/Tractor, Seed, Miscellaneous cost and Fixed cost. Gross margin analysis alone cannot give the effective decisions; hence need to carry out further analysis leading to dominance and marginal analysis (CIMMYT, 1998). In a dominated treatment, a higher total variable input cost is incurred to earn the same or a lower net benefit when compared with other treatments. Dominance analysis eliminates dominated treatments from further analysis. MRR (between treatment 'a' and 'b') is given by Change in Net Benefit/ Change in Total Cost. Marginal Analysis was based on the assumption that overhead costs were not included, owner's labour was not included and MRR>Minimum Acceptable Rate of Return (MARR) which is 100% would be acceptable for a farmer to change from one technology to another.

Results and Discussion

Gross margin contains details of cost components of rainfed rice production that vary with the type of rice varieties. Dominance Analysis gives details on interaction between total variable costs and net benefits. On equal footing marginal rate of return gives details on percent return to additional investments as a farmer changes from Radha-4 (locally adapted) to Sukha varieties.

Table 1: Gross margin per hectare for locally adapted and drought tolerant rice varieties

	Rice varieties			
Operations	**Local**	**Improved**		
Variable cost	Radha- 4	Sukha-1	Sukha-2	Sukha-3
Human labour	38000	45000	43000	42000
Bullock/Tractor	9000	9000	9000	9000
Seed	2000	1500	1500	1500
Miscellaneous Cost(Fertilizer,Plant protection,sprayer	4000	4500	4500	4500
Total Variable Cost	**53000**	**60000**	**58000**	**57000**
Fixed Cost (Land tax,Water tax, Farm Depriciation, Repair cost)	250	250	250	250
Total Cost	**53250**	**60250**	**58250**	**57250**

Revenue				
Yield(t/ha)	3.6	5.0	4.6	4.4
Adjusted yield(t/ha)	3.24	4.5	4.14	3.98
Selling price per ton	17000	15000	15000	15000
Total Revenue	**55080**	**67500**	**62100**	**59400**
Net Benifit	**1830**	**7250**	**3850**	**2150**

Source:Field Survey,2011

Table 1 shows that locally adapted rice variety Radha-4 had lowest gross margin per hectare compared to the drought tolerant Sukha rice varieties. The market price of Sukha varieties is lower than the Local varieties. Due to the highest yield of Sukha Varieities compared to the local one selling price per ton for Sukha varieties is highest. Total cost was smallest for locally adapted variety and highest for Sukha 1. It was only Bullock and Tractor cost that did not vary across the varieties. To generate more information for effective decision making there was need to perform Dominance Analysis.

Table 2: Dominance Analysis of local and sukha varieties

Rice Varieties	Total Variable Cost	Net benefit	Dominance
Local	53250	1830	Undominated
Sukha 3	57250	2150	Undominated
Sukha 2	58250	5200	Undominated
Sukha 1	60250	7250	Undominated

Source: Field Survey,2011

From Dominance Analysis all rice varieties were undominated which implies that increase in total variable costs associated with change from one variety to another and had a commensurate increase in the net benefit and hence decision on the best variety to adopt cannot be decided at this stsge. This leads to the analysis of the marginal rate of return (MRR) which threw more light on the relationship among the undominated varieties in terms of increasing costs and benefits. Results of the dominance analysis indicate that no variety dominates the other hence it is prudent to look at the effects on returns from changing from one variety to another.

Table 3: Marginal Rate of Return of Local and Sukha Varieties

Rice Varieties	Total Variable Cost	Net Benefit	MRR(%)
Local	53250	1830	-
Sukha 3	57250	2150	8
Sukha 2	58250	3850	40.4
Sukha 1	60250	7250	170

Source: Field Survey,2011

Table 3 shows the marginal rate of return for changing from Radha-4 to the drought tolerant sukha varieties. The highest marginal rate of return was 170% while the least was 8%. A change to Sukha 3, Sukha 2 and Sukha 1 would increase the farmers return of 0.08%,0.4% and 1.7% respectively. The total cost and Net Benefit increases which can explain why no variety dominated the other. The high MRR for Sukha 1 can be attributed to the high yield compared to other improved varieties.

Small scale farmers would be better off if they changed from locally adapted rainfed rice variety to drought tolerant rice variety due to higher MRR these varieties generates. The MRR was higher above 100% for the Sukha1 variety which is above the minimum acceptable rate of return. It was alsofound that none of the varieties was dominated suggesting that cost implications may not have a bearing on farmers decision to change from low net benefit technology to a high net benefit one, a farmer who is keen on high profit margin would choose Sukha 1 which gave the highest MRR compared to other Sukha varieties. It is recommended that farmers in rainfed rice growing area with scanty rainfall should adopt any of the Sukha varieties to address the food insecurity and poverty prevalence concerns in the country.

It seems profitable to adopt the Sukha varieties as compared to the local one. Very few study has been done regarding the Economic Analysis of the drought tolerant crop in Nepal. Similar result has been found by Okecl and wawire at Kenya, Africa. A experiment conducted at Kisumu District of Kenya under rainfed condition showed that the drought tolerant rice variety NERICA 1, NERICA 4, NERICA 10, NERICA 11 had the highest marginal rate of return compared to the local variety Durado precoce. NERICA1,4,10&11 had the Marginal Rate of Return 148%,148%,225%&303% respectively. This implies farmers would adopt any of the NERICA varieties since these varieties have got highest MRR.

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Community Forest Management: A Success Story of Green Economy in Nepal

Anup K C[1]

Abstract

Green Economy results in improved human wellbeing through social equity and reducing environmental risks and ecological scarcities. It includes renewable energy, low-carbon transport, and energy efficient buildings, clean technologies, improved waste management, improved freshwater provision, sustainable agriculture, forestry, and fisheries. Community forest management is one of the successful stories of green economy sectors in Nepal recognized by UNEP. It was initiated on an experimental basis in the 1980s in Nepal similar to other developing countries. It is an approach to mitigate increasing deforestation and forest degradation and address the negative impacts on rural livelihoods. With the formation of a Community Forest User Group, local forest users can gain membership that encourages them to practice sustainable management and observe institutional regulations. Various studies have demonstrated a significant increase in forest condition under community forestry showing that it is a proven model for controlling deforestation and forest degradation. Community forestry has co benefits of reducing poverty and addressing social exclusion by creating rural employment. It is contributing to livelihood promotion in many ways. Livelihood promotion includes fulfilling the basic needs of local communities, investing money in supporting income generation activities of the poor people and providing access to the forestland for additional income or employment.

Keywords: *community forest management, forest conservation, green economy, livelihood enhancement*

Introduction

Green Economy

A Green Economy is that economy which results in improved human wellbeing, social equity and reducing environmental risks and ecological scarcities (Sukhdev et al., 2010). In the global scenario, green sectors include renewable energy, low-carbon transport and energy efficient buildings, clean technologies, improved waste

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management, improved freshwater provision, sustainable agriculture, forestry, and fisheries (Sukhdev et al., 2010, K.C. et al., 2015). For any economy to go green in the context of Nepal, it is necessary that the private sector comes on board, understands and accepts the necessity of going green and pursues strategies necessary to become green (GoN, 2011). Community forest management is one of the green economy sectors in Nepal recognized by UNEP as one of the success stories in the world (Sukhdev et al., 2010).

Community Forestry Management

Forestry means use of forests for achieving specific objective that introduces it into different types (K. C. et al., 2015). But managing forests for the express intent of benefitting neighboring communities is a community forestry (Brendler and Carey, 1998). In community forestry, forest user group (FUG) control and manage the local forests while harvesting and pricing of all forest products and forest management is governed by an executive committee elected in the FUG assembly (Gilmour and Fisher, 1998, K. C. et al., 2015). With the formation of a FUG, local forest users can gain membership that encourages them to practice sustainable management and observe institutional regulations (Gilmour and Fisher, 1998). Community-based forestry presumes that forest areas can be sustainably managed to protect the natural resource base and forest ecosystem functions, and also provide enhanced income opportunities to community residents from traditional and nontraditional products and services (Brendler and Carey, 1998). Community-based forestry emphasizes collaborative, participatory and holistic management in local stewardship, local needs and local knowledge.

Community Forestry in Nepal

Community forestry policies was emerged in Nepal as a response to institutional failure at the local level which had led to progressive degradation of hill forests. During the initial period of democracy (1951-61), the forests were nationalized but Department of Forest (DoF) could not manage it which created an open access situation. Land registration processes contributed to encroachment, and consequent forest degradation began to threaten the sustainability of livelihoods in the Middle hills (Springate-Baginski et al., 2003). Nepalese people have faced an increasing loss of forest areas due to the increase in the values of timber and other natural resources (Hobley and Malla, 1996). In the late 1960s and 1970s, there was increasing recognition of the inadequacy of the prevailing exclusionary model of forest management (Springate-Baginski et al., 2003). Therefore, in the 1970s, local users' participation in forest management was

reconsidered by the government after recognizing the effectiveness and benefits of common property management (Brown et al., 2002). Community forestry was legally implemented with the 1993 Forest Act and the 1995 Forest Rules in Nepal. It is based on the operational co-operation of Forest Department officers and forest user groups (Pokharal, 2001). A total of 1,798,733 hectare of forest is handed over to 18,960 CFUGs (DoF, 2015).

Role of Community Forest Management in Forest Conservation

Various studies have demonstrated a significant increase in forest condition under community forestry showing that it is a proven model for controlling deforestation and forest degradation (K. C. et al., 2013). The situation of environmental crisis had emerged due to lack of participation of community in management of forests. By the late 1970s, Nepal had lost almost 2.2 million ha of forest cover resulting in serious flooding downstream (Ojha et al., 2009). Community forests could be a suitable option to conserve biodiversity. However, there are indications that Community Forestry User Groups (CFUGs) are moving towards providing sustainable forest product needs whereas the biodiversity issue receives less priority (Adhikari, 2003). But, active forest management by CFUG can lead to an increased supply of forest products without damaging the forest resource base (Adhikari, 2003). It contributes additional environmental services such as provision of water resources, wildlife habitat and carbon sequestration (Karky and Banskota, 2007).

In Kavre and Sindhupalchok districts of central Nepal, a study found that shrub land and grassland have been converted into productive forests by increasing forest area from 7,677 hectares to 9,678 hectares (Jackson et al., 1998, Ojha et al., 2009). A study in a mountain watershed covering three different time periods (1976, 1989 and 2000) spreading over 25 years showed that small patches of forest have enlarged and merged, reducing the number of forest patches from 395 to 175 and increasing the net forest area by 794 hectares. A study conducted in Kafley Community Forest of Lalitpur District shows that the biomass has increased at the rate of 4.13 ton/ha per year from 2012-2014 (Ghimire, 2013, Paudel and K.C., 2014). But in the case of Gwangkhola Sapaude Babiyabhir Community Forest of Syangja District, the rate of incremental biomass was 0.95 ton/ha per year (K. C., 2012). Thus, there is an overall improvement in forest protection contributing to local environmental conservation and increased greenery (Gautam et al., 2003, Ojha et al., 2009).

Role of Community Forest Management in Livelihood Enhancement

The community forest management strategy is successful and sustainable as local people are actively participating and managing the forest, harvesting and distributing forest products, setting rules and regulations, and fulfilling their demand of forest products for sustaining and enhancing their livelihood (K. C. et al., 2015). It was also addressing social exclusion, creating rural employment, and helping in carbon sequestration, which further increases the forest cover by controlling deforestation and forest degradation (K.C. et al., 2014). Community forestry fulfills the basic needs of local communities, invests money in supporting income generation activities of the poor people and provides access to the forestland for additional income or employment. From the community forests, 8 million cubic feet of timber, 336 million kilograms of firewood and 371 million kilograms of grasses were used by local people for their internal consumption which support the livelihood of local people (Kanel and Niraula, 2004). Study shows that CFUGs earned 416 million rupees annually from the sale of forest products which was used for different purposes including 12.6 million rupees for pro-poor community forestry, loans to poor families and training in forest based income generation activities. Sub-user groups of the poor, who have no alternative employment or income opportunities in Ghorlas of Myagdi and Jhauri of Parbat are given access to community forests to produce non timber forest products (NTFPs) or medicinal plants and are allowed to share the income generated (Kanel and Niraula, 2004).

The forest act and related regulations grant the freedom to undertake local development activities. Twenty five percent of the income from CFUGs has to be spent on the protection and management of community forests and remaining 75% of income can be spent on community development. (Ojha et al., 2009). The community forestry program has built capacity among many local people. About 7.7 million people or 35% of the population are involved with CFUGs and about 170,000 local people are working as committee members. Some local people in the user groups and committees have received training in many topic areas including silviculture, gender equity and record keeping. These trainings have strengthened local capacity to a large extent (Wakiyama, 2002).

Forest derived products generate additional income for households and also supply household needs such as fuel wood and provide food sources directly to the poorer households with little or marginal quality land (Pandit and Thapa, 2004). A wide range of NTFPs are harvested both for subsistence (such as food, medicines, and utensils) and for sale. Studies have calculated that NTFP earnings account for 14–25 percent of total

household annual income in various districts of Nepal (Pandit and Thapa, 2004, Ojha et al., 2009). Community forestry has contributed towards improving and diversifying livelihoods by mobilizing locally available and communally owned natural capital directly through the promotion of wild edibles and indirectly by providing financial and social safety needs to the poor. Forest-based incomes account for a substantial portion of overall household income in many rural areas of Nepal. Forest products derived through community forestry accounted for 20–25 percent of mean household income for 50 households surveyed in one middle hill district, regardless of wealth class (K.C, 2004, Ojha et al., 2009).

An analysis in the Western Terai district of Rupandehi shows that CFUGs managed about 8000 hectares of forest and generated about NRs 25 million in 2007, whereas government managed about 18,000 hectares and generated only NRs 3 million. Another study showed that in a recent year, Department of Forest controls around 66% of the forest and generated only NRs 550 million, whereas CFUGs controlled around 25% of the forest generated over NRs 893 million, of which over 84% is from the sale of forest products, and rest from grants and other incomes. This proves that communities are more effective in managing forests and generate financial resources, along with putting measures to control deforestation and degradation (Pandey, 2009).

Conclusion

Community forest management is one of the green economy sectors in Nepal recognized by UNEP. It is an approach to mitigate increasing deforestation and forest degradation to address the negative impacts on rural livelihoods. Studies have demonstrated a significant increase in forest condition under community forestry showing that it is a proven model for controlling deforestation and forest degradation. It has co benefits of reducing poverty and addressing social exclusion by creating rural employment. It is contributing to livelihood promotion such as fulfilling the basic needs of local communities, investing money in supporting income generation activities of the poor people, and providing access to the forestland for additional income or employment. Hence, community forestry management is a successful example of green economy leading to environmental, social and economic benefit to the country.

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Conservation, Management and Utilization of Agriculture Bio-Diversity in Duwachour, Sindhupalchok, Nepal

Suroj Pokhrel[1] and Niru Dahal[2]

Abstract

Participatory rapid appraisal (PRA) was conducted in the year 2011 to find out the status of conservation, management and utilization of agriculture bio-diversity for food security in Duwachour-9, Keurani, Sindhupalchok, Nepal. Two third of the major cereal varieties (Rice 9, Maize 2 and Wheat 2) were extinct and one fifth (Rice 2, maize 1,) were threatened because of invasion of the improved and hybrid crop varieties. The value of agro-biodiversity with it special varietal traits of these crop varieties have been lost within a decade. There is an immense need of conservation of Jhinuwa masino, Ganga jamuna and Valley pokhara varieties of rice and Murali makai (maize) and some other farmer's millet varieties in Duwachour. For this, strengthening the national agriculture biodiversity management program, linking them to poverty reduction and enhance food security in Nepal is necessary.

Keywords: *PRA, bio-diversity, extinct, threatened, hybrid, traits, farmers varieties*

Introduction

Agricultural biodiversity includes all components of biological diversity of relevance to food and agriculture at genetic, species and ecosystem level which are necessary to sustain key functions in the agro-ecosystem, its structures and processes (Altieri and Merrick, 1987). It is the variety and variability of plants, animals, pollinators, micro-organisms, human activities /the indigenous knowledge and skills. Nepal is the member country for Convention on Biological Diversity (CBD) 1993, Consultative Group on International Agricultural Research (CGIAR), Intellectual Property Rights (IPR), Plant genetic resources for food and agriculture (PGRFA), International Commission on Plant Genetic Resources (IPGR). Nepal has her own Nepal Agro-biodiversity Policy (NABP) 2063 BS and the Plant Variety and Farmers Right Nepal (PVFR) is also drafting.

We do not have calculated the value of agriculture bio-diversity in Nepal. It provides the goods and services for daily uses and raw materials to our industries. It contributes to sustainable livelihoods through production effects (crops, soil nutrient recycling, pest

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predators, etc). It helps for the important ecosystem functions, services and contributes to the livelihoods of a wide range of stakeholders (public sector, plant breeders, research scientists, etc). It has linkages to different sectors eg. tourism, conservation, income generation, and so on. It is the backbone of agriculture system responsible to supply balanced nutrition and maintaining health and environment. Poorer countries/communities are rich in bio diversity, but maintaining them and uses for a country like Nepal are a challenge (Pokhrel, 2012a). At present, more than 90 per cent of crop varieties have disappeared from farmers' fields; and several are under threat in the developed region. Developing countries are following the same path. The accompanying local knowledge, culture and skills on food production are forgetting throughout the world. Half of the breeds of many domestic animals have been lost.

In fisheries, all the world's 17 main fishing grounds are now being fished at or above their sustainable limits, with many fish populations effectively becoming extinct (Altieri and Merrick, 1987). The genetic erosion of agricultural biodiversity is also exacerbated. Losses of 'wild' relatives/land races, of agricultural species are declining with lower food availability from the forest. Some of the crop species are neglected and underutilized (Pokhrel and Joshi, 2012).

There have been reported 6035 kinds of crops in Nepal. Nepal ranks 31st position in world bio-diversity. In modern days Nepal is also rapidly losing her agricultural biodiversity. She is considered as the centre of origin for different crops like rice, millet, buckwheat, barley, cucumber, pumpkin, sponge gourd, colacasia, arhar and blackgram. Presence of a number of their wild a species, relatives and land races proof the statement. However, these wild species, relatives and land races are disappearing with the invasion of improved and hybrid varieties in Nepal. Many of them have been illegally exported/exporting to other developed and developing countries including Japan and India. We were not aware on the value of this bio-diversity, our richness on the wild species, relatives and land races of different crops in Nepal. Therefore identification, mapping, registration, management and use of the agro-biodiversity in Nepal are immensity important.

Methodology

A participatory rapid appraisal (PRA) was conducted in Duwachour-9, Keurani, Sindhupalchok, Nepal, in the year 2011. PRA tool used was focus group discussion, collection of secondary information, preparation of a social map and natural resource mapping. A 4 cell table developed by Li-Bird Pokhara was used to find out the safe, declining, and threatened crop varieties during PRA survey (Table-1).

Table-1: 4 cell table for measuring the threat of crop varieties to be disappeared, 2011

1. SAFE Large Nos. of HH adopting in larger areas	**2. DECLINE** Large Nos. of HH adopting in smaller areas
3. DECLINE Small Nos. of HH adopting in larger areas	**4. THREATENED** Smaller Nos. of HH adopting in smaller areas

Results and Discussion

Household Information

All the information was gathered in Duwachour-9, Keurani, Sindhupalchok, Nepal. The household number in Duwachour VDC was 1100. Total cultivated land they owned was 3300 ropanies.

Loosing Agro-biodiversity in Duwachour, Sindhupalchok

Rice, maize wheat and millet were the major food crops grown in Duwachour-9, Keurani, Sindhupalchok, Nepal.

Within the farmers memories there were 14 local rice varieties in Duwachour-9, Keurani, Sindhupalchok. Out of them 64.3% (N=9) were extinct within a decade, 21.4% are under threat and remaining 2 varieties are safe. It is because of invaded high yielding improved varieties (Table-2, 6). At present there are 9 improved rice varieties available in farmer's field with 88.89% safe side for replacing the local varieties.

Table-2: Status of rice varieties in, Duwachour-9, Keurani, Sindhupalchok, 2011

SN	Variety	Type	Trend	Trend (N=25)	Special Traits
1.	Khumal-4	Improved	Safe	6	Good taste and marketing quality
2.	Makwanpur-1	Improved	Safe	5	Lodging resistant
3.	Radha-4	Improved	safe	5	Big ear, Drought resistant
4.	Jhinuwa masino	Local	Decline	7	Good marketing quality
5.	Ganga-jamuna	Local	Threatened	1	Low yielding, drought resistant
6.	Velly pokhara	Local	Threatened	1	Low yielder
7.	Hardinath-1	Improved	Safe	3	Demand lower fertility
8.	Pokhreli masino	Local	Threatened	2	Lodging
9.	Himali	Improved	Threatened	1	Drought resistant
10.	Chaite-4	Improved	Safe	3	Drought resistant, Early maturing
11.	Japanese pokhara	Improved	Decline	1	Drought resistant

SN	Variety	Type	Trend	Trend (N=25)	Special Traits
12.	Taichung	Improved	Threatened	2	Drought resistant
13.	Red Anadi	Local	Threatened	7	Best for fry rice (Siraula/ Khatte)
14.	Mallika	Improved	Threatened	1	Low yielder
15.	Rato masino	Local	Extinct	o	Low yielder
16.	Dhayere	Local	Extinct	o	Suitable on low fertility
17.	Nagbeli	Local	Extinct	o	Better eating quality
18.	Pipal marsi	Local	Extinct	o	Good milling recovery
19.	Bange mashino	Local	Extinct	o	Low yielder Aromatic
20.	Mansara (Red)	Local	Extinct	o	Suitable under low fertility soil good eating quality
21.	Achhame	Local	Extinct	o	Needs lower fertilizer rate
22.	Thankote	Local	Extinct	o	Taste and soft eating quality
23.	Hile marshi	Local	Extinct	o	Short duration variety

Within the farmers memories there were 3 local maize varieties in Duwachour-9, Keurani, Sindhupalchok. Out of them 66.67% (N=2) were extinct within a decade and another one is under threat. None of the farmers maize varieties are safe at present. It is because of invaded high yielding improved varieties (N=2) and Indian hybrids (N=3). At present there are 5 improved (2 OP and 3 Hybrids) maize varieties available in farmer's field with 80% safe side for replacing the local varieties (Table-3 & 6).

Table-3: Status of maize varieties in, Duwachour-9, Keurani, Sindhupalchok, 2011

SN	Variety	Type	Trend	Frequency	Special Traits
1.	Kanchan	Hybrid	Safe	3	Early maturity
2.	Arun-2	Improved	Decline	5	Fit to wheat system early maturity
3.	Seed Tech	Hybrid	Safe	4	High yield or Insect suspeceptiable
4.	Murali makai	Local	Threatened	3	Good Pooping quality
5.	Rampur Composite	Improved	Safe	4	Insect resistant, good flour quality
6.	Shreeram	Hybrid	Threatened	3	Highly susceptible to insect
7.	Sathiya	Local	Extinct	0	Good flour quality small cob size yielder
8.	Talu kachhe	Local	Extinct	0	Tall variety with low flour recovery

Within the farmers memories there were 2 local wheat varieties in Duwachour-9, Keurani, Sindhupalchok. 100% (N=2) were extinct within a decade. There are 4 improved varieties safe available in farmer's field (Table-4 & 6).

Table-4: Status of wheat varieties in, Duwachour-9, Keurani, Sindhupalchok, 2011

SN	Variety	Type	Trend	Frequency	Special Traits
1.	Gautam	Improved	Safe	11	Good flour recovery, disease resistant
2.	RR-21	Improved	Threatened	4	Disease resistant
3.	Pasang lambhu (white)	Improved	Threatened	3	Good flour quality
4.	WK 1204	Improved	Safe	9	Disease resistant
5.	Red wheat (Rato gahu)	Local	Extinct	0	Suitable for bari land, tasty, resistant to storage insects, good flour recovery, low yield, demands lower rate of fertility
6.	Mudule gahu	Local	Extinct	0	Tasty fit for bari land, low yielder

There are 2 local millet varieties in Duwachour-9, Keurani, Sindhupalchok. 100% (N=2) of them are safe in farmer's field (Table-5 & 6). It is because of none of the improved or hybrid millet varieties invaded there until this time.

Table-5: Status of millet varieties in, Duwachour-9, Keurani, Sindhupalchok, 2011

SN	Variety	Type	Trend	Frequency	Special Traits
1.	Dalle	Local	Decline	8	High yielder
2.	Latte	Local	Decline	9	Good threshing quality

Thus, all together there were 21 local, 3 hybrid and 15 improved cereals varieties available in Duwachour-9, Keurani, Sindhupalchok (Fig. 1). Among local varieties two third (61.9%) were already extinct within a decade of time period. Invasion of improved and hybrid varieties was the cause of extinction, though the local/farmers varieties were having special traits. In total 33.3% of the varieties were extinct, 12.8% were under threat, 25.6% declining and rest 28.3% varieties most dominantly the improved and hybrids were persistently established in the farmers field (Table-6, Fig. 2).

Table-6: Summary of the varietal status of major cereals in, Duwachour-9, Keurani, Sindhupalchok, 2011

Crop	Improved	Hybrid	Local	Total	Safe	Decline	Threatened	Extinct	Total
Rice	9	0	14	23	5	7	2	9	23
Maize	2	3	3	8	4	1	1	2	8

Wheat	4	0	2	6	2	0	2	2	6
Millet	0	0	2	2	0	2	0	0	2
Total	**15**	**3**	**21**	**39**	**11**	**10**	**5**	**13**	**39**
%	38.5	7.7	53.8	100	28.3	25.6	12.8	33.3	100

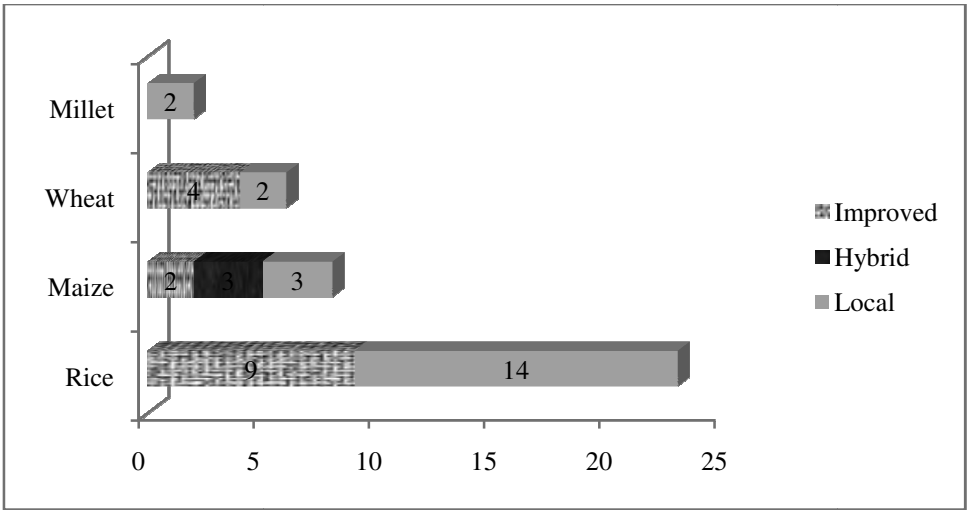

Figure 1: Type of crop varieties adopted by the farmers in Duwachour, 2011

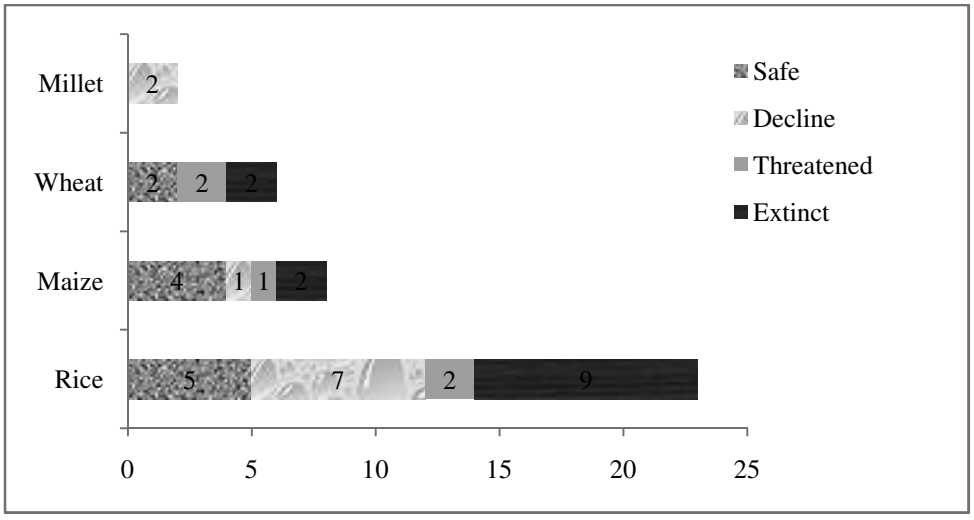

Figure 2: Status of crop varieties in Duwachour, 2011

Agro-biodiversity can be manage at traditional-type agricultural systems through, variety selection based on crop-morphology (phenotype), taste, texture, yield, storage characters, resistance to stresses, and maturity time. It is influenced by cultural diversity. They fail to keep the crop variety in a pure form for a longer period due to genetic deteriorating (Ashby *et. al*, 1996). This is true in case of sindhupalchok, Nepal. Local land races have been easily replaced by the improved ones. Thus, traditional crop varieties and land races are disappearing. Management of agro-biodiversity can be at at community level through enhancing local capacity, increasing access to off farm conservation and use, on farm genetic resources management, participatory plant breeding, participatory varietal selection, local level seed exchange through DISSPRO/CBSP or (Pokhrel, 2012b) community seed bank (Pokhrel and Joshi, 2012), through continue process of conservation agriculture for management of soil biota, moisture, nutrients, organic matter, management of crop pollinators and natural enemies (parasites and predators), enhancing agro-biodiversity educational activities like Bio diversity recording/Register, Bio-diversity fare, tour, IRD, demonstration, FFS etc and community sensitization (Pokhrel and Joshi, 2012). Management at GoN farms for exchange of genetic resources and introduction, maintenances of gene pool or parental lines, bio-diversity research, breeding of useful new crop varieties, maintenances of crop varieties also are equally important (Wood and Lenne, 1993). Conservation of Agri-bio-diversity needs the conservation of agro-ecosystems, landscape protection, soil health protection (Pokhrel, 2011), water cycle and quality maintenance, air quality maintenance, reduction on soil water and air pollution. For all these, the judicious use of agro-chemicals, use of alternative pest control tactics, promotion of pollination management practices, promotion of local knowledge and culture that help to conserve the agriculture biodiversity (Ashby *et. al,* 1996) and sustainable use of natural resources are equally important.

Conservation of land races can be at local level at community on farm or in community demonstration blocks or may be in conserved areas or in a botanical garden for the wild relatives of crop plants, It can be ex situ in a seed bank or in a gene bank, in community/ national/ regional levels. Sindhu Tuki Community seed Bank (CSB) has been operating in Thumpakhar which is far away from Duwachour VDC (Pokhrel and Joshi, 2012). However, they have initiated to conserve local varieties with this CSB.

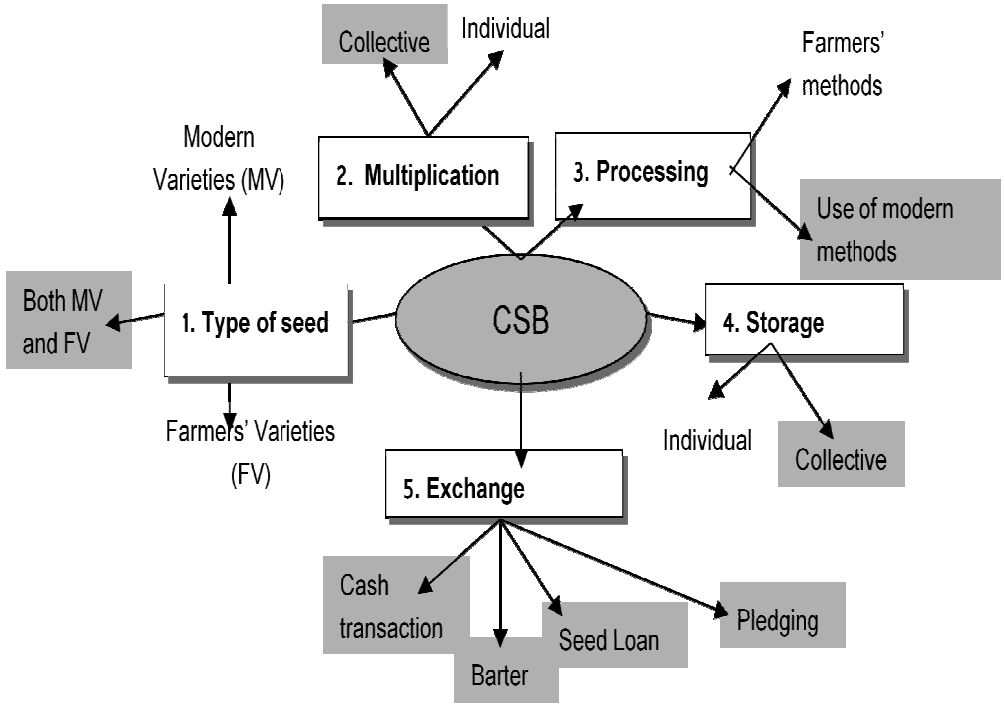

Figure. 3: Seed conserved in a seed bank, Sindhupalchok, 2011

The utilization of plant genetic resources is the farmers' rights. Farm-saved seed of crop varieties are essential for local level food security; CSB in Thumpakhar started its conservation activity to National Gene Bank, NDRC khumalter, Lalitpur from the same year (Sapkota and Pokhrel, 2010). Agro- biodiversity aims to help diversify agricultural production systems. It also helps to commercialization of local and under-utilized crops and varieties and increase genetic diversity. National and Global Plan of Action aim to make plant genetic resources more easily available to plant breeders and farmers. However, it have to initiated in Nepal, It makes access on the benefit from the sustainable use of most useful genetic characteristics with the appropriate species and varieties and incorporating diversity into crop varieties. It is helpful for benefit sharing on variety, seeds and skills. National programs need to integrate more closely in situ and ex situ conservation with breeding, seed production and distribution in Nepal. It seeks inter discipline and national and international cooperation, increased opportunities for developing joint conservation and use strategies. It can share the responsibilities and costs regionally and/or globally. It can help to facilitate the research partnerships and

exploit particular gene pools. That can increase farmer's access to improved genetics materials; relevant technologies and information (Pokhrel and Joshi, 2012).

Conclusion and Recommendations

Safe varieties may not need conservation, because they are growing in wider areas by a large number of farmers in local sites. The varieties grown by a larger number of farmers in smaller areas or in wider areas by few farmers are considered declining. Declining varieties needs attention and support by research and market making agriculture and extension activities. Moreover, the varieties grown in smaller area, with few farmers called threatened varieties, may extinct in near future. So needs to have conservation in-site or ex-situ. Among farmer's local varieties, Rato masino, Dhayere, Nagbeli, Pipalmarshy, Bange masino, Mansara, Achhame, Thankote, Hille marshi of rice, Sathiya and Talu kuchhe maize and Rato gahu and Mudule gahu of wheat have been extinct within last decade. In addition, Jhiunuwa masino, Ganga-jamuna, Velly pokhara, Pokhreli masino, Rato anadi of rice varieties, Murali and Sathiya maize, Dalle and Latte millet are the farmers varieties in Duwachor are either declining or threatened. These varieties need to have conservation through research and agriculture extention or related conservation activities. This is a typical example of Duwachor but Nepal should have institutional support for agricultural biodiversity assessment, monitoring and internalize ABD research with national agricultural research system to have access to genetic resources at national and international level and, linking agro-biodiversity to regulatory framework eg seeds, resources, benefit sharing, variety and farmers right. Use of agro-biodiversity for poverty reduction, income generation and food security in Nepal is also equally important for this conservation of agro-biodiversity building on national agricultural extension program; emergency relief and rehabilitation are also needed.

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Status of Anthropogenic Activities in Extended Area of Parsa Wildlife Reserve, Bara

Surya Man Shrestha[1], Shrijana Sitikhu[2], Gopal Prakash Bhattarai[3]

Abstract

Anthropogenic pressure in forest resources is becoming one of the serious threats in wildlife conservation. This study tried to find anthropogenic pressure in forest of Bara just before (in 2015) the area was integrated into Parsa Wildlife Reserve (PWR) i.e. 2014. The survey was conducted dividing area into gird and following trail transect as survey route. In the area twelve different types of anthropogenic activities were recorded of which tree felling, livestock grazing, and logging were found in great number i.e. 37%, 33%, and 14% respectively. In case of spatial distribution of the different anthropogenic activities, human mobility and tree cutting was found in more than 80% of the area. Along with this, livestock grazing, fodder collection and logging were found near to 50% of the area. During the study, hunting spots and killing endangered reptile species Golden Monitor Lizard (Varanus flavescens) were directly observed. Except adjacent some parts of pervious boundary of PWR, most of forest area was found highly disturbed especially eastern part such as Nijgadh and old Nijagadh area.

To conserve the remaining forest resources, sure shot counteract management program should be launch to reduce anthropogenic pressure in forest of the area.

Keywords: *anthropogenic pressure, forest, parsa wildlife reserve*

Introduction

Parsa Wildlife Reserve (PWR) gazetted in 1984 A.D. aims towards preserving Asian Wild Elephant (*Elephus maximus*), remaining habitat of historical "Char Koshe Jhadi" and associated flora and fauna. The reserve's core area is 627.37 sq. km and altitude ranges from 100 to 950 m (http://www.dnpwc.gov.np). Buffer Zone was established in 2062 B.S. with core area 285.30 sq.km It is located within latitude of 27°13'48" to 27°27'36" North and longitude 84°31'48" to 84°48'12" East (Bhuju et al. 2007). Of the total core area, 128 sq. km has been just extended in 2015 towards the Bara forests (http://www.wildlifeextra.com).

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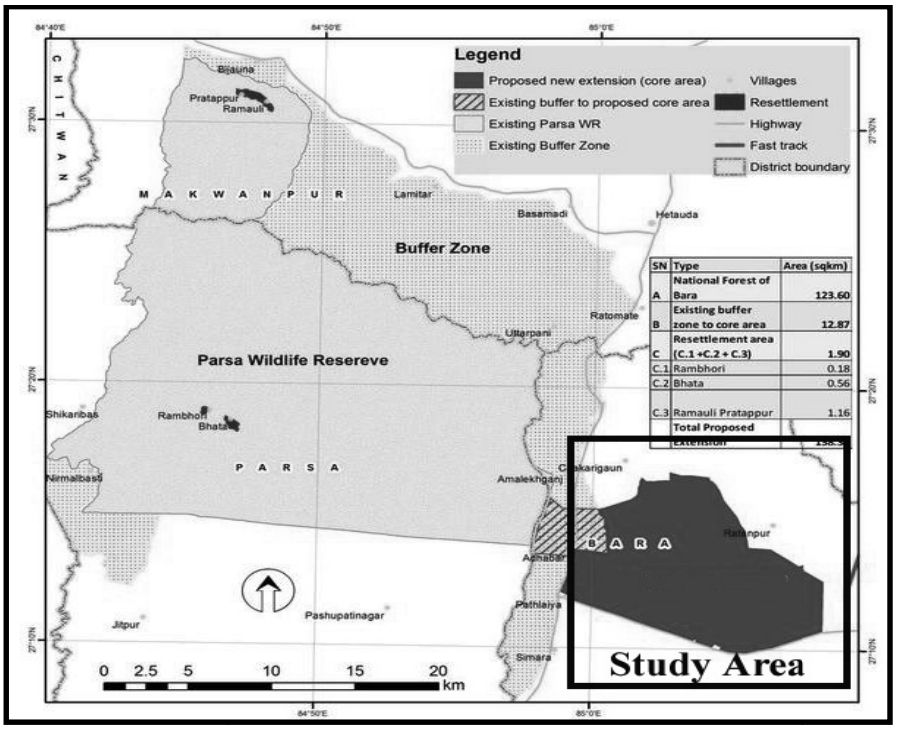
This research aims to assess the ongoing anthropogenic activities in the extended PWR and its periphery during its planning phase which could be beneficial for sustainable management of the ambitiously extended PWR for the conservation of the Tiger (*Panthera tigris*) and other endangered wildlife existed in the area.

Methodology

Study was done in and around forest area of currently extended (*in* 2015) core area (i.e. 122.503 sq. km during planning phase) and proposed Buffer Zone area i.e. 169.93 sq km of PWR, which is located in eastern part of currently existing PWR i.e. western part of Bara District (Map 1). The district is located from latitude 26°51' to 27°2' North to 84°51' to 85°16' East. Elevation of the district ranges from 152 m to 915 m. The area of the district is 1190 sq. km (CBS 2013). Geographically Bara is situated in Siwalik and Terai regions.



SN	Type	Area (sqkm)
A	National Forest of Bara	123.60
B	Existing buffer zone to core area	12.87
C	Resettlement area (C.1 +C.2 + C.3)	1.90
C.1	Rambhori	0.18
C.2	Bhata	0.56
C.3	Ramauli Pratappur	1.16
	Total Proposed Extension	138.37

Figure 1: Core and Buffer Zone area of PWR, and currently extended area i.e. study area
Map Source: http://www.wildlifeextra.com

Data Collection and Analysis

Field data was collected in Dec 2014. To study about anthropogenic activity, initially 4 main grids of 15 km×15 km were laid on the study map with 16 sub-grids of 3.75 km×3.75 km in

each main grid (Karanth et al. 2002). On the basis of forest coverage in each main grid, minimum 3 to 6 sub-grids were randomly selected. On those sub-grids survey was conducted by using trail transect (Hill et al. 2005). Trail transect was divided into km as replicate number and each replicate number was sub-divided into 100 m segments. Magnitude of the distance where survey has to be conducted was determined on the basis of coverage of the forest i.e. if 100% forest coverage in main grid, survey was conducted in 40 km and if less coverage then distance was maintained on same ratio. Human presence, tree cut, tree falls, forage collection, domestic cattle's signs, vehicle presence etc in each segments were noted on in standardized human disturbance form (Karanth et al. 2002). The trail transects survey was conducted in 102 km of walking distance.

Results and Discussion

Anthropogenic pressure in study area

During the study, 12 different types of anthropogenic activities were recorded. On the basis of recorded direct and indirect sighted number of anthropogenic activities signs, tree falling, livestock grazing, logging and human movements inside forest area were found as major (Table 1).

Table 1: Observed anthropogenic activities relating signs.

S. N.	Human Impact	Total Sign		
		Sign	Direct sighting	Total
1	Human Presence	-	109	109
2	Tree cutting/felling	341	6	347
3	Livestock	20	290	310
4	Fodder Collection	15	-	15
5	Logging	129	2	131
6	Firewood Collection	6	-	6
7	Sand Extraction	5	4	9
8	Litter Collection	2	-	2
9	Hunting Spot	-	1	1
10	Vehicles	-	1	1
11	Poaching	-	1	1
12	Encroachment	1	-	1
Total		**519**	**414**	**933**

Observed live sighting of human in most of the forest area indicate high mobility of human in the area (Table 2). Live human presence, tree falling and livestock grazing were also found in

most of the area, which created intense pressure on the forest resources and decreased forest quality. Disturbances such as Hunting Spot (at Halkhoria) and Encroachment (mostly in old Nijgadh area) were also recorded in least number. But, according to local people, encroachment of the forest area and tree cutting activities is increasing day by day in the area especially around Nijgadh area. Beside this, one of the local people was also found killing Golden Monitor Lizard (*Varanus flavescens*) in forest area of Nijgadh, which is one of the protected reptile species by NPWC Act 2029. Even though these type of signs were recorded in least number, such type of disturbances impact biodiversity in great magnitude than other. IUCN-Nepal (1995) had also identified some issues relating to biodiversity conservation in forest area of Bara district. These were uncontrolled forest fire, illegal cutting of wood (timber, fuel wood etc.), poaching of wildlife, clearing of forest land for agriculture and settlement, loss of habitat and biodiversity.

According to DNPWC (2012) the major reasons to decline the forest area of Bara is the purpose of the extension of Parsa Wildlife Reserve area, fast track road, and airport establishment. MFSC (2005) report shows the increment of forest area in PWR by 200 ha. But in contrast to this, in Bara district amount of forest land decreased by 11.56% during 1989-2005. The forest area of the district has been fragmented and deforested with annual rate of 0.72% (Kandel 2009). This process might be counteracted by managing forest though ecosystem based management. Similarly in order to mitigate biodiversity loss in the forest of Bara district, Salo & Marjokrpi (1996) had recommended to allow cogs and snags (possible 25% of the stands), maintain corridors, manage open grasslands, promote only site-specific mechanical operations during regeneration felling activities, discourage rampant poaching and introduce anti-poaching operations to preserve wildlife species, set aside one kilometer stretch of forests on both sides of rivers to serve as a contiguous linkage for migration of birds, and make water holes for wildlife species for the dry season.

Table 2: Anthropogenic activities recorded in study area

S. N.	Human Impact	Coverage
1	Human presence	82.35%
2	Tree felling	82.35%
3	Livestock	47.06%
4	Fodder collection	47.06%
5	Logging	41.18%
6	Firewood collection	17.65%
7	Sand extraction	17.65%
8	Litter collection	11.76%
9	Hunting spot	5.88%
10	Vehicles	5.88%
11	Poaching	5.88%
12	Encroachment	5.88%
N=17 sub-grids		

Most of the study area has been integrated to core area PWR and in its buffer zone area with aim to conserve the forest area and to make suitable for the tiger's habitat. This extension has also believed to support to make double national tiger population i.e. 250 adult tiger's population, by 2022 (GTI 2010). To achieve the goal behind the extension of the PWR, above described threats existing in the area should be managed as soon as possible.

Conclusion

This study was conducted in proposed extensions area of PWR, during its planning phase, record shows the existence of high anthropogenic pressure in the area especially in eastern and southern parts than in western part adjacent to the previous eastern boundary of PWR. Therefore, from this study it is concluded that if the area is managed wisely then it could be developed as one of the suitable habitat for the endangered species like Tiger and other big carnivorous animals along with wild flora of the area.

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Carbon Stock Estimation of Bailbandha Buffer Zone Community Forest of Suklaphanta Wild Life Reserve

Laxmi Kumari Thagunna[1]

Abstract

This study is about quantification of total carbon stock of BBBZCF of Suklaphanta wild life reserve. Total carbon stock is the sum total of biomass carbon and total soil organic carbon. Biomass carbon includes the aboveground biomass and belowground biomass. Soil organic carbon was estimated from the depth of 0 to 50 centimeters. Total carbon stock reserved in the community forest has great environmental significance in terms of climate change mitigation. The aboveground biomass was estimated using methodology given by Yoda et al and belowground biomass was estimated following Mac Dicken. The soil organic carbon was estimated using Walkely and Black method as cited by Baruah and Barthakur. The total carbon stock of the community forest was recorded as 4611.11 tons, i.e., 78.46 tons per hectare, out of which biomass carbon component was 880.8 tons and soil organic carbon component was 3729.46 tons.

Keywords: *carbon stock, community forest*

Introduction

Human influence on the climate system is clear, and recent anthropogenic emissions of green house gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems (IPCC, 2014). Regarding the climate change mitigation, forests sector is quite appealing sector. Forestry plays a profound role in reducing ambient CO_2 levels as they sequester 20 to 100 times more carbon per unit area than cropland (Brown and Pearce, 1994). According to Upadhaya et al., 2005, revitalizing degraded forestland and their soils in the global terrestrial ecosystem can sequester 50- 70 % of historic losses. Estimates show a quarter of global CO2 emission (IPCC, 2000) being emitted from deforestation in tropical regions. Community forests (CF) are inseparable part of more than 39% of total population of Nepal, i.e., 1,644,587 households (Shrestha, 2006). In Nepal, forest conditions have been improved in most places with positive impact on biodiversity conservation (Mikkola, 2002).

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The amount of carbon stock retained in the community forests is the amount of atmospheric carbon offsetted by it at the time of study. This study aimed to estimate total carbon stock of the Bail/bandha Buffer Zone Community Forest (BBBZCF) to show the important role the CF playing in terms of climate change mitigation alongwith other benefits to the people and the nature.

Methodology

Research Site

The study was conducted in Bailbandha buffer zone community forest of Suklaphanta wild life reserve. The BBBZCF is located in Chandani Village Development Committee (VDC) of Kanchanpur district of far western development region. It included two patches of forest covering total area of 58.77 hectare. It is bordered in the east by Mahakali barrage, in west by Indian border,in north by Indian boundary pillar (pillar no 8) and in the south by settlement area of ward no 7 of Chandani VDC.

Field work

The field work was conducted from August 2008 to September 2008. In the field first of all the total area of the community forest was divided in four parts with three far lines and then thirty quadrates of size 400 m^2 (20m× 20m) were laid down randomly. The quadrate positions were noticed in GPS (Global positioning system) so that the study could be repeated in the same place in the future. From each quadrate, data on the Dbh of each tree was measured with Dbh meter and the angle of elevation was recorded for each tree with the help of clinometer, soil sample from two depths i.e. from 0-25 cm and 25-50 cm was taken with core sampler.

Laboratory work

In the lab, different parameters of soil were tested. The estimation of the % soil organic carbon was done by Walkely and Black, 1934 method as stated in Baruah and Barthakur,1999.

Allometric Equations and Calculations The following equations and calculations were used in the research work:

Total carbon stock of forest = total biomass carbon+ total soil organic carbon

Estimation of Biomass Carbon

Total biomass carbon = aboveground biomass carbon + below ground biomass carbon

Aboveground Biomass: Aboveground biomass was estimated by using regression technique develped by Yoda (1965,1967,1968) for trunk and branch weight and the generalized allometric function developed by Ogwa et al 1965 cited by Yoda 1968 for lead weight as shown below:

a) Estimation of trunk steam weight (Ws)
   $Ws = 0.093 (D^2H)0.933$
b) Estimation of branch weight (Wb)
   $Wb = 0.0055 (D^2H)$
c) Estimation of leaf weight (Wi)
   $1/WI = 23.8/ (Ws + Wb) + 0.25$
   The height of the tree was estimated as follows:
   $H = \tan\theta \times b + a$
   Where,
   H= height in meter
   θ= angle of elevation
   b= distance between the tree base and the observer in meter
   a= height of the observer in meter

a) Aboveground dry weight = (weight of trunk + weight of branch + weight of leaves) in Kgs
b) Total aboveground biomass (Kg/m^2) = total aboveground dry weight (kg/400 m^2)

$$= \text{total aboveground biomass } 10^{-3} \text{ ton}/400\times10^{-4}$$

$$\text{Since, } 1 \text{ kg} = 10^{-3} \text{ ton}$$

$$1m^2 = 10^{-4} \text{ ton}$$

Belowground Biomass= 15% of total aboveground biomass (Mac Dicken, 1997)

Total Biomass Carbon= total biomass × carbon expansion factor

(Carbon expansion factor: 0.5 Brown, 1997)

Soil Organic Carbon Estimation:

Percentage soil organic carbon (%SOC) = 3.951/g (1-T/S)

Where,

g= weight of soil sample taken in grams

S=ml (ferrous) solution with blank titrant

T= ml (ferrous) solution with sample.

Soil organic carbon (SOC) = %SOC × soil bulk density (Kg/m^2) ×thickness of soil horizon (m)

Soil organic carbon (SOC in tones/ha) =soil organic carbon× 10^{-3} ($ton/10^{-4}$)

Results and Discussion

Dbh (Diameter at breast height) Class Distribution of Tree Species in BBBZCF:

Biomass carbon of a forest depended upon the condition of forest. Condition of forest is determined by the Dbh class distribution. Classification of forests into timber trees, pole trees and regeneration were made on the basis of Dbh (1.3m above ground diameter) class distribution. Regeneration was all the stems that were less than 10cm Dbh, poles with Dbh laid between 10-29.9cm and timber with Dbh greater than 30cm.In the BBBZCF, total 415 trees were measured from 30 sampling plots of 20m×20m,covering 58.77 hectare of the CF. The Dbh class distribution of the total trees obtained was as follows:

Table 1: Dbh class Distribution of the Total Tree Obtained in BBBZCF

SN	Ddh class(cm)	Number of trees	% of total trees
1	below 10 cm	149	35.9
2	10-29.9	146	35.18
3	above 29.9	120	18.92

In the CF, the Dbh range was found from 5cm to 125cm.The community forest have not shown significant percentage of any one Dbh group. The forest contained the

regenerating trees and the pole size trees in almost equal amount. This condition resulted because the forest was mixture of 6-year-old plantation forest and old degraded forest. Though the regenerating trees and pole size tree percentage of the CF is equal, still the BBBZCF contained slightly greater percentage of regenerating tree percentage. Higher biomass had recorded from the forest at mature stage i.e. the forest having maximum percentage of trees belonging to Dbh class greater 29.9cm.The above statement was also verified from the result of the study conducted by the Karki and Baskota in the CF of Lamatar and Illam in 2006. The Lamatar forest consisted about 75% of trees belong to the Dbh class less than 10cm and the Illam community forest consisted about 50% of the trees belonging to the Dbh class less than 10cm i.e. both forests were very young forests at regenerating condition, with relatively higher percentage of regenerating trees in the community forests of Lamatar. In the CF of Lamatar the above ground biomass was 93.05 ton/hectare and in the CF of Illam, the biomass found was 104.75 ton/hectare.

Total Carbon Stock of BBBZCF

Total biomass carbon of community forest was 880.79 tons and total (0-50cm depth) soil organic carbon was 3730.33 tons. Therefore, total carbon stock of BBBZCF was estimated 4611.110 tons. The carbon stock per hectare was 78.46 tons ranging from 192.707 ton/hectare to 21.040 ton/hectare.

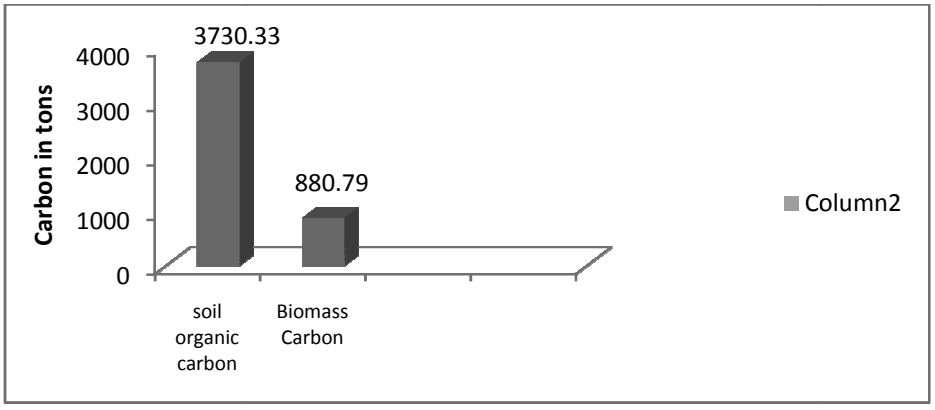

Figure 1: Share of Soil Organic Carbon and Biomass Carbon to the total Carbon Stock.

Dahal, 2007, estimated the total carbon stock as 126.58 ton/ha in pine forest and 49.76 ton/ha in Mixed Broad leaf Forest. Comparing it with the data of the present study, it was found that the total carbon stock in per hectare was higher than the per hectare carbon content of Mixed Broad leaf Forest and lower than per ha carbon stock of Pine Forest. The higher carbon stock of the Pine Forest might be due to the different forest condition. Pine forest was a matured forest containing maximum percentage of trees greater than Dbh 12cm where as the BBBZCF was a regenerating forest with 35.9% of trees with Dbh 10cm-29.9cm. The Mixed Broad leaf Forest had relatively lower amount of per hectare carbon, than the per hectare carbon of BBBZCF. It might be because the Mixed Broad leaf Forest contained maximum percentage of trees belonging to Dbh less than 12cm whereas the BBBZCF contained only regeneration and poles.

Total Biomass Carbon Stock

Aboveground biomass carbon was 764.78 tons and below ground, biomass carbon was 116.008 tons.

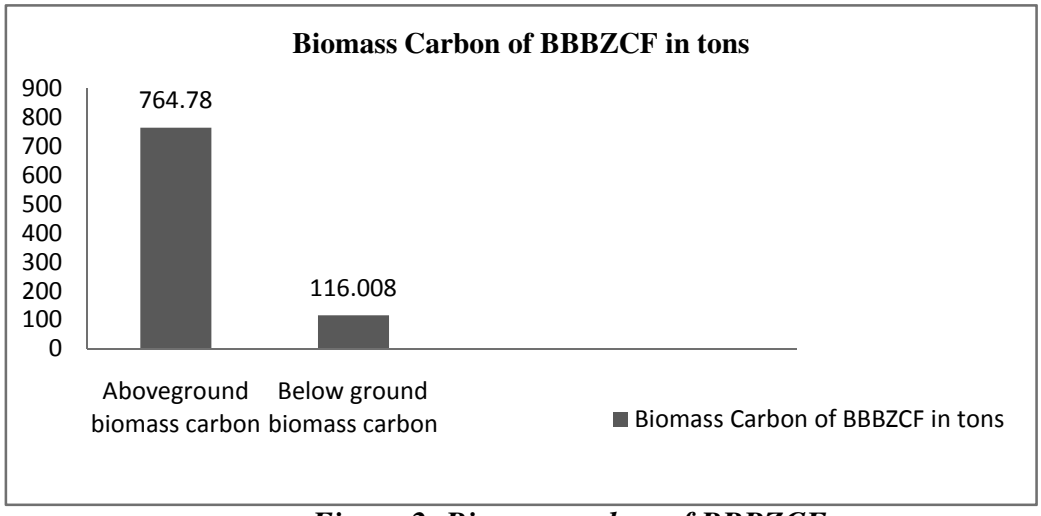

Figure 2: Biomass carbon of BBBZCF.

Total biomass carbon of BBBZCF was found to be 880.79 ton i.e., the biomass carbon was 14.987 tons/ha. It was found less than that of 116.50 ton/ha in pine forest and 25.95 ton/ha in the mixed broad leaf forest in the Sunaulo Ghyamph Dada Community Forest (Dahal, 2007). The biomass carbon in the BBBZCF was observed lower than that of biomass carbon of Mixed Broad leaf Forest of Sunaulo Ghyampu Dada Community

Forest. It might be due to difference in allometric equations used for biomass estimation.

Total Soil Organic Carbon

Total SOC of the Bailbandha Buffer Zone Community forest was found 3729.46 tons from the depth of 0-50cm, out of which 2287.034 tons of SOC was contributed by the soil layer 0- 25cm and 1442.392 ton of SOC was contributed by the soil layer of 25-50cm. In per hectare basis, 63.46 tons was recorded from the depth 0-50cm. 22.647% higher soil organic was recorded from the soil layer 0-25cm than the soil layer 25-50cm. Relatively higher amount of soil organic carbon was recorded in the upper (0-25cm) soil layer than the lower (25-50cm).

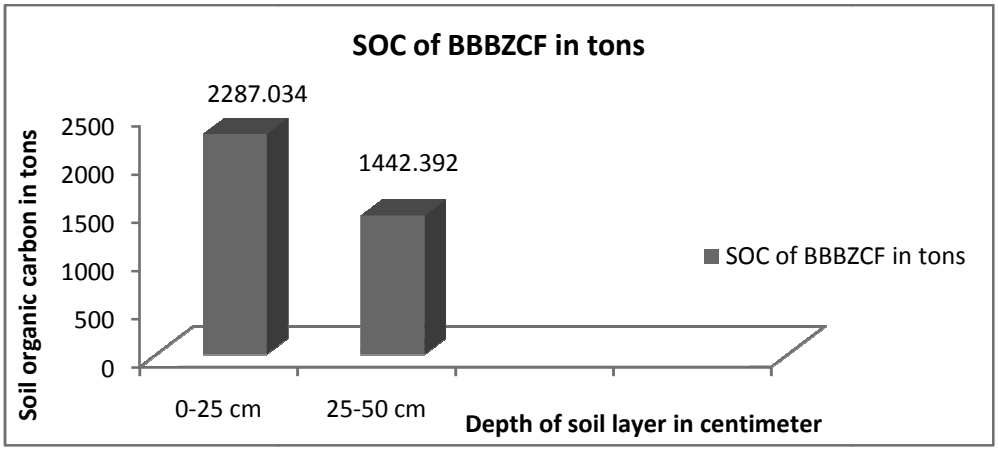

Figure 3: Soil Organic Carbon of BBBZCF.

Fundamentally, the amount of SOC stored in a given soil is determined by the balance of carbon entering the soil, mainly via plant residues and exudates, and C leaving the soil through mineralization (as CO2), driven by microbial processes, and to a lesser extent leaching out of the soil as dissolved organic carbon. Locally Carbon can also be lost or gained through soil erosion or deposition, leading to a redistribution of soil Carbon at local, landscape and regional scales (FAO, 2015). Soil organic carbon embraced the whole non-mineral fraction of soil and consisted essentially of a series of products ,which ranged from decayed plants and animal tissues to fairly amorphous brown to black materials bearing no traces of anatomical structures of the materials, i.e., normally defined as soil humus (Baruwa and Barthakur,1999). Since the sources of all

the organic carbon is found above the soil surface, higher amount of SOC was found on the top soil layer and keep on decreasing with the soil depth.

The finding was similar with that of Dahal 2007 that studied the SOC of the Sunaulo Ghamphu Dada community forest at two depths of soil layer. In pine forest 11.03 tons/ha of SOC was recorded from the soil layer of 0-25cm and 9.12 ton/ha SOC was recorded from the soil layer 25-50cm. In Broadleaf Mixed forest 27.98 ton/ha SOC was recorded from the soil layer of 0-25cm and 21.25 ton/ha SOC from the soil layer 25-50cm.In both cases the SOC was found higher in the upper soil layer than that of the lower soil layer as found in the BBBZCF.

Conclusion and Recommendations

The total carbon stock of the community forest of Bailbandha buffer zone community forest was found as 4611.11 tons. This indicated that the community forest has retained 4611.11 tons (four thousand six hundred and eleven tons) of carbon within it, 3729.46 tons as the soil organic carbon and 880.79 tons as the total biomass carbon, and offsetting its emission into the atmosphere, at the time of study. If the forest is sustainably managed, this amount of carbon could be stored within it for a long period of time and prevent 4611.11 tons of the carbon release into the atmosphere and help to mitigate climate change. Therefore the community forest is recommended to manage sustainably so that it could mitigate the climate change at its level along with other benefit to the people and nature.

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Walk of the Dead: Illegal Wildlife Trade Routes in Nepal

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Abstract

Wildlife trade is the biggest threat to biodiversity conservation. Being itself a home for world's endangered species and situated between biologically rich India and world's largest market for wildlife parts, Nepal has crucial role in Illegal wildlife trade as source and transit point. China is an important source of demand for wildlife products and harvesting from its neighboring Asian states. Criminal organizations have procured and dispatched wildlife products and they adjust organizational form to reduce the most significant transaction cost faced at each stage/point in the supply chain. Transport to the Chinese border is the tough job and local people have been used to reduce the cost and improve the success on transport wildlife products. This study focused to analyze the routes of illegal wildlife trade in Nepal. To fulfill the research objectives, key informants interview, interview with ex-poacher/trader wasdone. Additionally, the seizure location and species were mapped. The seizure trend shows that, 90% of the seizure was done while the arrestees were carrying those items towards Kathmandu. The general assumption of the illegal wildlife trade routes based on the seizure trend fails here. Enforcement has one of the decisive role to curb the illegal wildlife trade and the enforcement will not be efficient without the proper knowledge about the routes which the traders use. In the developing country like Nepal unemployment, illiteracy, poverty, has empirical relationship with poaching and illegal wildlife trade. Conservation programs must aware local people and to create visible incentives.

Keywords*: illegal wildlife trade, routes, trader, enforcement*

Introduction

Nepal has 210 species of wild mammal including human(Baral & Shah, 2008), 867 species of birds (BCN and DNPWC, 2011)and 137 reptiles and 53 Amphibians (Shah, 2013). Among them 37 mammal species, 15 birds, and 4 amphibian and reptiles, are listed in the IUCN Red List(IUCN, 2011). The Department of National Parks and Wildlife Conservation (DNPWC)

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Nepal has declared 26 mammals, 9 birds and 3 reptiles in the protected list (NPWC Act, 1973). These animals have started to face growing threats of poaching, and illegal wildlife trade (IWT). In this context, Nepal acts as a transitional hub as through well-established channels wildlife products reaches to its final destinationChina and South East Asian countries (Karki, Rai, Gautam, Dhakal, & Ghimire, 2014). A proper mapping of trade route of IWT is lacking and should be done so as to tackle their networks and people involved in IWT (Acharya & Kandel, 2012).In this case, this research focuses on fulfilling the gap answering thequestions about IWTroutes in Nepal.

Methodology

This study aims to explore the illegal trade routes of endangered wildlife in Nepal.To attain this goal, multidisciplinary approach was used, using different type of research methodologies, some more typical of the social sciences (interviews, documental research) and some more traditional, such as personal visits to ex-hunters and traders. The totals of 35 interviewees were identified on the basis oftheir reputation as trader knowledgeable, with a respondent-driven sampling method; some of them are still in jail. Interviewees were selected according to their availability and willingness to participate in an informal interview. Since it is illegal to hunt or to trade wildlife parts, the issues discussedas sensitive purposive sampling method (Tongo, 2007)was applied. All the collected data were analysed with the help of ArcGIS and MS Excel.

Ex-hunters/Traders Interview

Semi-structured interviews were conducted by team involving two persons, working within the guidance of an interview framework(Huntington, 2000), but without precise, pre-determined questions so that interesting lines of discussion was pursued(Bernard, 2000). Open questioning was employed wherever possible, to avoid leading the interviewee into an answer. All dialogue was recorded by a recorder and was clarified immediately after the interview. Interviews vary in content, length and interviewee attitude and knowledge, and number of interviewee depended on the chain-responses of them.

Seizure Trend

Published and unpublished research reports, project reports and news letters from Department of National Parks and Wildlife Conservation (DNPWC), Department of Forests (DoF),South Asian Wildlife Enforcement Network (SAWEN), Wildlife Conservation Nepal (WCN),WWF Nepal, Greenhood Nepal, Rural Development Society, and daily newspaperwas reviewed for the seizure data collection. District Forest Offices, Conservation Areas and Department of National Parks and Wildlife Conservation (DNPWC) were asked for the records of wildlife parts seizure cases.

Results and Discussion

Nepal is a signatory and party to Convention on International Trade in Endangered Species (CITES) and had in place all legal and institutional instruments to address wildlife trade issues, the illegal wildlife trade has recently become more organized, demand has increased and the traders have a more sophisticated system for transporting consignments(WWF, 20012). Nepal--both transit and source point for wildlife poachers and traders (DNPWC, Annual Report, 2013)from Tibetautonomous region (TAR) of China, Nepal and India.TAR China has had a thriving trade in furs and medicines across borders with Nepal, Bhutan and India(Li, Gao, Li, Wang, & Niemelä, 2000).Drugs, pangolins scales, tiger parts, rhino horn, turtles, sea horses and other wildlife contraband entering China via extremely porous border with Nepal (Todays Tibet, 2013), There have been reported many cases of seizure and arrest of the traders of wildlife body parts and their products from various areas mainly in Kathmandu-Kodari route. Kathmandu has been reported as centre of illegal wildlife trade, most wildlife products comes to Kathmandu and then dispatched to other destination(Yonzon, 2006).

The seizures of seahorses in Nepal clearly indicate the animal part trading is being conducted by international organized networks(DFO Sindhupalchok, 2014) and Nepal is becoming a new hub of wildlife parts in Asia.Despite the provision of a stiff penalty of up to NRs 100,000 or an imprisonment of up to 15 years in jail or both(GoN, 1973), wildlife crimesis increasing.

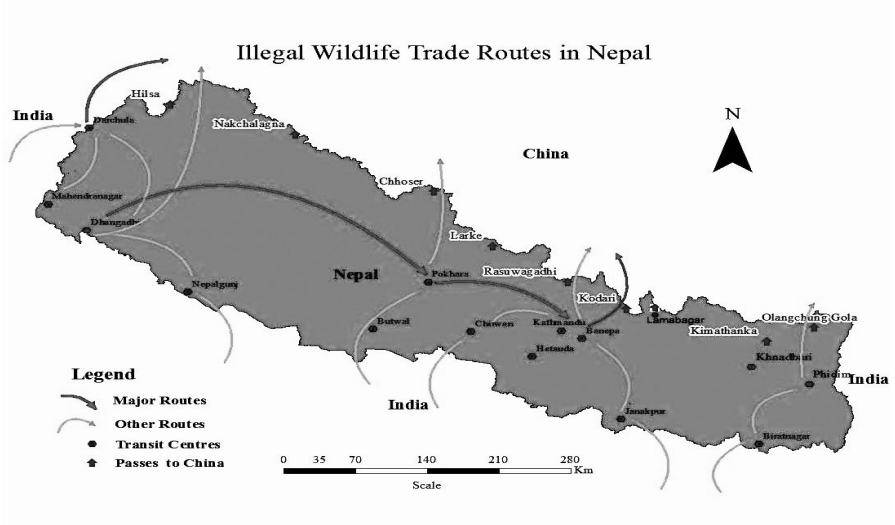

Figure 1: Illegal wildlife trade routes in Nepal

Olangchuggola in Taplejung, Kimathanka in Sankhuwasabha, Lamabagar in Dolakha, Kodari in Sindhupalchok, Rasuwagai in Rasuwa, Larkepass in Gorkha, Chhoser in Mustang, Mugupass and Nagchalanga in Mugu, Hilsa in Humla and Tinker in Darchula are the major gateways to

TAR from Nepal. These all passes are connected to Kathmandu either one or another way (Figure 1). The traders are making illegal wildlife trade using the porous gap of enforcement agencies by using local people at each level.

Araniko highway and surroundings are key routes to enter China for wildlife smuggler (Misra 2004, Wildlife Times 2012, SAWEN2014). The Tiger Skin Trail (EIA, 2004) found that traditional trade routes for wildlife parts via Dharchula, Taklakot, Gyriong, Sikkim, Siliguri including Tatopani (Araniko-trail),the collected illegal wildlife parts goes directly to Khasa via Thimsang-JhomKhola--Laptang--Khasa. Bokchen--laptang--Khasa route.Khasa itself a big market for wildlife parts and collected wildlife parts heads towards Lhasa via Nylam-Shigatse-Lhasa route.

Except some seizure cases of Shahtoosh (wool of Tibetan antelope)transporting from TAR-Nepal-India, Pangolin scales and tiger bones transporting Nepal to TAR, trend shows 90% of the seizure was done while the arrestees were carrying wildlife parts towards Kathmandu. The general assumption of the illegal wildlife trade routes based on the seizure trend fails here. Nepal Police seized two vases made of elephant ivory in Kathmandu(Kathmandu Post, 2013), which indicate the second level of IWT starts in Kathmandu by changing the form of wildlife parts. The value addition on each transit and change in the form is new challenge for enforcement and may not easy. The focus of investigation has to dig out the form or products that is made from these item as further seizures are not much reported. This may be because of the higher level of trade chain may have better ways to hide them being organized in nature.

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Pre-Disaster Knowledge Increases Humanitarian Program Efficiency

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Abstract

The majority of Nepalese people were living with poor sanitation, drinking water and hygiene; suffering from infectious diseases. In addition, the destructive earthquake in 25 April 2015, left Nepal with further misery. This article explores the author's experiences while working as Solidarités International's WASH Hygiene Promotion Team Leader focusing on WASH (Water, Sanitation and Hygiene) for women in Sindhupalchok district, Nepal. Qualitative research was conducted in 4 villages of Sindhupalchok: Karthali, Ghorthali, Golche and Gumba. Data was collected on challenges, knowledge, attitude and behavior of the female beneficiaries, after receiving informed consent.Focused on emergency need, ignoring the pre-disaster shortcomings in the WASH sector, the aid-providing agencies failed to meet the optimum need of the women. Lack of information on beneficiaries' culture, knowledge and behavior, and geographical constraints led to improper planning and implementation of the program, which could lead to compromised health of the women, and therefore, inefficient project.

Keywords: *earthquake, humanitarian aid, disaster, Women's health*

Introduction

On April 25th, 2015 the district of Sindhupalchok was ready to be declared an Open-Defecation Free (ODF) zone, when a massive earthquake measuring 7.8 on the Richter scale struck Nepal (Asian Development Bank (ADB), 2015). Due to this disaster, there were incalculable human losses and suffering, with millions of people rendered homeless, affecting35 out of 75 districts, which accounts for 20% of the country's population(Shelbayah & Mullen, 2015). This earthquake caused unimaginable destruction because Nepal had not faced a disaster of this magnitude for over 80 years,

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and so was not prepared (Gurubacharya & Daigle, 2015 and ADB, 2015 and Paulin, Katayama, & Yousaf, 2015).

In addition, the heavy monsoon worsened the situation, with frequent landslides and road blocks, hindering the arrival of help by road, and the bad weather causedmultiple flight cancellation, additionally obstructing help by air. Moreover, the poor history of Water Sanitation and Hygiene (WASH) in Nepal exacerbated the challenges, because according to Nepal's Tenth Five Year Plan (2002–2007), as cited by UNICEF, approximately 30% of the total population did not have access to basic drinking water, and 75% deprived of sanitation facilities (UNICEF Regional Office for South Asia (UNICEF ROSA).

However, various agencies were exploring the possible options for rehabilitation to overcome this disastrous phase. One of them was a French NGO, Solidarities International (SI). SIlaunched their humanitarian project for four villages in Sindhupalchok (Karthali, Ghorthali, Golche and Gumba), assisting 3436 households and their WASH program activities were:

- Distributing hygiene kits (plastic bucket with lid/metallic jar called *gagri*, soap, mug, cotton cloth for water filter, nail cutter, water purifier called *piyush*), latrine kits (tarpaulin, plastic slab with syphon, wood nails, PVC pipes, elbow PVC, 20L plastic bucket with tap & bucket lid), and tool kits for constructing latrines (claw hammer, pick axe, hand saw, shovel, trowel, nails, plastic bucket, jute sac)
- Providing technical guidance on building latrines
- Conducting hygiene promotion sessions for engaging the victims on hygienic behavior
- Reconstructing and/or renovating the partially or fully destructed latrines for Health Posts, sub-Health Posts, Primary Health Centers and mobile clinics.

Considering the fact that humanitarian projects were launched during the state of emergency and had to face several challenges, we should also acknowledge that they should be a step ahead in identifying the problem of the victims. But they seemed to

have ignored the cultural and social differences, geographical constraints and illiteracy dispersed all over Nepal. Due to this reason, even today, after more than 8 months has passed there hasn't been full coverage for the provision of safe drinking water and proper sanitation, with the prevalence of open defecation and many more people living in tents (Pokhrel, 2015). Therefore, to explore more about these shortcomings, this research has focused on possible health and sanitary issues that should be considered while providing humanitarian assistance following disaster.

This research paper aims to analyze the situation of the beneficiaries, the intensity to which the help was provided, the actual need of the beneficiaries which might not have been fulfilled during this crucial time. Hence, the problems and constraints identified and discussed could be of general interest to other external support agencies working in similar ways in other countries and sectors (Lane, 1992). This paper also intends to transcribe the research experience as a WASH Hygiene Promotion Team Leader while working under the humanitarian assistant team of Solidarities International Nepal.

Methodology

Study setting

This 9-month long research included literature review from the online journals like, Oxford journals, JSTOR, EBSCOhost, Royal College of Physicians, Wiley Online Library, Google and Google Scholar. Along with literature review, field research included Focus Group Discussion with a group of 3-7 women who were chosen based on convenient random sampling, with whom we discussed on WASH activities and behaviors prevalent in the society. Located at Bagmati zone, the hilly region of Central Development Region of Nepal, the four villages of Sindhupalchok: Karthali, Gorthali, Golche and Gumba, were visited with an attempt to analyze the WASH situation in these affected regions.

Ethical considerations

Before every Focus Group Discussions, informed consent was obtained from the participants, after explaining them the intention of this research.

Results and Discussion

Cultural and Social Differences

Nepal has a rich cultural, religious and traditional background. Although this diversity is a source of pride for the nation, this difference brings drawback because of the challenges faced during the project planning. Inadequate knowledge/information about the community knowledge, attitude and customs lead to cultural barrier and hence, improper planning and implementation of the intended program. Therefore, along with the knowledge of the epidemiology of deaths, injuries, and illnesses, it is essential to learn about other additional factors like cultural and traditional background, to establish priorities, planning, and training (Noji, 2000).

The hygiene promotion sessions were held during Focus Group Discussion with an attempt to help earthquake victims to continue healthy behaviors like: to wash hands frequently; how to wash hands properly using six steps of hand washing, how to store foods and water in an appropriate way, etc. These sessions were held based on 'our' definition of healthy habits; on what we expected the community people to do, what the people should do or not do, that we thought the people need to know, and what we thought the people might not have been following properly. In other words, without knowing the local people's understanding on health, sanitation and hygiene, the information and education sessions were being held randomly.

While traveling and monitoring in Gumbathan village of Sindhupalchok, one of the female beneficiaries was asked whether or not she washes her hands after using the toilet, she implied, "*No, I don't wash hands after using toilet. I don't need to.*" When asked why she didn't use soap after using toilets, she said,"*We don't use hand to wipe the shit on our back. That is disgusting.So I don't need to wash hands.*" Then we got

curious to know more about her habit so we asked, "*So how to you clean the dirt after using toilet?*" and she told, "*I splash some water on my back.*"This response taught us that here, the WASH situation was worse than we had expected. However, learning this habit helped us immediately change our hygiene related messages. Instead of saying "Wash your hands after using the toilet", the message became "Clean the feces with your hands, and then Wash your hands with soap and water."Although the villagers had not expressed anything negative towards the outsiders, it was their feeling that I belonged to a familiar cultural background that helped us understand their need. And understanding their behavior and knowledge helped us target the right group of people effectively.

Change is inevitable after disaster so we should aim to bring about positive changes for the health and welfare of these victims. And it is possible through pre-disaster knowledge and with the idea about the habits prevalent in the society Loss of life and property, social structures and ways of life are temporarily and sometimes permanently altered due to earthquakes. Sources of change are both from within due to loss and damage as well as from the outside through new ideas, relief, and economic aid (Glittenberg, 1989). Hence, we should take advantage of this moment and replace the negative aspects of the culture and tradition with the positive ones, as a part of humanitarian assistance.

Geographical Constraints and Social Structure

Nepal has geographical differences along with cultural diversity, which created one of the major obstacles during humanitarian assistance. This obstacle was greatly felt during the distribution of latrine kits. The planning of this distribution was supposed to be based on the universal standard of humanitarian aid and assistance, the Sphere handbook. According to this handbook, during the time of similar emergencies, like earthquake, as a response to humanitarian assistance, a maximum of 20 people can use each toilet. And where there are no existing toilets, it is possible to start with one for 50 people and lowering the number of users to 20 as soon as possible. Moreover, the

handbook also says that the toilets should not be more than 50 meters from dwellings (The Sphere Project, 2011).

However, WASH Cluster in Nepal decided to take prompt action during this time of emergency. They declared to provide one latrine to one cluster, which consists of 5 households, that is, 5 households make one cluster and each cluster were provided with 1 latrine. The cluster were determined based on the houses nearby. The organization was guided by WASH cluster. WASH Cluster claimed to follow the Sphere handbook but in practical, did not match the requirements of the handbook. The discrepancies were ignored until the distribution, when from all the villages similar complaints were reported continuously.

Following latrine distribution, from almost all the villages we visited after the distribution, there were a number beneficiaries dissatisfied because 4 to 5 households were provided with one latrine which to them was not feasible, considering the geographical background of the nation. Therefore, they furiously asked, "*The latrine is down the hill and my home is up. Should I walk all the way long just to defecate?*" Another person said, "*The latrine is far away so I prefer open defecation instead. I am not ashamed to say so, because I don't have any other option. I don't have proper shelter, so first I will build shelter and then construct a latrine. I wish the organization could provide more latrines.*"

Sadly, the distribution had come to an end, and it was the WASH cluster of Nepal who had decided and enforced this ration of latrines per households as an emergency humanitarian assistance rule. In Nepal it is beyond imagination to share a single latrine by 5 households, especially for the rural people where houses are more than 100 meters away from each other. Although, these places had been open defecation free, due to lack of latrines and resources to build latrines, people were being forced to defecate in open. One of the young women pointed out, "*Right now 10 of us are living together in my home, with around 15 in my neighbor's home and so on. So more than 50 people are using one latrine. Sometimes we have to line up to use it.*" Nothing much to avoid that was possible at this point of emergency, but in the second phase of assistance, it could

be taken into consideration. In order to prohibit such incidents during humanitarian assistance, the responsible organizations such as the WASH cluster should utilize the humanitarian handbook, the Sphere project's guidelines for credible decision-making. The assistance should be genuinely effective for the people and the locality of that region and should not be a formality mistargeted effort, or just a pretense of aid.

Lack of Knowledge and Flow of Information

Communication gap was one of the other major problems that might have hindered the efficient outcome of the program. It is true that because the villages were in high altitude it was difficult to contact them, even for days to weeks or even months; the locals had to stay out of contact from the rest of the world. There were days when satellite phone failed to contact these people. Regardless of this fact, planning was vigorous to provide best help possible. For instance, several distribution sites were spotted to make it the best possible place and a central point for all the beneficiaries to collect the materials. However, the beneficiaries were not aware of the planning the institution was undergoing nor were they aware about number and type of materials they would receive, also they were unaware about the material's uses, reasons behind why the institution decided to provide these particular objects; a presence of huge gap in communication flow.

While teaching a group of women how to use the provided water purifier, *piyush*, one of the elderly women told us, "*I thought it was some kind of medicine but I didn't know how to use it so it is lying at my home. I had heard that it is a water purifier but I didn't believe because it has this bad smell. I also made fun of my neighbor for using it for water purification. No one told us how to use it.*"People were provided with water purifier but maximum of the people didn't know how to use it and for what was it provided for. This was because of the geographical constraints and distribution of aid by air, which caused hygiene promotion sessions to delay. This gap in flow of information caused people to make assumptions and could have led them to serious health issues, however, no any cases with adverse effects were encountered. And due to this barrier in

communication between the beneficiaries and the organization, the beneficiaries were not able to use these materials efficiently.

Lack of knowledge and information flow was a major problem, but all these situations could have been averted utilizing the local social mobilizes of the community. They would be accountable for the information flow; informing the community people that they could expect from this project, aids to be provided; explaining them about the items provided and how to use these materials; and finally making them aware on whom they could consult for effective comments, feedbacks, complaints and demands. Moreover, ordinary cell phone network problem was a common issue, therefore, amongst the mobilizes, the eligible leader would guide rest of the candidates, and would be provided with a satellite phone so that they can use it to contact the organization. In this way, the bonding between the organization and the community people would have been stronger and maximum utilization of the materials provided, time and energy could have been possible.

Conclusion

Providing rapid and effective relief to the population devastated by the effects of a disaster involves challenges that include environmental, cultural, social, knowledge and information barriers (Morton & Levy, 2011). Similarly in case of Nepal diverse cultural and social background, lack of education/low literacy rate and major geographical constraints should be considered before initiating any public health program. Moreover, help has been provided for facilitating the people during the time of emergency, so program planning should be considered after keen observation and analysis; not in a hurry.

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"Nepal Earthquake – 2015" and its Impact on Water Quality of Jiri Municipality, Dolakha

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Abstract

Spring flow hydrology changes after earthquake (Rjostaczer et al. 1995; Montgomery and Magna 2003). This hydrological changes makes water scarce and vulnerable for disease outbreaks.Realizing the immediate need to assess impact of earthquake and post disaster contamination vulnerability of drinking water systems, rapid assessment study was carried out on June/July 2015 in Jiri municipality. A cross sectional study design of linear water supply system (i.e. Source, Reservoir, Tap, and Point of Use) was considered. Here, locally generated score based observation checklist was validated and used to assess post disaster status and contamination vulnerability. Further, enumeration of E.coliwas performed bymembrane filtration process using Wagtech field test kits following American Public Health Association (APHA) 1998 standards. To understand behavioral aspect of post disaster Water Sanitation and Hygiene (WASH), random interview was also performed in temporary shelters/ cottages. Correspondingly, 391sampleanalysis was performed, which comprised of 97 sources, 51 reservoirs, 119 communal taps and 124 PoU.Majority (67%) of drinking water sources were unprotected type. Six sources, and three reservoirs wereobservedto be completely damaged and nonfunctional. Significant difference (P<0.05) was observed for contamination vulnerability where sources were at very high risk. E.coli enumeration revealed significant difference (P<0.05) for coliform contamination where,PoU were highly contaminated as compared to other sampling points. The risk was majorly due to behavioral aspect and almost no treatment practice of water prior drinking. Availability of water treatment provision yet alone didn't possessed to practice the provision. Knowledge and capacity to utilize the available resource does plays a vital role for adaptation of practices. Also, it is learned that it is not viable to impose any interventions or tools without understanding local status and feasibility.

Keywords: *Jiri municipality, earthquake, water quality*

Introduction

In the Himalayan region, major earthquakes have occurred in 1803, 1833, 1897, 1905, 1934, 1950, 1988 and recently in 2015. April 25, 2015 at 11.56 am, Nepal was shaken

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by 7.8 Richter scale earthquake with epicenter in Gorkha. Again on May 12, 2015another big aftershock of 7.3 Richter scale devastated Dolakha. The percentage of affected population at Dolakha was estimated to be 11% till May 11, 2015 which drastically increased to 107% after the powerful aftershock of May 12, 2015(OSCOCC 2015).

Spring flow hydrology changes after earthquake (Rjostaczer et al. 1995; Montgomery and Magna 2003). This hydrological changes makes water scarce resource. The surviving population will be more susceptible to disease outbreaks due to compromised water conditions. Realizing the immediate need for assessing impact of earthquake on drinking water systems, post disaster risk assessment of water supply systems in Jiri municipality ofDolakha was performed on June/ July, 2015.

Methodology

Rapidassessment oflinear water supply system (i.e. Source→Reservoir→Tap→Point of Use) of complete drinking water sources in Jiri serving at-least 10 households was assessed. Microbial contamination vulnerabilityassessment of drinking water system was assessed withlocally developed score based observational checklist (Table 1). The particular checklist was piloted and validated as per local context.Total 10 observational indicators was used for source assessment, 6 for reservoir &5 for tap's microbial contamination vulnerability assessment. Here, the indicators ranged from technical design of system to sanitary status of systems. Score 1 was given to vulnerable condition & 0 to non-vulnerable condition. Then the summed scores was categorized into risk categories namely.

Total four categoriesfor source [i.e. -Low Risk (score=0-2), Intermediate Risk (score=3-5), High Risk (score=6-8), Very High Risk (score=9-10)], three categories for reservoir [i.e.Low Risk (score=0-1), Moderate risk (score=2-3), and High Risk (score=4-6)], and three categories for tap [i.e. Low Risk (score=0-1), Moderate risk (score=2-3), and High Risk (score=4-5)] were categorized for assessing microbial contamination vulnerability assessment.

Microbial analysis of water supply system was performed by membrane filtration process using wag-tech field test kits following American Public Health Association (APHA) 1998 standards. The result was then compared with National drinking water quality standards (NDWQS) 2005 and WHO bacteriological risk grading 1998. In addition,brief questionnaire in temporary shelters/ cottages was also assessedto

understand post disaster Water Sanitation and Hygiene (WASH) behavioral aspects of survivors.

Total 97 sources, 51 reservoirs and 119 communal taps were assessed for its operational condition. It is to be noted that not all reservoirs were assessed for the study.Randomly at-least one reservoir of a protected supply system was considered. Correspondingly,391microbial analysis was performed, which comprised of 97 sources, 51 reservoirs, 127 communal taps and 124 point of use water samples. For unprotected sources, assessment was performed in source and Point of Use (PoU).To understand behavioral aspect of post disaster Water Sanitation and Hygiene (WASH), random interview was performed in temporary shelters/ cottages. Particular interview points are those from where Point of Use (PoU) water samples were sampled..

Table 1. Microbial contamination vulnerability assessment observational checklist

Source Microbial contamination vulnerability assessment		
S.N.	**Indicators**	**Score**
1	Is source unprotected by masonry or concrete wall or spring box & therefore Open to surface contamination?	
2	Is the masonry protecting the spring source faulty?	
3	If there is a spring box, is there an unsanitary inspection cover in the masonry?	
4	Does the spring box contain contaminating silt or animals?	
5	If there is an air vent in the masonry, is it unsanitary?	
6	Is the area around the spring unfenced?	
7	Can animals have access to within 10m of the spring source?	
8	Does the spring lack a surface water diversion ditch above it, or (if Y/N present) is it non-functional?	
9	Are there any latrines uphill the spring?	
10	If there is an overflow pipe, is it unsanitary?	
	Total Score	

Reservoir Microbial contamination vulnerability assessment						
S.N.	**Indicators**	**R1 Score**	**R2 Score**	**R3 Score**	**R4 Score**	**R5 Score**
1	IS there any point of leakage between source & reservoir?					
2	If there are any pressure break boxes, are their covers unsanitary?					
3	Is the inspection cover of unsanitary?					
4	Are any air vents unsanitary?					
5	Is the reservoir cracked or leaking?					
6	Are there any leaks in distribution system?					
	TOTAL SCORE					

Tap Microbial contamination vulnerability assessment						
S.N.	**Indicators**	**Tap1**	**Tap2**	**Tap3**	**Tap4**	**Tap5**
1	Is the area around the tap stand unfenced? (dry stone wall or fencing incomplete)					
2	Does water accumulate near the tap stand? (requires improved drainage canal)					
3	Are there Human excreta within 10m of tap stand?					
4	Is the plinth cracked or eroded?					
5	Does the tap leak?					
	Total Score					

Results and Discussion

In total 97 drinking water sources serving total 2,709 households (i.e. 79.21%) of municipality was assessed. Majority (67%) of drinking water sources were unprotected type as per Joint Monitoring Programme (JMP) definition. Among 97 assessed sources, six (6.2%), and among 51 reservoir three (5.9%) wereobservedto be completely damaged by earthquake at the time of assessment (Fig. 1). Here those systems which are completely non-functional are categorized as damaged sources.Dried out, completely squashed or cracked condition were considered to be non-functional.

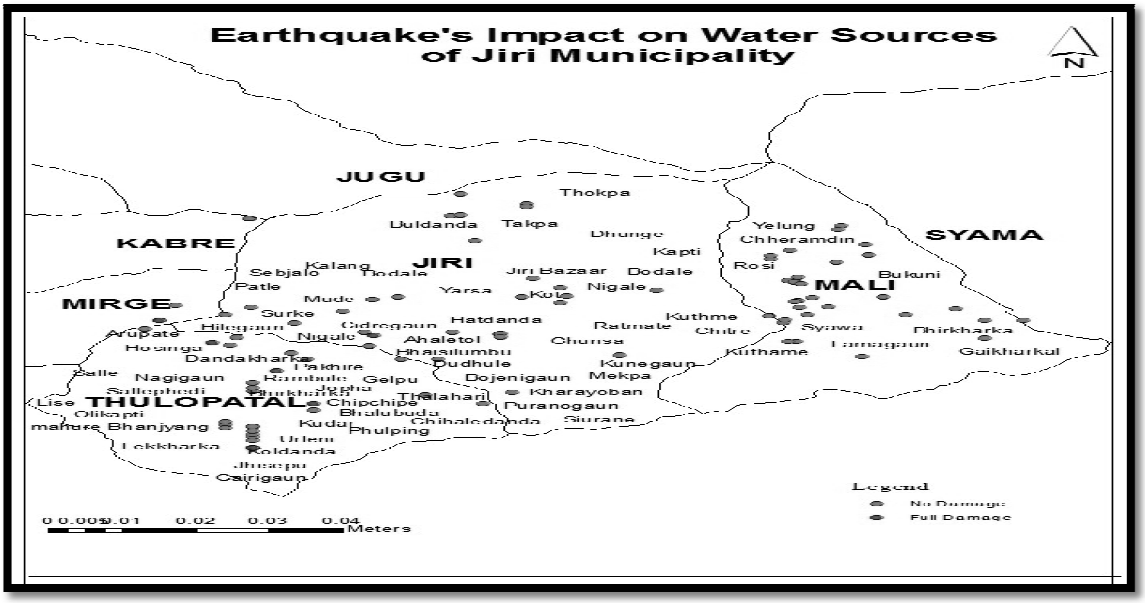

Figure 1: Earthquake's Impact on Water Sources of Jiri Municipality

As per sampling point significant difference (P<0.05) was evidenced for Contamination vulnerabilityof drinking water system.Contamination vulnerability of sources were very high (42.3%). Taps (44.5%) and Reservoirs (35.3%)were also in high risk state for microbial contamination. Further, enumeration of *E.coli*revealed significant difference (P<0.05) in coliform contamination as per sampling point. Coliform contamination was highest at PoU (43.5%) followed by sources (34%), reservoirs (23.5%) and tap (21%). Despite of high contamination vulnerability, majority of water samples were coliform negative. Low average temperature of sample water can be the reason for negative contamination of thermos tolerant coliform. The average temperature of source water sample was 21.36 °C (19.90 °C to 20.10°C), whereas for PoU average was 21.22°C (20.10°C to 22.40°C).

Temporary shelters/ cottages sheltered 634 people. Sixty-three (10%) individuals were suffering from diarrhoea at the time of study. Total 63 (10% of total population) of under 5 years children resided at temporary shelters.Twenty two (35%) under 5 year's children were reported to be suffering from diarrhoea at the time of study. Fifty four (43.5%)PoUsamples were coliform contaminated.

Majority (75.8%) of shelters reported of not practicing any treatment of water prior drinking. Few (21%) reported to boil and 2.4% reported to use filter.Only one shelter reported to use chlorine tablet, Free Residual Chlorine (FRC) of particular sample revealed FRC was not as per required level.It would be worth noting that chlorine tablets were freely after earthquake. It was then understood that unawareness of chlorination process was the main reason for under use of chlorine tablets. Also, labelsonchlorine tablets were in foreign language making general community impossible to understand given instructions.

Table 2: Contamination Vulnerability assessment as per sampling site

Sampling Point		CONTAMINATION_RISK_GRADE				Total	P-Value
		Low	Intermediate	High	VeryHigh		
Source	Count	10	13	33	41	97	
	% within Sampling Point	10.3%	13.4%	34.0%	42.3%	100.0%	
Reservoir	Count	21	12	18	0	51	0.00
	% within Sampling Point	41.2%	23.5%	35.3%	.0%	100.0%	
Tap	Count	23	43	53	0	119	
	% within Sampling Point	19.3%	36.1%	44.5%	.0%	100.0%	
Total	Count	54	68	104	41	267	
	% within Sampling Point	20.2%	25.5%	39.0%	15.4%	100.0%	

Table 3: Coliform Contamination as per sampling point

Sampling Point		Contamination		Total	P Value
		Negative	Positive		
Source	Count	64	33	97	0.001
	% within Sampling Point	66.0%	34.0%	100.0%	
Reservoir	Count	39	12	51	
	% within Sampling Point	76.5%	23.5%	100.0%	
Tap	Count	94	25	119	
	% within Sampling Point	79.0%	21.0%	100.0%	
PoU	Count	70	54	124	
	% within Sampling Point	56.5%	43.5%	100.0%	
Total	Count	267	124	391	
	% within Sampling Point	68.3%	31.7%	100.0%	

Six sources, and three reservoirs wereobservedto be completely damaged and nonfunctional.Sources were also at very high vulnerable for probable contamination as most of the sources were unprotected. In addition, presence of latrines uphill the source, access of animals within 10 meters distance of source is another prime reason for contamination vulnerability. High contamination vulnerability of reservoirs was mainly due to presence of leakage points, and unsanitary inspection cover of reservoir. While for high communal taps contamination vulnerability was mainly due to lack of improved drainage canal allowing used water to accumulate near tap stand. Lack of plinths and leakages in taps are the major reason for contamination risk at communal taps. Moreover observed human excreta nearby tap stands and unhygienic practices near tap stand increased the susceptibility contamination vulnerability of communal taps.

Despite of high contamination vulnerability, low water temperature can be the reason for contamination negative of thermo-tolerant coli form in most of the samples. The PoU water samples and Communal taps were more contaminated as compared to other supply systems. This is generally due to unsanitary physical status of communal taps and poor behavioral practice of individuals in temporary shelter.

Comparatively, under 5 years children were recorded to be at higher risk from diarrhoea at the time of study. Contaminated PoU drinking water and no practice of water treatment prior drinking can be theforemost reason for under 5 diarrhoeal risk. Availability of chlorine tablets yet alone didn't possessed practice of treating water. Lack of proper knowledge on chlorination process also played vital role for absence of treatment practice.

Conclusion

From the assessment results and findings it can be concluded that the earthquake had an effect in terms of structural and functional status of the sources and reservoirs of Jiri municipality. Various degree of contamination vulnerability existed specially at sources. PoU drinking water were highly contaminated by *E.coli* as compared to other sampling points. The risk was majorly due to behavioral aspect and almost no treatment practice of water prior drinking. Availability of water treatment provision yet alone didn't possessed to practice the provision. Knowledge and capacity to utilize the available resource does plays vital role for adaptation of practices. Also, it is learned that it is not viable to impose any interventions or tools without understanding local status and feasibility.

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Land Use Change Detection and Urban Sprawl Analysis of Biratnagar Sub-Metropolitan City

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Abstract

Urban sprawl is an increasingly common phenomenon linked to urbanism and urbanization in the world converting vast rural areas into urban areas sometime causing environmental problems like decreased air quality, increased storm runoff, increased local temperature, deterioration of water quality, etc. In this work we have taken Biratnagar sub metropolitan city as case to study the urban expansion and land cover change that took place in a span of 46 years from 1968 to 2014. Land use map of three different years were prepared and studied using GIS. Five land use classes have been identified as urban (built-up area, industrial area and airport), water body, agricultural land, barren land and forest. Change detection analysis showed that built-up area in 2014 has increased from 13.89% to 43.95% since 1968. Agricultural land has decreased to 52.29% and barren land increased to 3%. GIS based analysis on the pattern of expansion indicated that the growth has mainly taken place linearly along the road networks. Lack of proper town planning, road extension, presence of infrastructural facilities, job opportunities, health facilities, educational facilities are causes for sprawl. Study on urban growth, land use and land cover change is very useful for local government and urban planners in planning the sustainable development of the city.

Keywords: *land use/land cover, urban sprawl, biratnagar, change detection analysis*

Introduction

Urbanization is rapidly increasing in South Asia and expected to increase in the future as well at least up to the year 2020 (Ansari,2009). Settlement is increasing rapidly at selected places on the urban border areas for spacious living and clean environment. This transformation creates new fringe lands around. Such fringe lands are not static and are likely to experience spatial shifts even in the short run leading to sprawling effect. Though managed urbanization has positive inference in development, the sprawling process of expansion is disordered, unplanned, leading often to inefficient and unsustainable urban expansion patterns (Chawla, 2012). Land use and land cover change as the consequence of sprawl have impacts on a wide range of environmental

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and landscape attributes including the quality of water, land and air resources, ecosystem processes and function, (Sundarkumar 2012).

Government of Nepal recently declared the existence of 191 municipalities in total. It is essential to understand the factors that drive sprawl to address the onslaught problems related to. To an agro based country like Nepal increasing sprawl is also a threat for food security. There are several studies on land cover change in cities (Shrestha, 2011; Rimal, 2012; Rimal, 2013) in Nepal. Majority of them have only focused on landuse change. Being the third largest city in Nepal, and sharing 19.77% of population of Morang District, Biratnagar has a lot of scope for development and urban growth. The study has unfolded land cover conversion and the trends and pattern of sprawl at Biratnagar which can make its use in rational land use plans, policies and design.

Methodology

Study Area

Biratnagar Sub metropolitan city is the third largest city of Nepal located at Morang district, Koshi Zone in the Eastern Development Region on the southern Terai belt of Nepal with latitude 26^0 23'10" to 26^0 30'44" N and longitude 87^0 14'27" to 87^0 18' 29" E (UNDP, 2009). The sub metropolitan city lies at 62m to 78m above mean sea level and falls in the climatic range of warm, humid and warm sub-tropical plain (Shrestha, 2007). Monsoon is usually experienced during warm seasons of mid June to mid August. Average maximum and minimum temperature recorded in the last ten years is 33.3^0C and 9.0^0C (DHM, 2012). The average annual rainfall over the last ten years at Biratnagar Airport Station has been recorded as1891.8mm (DHM, 2012). The topography of Biratnagar is flat. It covers total area of 58.48 km^2 and population around 201,125 (CBS, 2011). Biratnagar is one of Nepal's main centers of business, commerce and industry with large market place. Cycle, rickshaws and taxis serve the city center. Electric rickshaws are most used transportation here, which connects all part of Biratnagar and is very cheap. Biratnagar is the centre of education in the Eastern Development Region of Nepal.

Data Sets

Land use maps of three different years i.e. 1968, 1996 and 2014 were used for this study. First, 1968 data was obtained from land use maps of scale 1:50,000 compiled from ground verified aerial photographs prepared under the Canadian Assistance Program to Nepal by the Topographical Survey Branch, Survey Department of the Ministry of Land Reform of His Majesty's Government of Nepal (HMGN) and Kenting

Earth Sciences Ltd. of Ottawa, Canada. Second, the topographical map with the scale of 1:25,000 prepared by the Survey Department of HMGN in co-operation with the Government of Finland was used. The map is based on the aerial photograph of 1992 at the scale of 1:50,000 verified in 1996. With the help of ArcGIS 9.3, digitized Google Earth Map was prepared for 2014. Also the available land use maps were digitized and allowed for reclassification into categories appropriate viz urban (built-up and industrial area, airport), water body, agricultural land, barren land and forest. The Geo-referencing of the map was done by coordinate system. All the data were projected to the Universal Transverse Mercator (UTM) projection system that is World Geodetic System 1984.

Questionnaire survey was carried among 384 households. The sample size was determined using a formula devised by Arkin and Colton (1963), whose confidence and error levels are 95 percent and 5 percent respectively. Population and household data of different time scale were obtained from Central Bureau of Statistics (CBS).

GIS Analysis and Land Use Map

The complexity involve in a dynamic phenomenon such as urban sprawl could be understood with land use change analysis. Arc GIS 9.3 was used for digitization, preparation of land use/land covers layer, composition and generation of maps for quantifying the extent of urban area in different time periods. By digitization, data are converted in vector format. Various GIS based layers such as land use/ land cover map, roads network and the administrative boundaries from the toposheets were created. Also the pattern of development was determined.

Change Detection Analysis

Change detection analyses describes and quantify differences between images of the same scene at different times (Sundarkumar 2012).The classified images of the three dates can be used to calculate the area of different land cover and observe the changes that are taking. This analysis is very much helpful to identify various changes occurring in different classes of land use like increase in urban built-up area or decrease in vegetation and so on.

Average/Mean Analysis

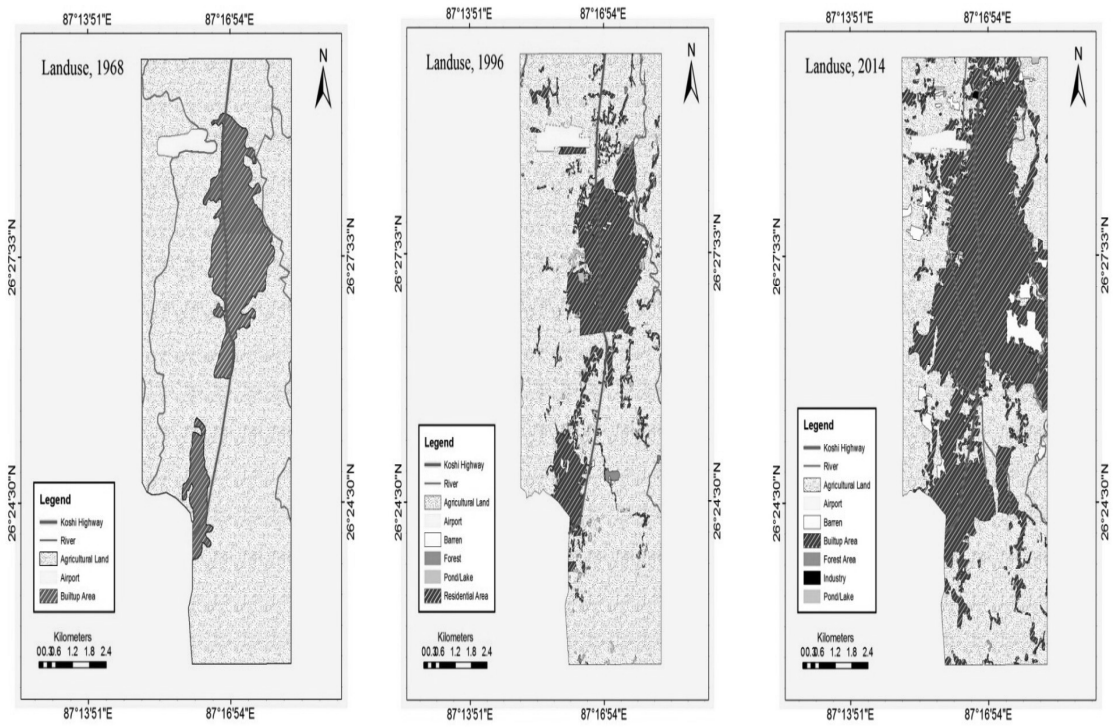
Mean analysis was done in order to know the view of the respondents about the possible cause behind the sprawl in the study area. For which the list of 10 possible reasons where given and respondents were requested to provide their opinion in likert scale ranging from 1 to 5 i.e.strongly disagree to strongly agree. Then the mean was

calculated for every single reason. Although the study was based on some theoretical ideas, the goal of this analysis was to develop a theory that makes sense of data generated in the context of a particular investigation. The collected data were recorded and analyzed with the help of statistical SPSS software and the possible cause behind the sprawl was revealed successfully.

Results and Discussion

Change Detection Analysis

Change detection analysis described and quantified the changes taking place in the time span. For the years 1968, 1996 and 2014 the land use areas were calculated from the respective polygon maps (Fig. 1 A, B & C).



A *B* *C*

Figure 1: Landuse map A. 1968,B. 1996, C. 2014

Table 1: Land use Change

Land Type	**1968**		**1996**		**2014**	
	Area (Km^2)	**% of total**	**Area (Km^2)**	**% of total**	**Area (Km^2)**	**% of total**
Agricultural land	56.91	85.02	54.19	80.94	35.01	52.29
Built-up Area	9.31	13.89	10.51	15.70	29.43	43.95
Airport	0.73	1.09	0.73	1.09	0.73	1.09
Pond/Lake	_	_	0.74	1.10	0.33	0.49
Forest	_	_	0.33	0.50	0.01	0.01
Barren Land	_	_	0.37	0.54	2.28	3.41
Industrial Area	_	_	_	_	0.04	0.06

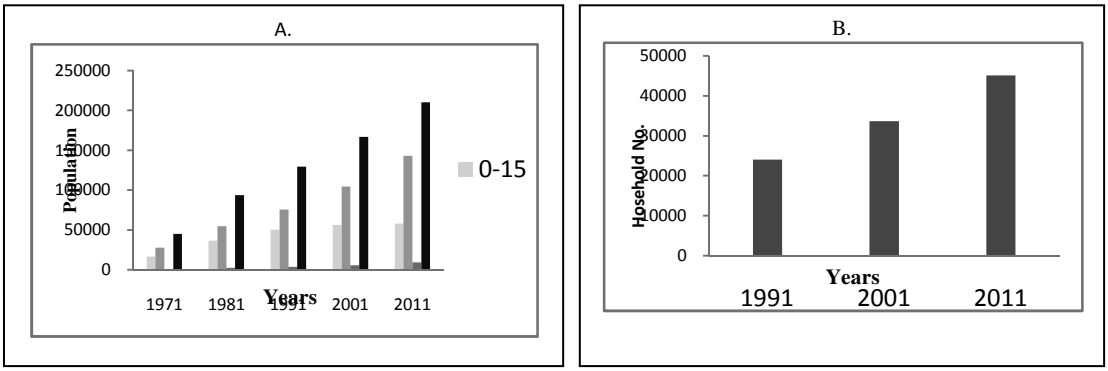
The scenario in the year 1968 (Fig1 & Table1) depicts the region had a vast agricultural land covering (85.02% of the total area) which contributed the highest among the areas. But a drastic reduction in percentage of agricultural land from 80.94% in 1996 to 52.29% in 2014 was observed (Fig1 & Table1). On 2014, there is considerable increment of built up area to 43.95% in comparison to year 1996 (Fig1 & Table1). This illustrates that among all the land parcels, agricultural land was substituted markedly by other land use forms. Also, the barren land area has increased in contradict to decrease in area occupied by forest and ponds and lakes. This is due to the reason that agricultural lands these days are left fallow for plotting new residential area. Most of the fertile agricultural fields are rapidly converting into residential and commercial areas, among which the northern part of the Sub-Metropolitan City is observed to have greater impact of change compared to other areas (UNDP, 2009). Increase in residential area and barren land was observed in the similar study of Birtanagar (Rimal, 2012) and Pokhara (Rimal, 2013).

The land use map revealed that the study area is under the grasp of sprawling. The urban and industrial areas are rapidly increasing and the cultivated lands are considerably decreasing. A careful analysis on the dynamics of sprawls indicates the residential shifting is along the Koshi highway. The growth of built up areas is mainly towards the north-south route along the same Highway in a linear pattern. This linear pattern of sprawl was also observed along the Rangeli Road and Biratnagar Road. The core area was reported to have higher density of population and the compact sprawl pattern while its fringes have The expanding networks of roads and increasing reliance on the automobiles could be the reason behind the increased number of population shifting from cities to the fringe areas. Also, easy access to the service had played an important role in linear sprawl pattern in the study area. Some Indian cities

like Noida City (Mohan, 2010) and Jaipur City of Rajesthan (Rajpoot et al, 2014) had similar change in land use.

Population Analysis

Rapid increase in population is observed from the data of population growth (Fig 2). Increase in population among the age group 16-64 (active age group) is noticed higher among all.



Source: (CBS 1991, 2001, 2011)

Figure 2: Variation of A. Population Growth among Different Age Group, B. Household Number

Gradual increase in household number is observed with increase in population size (Fig 2). The population growth data and household number (Fig 2) supported the rapidly increased population pressure as well as gradual shifting of agricultural land to residential and other land use types. Infrastructural facilities, good education, health, employment facilities available here might have attracted more number of immigrants. And thus increasing population and household numbers have influenced sprawl. Land use change was influenced directly by infrastructural development, where all types of human facilities were concentrated and people develop their all qualities and spend luxuries (Rimal, 2012).

Reasons Behind Increased Sprawl

Average Mean Analysis (Table 2) was done to find the reason behind the sprawl in the study area and to view the overall impact of it on environmental aspects of the study area. Maximum percentages of respondents strongly agreed with the given factors as the cause of sprawl except cheap land value of the study area. It is because the mean values of respondent ratings were above 4.

Most of the respondents from survey rated the availability of infrastructural facilities, job opportunity, health facilities and road extension as the major reasons of sprawl in the area. These factors altogether had caused a large amount of inflow of population as well as extensive sprawl within the suburbs and the fringe lands. Also, lack of proper town planning and presence of administrative centers have profound role on causing sprawl. Contradict to these; cheap land value was not the reason for the prevailing sprawl as the land price of the place was higher since the place was declared as industrial sector in 1936 B.S. The increasing rate in extraction of natural resources like gravels and sands from the rivers; increased consumption of land, water and soil, decline in water resources, agricultural land and production, etc. are the major concern of the place. Decrease in agricultural land and agriculture based activities as well as decrease in quality of environmental services are the major impact of it. In the similar study of Gorakhpur City, Uttar Pradesh decline in vegetative and agricultural land were noticed along the main transportation route (Dubey et al, 2013).

Where, 1= strongly disagree, 2= disagree, 3= neutral, 4=Agree, 5= strongly agree.

Table 2: Average Mean Analysis to Represent Reason behind Sprawl

Reason	Minimum	Maximum	Mean	SD
Lack of proper town planning	4	5	4.62	.487
Road extension	4	5	4.51	.500
Presence of Infrastructural Facilities	4	5	4.90	.302
Presence of Administrative Facilities	3	5	4.32	.471
Job opportunity	4	5	4.86	.343
Health facility	4	5	4.66	.473
Educational facility	4	5	4.34	.475
Cheap Land value	1	1	1.00	.000
Share boarder with India	3	5	4.14	.358

Conclusion

Biratnagar is rapidly urbanizing with large portion of agricultural land being converted to residential land and other land form. Sprawling was observed along the Koshi highway with linear sprawling pattern. From the study it can be concluded that the urban development in Biratnagar is random and going in an unplanned manner. Identification and analysis of the patterns of sprawl would help in effective landscape planning and environmental management.

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Assessing Wetland Condition Through Remote Sensing Image - A Case from Ghodaghodi Lake (Ramsar Site), Kailali Nepal

Niroj Timalsina[1] & Nabina Maharjan[2]

Abstract

Wetland is most important natural resources, conservation for which is directly related to survival of different flora and fauna. Implication of remote sensing can provide essential support for study of such natural resources. The NDWI and WRI use for extraction of wetland area from Landsat images is effective in case of Ghodaghodi lake which further calibrated according to Google images of respective duration gives clear representations of such wetland system. The study clear indicates that rate of formation of new wetland in Ghodaghodi lake system is higher during 1992-2002 whereas degradation is lower in 2002-2013.

Keywords: *normalized difference water index, remote sensing, water ratio index, wetland system*

Introduction

"Natural or artificially created areas, such as swamp, marsh, riverine floodplain, lake, water storage area and agricultural land containing water from underground water resource or atmospheric precipitation that may be permanent or temporary, static or flowing and freshwater or saline" is wetland as per Nepal's National Wetland Policy (2003).Wetland health assessment is very limited in context of Nepal which can be evaluated through remote sensing (RS) Image analysis. RS technique uses visible, infrared and microwaves to study the dynamic of the wetland (Prigent, Matthews, Aires, & Rossow, 2001). It has been widely used in monitoring spatial variation in wetlands at different time intervals(Lee & Yeh, 2009; Sigimaran, Harken, & Gerjevic, 2004). Data analysis through RSis considered as one of the cheapest and time saving method to conduct large scale monitoring (Okin, Roberts, Murray, & Okin, 2001). Thus this paper attempt to explore spatial and temporal change rate as well as their conditionin Ghodaghodi lake systems situated in Kailali district.

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Methodology

Study Area

Ghodaghodilake is Ramsar site of Nepal having largest natural lake system, situated in Darakh, Sandepani and Ramshikharjhala VDCs of Kailali district covers an area of 2563 ha is also enlisted as an Important Bird area by Bird Conservation Nepal as well as Bird Life International. The lake system has finger like projection with three types of wetland habitats viz riverine, Palustrine and Lacustrine (Kafle, 2005). The lake inhabitant endangered as well as threatened 34 different species of mammals and 140 species of birds (Kafle, 2005)

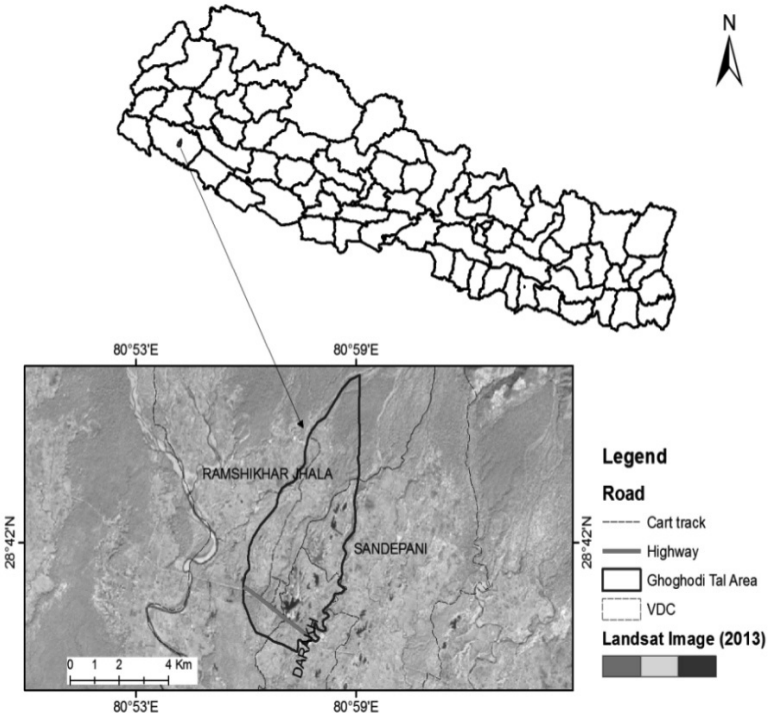

Figure1: Ghodaghodi Lake system

Study Procedures

At the beginning of the study, free Landsat imageries available on http://earthexplorer.usgs.gov for the year 1992, 2002 and 2013 were downloaded.

Table 1: Characteristics of downloaded Images

LANDSAT SCENE ID	Path	Row	Date of Acquisition	Landsat Archive
LT51440401992350ISP00	144	40	1992-12-15	L4-5 TM
LE71440402002305SGS00	144	40	2002-11-01	L4-5 TM
LC81440402013311LGN00	144	40	2013-11-07	L8 OLI/TIRS

Normalize difference on Water Index (NDWI), actually developed for the extraction of water features from Landsat imagery (Mcfeeters, 1996) was used together with Water Ratio Index (WRI) in order to delineate water surface and swamp areas of Ghodaghodi lake system. These methods have been found effective for the detection of surface water change (Rokini, 2014).NDWI and WRI can be calculated as:

Normalized difference Water Index = (Green Band –NIR band)/ (Green Band+NIR band)

Where, NIR is the near near-infrared of Satellite Image.

Similarly, Water Ratio Index (WRI) was calculated as proposed by Shen, 2010:

WRI = (Green + Red)/(NIR + MIR)

Where, MIR is middle- infrared band

Additionally, the topographic maps published by Department of Survey under GoN were used for verification and interpretation of wetland area of 1992. Wetland area here includes both swamp and lake area. Similarly, high resolution images of Google Earth (2002/2003 & 2013/2014) were used for wetland delineation and validation of respective year. Later on field verifications was performed for every aspects of the study. The rate of change was calculated as similarly to study conducted by Pokharel, Niraula,Timalsina & Neupane, 2015.

Table 2: Matrix of Wetland change

Wetland Change	**Definition**
Degraded wetland	Wetland in early decade change into other land cover
New wetland	Non wetland in early decade changed into wetland
Unchanged wetland	Wetland in early decade with no change
Other land	Land other than wetlands

Finally, matrix was developed in order to determine the extent of change in wetland area in Ghodaghodi lake system(table 2) where other land include dense forest, sparse forest, grass/bush, barren land and cultivated land.

Results and Discussions

Wetlands are one of the most important features of the Environment which can be monitored through remote sensing (Ashraf and Nawaz, 2015). Remote sensing satellites at different spatial, spectral, and temporal resolutions provide an enormous amount of primary data that have become sources for detection and extraction of surface water and its changes. The result of NDWI and WRI of Ghodaghodi lake system is shown in table 3.

Table 3: Statistics of NDWI and WRI in and around Ghodaghodi lake

Index	Statistics	Year		
		1992	2002	2013
NDWI	Minimum	-0.39	-0.22	-0.36
	Maximum	0.04	0.4	0.14
	Mean	-0.23	-0.03	-0.23
	Standard deviation	0.06	0.09	0.06
WRI	Minimum	0.45	0.61	0.53
	Maximum	1.31	2.33	1.4
	Mean	0.63	0.84	0.68
	Standard deviation	0.07	0.11	0.07

Greater the value of NDWI higher is the water content. The maximum and mean NDWI value for the year 2002 was found highest showing expansion of surface water in the form of lake. The classified map statistics shown in above table was used for delineations of the wetland of respective years. Similarly, in case of WRI, greater is the value greater is the water content of land cover.

Table 4: Wetland area and Rate of change of Ghodaghodi lake system

Year/Change	Area (ha)	
	Wetland	Other Land
1992	85.71	2471.77
2002	123.09	2434.39
2013	124.38	2433.1
Rate of Change (1992-2002)	3.68	-0.15
Rate of Change (2002-2013)	0.09	-0.004

Change in area of Ghodaghodi lake system in two different time frame viz 1992 -2002 and 2002-2013 shows positive change in lake system and rate of change in lake is the highest during 1992- 2002 (table 4). Wetland under the Ramsar site has been conserved which might be because of increasing awareness.

Wetland Condition Assessment (RS analysis)

The result of RS analysis of the wetland condition is shown in table 5. Areas of new wetlands was found more during 1992-2002 than recent decade whereas area of degraded wetland was less in 2002-2013 than during 1992-2002 figure 2 and 3. In 2002-2013, about 121 ha of the wetland remained unchanged that shows effectiveness of conservation practises after designation of Ramsar site.

Table 5: Wetland condition of Ghodaghodi lake system

Wetland Condition	Area (ha)	
	1992-2002	2002-2013
New wetland	48.64	2.51
Degraded wetland	11.26	1.22
Unchanged wetland	74.45	121.87
Unchanged other land	2428.65	2437.4

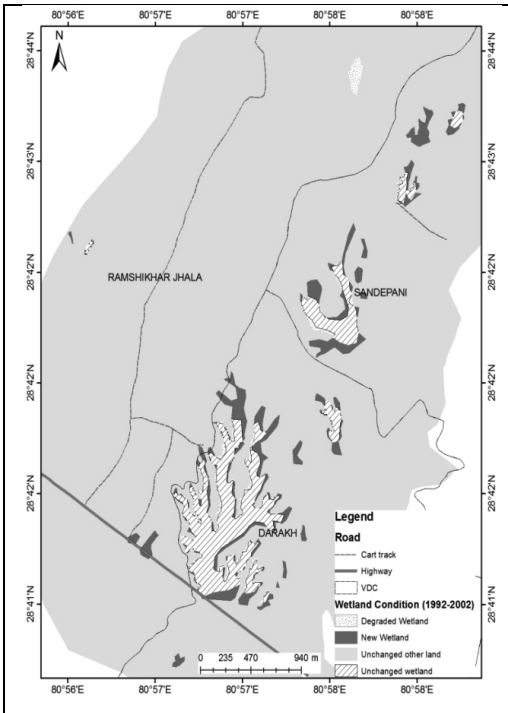

Figure 2: Wetland condition during 1992-2002

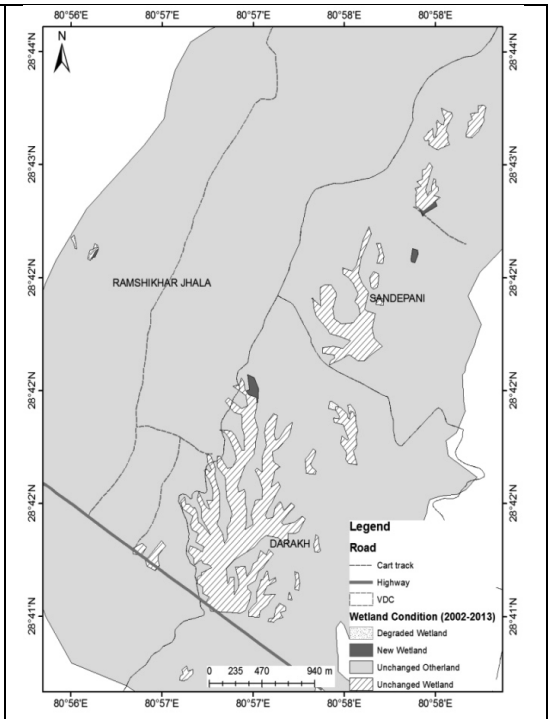

Figure 3: Wetland condition during 2002-2013

Conclusion

Using remote sensing for analysis of condition of Lake System of Nepal is one of the cheap method which can be commenced in limited time period. NDWI and WRI, is found effective in extraction and analyses of water bodies and wetlands of Ghodaghodi lake system. This method can be replicated to other wetland systems in the Terai region. Less degradation of Ghodaghodi wetland system in the last decade might be attributed to Ramsar site management through government and non-government organisations as well as Community Based Organisations and locals.

Acknowledgements

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Estimation of Global Solar Radiation using Artificial Neural Network in Kathmandu, Nepal

Kulchandra Panthee[1], Ajay Kumar Jha[1]

Abstract

There is no doubt that information of the measured data of solar radiation is the best for designing any reliable solar energy systems but in Nepal the measured solar radiation data are not available for most of the sites due to high cost and requirement of daily maintenance of the measuring instruments. The alternative is to use the estimated data of solar radiation using any of available estimation models. In this study an Artificial Neural Network (ANN) was used to estimate the solar radiation in Kathmandu with the help of meteorological data of maximum and daily average temperature, relative humidity, rainfall amount, sunshine hour and solar radiation available for Tribhuvan International Airport. Data from 2002 to 2011 were used to train the Network and it was tested by using the data of 2012 and 2013. A multi-layer feed-forward neural network was devised using MATLAB programming. Five different models with different input combinations were modeled with Feed-Forward Multilayer Preceptors. The results of ANN model were compared with measured data on the basis of root mean square error (RMSE), mean bias error (MBE), mean percentage error (MPE) and Correlation Coefficients (CC) in order to check the performance of developed model. The obtained result indicate that the ANN based model for estimating solar radiation is precise in the selected location thus the model can be used anywhere in the Nepal having similar climate conditions where the meteorological data are available. The best prediction was from Model 1 as it exhibit minimum value of RMSE (0.2781) and maximum value of CC (0.9880) for which input parameters were average temperature, relative humidity, sunshine duration and rainfall amount.

Keywords: *artificial neural network, global solar radiation, root mean square error, mean percentage error, mean bias error, correlation coefficient*

Introduction

Nepal has been facing energy crisis problem since long ago and has to depend on costly fossil fuel to meet the daily demand of energy with very few portion from renewable energy. The annual peak power demand of the Integrated Nepal Power System (INPS) in fiscal year 2013/14

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is estimated to be 1,201 MW, with 410 MW power estimated to have been shed. Out of the 791 MW of power actually supplied, 436.4 MW was contributed by Nepal Electricity Authority hydro, 22 MW by Nepal Electricity Authority thermal, 216.4 MW by IPP hydro and the rest 116.2 MW was import (NEA, 2014). In the Global context the depleting oil reserves, uncertainty and political issues concerning nuclear generation and the environmental concerns associated with coal and natural gas-fired generation encouraging to look for alternative and sustainable sources of energy. The solar-energy systems in contrast offer ease of installation, declining cost of technology and environmental benefits. On the other hand Nepal is located between 26˚12' and 30˚27'north latitude. Here are over 300 days of sunshine annually and annual average solar radiation is 5kWh/m^2 per day (AEPC, 2015). All these data indicate that the country has sufficient solar radiation intensities for solar applications. So the optimum utilization of solar energy could beneficial to reduce the energy crisis problem and to reduce our dependency on costly fossil fuel to some extent.

The utilization of solar energy, like any other natural resource, requires detailed information on availability. Since solar radiation reaching the Earth's surface depends on many factors which are not global character, a study of solar radiation under local weather conditions is also essential (Becker et al., 1957). Solar radiation data is always a necessary basis for designing reliable solar energy system such as solar photovoltaic, solar energy supported drying systems and water heaters as well as for a feasibility study of the possible use of solar energy. There is no doubt that the measured data of solar radiation are the best. The traditional way of knowing the amount of global solar radiation (GSR) in a particular region is to install pyranometers at as many locations as possible thus requiring daily maintenance and data recording, and consequently increasing cost of GSR data collection. Therefore, it is rather more economical to develop methods to estimate the solar radiation using climatological parameters (Kasseam et al., 2009).

Different empirical methods can be used to estimate the global solar radiation of desired locations. Empirical methods to estimate global solar radiation requires the development of a set of equation that relate it to other meteorological parameters (Donatelli et al., 2003). Artificial neural network (ANN) models are the latest type of solar prediction models. This study Artificial Neural Network is used to estimate the solar radiation in Kathmandu.

Different literatures reveal that many researchers outside Nepal (Mohandes et al., 2000), (Rehman et al., 2008), (Fadare, 2009), (Behrang et al., 2010), (AbdulAzeez, 2011), (Ahmed et al., 2013), (Waewsak et al., 2013) use ANN model to estimate the global solar radiation using meteorological parameter. These models cannot be used efficiently in Nepal due to seasonal variations, different climatological and geographical conditions. In Nepal one of the research (Poudyal et al., 2012) uses regression model using clearness index and cloud transmittance at Lukla to estimate monthly and seasonal variation of global solar radiation. Adhikari et al.,

(2013) employs regression model based on sunshine hours, temperature and relative humidity for four different locations (Kathmandu, Pokhara, Biratnagar and jumla) of Nepal. In this research the linear regression technique has been used to develop a model for Biratnagar, Kathmandu, Pokhara and Jumla. Das (2014) conducted a comparative study of seven different regression models. However no studies have been carried out on estimation of global solar radiation using Artificial Neural Network Model.

The main objective of this study is to estimate the solar radiation in Kathmandu using ANN. In this present study Meteorological parameters; temperature, relative humidity, rainfall amount, sunshine hours and global solar radiation were used to train the ANN. The Artificial Neural networks can use a variety of topologies. They can be grouped into two major categories: feed-forward and feedback (recurrent) networks (Jain et al., 1996). Multilayer preceptors (MLPs) are the most common type of feed-forward networks which is used in this study to estimate the solar radiation in Kathmandu.

Methodology

Data Collection

This study is based on the six meteorological parameters namely: daily data of maximum temperature (°C), average temperature (°C), sunshine duration (hours), mean relative humidity (%), rain fall amount (mm) and solar radiation (MJ/m^2/day). All these data for 12-year period from 2002 to 2013 were collected from Meteorological Department, Kathmandu. After collecting the required data problem of missing data was solved using linear interpolation and data were normalized before presenting the input data to the network.

Building Network

During this step number of hidden layers, neurons in each layer, transfer function in each layer, training function and weight/bias learning function were specified. In this study five different ANN models were formed using different meteorological input parameters as illustrated in Table 1.

Table 1: Five different ANN models with different input combinations

S.N.	Model Name	Input Parameters
1	Model 1	Average Temperature (°C), Mean Relative Humidity (%), Sunshine Duration (Hour) and Rainfall Amount (mm)
2	Model 2	Maximum Temperature (°C), Mean Relative Humidity (%), Sunshine Duration (Hour) and Rainfall Amount (mm)

S.N.	Model Name	Input Parameters
3	Model 3	Average Temperature (°C), Mean Relative Humidity (%) and Sunshine Duration (Hour)
4	Model 4	Average Temperature (°C), Sunshine Duration (Hour) and Rainfall Amount (mm)
5	Model 5	Average Temperature (°C) and Sunshine Duration (Hour)

Tangent Sigmoid and linear activation functions are used in the hidden layer and in the output layer, respectively. The ANNs models were implemented in MATLAB software package.

Training Network

After building the network, different input data from 2002 to 2011 were used to train the network. Levenberg-Marquardt back-propagation training function was used to train the network.

Testing Network

Network was tested using the data of 2012 and 2013. Statistical indicators were used to test the ANNs performance; these are Root Mean Square Error (RMSE), the Mean Bias Error (MBE), the Mean Percentage Error (MPE) and correlation Coefficient (CC). The measured GSR in 2012 and 2013 is used to compare with predicted GSR to compute the RMSE, MPE, MBE and CC. The extent of the error in the predictions was assessed using the RMSE where the MBE was used to describe how much the ANN under-estimate or overestimate the actual data. Lower the value of RMSE, MBE and MPE the better is the ANN model's performance where as higher value of co-relation co-efficient is desirable. Statistical indicators RMSE, MBE, MPE and CC are given below.

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(H_i - H_{pi})^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\mathrm{MPE} = \frac{1}{n}\sum_{i=1}^{n}\frac{(H_i - H_{pi})}{H_{pi}} * 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\mathrm{MBE} = \frac{1}{n}\sum_{i=1}^{n}(H_i - H_{pi}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\mathrm{CC} = \frac{(H_i - \overline{H})(H_{pi} - \overline{H_p})}{\sqrt{\left\{\sum(H_i - \overline{H})^2\right\}\left\{\sum(H_{pi} - \overline{H_p})^2\right\}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where H_i are the measured data of Global Solar Radiation and H_{pi} are the predicted value of the Global Solar Radiation

Programming Analysis

Procedural steps to develop ANN model is shown in Figure 2. The program started by reading the data from excel file. After reading the data from excel file the training samples were randomized while the order of columns was kept unchanged. After randomizing the training data training and testing set input and target set were specified. The inputs and target data were normalized in order to yield zero mean and unity standard deviation. The output was converted back into the same unit that was used for the original target. Before presenting these data to neural network they were converted into rows.

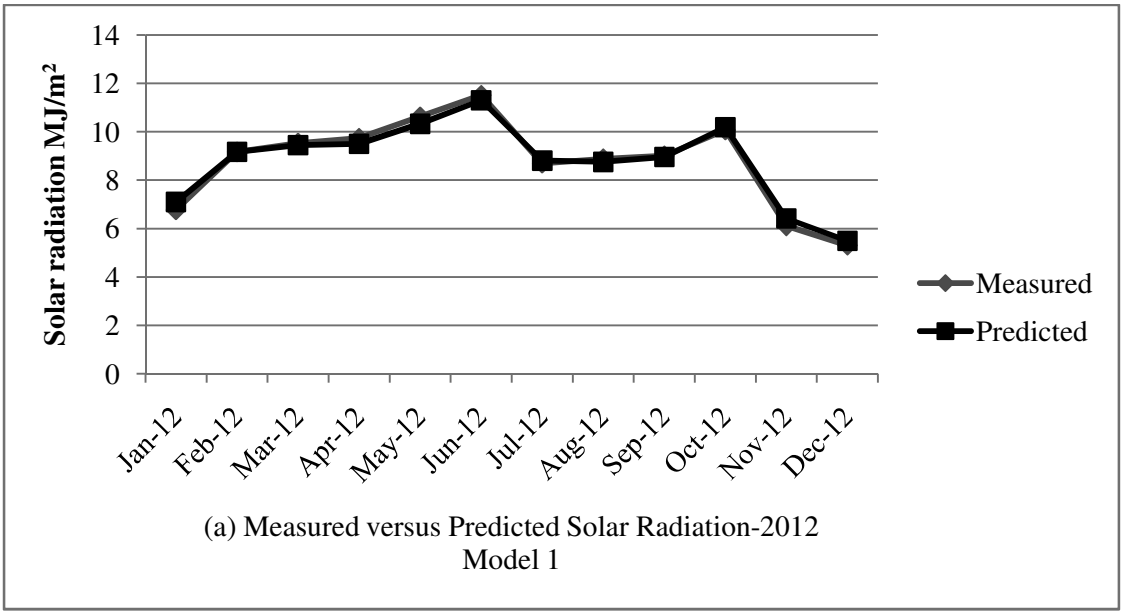
The built-in function ***"newff ( )"*** is used to build the MLP model which creates a feed-forward back-propagation network. With this function the number of hidden layers, the neurons in each layer, the transfer function in each layer can be specified. This command also automatically initializes the weights and biases. After configuring the network the network was trained several times with different number of neuron in hidden layer to get the best result. The trained network with best result was saved for each model.

Since the input data to the network were normalized before presenting them to the network the output obtained from the network (solar radiation for 2012 and 2013) are de-normalized in order to compare it with the measured data. The function ***"mapstd ( )"*** was used to de-normalize the output. Then the daily data (measured and predicted) were processed to produce the monthly mean. The monthly mean values of predicted data were compared with the corresponding monthly mean of measured data to check the validity of developed model and the mean monthly results and corresponding statistical data were written to an Excel file.

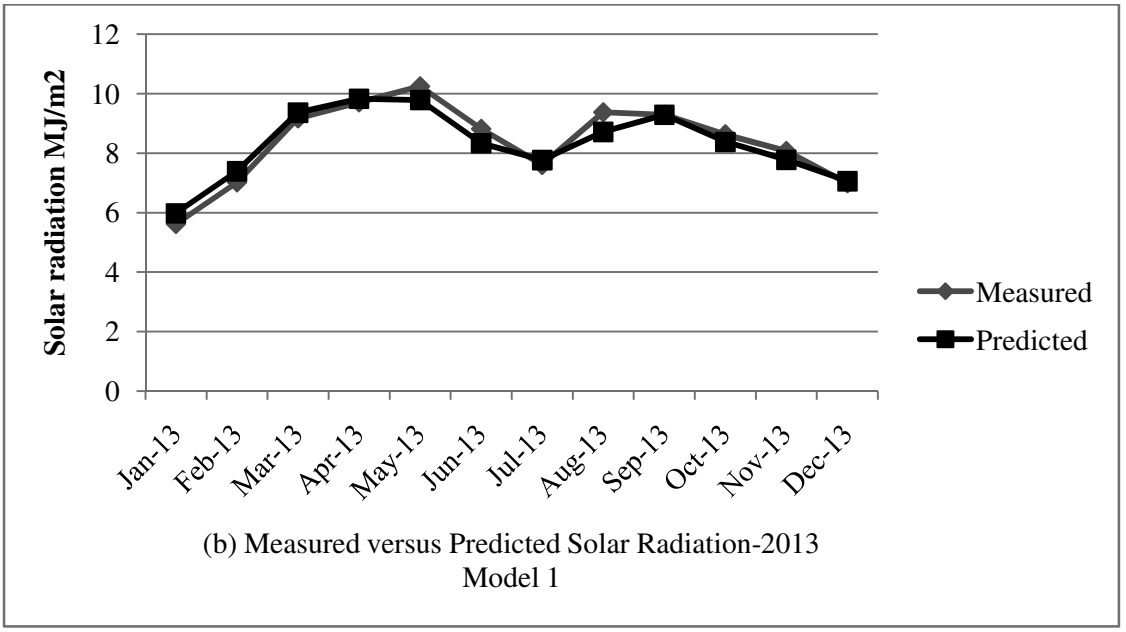
Results and Discussion

Comparison between Predicted and Measured GSR

Global solar radiation for the year 2012 and 2013 was predicted using five different ANN model. Figure 1, 2, 3, 4 and 5 shows the comparison between measured value of Global Solar Radiation and its predicted values for five different ANN models.



(a) Measured versus Predicted Solar Radiation-2012
Model 1



(b) Measured versus Predicted Solar Radiation-2013
Model 1

Figure 1: Comparison between measured and predicted values of GSR from Model 1

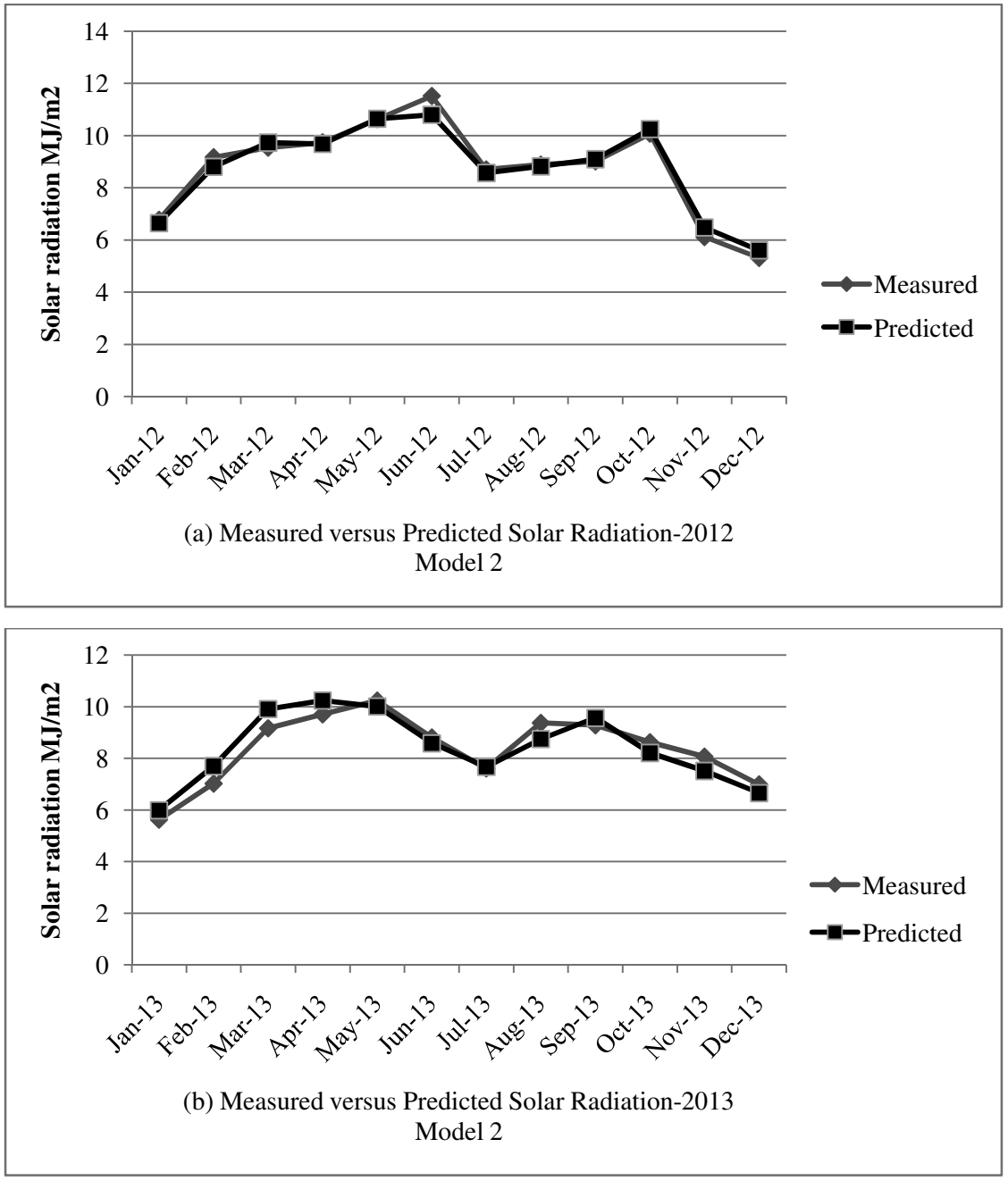
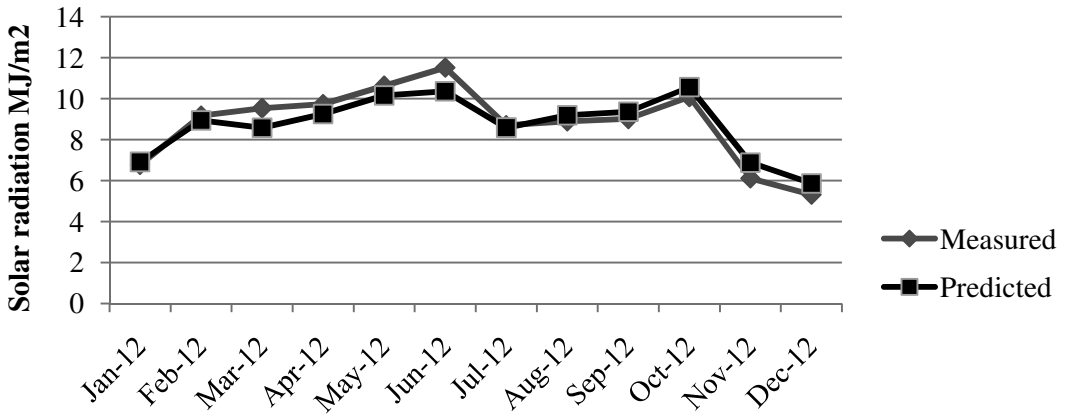
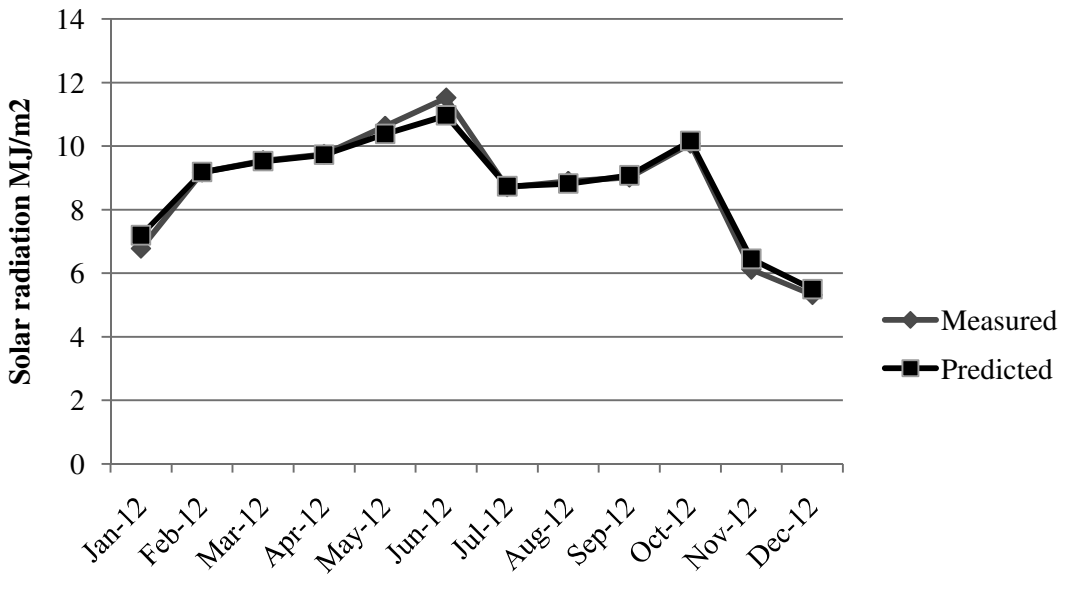


Figure 2: Comparison between measured and predicted values of GSR from Model 2



(a) Measured versus Predicted Solar Radiation-2012
Model 4



(a) Measured versus Predicted Solar Radiation-2012
Model 3

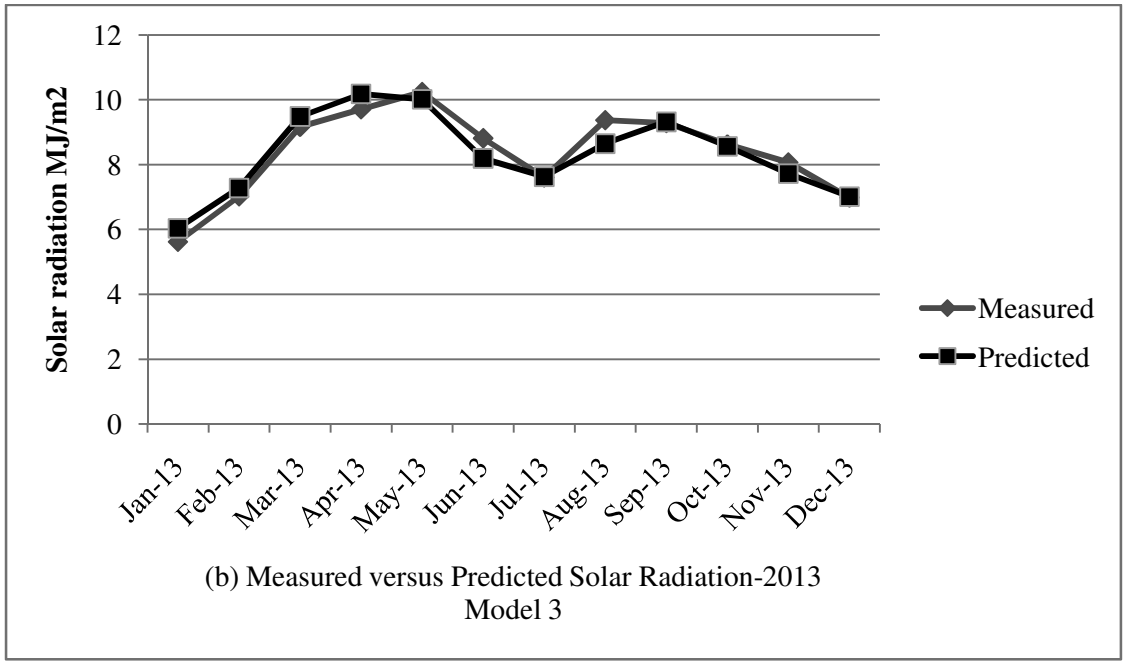


Figure 3: Comparison between measured and predicted values of GSR from Model 3

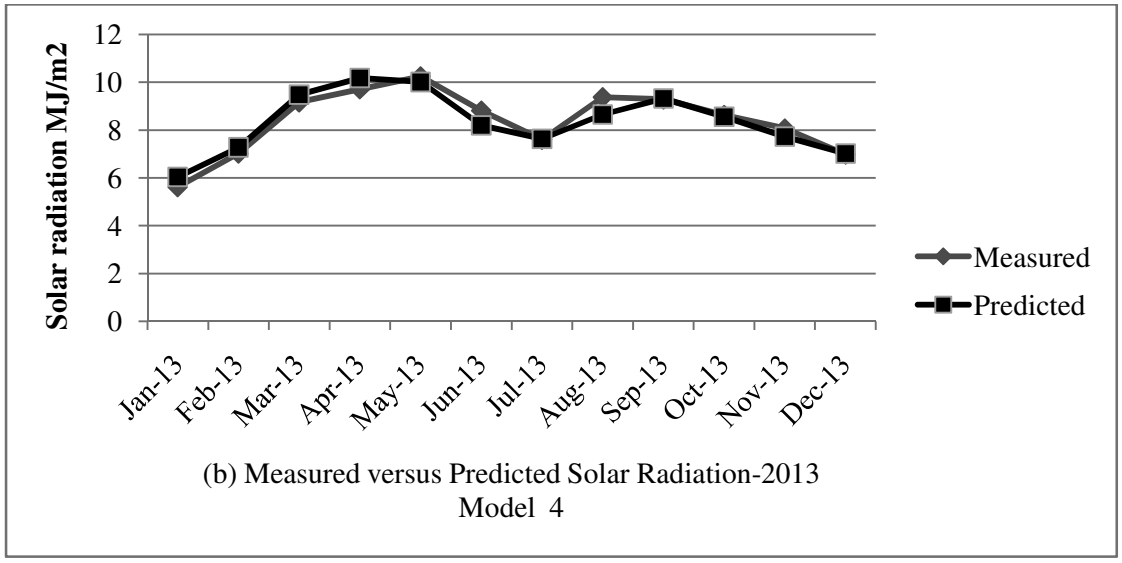
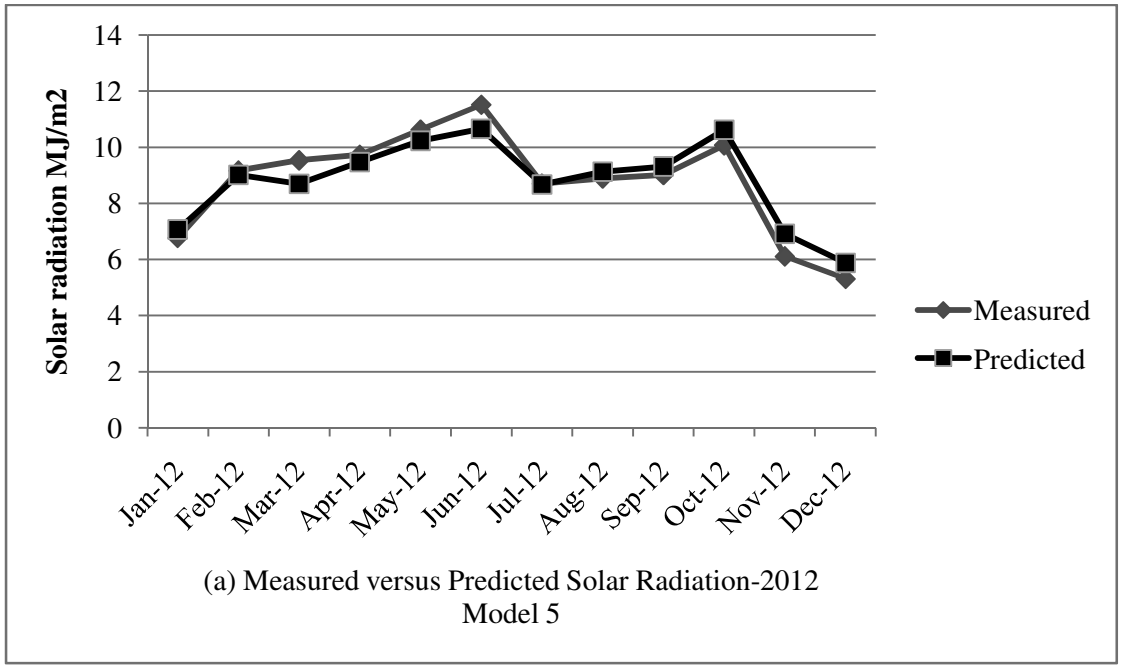
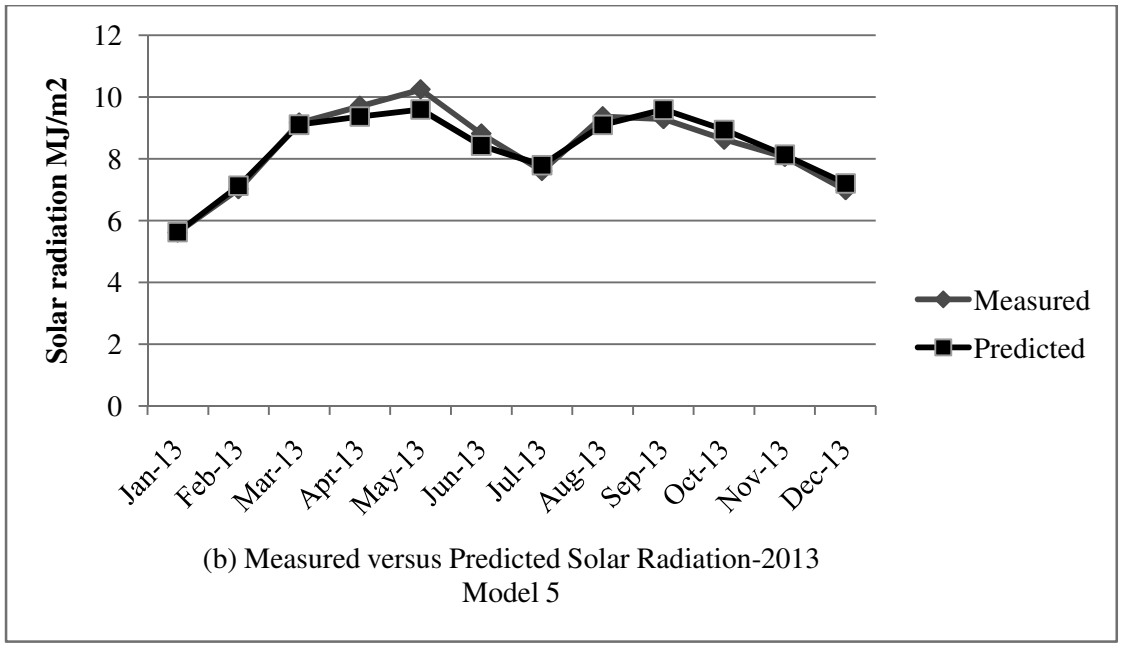


Figure 4: Comparison between measured and predicted values of GSR from Model 4



(a) Measured versus Predicted Solar Radiation-2012
Model 5



(b) Measured versus Predicted Solar Radiation-2013
Model 5

Figure 5: Comparison between measured and predicted values of GSR from Model 5

From Figure 1, 2, 3, 4 and 5 we have seen that the ANN models provide a very good prediction of Global Solar Radiation in Kathmandu. As the two lines each one for predicted and measured value of GSR in the Model 1 and Model 3 are more close to each other compared to those for other models, these two models provides better estimation of GSR.

Statistical Error parameters

Different statistical errors RMSE, MBE, MPE and CC were calculated using the measured value of Global Solar Radiation and that of Predicted values, these error parameters are presented in the Table 2.

Table 2: Statistical indicators for seven different models

Models	MBE	MPE	RMSE	CC
Model 1	0.0368	0.1243	0.2787	0.9880
Model 2	0.0024	-0.0786	0.3871	0.9690
Model 3	0.0098	-0.1481	0.3138	0.9821
Model 4	0.0807	0.5850	0.4779	0.9604
Model 5	0.0115	-0.2575	0.4206	0.9705

Form Table 2 we observed the Model 1 yields minimum RMSE (0.2787) among the five different ANN models developed here, which is desirable. After the Model 1 the Model 3 exhibit minimum value of RMSE (0.3138) where as Model 4 yield the maximum RMSE (0.4779). Model 2 and Model 5 exhibit RMSE 0.3871 and 0.4206 respectively these values are higher than the RMSE obtained from Model 1 and Model 3 but lower than the RMSE obtained from Model 4.

The MBE for Model 2 is 0.0024 which is lowest among all other models. Model 3 exhibit minimum MBE (0.0098) after Model 2. Model 5 exhibit MBE of 0.0115. Model 1 yields MBE of 0.0368 which is lower than the MBE obtained for Model 4 (0.0807). Model 4 yields maximum MBE of 0.0807 which is undesirable. Although the MPE of Model 1 (0.1243) and Model 3 (-0.1481) are relatively higher than that of Model 2 (-0.0786) this model exhibit lower MPE compared to Model 4 (0.5850), Model 5 (-0.2575).

The Model 1 (0.9880) and Model 3 (0.9821) yield respectively highest value of CC among all other models which means the predicted values of GSR from Model 1 and Model 3 are highly

correlated with that of measured values than other four models presented here. However the Model 4 exhibits lowest value of CC (0.904) which is undesirable for good prediction.

From analyzing the result of five different models Model 1 and Model 3 provide the best prediction of GSR compared to other models since these two models have relatively lowest values of RMSE, MBE and MPE and highest values of CC. In Model 1 input parameters are average temperature, relative humidity, sunshine duration and rainfall amount. In Model 3 input parameters are average temperature, relative humidity and sunshine duration. However Model 4 and Model 5 provide relatively bad prediction of GSR among other models.

Comparison of ANN Models with Empirical Models

Table 3 shows the statistical error parameters obtained for seven different empirical models based on one year data analysis which has been taken from journal of IOE Graduate Conference 2014 (Das, 2014).

Table 3: Statistical error parameters of empirical Models based on one year data analysis (Das, 2014)

Model	RMSE	MBE	MPE	CC
Model 1	0.5203	0.0290	0.2409	0.9525
Model 2	0.5182	0.0291	0.2455	0.9526
Model 3	0.6303	0.0375	0.2481	0.9385
Model 4	0.5192	0.0312	0.2777	0.9515
Model 5	0.4806	0.0208	0.2403	0.9562
Model 6	1.0060	0.0626	0.8193	0.8233
Model 7	0.3658	-0.0099	0.1413	0.9760

Form Table 3 we have observed that the ANN models presented here provide very good prediction of GSR compared to empirical model presented in that journal. Ahmed et al. (2013) conducted a study to estimate the GSR in Qena, Upper Egypt and obtained the correlation coefficient of 0.998. In this work the best result achieved is 0.988 which is convincing for the country like Nepal known for complex climate and terrain.

Conclusion

The ANN models seems promising for estimating the GSR in the locations where there are no solar radiation measurement stations provided that the samples of meteorological parameters such as the samples of temperature, relative humidity and sunshine duration are available. The

obtained result in this present work indicate that the ANN based model for estimating solar radiation is precise in the selected location thus the model can be used anywhere in the Nepal having similar climate conditions where the meteorological data are available. The best prediction was from Model 1 as it exhibit minimum value of RMSE (0.2781) and maximum value of CC (0.9880) for which input parameters were average temperature, relative humidity, sunshine duration and rainfall amount.

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