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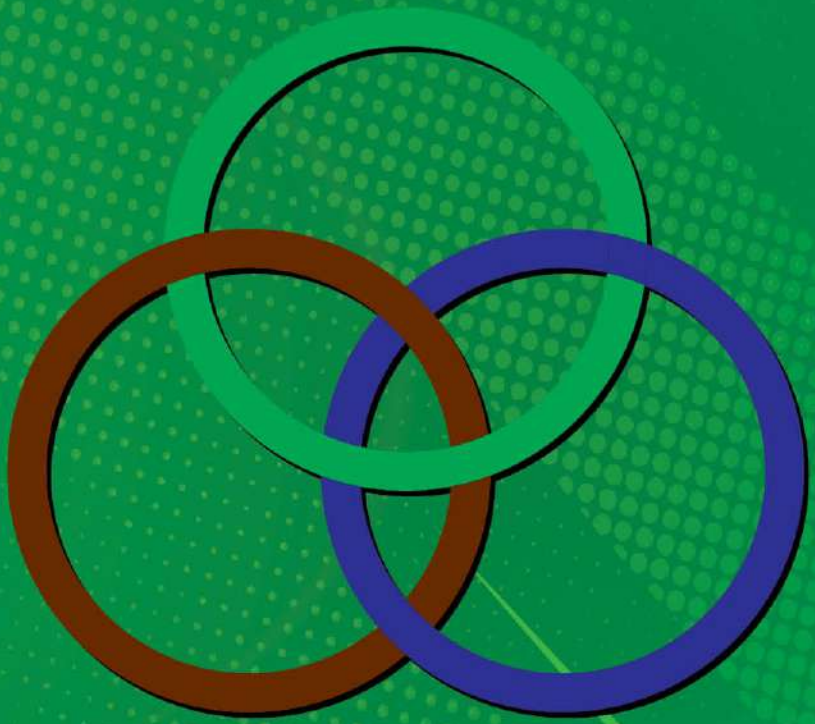

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Editorial

It is our pleasure to bring out the current issue of Journal of Environment Sciences. Fourteen articles on different thematic areas and cross cutting issues have been included here. Environmental knowledge generated in environmental sectors by different researchers, GOs/NGOs/INGOs, academic institutions has been assembled in the form of Journal of Environment Sciences, Volume 7, 2021 as our yearly publication.

Journal of Environment Sciences aims to share environmental information and also promote to establish link among professionals, researchers, academicians and policy makers by providing them a common platform for further coordination and cooperation. We believe that the findings, outcomes, and suggestions obtained from these researches could serve for betterment of society and help to achieve environmental governance. We also believe that this journal will further help to pile up the scattered knowledge, information, techniques, technologies that have been generated in different paradigm of environment.

We want to assure here that the views expressed in the articles are those of authors and do not represent the official views of the Department of Environment. We acknowledge the valuable contribution from authors, researchers, reviewers and other human resources of the Department of Environment to continue this publication. With your cooperation, coordination and feedback, this Journal will remain uninterrupted.

Thank you
Editorial Board

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Phytoremediation Potential of Vetiver Grass (Chrysopogon Zizanioides) from Sisdol Landfill Site Leachate Contaminated Water of Kolpu River, Nepal

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Abstract

Vetiver, a perennial bunchgrass native to India is known for its superabsorbent characteristics suitable for disposal of leachate and effluents generated from landfill and wastewater treatment plants. The applicability of the grass is in the state of being explored in Nepal. The present study was done to find the phytoremediation potential of Vetiver grass from Sisdol landfill site leachate contaminated water of Kolpu River in terms of physico- chemical parameters. The experimental setup was done by planting a total ten Vetiver Grass in a ten-liter capacity bucket filled with leachate contaminated water using thin sheet of thermocol plate as a medium that would support Vetiver Grass for 25 days. The parameters were checked at the interval of a day. The parameter under study included pH, Electrical Conductivity, turbidity, chloride, total alkalinity, total hardness, calcium hardness, phosphate, nitrate, ammonia and iron. Electrical Conductivity (53.8%), Chloride (52.7%), Phosphate (67.2%), Nitrate (92.3%) and Iron (82.9%) seems to be effectively removed. All the physico-chemical parameters were found to be significantly decreased after intervention of the Vetiver Grass into the leachate contaminated water from Sisdol Landfill site (p value < 0.05). Vetiver plantation along the landfill sites can be beneficial to reduce the negative impacts caused by leachate.

Keywords: *Kolpu River, Leachate, Sisdol Landfill Site, Vetiver*

Introduction

Phytoremediation is emerging clean up technology applied in controlling, removing noxious pollutants and toxic chemicals from water, soil and air by using green plants (Salt et al., 1998; Banerjee et al., 2016). A large species of plants such as Paspalim notalum Flugge, Typha, Phragmites austr alis, Eichornia crassipes, Pistia stratiotes L. have been identified as plants with phytoremediation potential (Gupta et al., 2012 as cited in Suelee et al., 2017). Among the various phytoremediation potential plants Vetiver Grass (VG) (Chrysopogon zizanioides), a perennial bunchgrass, native to India (Darajeh et al.,

2014) is a special plant species covering all the criteria needed for removal of pollutants including organic and inorganic pollutants present in waste water (Suelee et al., 2017).

From the early days Vetiver has been serving as multipurpose grass. Primary uses included using in household for thatching, medicinal use, aromatic oil production etc. Vetiver had been extensively applied in agricultural areas all over the world for slope stabilization and to reduce erosion (Donaldson & Grimshaw, 2013). The true magic of VG was recognized in 1995 in Queensland, Australia when its superabsorbent characteristics was found to be suitable for disposal of leachate and effluents generated from landfill and wastewater treatment plants. Such characteristics along with advantages of being cheap maximized the use of Vetiver in various countries of the globe including India, Australia, China, Vietnam and Thailand (Truong, 2000) for treating landfill leachates, domestic sewages and various form of waste water including industrial waste water (Donaldson & Grimshaw, 2013). However, the history of Vetiver in Nepal for abovementioned purpose is not old as it was introduced in 2011 only and is in the phase of being more explored (Maharjan & Pradhanang, 2017).

The straight stiff stem of the grass allows it to withstand with high velocity of water the grass up to 2 meters high survives in relatively deep-water flow (Truong et al., 2002; Danh et al., 2009). This helps in increasing detention time. The long narrow leaves produce think growth loving barrier cutting off and spreading runoff water (Sulee et al., 2017). Such growth allows the grass to act as effective filter by trapping sediment bound pollutants, pesticide residue etc. (Truong, 1999; Chomchalow, 2003). With its unique morphological ad ecological characters, the grass has been effectively used in various environmental protection measures among which utilization for waste water treatment developed in Queensland by Department of Natural Resources and Mines is highly effective (Truong & Hart, 2001 as cited in Maharjan & Pradhanang, 2017).

Landfill leachates are one of the major environmental threats contaminating and polluting groundwater, surface water and soil which is very sensitive issue and are of high concern from environmental point of view (Fatta et al., 1999; Naveen et al., 2018). The leachate contains high organic and inorganic load (Cheremisinoff, 1977). Dissolved organic matter (volatile fatty acid and more refractory organic matter such as humic substances), inorganic compounds (bicarbonate ions, Calcium, Magnesium, Sodium, Potassium, Iron, Manganese, Ammonium ion), heavy metals (Zinc, Nickel, Copper, Lead, Cadmium) and xenobiotic organic compounds from chemical and domestic residue are four recognized groups of pollutants present in aqueous solution of leachate (Christensen & Kjeldsen, 1991). Large cases regarding pollution of water bodies due to solid waste landfill sites have been recorded (Gzar et al., 2014).

Leachate from Sisdol Landfill Site (SLS) which are directly being discharged into Kolpu River without any treatment has serious degraded the social and ecological environment and brought many negative environmental consequences. The leachate contaminated water from Kolpu River has decreased crop productivity, made humans and animals sick and disturbed aquatic environment (NAST, 2019). This experimental research tries to access the phytoremediation potential of VG in terms of removal of physicochemical parameters before and after the treatment with VG and determine its removal efficiency. The experimental research will be scientific evidence in bringing out into a better solution for treating leachate contaminated water from Kolpu River as well as leachate from landfill sites.

Materials and Methods

Study Area

Sisdol landfill site (SLS) located at geographical coordinate between 27°46'00" to 27°46'30" N and longitude 85°14'30" to 85°15'30" E in Nuwakot and Dhading district is a semi aerobic landfill site. The SLS is well linked to Kathmandu via black topped road at the distance of 18km from Balaju industrial area and 21.6 km from Teku transfer station. SLS is bordered by Kolpu River to the South from Dhunibesi municipality (Dhading district), southeast by Tarkeshwor municipality (Kathmandu district) (Figure 1). The River Kolpu flows from South- East to West through landfill site and the leachate from the landfill site is directly mixed into it without any treatment.

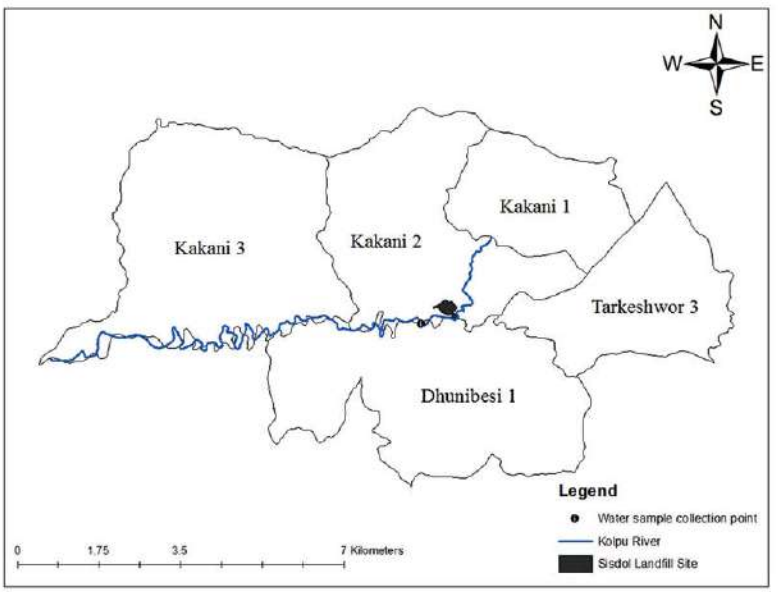

Figure 1. Map showing leachate contaminated water collection point

Sampling and experimental set up

The water samples from Kolpu River were collected in October, 2019. The leachate contaminated water sample was collected from about approximately 300 meters downwards from SLS soon after leachate directly mixes to Kolpu River from geographical coordinate of latitude 27.77386 N and longitude 85.239744 S (Figure 1). The water sample was collected in a jar of 20 L capacity after it was properly rinsed with distilled water first and again water sample itself. The water sample was immediately transferred to Nepal Academy of Science and Technology (NAST) laboratory and refrigerated at 4°C. For evaluating phytoremediation potential of VG, the leachate contaminated water samples were filled in bucket of 10 liters capacity and a total ten VG were planted in them using thin sheet of thermocol plate as a medium that would support VG. For experimental purpose VG was provided by STAGE- Nepal. The physico- chemical parameters were checked at the interval of a day for twenty-five days removal efficiency was also analyzed.

Methodology

Physico-chemical parameters were analyzed by following APHA, 1989.

Table1. Physico-chemical parameters under study, methods of analysis and instruments used

		Analysis	Instrument
Physical parameters	pH	pH meter	EC210 Rocker Scientific Co.
	Electrical conductivity	Conductivity meter	HI 8633 HANNA
	Turbidity	Nephelometer	HI 98713 ISO Turbidy meter HANNA
Chemical parameters	Chloride	Argentometric method	
	Total hardness	EDTA method	
	Calcium hardness	EDTA method	
	Total alkalinity	Titration method	
	Phosphate	Stannous chloride method	Spectrophotometer Model: 6715 UV/Vis Spectrophotometer JENWAY
	Ammonia	Phenate method	
	Iron	Phenonthroline method	
	Nitrate	Brucine method	

The removal efficiency was calculated to determine the potential uptake of VG using Equation 1 (Darajeh et al., 2014).

$$\%\ removal\ efficiency = \frac{Cini\text{-}Cfin}{Cini} X\ 100 \quad \text{.....Equation 1.}$$

Where, Cini is the initial value of the parameter and Cfin is the final value of the parameter.

Results and Discussion

The day wise value of physico-chemical parameters before and after intervention of the VG is presented in the table 2. Similarly, the removal efficiency of the VG is presented in table 3.

Physical Parameters

pH

The initial pH value before the intervention of the leachate contaminated water with VGs was found to be 9.7 which is basic in nature. But after intervention VG, it showed the decrease in pH value. At the last day of experiment the value was found to be 8.2. Removal efficiency of pH was found to be 15.3% (Table 3). Water with pH value less than 6.5 and greater than 8.5 are considered as polluted water (Trivedi & Goel, 1986) and are not suitable for intended purpose. According to FAO water with pH ranging from 6.5 to 8.4 are suitable for irrigational purpose. Bwire (2011) in his study also found that use of vetiver grasses in experimental unit resulted in decrease in pH values. This may be due to the rhizosphere around the roots having the adsorbed NH4+ ions which may replace H+ ions on the root surface thereby bringing about the pH reduction. Another reason might be the dissolving of carbon dioxide in water obtained from decomposing organic matter and root respiration which results in formation of weak acid and lowering of pH value (Kadlec & Knight, 1996).

Electrical Conductivity (EC)

Due to the presence of dissolved salt and solids there is increase in pollution amount which is further responsible for increase in conductivity of water. Initially before intervention the Electrical Conductivity (EC) was found to be 935 µS/cm which was further reduced to 432 µS/cm. Removal efficiency of EC was found to be 53.8% (Table 3). Although the EC was found to be steadily decreasing, the water is not suitable for irrigational purpose as the water with conductivity more than 20 µS/cm is not suitable for irrigation (Trivedi & Goel, 1986). The EC values of contaminated water are directly

proportional to its dissolved mineral matter content, and after use of vetiver grass, EC reduced to a very low value (Keshtkar et al., 2016).

Turbidity

The initial turbidity of the sample before intervention with Vetiver was found to be 85 NTU which was found to be decreased to 72 NTU at the interval of 25 days. Removal efficiency of turbidity was found to be 15.3% (Table 3). Mathew et al. (2016) in her study also found that with the increase in time, the vetiver grass started growing properly and the percentage turbidity removal also increased.

Chemical Parameters

Chloride

Initially the chloride content in the leachate contaminated water sample was found to be 363.5 mg/L which was reduced to 171.8 mg/L at the final day of experiment. VG showed the significant amount of decrease in chloride content. Removal efficiency of chloride was found to be 52.7% (Table 3). Chloride tolerance level for irrigation and aquatic life survival is 1-1000 mg/L and <600 mg/L respectively (Trivedi & Goel, 1986). The high concentration of chloride content in the waste water is due to pollution due to sewage (Chourasia & Adoni, 1985). However useful amount of chloride present in water is essential nutrient for aquatic creatures, animals and human beings as it helps in purification of water against infectious germs.

Hardness

Initially before introducing VG the total hardness of the water sample was found to be 818 mg/L as Ca2CO3 which was found to be decreased to 358 mg/L at the interval of 25 days. Calcium hardness initially before introduction of VG was found to be 283.8 mg/L as Ca2CO3 and after 25 days it was found to be 141.1 mg/L. Removal efficiency of total hardness and calcium hardness were found to be 56.2% and 50.3% respectively (Table 3). Hardness of water is elevated by sewages and presence of detergents (Mohanta & Patra, 2000). Likewise, Keshtkar et al. (2016) found the hardness removal efficiency to be 46% in waste water over the period of four weeks after culturing vetiver.

Alkalinity

Initially the alkalinity of the water sample before treatment with VG was found to be 360 mg/L Ca2CO3 which later reduced to 231 mg/L at the interval of 25 days. Removal efficiency of alkalinity was found to be 35.8% (Table 3). Higher value of alkalinity in the water is due to bicarbonates, carbonates and hydroxide in the water body (Jain, 2000).

Table 2. Values of physico-chemical parameters before and after intervention of the VG

	Para-meters	pH	EC (µS/cm)	Turbidity (NTU)	Chloride (mg/L)	Total hardness (mg/L)	Calcium hardness (mg/L)	Alkalinity (mg/L)	Phosphate (mg/L)	Nitrate (mg/L)	Ammonia (mg/L)	Iron (mg/L)
Before intervention	Sample	9.7	935	85	363.5	818	283.8	360	6.4	3.9	20.4	6.4
After intervention of VG	Day 1	9.5	892	84.4	350.7	766	259.7	342	6.1	3.3	19.7	6.0
	Day 3	9.2	843	83.2	336.5	718	238.9	321	5.6	3.1	19.1	5.0
	Day 5	8.9	781	82.2	333.7	690	230.1	312	5.1	2.7	18.5	4.7
	Day 7	8.6	710	82	312.4	648	208.4	309	4.9	2.3	18.2	4.6
	Day 9	8.5	623	81.4	269.8	618	201.2	298	4.7	2	16.7	4.3
	Day 11	8.3	600	80.2	259.9	586	193.2	291	4.1	1.8	16.3	3.2
	Day 13	8.3	521	76.9	242.8	556	183.6	287	3.7	1.5	15.4	3
	Day 15	8.3	509	75.1	231.5	538	173.9	276	4	1.3	15	2.4
	Day 17	8.3	495	74.2	220.1	502	166.7	261	3.3	1	14.7	2.2
	Day 19	8.3	475	73.1	210.2	442	158.7	255	3.1	0.8	14.5	2
	Day 21	8.3	447	72	190.3	374	149.1	241	2.8	0.5	14.5	1.8
	Day 23	8.2	432	72	171.8	358	141.1	231	2.1	0.3	13.8	1.1

Phosphate

Before treatment with VG the phosphate amount in the water sample was found to be 6.4 mg/L which was reduced up to 2.1 mg/L at the interval of 25 days. Sharp decrease in the phosphate content was observed at the interval of 25 days. Removal efficiency of phosphorus was found to be 67.2% (Table 3). Vetiver seems very effective in removal of water containing high amount of phosphorus. In water bodies, phosphorus acts as an essential nutrient for grass growth but high amount of phosphorus leads to eutrophication. Water is considered as polluted if it contains phosphorus level above the range 0.005-0.20mg/L (ENPHO, 2003).

Nitrate

Nitrates are one of the important limiting nutrients and presence of nitrate indicates organic pollution in water (Dhanya & Jaya, 2013). Before introduction of VG in the leachate contaminated water sample the nitrate was found to be 3.9 mg/L which reduced to 0.3 mg/L after Vetiver was introduced in it at the interval of 25 days. Removal efficiency of nitrate was found to be 92.3% (Table 3). VG has shown the sharp decrease in the nitrate content in the leachate contaminated water sample. High amount of nitrate in the water causes water bodies to eutrophy. Bacterial action upon ammonia forms the nitrates in the water. High concentration of nitrate in the leachate contaminated water or any other waste water may be due to use of nitrogenous fertilizers during agricultural food production or other organic wastes (Trivedi & Goel, 1986). Plant absorption acts as dominant mechanism of nitrogen removal (Billore et al. 2002) and also the study conducted by Dhanya & Jaya (2013) found the removal of nitrate content in all waste waters by 100% using vetiver grass.

Ammonia

Before introducing VG, the ammonia in the leachate contaminated water sample was found to be 20.4 mg/L which was reduced to 13.8 mg/L after treatment in the interval of 25 days. Removal efficiency of ammonia was found to be 32.4% (Table 3). According to Dhanya & Jaya (2013), plant uptake is the major mechanism of ammonia removal in the system.

Iron

Iron was found to be significantly reduced from 6.4 mg/L (before treatment) to 1.1 mg/L (after treatment) at the interval of 25 days. Removal efficiency of pH was found to be 82.9% (Table 3).

Table 3. Removal efficiency of the VG

Parameter	Initial value before intervention	Final Value after intervention	Removal efficiency (%) (Darajeh et al., 2014)
pH	9.7	8.2	15.3
EC (µS/cm)	935	432	53.8
Turbidity (NTU)	85	72	15.3
Chloride (mg/L)	363.5	171.8	52.7
Total hardness (mg/L)	818	358	56.2
Calcium hardness (mg/L)	283.8	141.1	50.3
Alkalinity (mg/L)	360	231	35.8
Phosphate (mg/L)	6.4	2.1	67.2
Nitrate (mg/L)	3.9	0.3	92.3
Ammonia (mg/L)	20.4	13.8	32.4
Iron (mg/L)	6.4	1.1	82.9

Table 4 represents the mean value of the physico- chemical parameters after the intervention of the VG, the value of which is further used for t test analysis by comparing with the test value i.e. value before intervention of the VG.

Table 4. Mean value of the physico- chemical parameters after intervention of VG (Day1-Day 23)

Parameter	n	Mean value	Std. Deviation	Std. Error Mean
pH	12	8.57	0.42	0.12
EC (µS/cm)	12	610.67	159.87	46.15
Turbidity (NTU)	12	78.06	4.65	1.34
Chloride (mg/L)	12	260.81	60.44	17.45
Total hardness (mg/L)	12	566.33	131.01	37.82
Calcium hardness (mg/L)	12	192.05	37.13	10.72
Alkalinity (mg/L)	12	285.33	33.67	9.72
Phosphate (mg/L)	12	4.13	1.20	0.35
Nitrate (mg/L)	12	1.72	0.99	0.29
Ammonia (mg/L)	12	16.37	2.04	0.59
Iron (mg/L)	12	3.37	1.54	0.44

All the physico-chemical parameters were found to be significantly decreased after intervention of the VG into the leachate contaminated water from SLS (p value =0.000< 0.05) (Table 5). The negative value of mean difference (test value before intervention and mean value after intervention) also shows that there is notably change in the values of physico- chemical parameters.

Table 5: t- test (Comparison with before intervention of VG)

Parameter	Test Value (Before intervention)	Mean value after intervention	t	Df	Sig. (2-tailed)	Mean Difference Value
pH	9.72	8.57	-9.380	11	0.000	-1.15
EC (µS/cm)	935	610.67	-7.028	11	0.000	-324.33
Turbidity (NTU)	85	78.06	-5.169	11	0.000	-6.94
Chloride (mg/L)	363.52	260.81	-5.887	11	0.000	-102.71
Total hardness (mg/L)	818	566.33	-6.655	11	0.000	-251.67
Calcium hardness (mg/L)	283.77	192.05	-8.557	11	0.000	-91.72
Alkalinity (mg/L)	360	285.33	-7.683	11	0.000	-74.67
Phosphate (mg/L)	6.40	4.13	-6.588	11	0.000	-2.28
Nitrate (mg/L)	3.90	1.72	-7.606	11	0.000	-2.18
Ammonia (mg/L)	20.40	16.37	-6.851	11	0.000	-4.03
Iron (mg/L)	6.43	3.37	-6.902	11	0.000	-3.07

Landfill sites are mostly contaminated with high concentration of heavy metals such as Arsenic, Nickel, Copper, Cadmium, Lead, Mercury, Chromium etc. and other organic and inorganic pollutants from various wastes it receives. (Maharjan & Regmi, 2019; NAST, 2019; Gamon et al., 2019 Shrestha et al., 2020) and has large environmental and socio- economic impacts (Danthurebandara et al., 2012; Adhikari et al., 2013). These heavy metals and other pollutants mix to with the rainwater from the landfills during precipitation which eventually end up being in soil or water and cause wide range of environmental impacts. The leachate of SLS is found to have many organic and inorganic pollutant parameters, heavy metals beyond the level as prescribed by Generic National Standard of Government of Nepal (GoN) for wastewater to be discharged in inland surface water (NAST, 2011; NAST,2013; Shrestha et al., 2014; NAST, 2019; Maharjan & Regmi, 2019). Shrestha et al., 2020 has also revealed the high concentration of physico chemical parameters of landfill leachate.

The leachate contaminated water that flows in Kolpu River is not only responsible for degrading surface water quality but it has imparted impacts in many ways. The leachate contaminated water has decreased the agricultural productions in the fields in which irrigation has been one from the Kolpu River. Paddy, wheat, potato and other crop

productions were reported to have significantly decreased. Similarly, the animals like cattle, goats, buffaloes that fed on the contaminated water was found to be sick. People when they come in contact with the leachate contaminated water from Kolpu River got infected in their legs (NAST, 2019; Shrestha, 2020). VG possesses unique attributes which makes it extraordinary for environmental protection and rehabilitation at very low cost and human resources. VG when applied to leachate it not only treats and absorbs nutrients and pollutants such as heavy metals but it reduces the volume of wastewater too as a form of phytoremediation (Truong, 2002; Danh et al., 2009; Truong et al., 2010). The Grass has been found highly capable to remove Nitrate and Phosphate in dry, wetlands and hydroponic conditions (Veticon, 2017). The grass has strong affinity towards Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) also (Darajeh et al., 2016; Shu, 2003; Xia et al., 2002 as cited in Suelee et al., 2017). Maharjan & Pradhnang (2017) in their research have found that VG in one month of time had significantly reduced the concentration of parameters such as BOD, Chloride, Nitrate, Phosphate hardness and Alkalinity. As this multipurpose grass is found to work excellent in tropical and sub-tropical climates (Donaldson & Grimshaw, 2013) plantation of VG in and around SLS can significantly reduce the pollutants which runoff via leachate in surface and groundwater.

Conclusion

Vetiver Grass seems to be very effective in treatment of leachate contaminated water and other waste water in very low cost without modern techniques and tools and manpower and yet shows excellent results. EC (53.79%), Chloride (52.73%), Total Hardness (56.23%), Calcium hardness (50.28%), Phosphate (67.18%), Nitrate (92.30%) and Iron (82.89%) had removal efficiency greater than 50%. The removal efficiency was in terms of order Nitrate> Iron> Phosphate> Total Hardness> Electrical Conductivity> Chloride> Calcium Hardness> Alkalinity> Ammonia> pH> Turbidity. All the physico-chemical parameters were found to be significantly decreased after intervention of the VG into the leachate contaminated water from SLS (p value =0.000< 0.05). The grass is recommended to plant in the periphery of the Sisdol landfill site where the leachate is collected and from where the leachate flows into the Kolpu River.

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Addressing Social and Environmental Concerns During Hydropower Developement:
A Case from Gandaki Rural Municipality-5, Gorkha, Nepal

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Abstract

The consideration of socio-economic and environmental issues is essential for hydropower development. Environmental Impact Assessment are conducted to attempt all the issues of the project and strategic level so measures provided are ineffective. The study is focused on the collection of baseline condition and application of Environmental Assessment to identify the environmental and social issues during the planning stage of hydropower development of Budhi Gandaki Hydropower Project (BHEP) and develop strategies to mitigate the identified issues. The study has been done only in the inundation region of Gandaki Rural Municipality-5 of Gorkha district which is going to be directly affected by BHEP. For this, household questionnaire survey, interview, field observation and desk study were done to collect the baseline condition of the study area. After data processing and analysis, environment assessment was carried out through assessment framework. It was influenced by good practice criteria approach which includes evaluation area, aspects, indicators and good practice criteria for evaluation based on hydropower development of Aurland Hydropower development according to International Energy Agency. The aspects were breakdown into various elements through which strategies were developed to mitigate the issues by strength, weakness, opportunities and threats (SWOT) matrix method. Regarding the land use change of the study area, the cultivated land, settlement area and forest area will be submerged by the reservoir of the hydropower project. As per the ecological significance, the study area did not have national park and wildlife reserve. Mostly, the raised social issues like access of land, land acquisition, stakeholders in hydropower development, public participation and access of information needed to be addressed in both project and strategic level of implementation. Hydropower project should allocate social development program and land use plan for minimizing the social and environmental effects. The Governance principle like public participation and access to information should be maintained in the planning phase of hydropower development.

Keywords: *EIA, Governance, Land use, Strategies, Sustainable development*

Introduction

Nepal is ideally suited to hydropower generation with its steep rivers and high flows fed by snowmelt from the Himalayas, and winter and monsoon rains (Karki 2006). Hydropower development effects environment by affecting the landscape of the area. The chief implications are ecological interferences, reduction of productive lands and involuntary settlement of displaced people (Agrawal et al. 2010). Implementation of hydropower projects affects terrestrial and aquatic resources, the physical, socio-economic and cultural infrastructure and facilities used by the local communities, land use, agriculture, public health, local residents and their livelihood and results in the involuntary settlement of displaced people. The basic guidelines for policy formulation include public participation, economic and environmental priorities, and a collaborative model for environmental and natural resources governance and policy decision-making (Poudel 2009). Environmental Impact Assessment is the systematic and interdisciplinary evaluation of the potential effects of project and its practical alternatives on the physical, biological, cultural and socio-economic attributes of particular geographical area (UNEP 1998). The initiation of developing mechanism, tool and procedure to promote the integration of environmental aspects into development initiatives, these tools commonly known as the Environmental Assessment is used to understand the impacts of projects on the environment (Stronmquist and Tatham 1992). The strategic issues like people's displacement, land acquisition and settlement, biodiversity issues and waste disposal are not easy to address at project level implementation so need policy, plan and program intervention; EIAs conducted to attempt all issues of project and strategic level so measures provided are ineffective (Khadka et al. 2013). EIA has become a ritual process to comply with the country's environmental legislation and regulations. But its implementation part has been forgotten completely. Unless, it is not implemented in the project construction and operation, the EIA system of this region is not going to improve, because of the lack of feedback information on implementation (Khadka and Shrestha, 2011). The living condition of the people is determined by the amount and type of resources available and also by the land use planning of the hydropower project. Transparency in information dissemination, decision making, involvement of key stakeholders on key issues and time bound solution can hardly be found during hydropower development (Shah 2008). On this background, the present study is focused on the collection of baseline condition and application of Environmental Assessment to identify the environmental and social issues of planning stage of hydropower development of Budhi Gandaki Hydropower project and develop strategies to mitigate the issues. The study has been done only in the inundation region of Gandaki Rural Municipality-5 of Gorkha district.

Materials and Methods

Gandaki Rural Municipality-5 of Gorkha district is going to be directly affected by Budhi Gandaki Hydroelectric Project. Darbunphant, Magardihi, Aptar, Eklephat, Gylmadobhan and Bhasbhase are the settlements where physical and economic displacements are the effects that people will have to face. Settlements and agro field are going to be affected by the reservoir area of the project (NESS 2014). The study has covered only the inundation area of Gandaki Rural Municipality-5 which holds about 275 households which will be displaced due to the construction of dam by planned and proposed BGHEP.

The research design involves the logic which connects the various data which are to be collected to initial research questions of study. The two methodologies, methodology to understand the concepts in desk study and methodology to see the reality in case study (Yin 1996) will be overlooked. The spatial data of inundation region of study area was processed by using Arc map version 9.3. Identification of data required before the field work and data analysis were supported by literature reviews. After data processing and analysis by Statistical Package for the Social Science, environment assessment was carried out through assessment framework. An assessment framework finds the issues in different aspects that are to be expected and considered in an assessment process (Crisp et al. 2007). An assessment framework was influenced by good practice criteria approach which includes evaluation area, aspects, indicators and good practice criteria for evaluation (Steudler et al. 2004). Scope was the evaluation areas which cover the extent of Budhi Gandaki Hydropower development where key stages were political decision making, planning, design and pre-feasibility study. Policies, governance, rights on land, land acquisition, are the major aspects for assessment (Galudra et al. 2010). External factor and impact are also the key aspects for the assessment (Steudler et al. 2004). All of these aspects were further breakdown into various elements. The elements for the assessment were developed from common understanding and experiences of hydropower development of various countries. Based on these elements, strategies were developed by strength, weakness, opportunities and threats (SWOT) matrix method. Indicators are measurable variables developed from the strategies. Good practices criteria are performance of indicator which were developed from the literature review based on the experience of hydropower development of Aurland Hydropower development Project in Norway according to International Energy Agency (IEA) Hydropower Implementing Agreement Agency Annex VIII (2006) (VIII 2006).

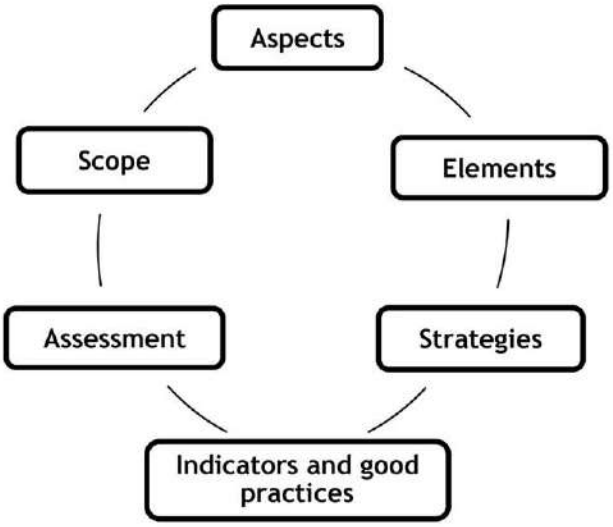

Figure 1: An assessment framework

Based on these elements, strategies were developed to mitigate the issues by strength, weakness, opportunities and threats (SWOT) analysis, known for the situation analysis within the strategic planning process and the situation analysis is the way of identifying strategic fit within internal strengths and external opportunities while working on internal weakness and external threat (Groenendijk and Dopheide 2003).

Results and Discussion

Based on socio-economic condition from the field study, the male respondents were found to be higher as compared to the female respondents and none of the women were found to be active within the project area to enhance social development and awareness program of the project. Most of the project affected families (PAF's) belong to Brahmin and Magar ethnicity, followed by other ethnic groups like Gurung and Chettri. Occupational castes like Kami, Damai and Sharki were also exist in the project area. The major source of income of the people was found to be agriculture which shows majority of the respondent were unemployed with services and business. The project had provided access of road facilities to improve the socio-economic status but has not launched any social development program. Social development program and trainings increases stakeholders' capacity and meet the stakeholders' expectation and increase the socio-economic status of the people (Ghimire 2011). BGHEP would be required to acquire private land and state land. The permanent land use change results in permanent loss of production resource based particularly on the cultivated land, private forest and grassland of the study area. For mitigation and adaptive measures of environmental and social issues, the strategies develop by the SWOT matrix method is represented on the table below.

Table 1: SWOT matrix

	Strength	Weakness
Internal factors	• Improvement of livelihood of the people • Improvement of access to land and land security by land registration	• Management of land required for hydropower development • Resettlement and relocation of the people • Provision of access to information • Implementation of good practice
	Opportunities	**Threat**
External factors	• Public awareness can be increased • Right to land and equity in excess of land can be increased	• Stakeholder's satisfaction • Identifying various land conflicts • Sustainable hydropower projects • Better policy formulation. • Maintain properly the land records

The strategies from SWOT matrix are represented in the table below:

Table 2: Strategies from SWOT matrix

SO Strategies	ST Strategies
• Improve the right to access land • Improve living standards. • Improve land security and equity	• Measure stakeholder's satisfaction • Define clear role and responsibility of stakeholders • Involve local stakeholders and communities. • Cooperation with funding agencies.
WO Strategies	**WT Strategies**
• Increase public awareness and access to information • Apply suitable land acquisition and compensation procedure • Relocation/resettlement of the people by hydropower development • Provide information for affected people	• Maintain land records properly • Identify various land conflicts • Follow better policy formulation • Support sustainability

National Electrical Authority (NEA) has carried out additional studies in fiscal year 2010/11 including the identification of alternative locations of projects facilities structures with the view to achieve optimum utilization of hydropower potential of the project site (NEA 2011).

In two alternative options for the construction of dam, there would be loss of 1110.70 hectares and 1323.18 hectares in 500 masl and 540 masl respectively (Table 1).

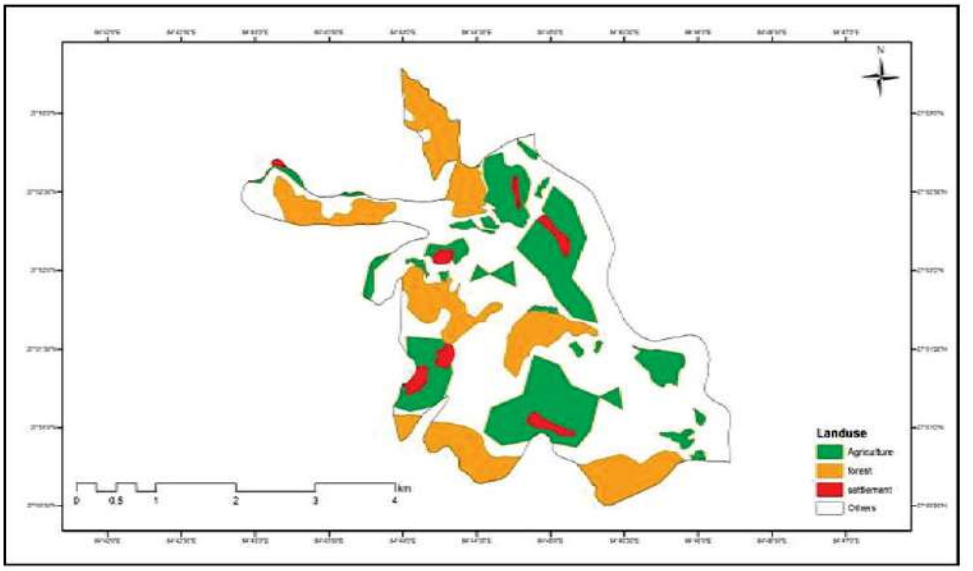

Figure 2: Land use pattern in 500m elevation of Darbhung VDC

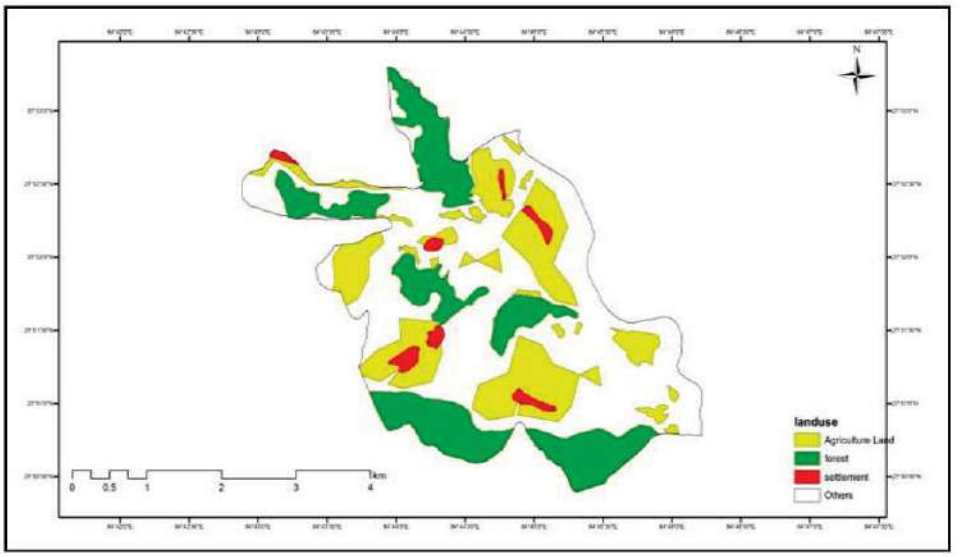

Figure 3: Land use pattern in 540m elevation of Darbhung VDC

Table 3: Land use change by two alternative options of construction of dam

Land types	Land cover in (ha) Gandaki Rural Municipality-5	After 500 m of dam construction (ha)	After 540 m of dam construction (ha)
Agricultural Land	768.34	273.41	306.96
Settlement Area	57.9	26.92	30.6
Forest land	648.9	246.16	325.05
Others	827.12	564.2	660.56
Total	**2302.28**	**1110.7**	**1323.18**

(Source: National Electricity Authority, 2011)

In impact aspect, there will be loss and disturbance in vegetation and fauna and their habitat because of inundation by construction of dam in the study area. As per the ecological significance, the study area does not have any national Park and wildlife reserve. However, the alternative options were selected for constructing the height of the dam to minimize the effects on environment, Arun III hydroelectric project in Nepal was cancelled by World Bank because it has not focused on policies related with environment effects in hydropower development (Sharma 2003). The technical development of tunnel and underground structures and the allocation of the Aurland Hydropower Project with land use planning create minimum environmental effects in Norway and the environmental issues should be considered in political decision making to make the development of the project environmental friendly and successful as experienced from Aurland Hydropower Project of Norway (Ghimire 2011). The Forest policy directive has already spelled out for the compensatory plantation of 25 samplings for removal of 1 tree (and 2 samplings for hydropower Projects). This is a strategic norm; however, its implementation could be designed within the framework of EIA by incorporating other aspects of vegetation study at the project level implementation. There should be estimation of tree removal and prepare a compensatory plantation plan in the project area in accordance with forest policy. Forest policy directives for compensatory plantation of 1:25 should be addressed at the strategic level.

Most of the respondents were land owner and they have no idea of equal access of land which can create land conflict. So, to reduce land conflicts and for smooth project activities land tenure in hydropower development plan should be focused (Galudra et al. 2010). The proposed and planned BGHEP is now in the project level but the allocation of the project was not defined clearly in any reports whether the project holds more government land or private land. According to Kali Gandaki Environmental Management

Unit (2002), even an Acquisition compensation and rehabilitation plan (ACRP) was prepared there was differentiation to affected people as project acquired more private land than state land. According to International Energy Agency (IEA), Hydropower Implementing Agreement Agency Annex VIII, 2006 as good practice criteria, the project should prepare the relocation plan and follow the comprehensive compensation procedure to resolve the conflicts during land acquisition in the future. The respondents were afraid of conflicts like low valuation, land use conflicts etc. So, it was found that land acquisition procedure applied in BGHEP should be comprehensive. Bottom-up approach of policy formulation is supposed to be in good practice of policy aspect because public participation during land acquisition has been extensively considered in the hydropower development.

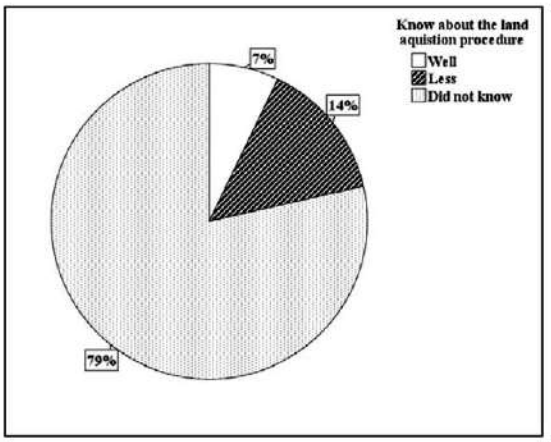

Figure 4: Response of land acquisition procedure

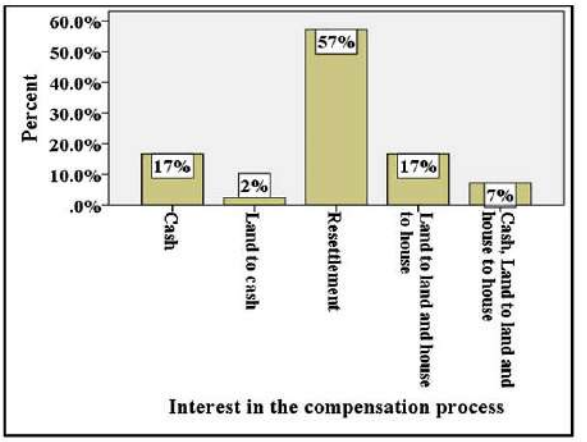

Figure 5: Interest in the compensation process

The land acquisition process was not well accepted in case of UTHEP (Upper Tamakoshi Hydroelectric Project) because the public participation was not extensively considered (Ghimire 2011). Therefore, land acquisition procedure should be well informed to the affected people for the progress of the project (UNEP/DDP 2001). Based on the conceptual framework, when hydropower development plan did not focus on land tenure, conflicts will be created in the society as described in threat aspects and assessment of land acquisition. Due to these conflicts, the progress of the construction work will be hindered. Land conflicts such as low valuation, unfair compensation etc. can be resolved if land tenure is focused explicitly in hydropower development plan. The concept of procedure of land acquisition was not well informed to the affected people. People responded to have resettlement in a secured place as an interest of compensation process. It reflects those issues such as land acquisition should be properly considered in hydropower development plan. Land acquisition for public purposes in

Nepal is governed by the Land Acquisition Act 1977 which has the provision for the government to form a Compensation Fixation Committee under the chairmanship of the Chief District Officer (HMG 1977). EIA report should make assessment of social and economic status of such family to make recommendation of the compensation strategy, and also give recommendation to the Resettlement and Acquisition Plan (RAP). The EIA studies should be able to make recommendation based on social and economic analysis of the affected families. Land use planning of the country to prioritize land use type for acquisition and Land Acquisition Act, 1977 to give directions to land acquisition and resettlement should be addressed at the strategic level (Mathema and Khadka, 2014).

Only limited respondents had participated in the public hearing process of the project and therefore access to information is likely limited for to be affected families. The respondents wanted to have their involvement in the events and programs conducted by BGHEP to present their interest and views on the project development. None of the respondents had participated on the decision making, planning process of the proposed project. The source of information about the BGHEP and inundation of the area were neighbors and friends. So, the multipurpose of BGHEP was unknown for the people. This showed that the flow of information to the affected families by media and project was weak and people were not hopeful that BGHEP will produce enough hydropower for nation. Women were the disadvantaged group within the affected families in the area which was represented by participation of people in the event organized by BGHEPDC. Extensive public participation and access to information is supposed to be ensured in the planning stages of hydropower development (UNEP/DDP 2001), it is found that governance principles such as public participation and access to information in the planning and feasibility stage of hydropower development are weak in BGHEP.

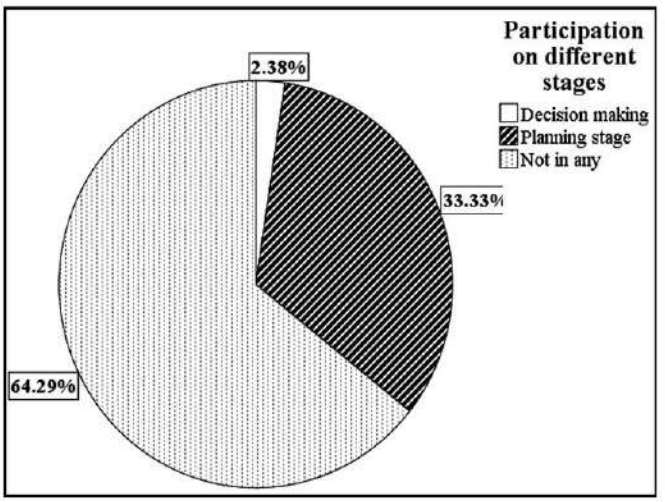

Figure 6: Respondent views on the participation at different stages

It was found that various stakeholders involved for the development of BGHEP had different roles. With reference to good practice criteria, they should have good coordination among stakeholders and interest of stakeholders should be addressed in hydropower development. The lack of harmonization among the stakeholders creates duplication of activities as VDC and UTHEP had supported the school as social development program and expected progress has not been achieved in construction activities which lead to time and cost overrun of the project (Ghimire 2011). Communication, consultation, involvement, and collaboration are important to collect the social issues for project preparation and sustainable decision (UNEP/DDP 2007).

Conclusion and Recommendation

The environment and socio-economic issues of the study area are found to be related to policies, rights on the land, governance, land acquisition, external factors and impacts aspects with good practice criteria which had both strategic as well as project level implication. Mostly, land and environmental issues should be considered in planning stage of hydropower development. Social development program and proper land use plan creates minimum environmental effects and consideration of environmental issues in political decision making helps to develop the project environmentally friendly. In hydropower development, the governance principle like public participation and access to information are required for broader negotiation, agreement and sharing of benefits. The development of assessment framework can be carried out for the environment assessment to identify environmental and social issues in major development of programs and incorporate the strategies to address them into planning and project development.

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Mapping of Spatiotemporal Changes in the Magnitude of Thulagi Glacier and Glacial Lake, Manang, Gandaki Province, Nepal

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Abstract

Glaciated areas are sensitive to climate change and as a result, the glaciers are receding in the Himalayas, which could increase the number and size of glacial lakes. The potentially dangerous glacial lakes (PDGLs) are classified as Rank I, II and III based on its risk to outburst. Out of 21 potentially dangerous glacial lakes identified in Nepal, Thulagi lake is ranked I which spreads through the terminus of Thulagi glacier. The triggering factors like snow/ice/landslide avalanches, lake area/volume makes Thulagi glacial lake susceptible to outburst, which can have a huge impact on downstream. For this study, satellite images obtained from Landsat 1,3,5,8 were processed for Normalized Difference Snow Index (NDSI), Normalized Difference Water Index (NDWI) and digitization was carried out in Arc GIS. Images of different years were analyzed from 1972 to 2018. A total 9.74% area of the glacier has retreated since 1972 to 2018 while the lake area has increased by 103.63%. This study identifies the retreat of Thulagi glacier with an increase in lake area depicted by time series analysis which provides the base for new study on Thulagi lake and glacier. Detail study along with field survey is necessary to understand and avoid possible hazards like GLOF and its impacts on downstream.

Keywords: *ArcGIS, Glacier retreat, Satellite image interpretation, Thulagi*

Introduction

Glaciated areas are extremely sensitive to climate change (Barry, 2006; Bhambri & Bolch 2009; Bolch et al., 2012; Yao et al., 2012, Xu et al., 2009) and considered as the hotspot for impact of climate change. As a result, glaciers are receding in most parts of the world and could result in an increase of the size and number of supraglacial and proglacial lakes which combine to form larger glacial lakes behind the loose terminal moraine and lateral moraine. However, they respond to climate change on a range of time scales usually a few decades to a century (Kraaijenbrink et al., 2017). In the past decade, the researches on Himalayan glaciers have been greatly improved along with

documentation of the spatiotemporal frequency and magnitude of changes in Himalayan glacial lakes (Haritashya et al., 2018).

The warming atmosphere and expanding size of the glacial lakes could be potential threat to the downstream community consequently it is basic to lead glacial mapping and research in glacial geomorphology (Wangchuk & Bolch, 2020). Mapping of spatiotemporal changes in the magnitude of Himalayan glaciers and glacial lakes, hence are of key concern to highlight on the glacier shrinkage. Glacial loss and shrinkage not only affect water resources and hydrological processes, but also influence the formation and expansion of glacial lakes (Yao et al., 2010). The localized consequences of glacier retreat on mountain are affecting the geomorphology and hydrology of the glacier valleys (Fischer Meier et al., 2006) and are potential to natural disasters like glacier lake outbursts flood (GLOF) (Bajracharya and Mool, 2009; Rignot et., al., 2003).

The International Centre for Integrated Mountain Development (ICIMOD) had started inventories and exploring the potential threats from glacial lake outburst in Nepal since 1980s (Ives, 1986; Bajracharya et al., 2020) .They used the blueprint maps of 1 inch to 1 mile published by survey of India from 1963 to 1982, and satellite images from 1999 to 2000, aerial photos taken from 1957 to 1959 for the time series assessment (Mool et al., 2001; Bajracharya et al., 2020).

In 2010, a total of 3,808 glaciers were identified with a total area of 3,902 km2 and estimated ice reserves of 312 km3. The average area of individual glaciers was 1 km2. The Ngojumba glacier in the Dudh Koshi sub-basin was the largest single glacier with an area of 79 km2. About 90% of the glacier area lay between 4,500 and 6,500 masl; with 65% between 5,000 and 6,000 masl (Bajracharya et al., 2014). The total glacier area is decreased by 24% between 1997 and 2010, and ice reserves decreased by 29%. The number of glaciers also increased due to fragmentation alongside shrinkage (Bajracharya et al., 2014).

Reports suggested warming atmosphere was forming more new supraglacial lakes and decreasing the total size of glacial area changing by 24% between 1977 and 2010 (Bajracharya et al., 2014; Khadka et al., 2018). Study of 2015 showed 2,070 glacial lakes in Nepal equal to or larger than 0.003 km2 using Landsat images and remote sensing tools for the Koshi, Gandaki, and Karnali basins of Nepal (Bajracharya et al., 2020). It has been found 21 Potential Dangerous Glacial Lakes are in Nepal among which 18 lie in the Koshi basin, two in the Gandaki basin, and one lake in the Karnali basin (Bajracharya et al., 2020).

Recent studies reports that the Koshi, Gandaki, and Karnali basin of Nepal, the Tibet Autonomous Region (TAR) of China, and India has 3,624 glacial lakes in total, of which

2,070 lakes are in Nepal, 1,509 lakes in the TAR, China, and 45 lakes in India. In total of 47 glacial lakes are identified as PDGLs and are categorized as rank I, II and III based on the danger level; rank I being the most dangerous (Bajaracharya et al., 2020). Thulagi glacial lake is large size lake with possibility of expansion due to the calving of glaciers and close to the loose moraine end. Also, lake has steep outlet slope accompanied by hanging source glacier and the chances of snow and/or ice avalanches and landslides in the surroundings is higher, hence lake ranks 'I' along with 15 other glacial lakes out of 21 PDGLs in Nepal (Bajracharya et. al., 2020). Thulagi Glacial Lake has moderate hazard but high risk (Rounce et al., 2016) with considerable risk of potential mass movements into the lake, erosion and enlargement of the outlet and presence of Tal village, major trekking route and three hydropower plants in its downstream (Maskey et al., 2020).

Overall glacier studies in Nepal are at the state of infancy compared to other nations. Chronicled records on glacier and glacial lakes are confined to limited academic and non-governmental institutions. Also, glacier research in western Nepal seems neglected, besides those mentioned by Maskey et al. (2020). In this context, this study aims to map of spatiotemporal changes in the magnitude of Thulagi glacier and associated glacial lake located at Manang district of Nepal.

Materials and Methods

Study Area

Thulagi Glacial Lake, locally known as Dona Tal, is located in Manang District of Gandaki Province, Nepal. It lies at 28°29.24′N latitude and 84°29.17′E longitude at an altitude of 4050 m a.s.l. The glacial lake lies at the terminus of ~4.5 km long debris-covered Thulagi Glacier to the southwest of Mount Manaslu. The headwater of Dona Khola is a tributary of the Marsyangdi River.

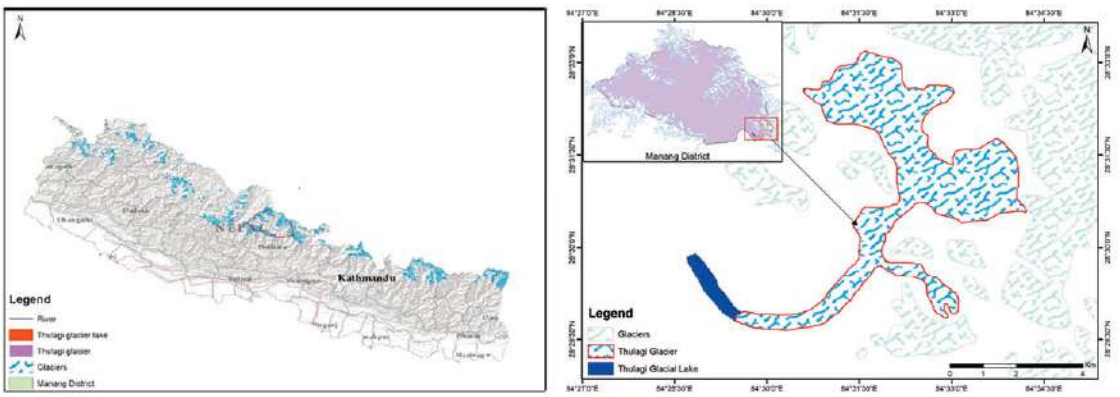

Figure 1: Map showing the Thulagi glacier and Glacial lake

Figure 2: Thulagi Glacial Lake, Manang ©Badri Baral

Data

Landsat image analysis is the most effective remote sensing technique available for analyzing the temporal variations of cryospheric phenomena since it provides short wave infrared acquisitions, as this wavelength allows automated identification of clean ice and snow (Bolch et al., 2019). Also, the long-term temporal data (1972-till date) can be accessed freely; but its spatial resolution may pose difficulty to map glaciers. Least cloud covered images from Landsat satellites' different sensor data from 1972 to 2018 were used for this study (Table 1). Landsat are widely used for mapping glacial lakes because of their high spatial and temporal coverage, moderate resolution (30 m), open access, and easy accessibility (Wang et. al., 2013). Likewise, Shuttle Radar Topography Mission Digital Elevation Model (SRTM DEM) data were accessed and downloaded from National Aeronautics and Space Administrations' (NASA) web portal (earthexplorer.usgs.gov). The Universal Transverse Mercator (UTM) WGS 84 projection system was used for glacier mapping because the base satellite imagery (Landsat) was provided in this projection.

Table 1: Details of Landsat data used for the study

Landsat Mission	Acquired data	Scene ID (Path/row)	Sensor	Spatial Resolution	Number of Bands
Landsat 1	1972	152040	MSS	60 m	4
Landsat 3	1979	153040	MSS	60 m	4
Landsat 5	1988	142040	TM	30 m	6
Landsat 5	1998	142040	TM	30 m	6
Landsat 5	2010	142040	TM	30 m / 15 m	6
Landsat 8	2018	142040	OLI/TIRS	30 m / 15 m	11

Methods

The multi-stage process with semi-automatic classification method (Figure 2) were used for the delineation of glacier and lake boundary (Bajracharya et.,al 2014). Many studies have used manual digitization (Salerno et al., 2012; Wang et al., 2015; Zhang et al., 2015) and Normalized Difference Water Index (NDWI) based automated or semiautomated methods for the delineation of glacial lake outlines. The NDWI is the most widely used method to delineate the water bodies from remote sense data. We used semiautomated NDWI (equation 1) to delineate glacial lake boundary with manual post-correction by visually checking.

Likewise, Normalized Difference Snow Index (NDSI) (equation 2) is used to identify clean ice which is often used to distinguish between snow, soil rocks and cloud cover and provide good contrast between bare ice and its surroundings at the glacier tongue (Bajracharya et al., 2014). And debris covered glaciers were mapped from the remaining unclassified images and post processing was done using slope and shaded relief generated from SRTM DEM.

$$NDWI = \frac{(\rho G - \rho NIR)}{(\rho G + \rho NIR)} \qquad \text{(equation 1)}$$

$$NDSI = \frac{(\rho R - \rho SWIR)}{(\rho R + \rho SWIR)} \qquad \text{(equation 2)}$$

Where, ρG, ρR, ρSWIR and ρNIR represent the top-of-atmosphere (TOA) reflectance for the green, red, short wave infrared and Near Infrared (NIR) bands, respectively (Barsi et al., 2014).

The topographic normalization was performed by modelling of illumination surface. Illumination value for each pixel is calculated as the cosine of the incident angle γi (Meyer et. al., 1993).

$$\cos\gamma i = \cos\theta p \cos\theta z + \sin\theta p \sin\theta z \cos(\varphi a - \varphi o) \quad \text{(equation 3)}$$

where

γi = incidence angle

θp = slope angle

θz = solar zenith angle = (90 – sun's elevation angle)

φa = solar azimuth angle

φo = aspect angle

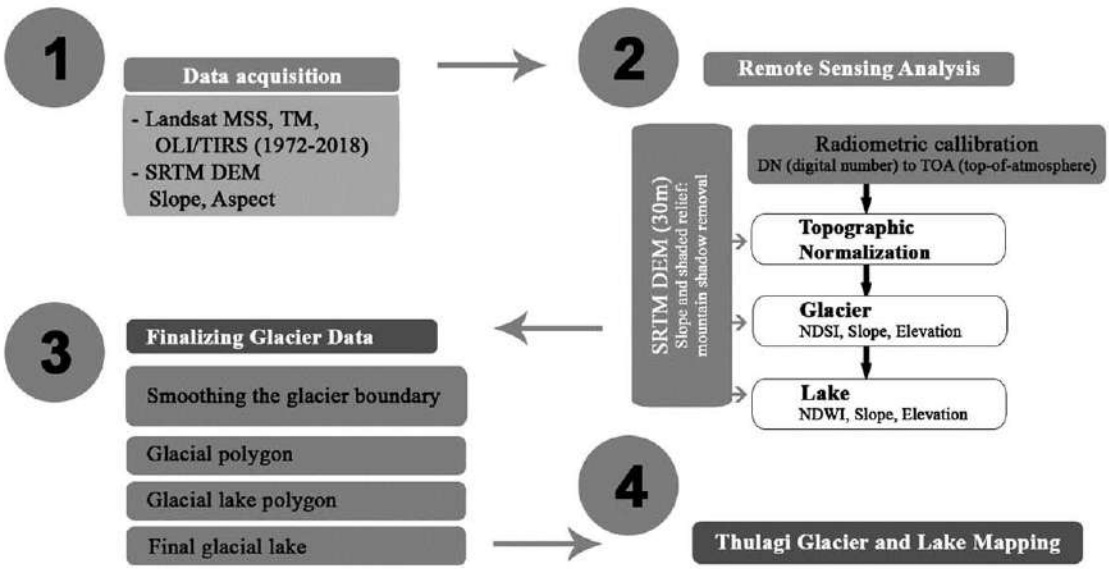

Figure 3: Flowchart of the mapping process for Thulagi glacier and glacial lake (adapted from Bajracharya et al., 2011 and Khadka et al., 2018)

Results and Discussion

The Thulagi glacier has shrunk 9.74 % in last 46 years but the area of glacial lake has more than doubled in the same period of time. The decadal changes seen are not same for the entire period of time (table 2). In the last decade (2008 to 2018), the area of

Thulagi glacier has increased by 0.0017 sq.km. The study on the glacier changes across the Manaslu range reported a reduction of glacier area by 8.2% from 1999 to 2013 (Robson et al., 2018). There are significant evidence of glacier retreating over the past decades in the Nepal Himalayas (Kadota et al. 1997; Fujita et al. 2001; Bolch et al. 2008; Bajracharya et al. 2010, 2011) and overall glacier area is decreasing from 1980s to 2010 (Bajracharya et al., 2017). The glacier mapping based on the satellite image found that the overall glacier area decreased from 3.6% of the total land area of Nepal to 2.6% area (Bajracharya et al., 2014). During the time period from 1977 to 2010, 24% of the total glacier area of Nepal decreased. However, the number of glaciers increased by 11% due to fragmentation and shrinkage of glaciers (Bajracharya et al., 2014).

Table 2: Surface area of Thulagi glacier and glacial lake for different time period.

SN	Year	Glacier area (sq. km)	Changes (sq. km)	Lake area (sq. km)	Changes (sq.km)
1	1972	18.5952	–	0.4598	–
2	1977	17.6719	-0.9233	0.6306	0.1708
3	1988	17.4292	-0.2427	0.6917	0.0611
4	1998	17.2194	-0.2098	0.7424	0.0507
5	2008	16.7818	-0.4376	0.8801	0.1377
6	2018	16.7835	0.0017	0.9363	0.0562
		(-9.74)		(103.63)	

The value in parentheses indicates changes in area of glacier and glacial lake in percentage since 1972. The glacier was retreated by 0.21% per year in the past five decades (Figure 4), which is slightly lower than an annual retreat of about 0.47 % from 1990 to 2000 for Himalayas (Qui Je, 2020). Previous study in the Manaslu region reported the Thulagi glaciers has retreated at of 0.49 ± 0.03 meter per year in the time period from 1970 to 2013 (Robson et al., 2018). Nepal's glacier is decreasing 30 sq. km per year since 1970s and if the trend continues in 2150, all glaciers of Nepal will disappear (Bajracharya et al., 2011). Temperature, precipitation and glacial hydrogeomorphic processes has been vigorously driving glacial lake changes in the Himalaya (Nie et al., 2017, King, 2018). Glacier mass at Hindu Kush Himalaya (HKH) loss has increased since 2000 and will accelerate in the future and glacier volume will decline substantially by 2100 (Wester et al., 2018). Two-degree Celsius rise in average global temperature by 2100 could melt down the glaciers of HKH into half (Wester et al., 2018).

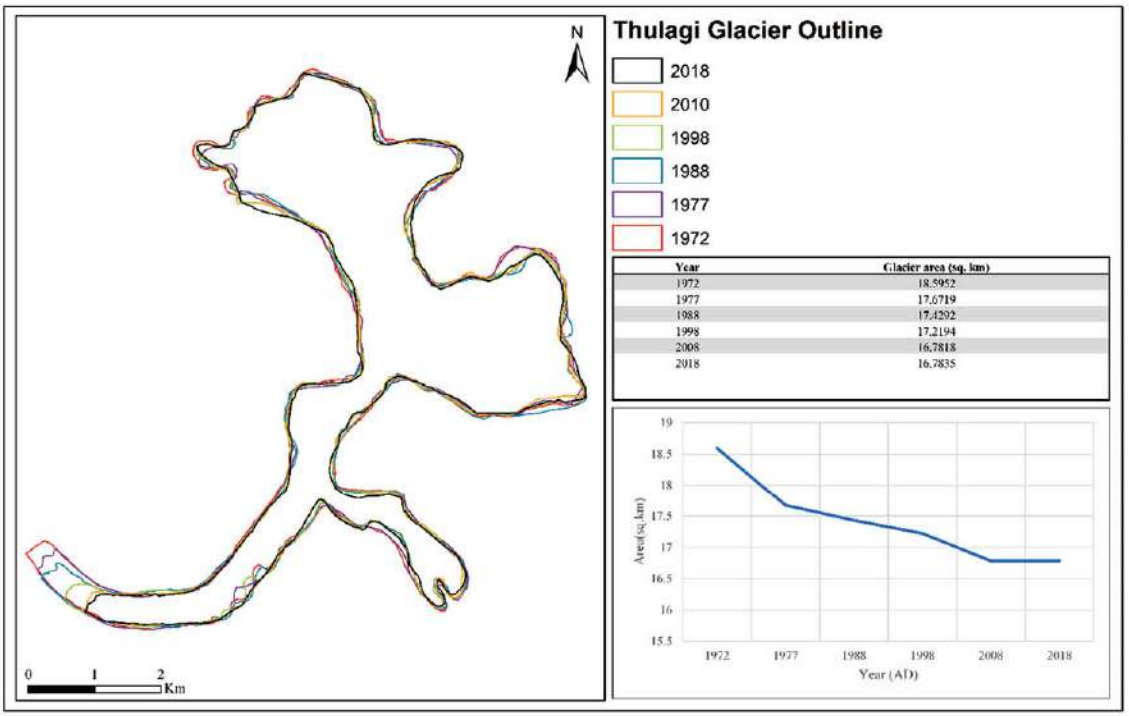

Figure 4: Spatiotemporal changes in the area of Thulagi glacier over the thirty years'

Previous study on decadal glacial lakes dynamics from 1977 to 2017 in the Nepal Himalaya has reported that the proglacial lakes with ice content has experienced the highest incremental changes in surface area (82%) (Khadka et al., 2018). It is found that the lake area expansion trend was consistent with the projection made by Maskey et al. (2020). Thulagi glacial lake area has been increasing since last four decades also increasing the volume of the water in the lake. Snow avalanches, landslides, rock falls, and other mass movement processes dictate the quantity of lake debris that makes its way onto the glacier lake diminishing its breadth (Benn et al., 2012; Haritashy et al., 2018; Thakuri et al., 2016) (Figure 4).

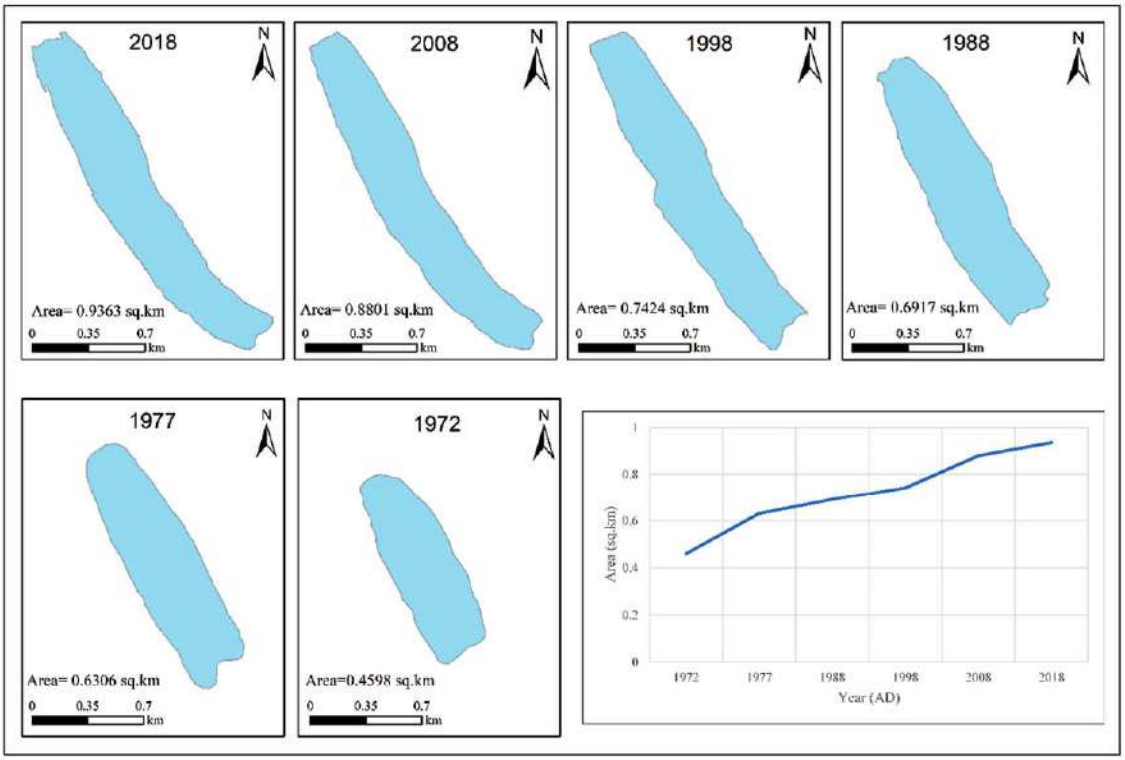

Figure 5: Spatiotemporal changes in the magnitude of Thulagi glacial Lake over five decades (1972-2018)

This paper emphasizes requirement for more intensive research over a period of time to improve understanding of the people living downstream of Thulagi who are exposed to the risk of GLOF.

The aforementioned dynamics are initially controlled by regional topographic conditions related to topographic stress tectonism, and climate. Given the paleoclimatic and glacial chronological conditions that have sculpted the surrounding topography, the three-dimensional topographic stress field strongly influences rock strength and slope-failure potential.

The valley-wall slope failures and landslides contribute to the lateral debris load. Active tectonics and earthquakes also generate material, and there may be considerable variation in lateral debris characteristics given variations in the topographic and geological setting.

Nepal's National Disaster Risk Reduction and Management Strategic Plan of Action (2018-2030) developed in line with the Disaster Risk Reduction and Management Act (2017) is a legal document that explains the planning framework covering all stages

of disaster risk management in the country. Understanding risk caused by GLOF requires better information, impact modelling and risk assessment. To fulfill this target understanding the disaster caused by GLOF and its risks is very important which falls under Priority Area 1 of the Sendai Framework for Disaster Risk Reduction as well as the Disaster Risk Reduction National Strategic Plan of Action of Nepal. Hence, this mapping illustration on spatiotemporal change in Thulagi Lake and its glacier provides better understanding to the People residing downstream (Nache, Tal) exposed to potential hazard of GLOF. Understanding potential disaster of GLOF requires vulnerability and risk and capacity assessment to strengthen the capacity of people residing downstream of Thulagi.

Conclusion

This study is based on the satellite image analysis. The satellite image is taken from Landsat 1, 3, 5 and Landsat 8 for mapping Thulagi glacier located at Manang district of Nepal. Glacier retreat was observed for past thirty years at the area. The glacier was retreating at the rate of 3.73% from 1998 to 2008 and the percentage of retreat increases to 10.55% by 2008 to 2018. The retreat of the Thulagi glacier is more prominent in the calving front of the debris-covered glacier intact with lake. Thulagi glacial lake has evolved from small supraglacial lakes into larger proglacial lake, doubled in size over last five decades. Linear trend analysis shows significantly decreasing area of the glacier and increasing area of lake which may affect hydrological cycle of the area and further research related to hydrological cycle of the area and GLOF susceptibility of the lake is recommended.

Acknowledgements

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Vegetation Composition and Regeneration Status of Inactive Landslides in Panchase Region, Western Nepal

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Abstract

Nepal is highly vulnerable to landslides. The steep mountains, high population density, over-grazing, deforestation, monsoon climate are the reasons that make the country prone to landslides. The landslide also provides opportunities for plant colonization and succession. However, there are very few studies related to a succession of vegetation in the landslide area. This study was carried out in the Bhat Khola River and Seti Khola River sub-watersheds of Phedikhola Rural Municipality of Panchase region, western Nepal. Altogether three inactive landslides of different ages were identified and selected for the study purpose. A total of 13 quadrant plots of size 10m × 10m for tree species and 52 plots of 2m × 2m for shrub/herb species were laid down using systematic sampling method and foot trial as belt transect in different ages of inactive landslides. Identification, count and measurement of all the species were carried out. There was higher herb richness in younger inactive landslide i.e., Inactive Landslide of seven years. However, the shrub richness of studied inactive landslides was not significant. There was higher sapling/adult tree density in older inactive landslide i.e., Inactive Landslide of thirty-four years. There were many new regenerating species in a younger inactive landslide. Soil parameter such as pH of inactive landslides was assessed to be slightly acidic ranging from 6.78 to 6.9. The soil moisture and bulk density showed an inverse relation to each other with a strong negative correlation. The present study unveiled vegetation succession of inactive landslides area.

Keywords: *Bulk density, Importance Value Index, Moisture, Plant Species, Species succession*

Introduction

Landslides are major problems in Nepal (Chapagai, 2011). Landslides are significant cause of vegetation disturbance (Veblen & Ashton, 1978) and affect subsequent timber productivity for several decades at least (Miles & Swanson, 1986). The newly exposed subsoil in landslide scars holds few residual root crowns or seeds to sprout and occupy the site (Miles & Swanson, 1986). When changes in the landslide environment favor a new set of species better adapted to the changing conditions, species replacements

occur. This process is known as succession (Glenn-Lewin et al., 1992). Landslides are generally categorized as examples of primary succession because the initial disturbance removes most of the soil and vegetation (Walker & Moral, 2003).

The composition of the forest is diverse and varies from place to place because of varying topography such as plains, foothills and upper mountains (Singh, 2006). All plant species occur in a limited range of habitat and most abundant in their particular environmental optimum in the absence of competition (Braak & Prentice, 1988). Species components of communities thus change along environmental gradients (climatic, edaphic, and topographic); the replacement and separation of species in the environment depend on the variation of resources along the gradients (Pickett, 1990). Natural regeneration of forest is fundamental for evolution in forest ecosystem (Ackzell, 1994) (Ackzell, 2008). Natural regeneration and germination of seeds and their diversity, distribution, composition depend mainly on light regimes, soil moisture and compactness (Denslow, 1987). It is important for the production role and for ensuring the replacement of any member of the community that dies after completing the life cycle (Fatabarian, 1987).

Forest soil plays an important role by influencing the vegetative composition of the forest stand, rate of tree growth and ecosystem diversity (Parfitt et al., 2005). Topography, climate, physical weathering processes, microbial activities with several other biotic and abiotic components determine the physiochemical properties of the forest soil (Liebig et al., 2004). Similarly, the vegetation pattern of a particular forest stand also plays an important role in the formation of soil (Chapman & Reiss, 1992). The growth of vegetation depends upon the nutrient supplying capability of the soil (Jha et al., 2003). The present study aims to analyze the vegetation composition status of inactive landslides in Phedikhola Rural Municipality of Panchase Region; to know the regeneration status of vegetation of inactive landslides of the study site, and to test soil properties of inactive landslides of the study area.

Materials and Methods

The study was carried out in the inactive landslides of Bhat Khola River and Seti Khola River sub-watersheds of ward no. 3 (Bhatkhola) and ward no. 4 (Arukharka) of Phedikhola Rural Municipality. Phedikhola Rural Municipality lies in Syangja District of Panchase Region, Nepal (Fig. 1). Panchase region is situated at the nexus of three districts (Kaski, Parbat and Syangja District) in Gandaki Province of Nepal. Phedikhola Rural Municipality is created by merging the former four Village Development Committees namely Bagephatake, Bhatkhola, Arukharka and Phedikhola. It occupies a total area of 56.73km2.

Fig 1: Location Map of Study Area

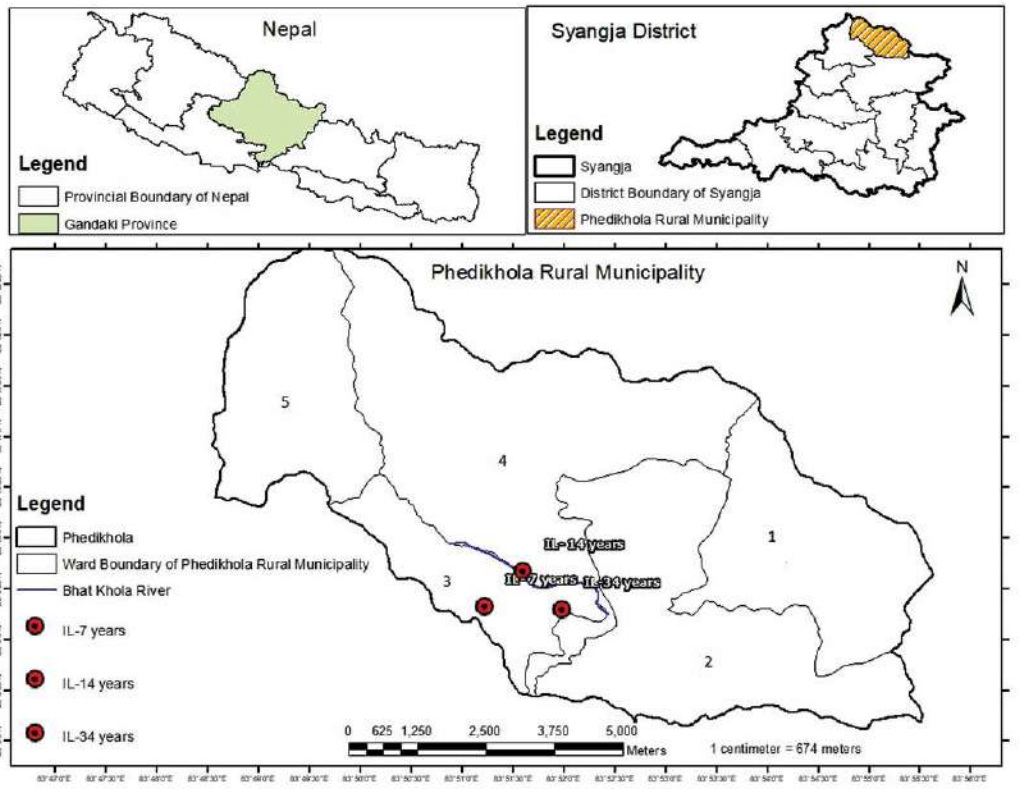

Fig 2: Map of the study area

The inactive landslides of Phedikhola Rural Municipality were explored in consultation with local people and information from District Soil Conservation Office (DSCO). Altogether three inactive landslides of different ages were identified and selected for the study purpose. They were: Inactive Landslide of 7 years (IL-7), Inactive Landslide of 14 years (IL-14) and Inactive Landslide of 34 years (IL-34). The IL-7 and IL-14 lie in Bhat Khola sub-watershed and IL-34 lie in Seti Khola sub-watershed region. Likewise, IL-34 and IL-7 lie in Bhatkhola ward number 3 and IL-14 lie in Arukharka ward number 4 of Phedikhola Rural Municipality. The description of the plots of inactive landslides of the study area in Phedikhola Rural Municipality was shown in Table 1.

Table 1: Site description of the plot of inactive landslides in study area

Site	Plot no.	Altitude (m)	Latitude	Longitude	General slope	Aspect	Landslide Area(m2)	Sampled Area(m2)	% sampled
IL-7	1	1291.71	N28°9'21.672"	E83°51'11.88"	22°	North East	2557	300	11.73
	2	1284.53	N28°9'22.14"	E83°51'11.628"					
	3	1288.66	N28°9'22.356"	E83°51'11.736"					
IL-14	4	1033.73	N28°9'40.104"	E83°51'37.584"	30°	South West	3404	700	20.56
	5	1032.12	N28°9'40.536"	E83°51'37.116"					
	6	1037.57	N28°9'40.536"	E83°51'37.116"					
	7	1120.4	N28°9'39.924"	E83°51'35.532"					
	8	1058.85	N28°9'40.644"	E83°51'36.18"					
	9	1054.92	N28°9'40.788"	E83°51'35.676"					
	10	1047.38	N28°9'41.004"	E83°51'35.568"					
IL-34	11	1013.64	N28°9'16.848"	E83°51'59.58"	22°	South	2742	300	10.94
	12	1007.31	N28°9'17.208"	E83°51'59.58"					
	13	1006.47	N28°9'17.712"	E83°52'0.048"					

Sampling Techniques

The selected landslides were studied following the methods designed. For sampling, individuals of tree species were divided into three growth stages: (i) adult tree [Diameter at breast height (DBH) $\geq$ 10cm], (ii) sapling (DBH < 10cm, height > 30cm), (iii) seedling (height < 30cm) according to Sundriyal and Sharma (1996). A systematic sampling method with belt transect method referring foot trail as belt transect was done. A quadrat of 10m $\times$ 10m size was used for sampling of tree species. The number of individuals of seedling, sapling and adult tree was noted down in each sampling plot. Also, the height and DBH of sapling and adult trees were measured. DBH was measured at 1.37m above the ground. In each corner of 10m $\times$ 10m size quadrat, four sub quadrats of 2m $\times$ 2m were marked for the study of shrub and herb species. The number of individuals and

coverage percentage of all shrub and herb species present in the quadrat were noted down. Depending on the area of the study site, altogether 13 sampling plots were studied i. e., 3 plots from IL-7, 7 plots from IL-14 and 3 plots from IL-34.

The soil samples were collected from each plot used for vegetative analysis. The samples were collected by digging a V-shaped pit of 15 cm depth from the ground and kept in separate polythene bags making it airtight. Altogether 30 samples were collected. From each study sites, 10 samples were collected. The samples were then taken to the CDES laboratory of Tribhuvan University at Kirtipur for analysis of bulk density, organic matter, carbon and total nitrogen through laboratory methods.

Analysis Techniques for Vegetation

Vegetation composition was evaluated by analyzing the frequency, density, abundance and IVI (Importance Value Index) (Kent & Coker, 1992). The Shannon index is used for the estimation of species diversity (Shannon & Weiner, 1949). The Simpson's diversity index given by Simpson (1949) is used for the calculation of plant diversity within a habitat. Shankar (2001) was followed to calculate regeneration status.

Analysis Techniques for Soil Parameter

The instruments and methods used for the analysis of soil parameters are presented in Table 2.

Table 2: Instruments and methods of analysis of soil parameter

S.N.	Soil Parameters	Instruments/ Methods
1	Soil pH	Soil pH moisture meter
2	Soil Moisture	Soil pH moisture meter
3	Bulk density	Core method
4	Organic matter	Walkley and black method
5	Nitrogen	Kjeldahl method

Results and Discussion

A total number of 19 tree species, 2 shrub species and 10 herb species were found (Table 2). The study area, comprising of three aspects (Table 1), had a total of 13 families of trees, 2 families of shrubs, 3 families of herbs (Table 3). Here, the plant species were arranged systematically according to the presence of tree, shrub and herb species in accordance to increasing ages of inactive landslides of Phedikhola Rural Municipality.

Table 3: Plant species found in inactive landslides in study area

S. N.	Name of Species		Family	Habit (Tree/ Shrub/ Herb)	IL-7	IL-14	IL-34
	Scientific Name	Local Name			Present (P)/Absent (A)		
1	Schima wallichii	Chilaune	Theaceae	Tree	P	P	P
2	Ajuga bracteosa	Ratpate	Lamiaceae	Tree	P	A	A
3	Lyonia ovalifolia	Angeri	Ericaceae	Tree	P	A	A
4	Rhododendron arboretum	Laliguras	Ericaceae	Tree	P	A	A
5	Myrsine capitellata	Seti kath	Myrsinaceae	Tree	P	A	A
6	Holarrhena antidysentrica	Khirro	Apocynaceae	Tree	P	A	A
7	Eurya cerasifolia	Jhyano	Theaceae	Tree	P	A	A
8	Fraxinus floribunda	Lakuri	Oleaceae	Tree	P	A	A
9	Diospyros malabarica	Teju	Ebenaceae	Tree	P	A	P
10	Castanea indica	Katus	Fagaceae	Tree	P	A	P
11	Myrica esculenta	Kafal	Myricaceae	Tree	P	A	P
12	Alnus nepalensis	Utis	Betulaceae	Tree	A	P	A
13	Psidium guajava	Amba	Myrtaceae	Tree	A	A	P
14	Ficus cunia	Khanyu	Moraceae	Tree	A	A	P
15	Streblus asper	Bedulo	Moraceae	Tree	A	A	P
16	Bombax ceiba	Simal	Bombacaceae	Tree	A	A	P
17	Engelhardtia spicata	Mauwa	Juglandaceae	Tree	A	A	P
18	Rhus succedanea	Bhalayo	Anacardiaceae	Tree	A	A	P
19	Unidentified 1	Ghokro	-	Tree	A	A	P
20	Rubus ellipticus	Aiselu	Rosaceae	Shrub	P	P	P
21	Leucaena leucocephala	Ipil ipil	Fabaceae	Shrub	A	A	P
22	Arundinella nepalensis	Furke	Poaceae	Herb	P	P	P
23	Chrysopogon gryllus	Salim Khar	Poaceae	Herb	P	P	P
24	Eupatorium adenophorum	Banmara	Asteraceae	Herb	P	P	P
25	Unidentified 2	Dankirno	-	Herb	P	P	P
26	Unidentified 3	Hadeunyu	-	Herb	P	P	P
27	Unidentified 4	Kharibanso	-	Herb	P	P	P
28	Thysanalaena maxima	Amliso	Poaceae	Herb	P	P	A
29	Imperata cylindrical	Siru	Poaceae	Herb	P	P	A
30	Nephroleplis cordifolia	Paniamala	Devalliaceae	Herb	P	A	A
31	Unidentified 5	Tite Ghas	-	Herb	P	A	A

(Source: Press et al., 2000)

Vegetation Analysis

Inactive Landslide of 7 years (IL-7)

The quantitative status of plant species found in IL-7 was presented in Table 4.

Table 4: Quantitative status of plant species found in Inactive Landslide of 7 years in study area

S.N.	Name of Species		Total number	F (%)	R F (%)	D (no./ ha.)	R D (%)	A/BA/C	R A/ R BA/ R C (%)	IVI
	Scientific Name	Local Name								
Seedling Tree Species										
1	Schima wallichii	Chilaune	8	100.00	21.43	266.67	28.57	2.67	17.58	67.58
2	Lyonia ovalifolia	Angeri	3	66.67	14.29	100.00	10.71	1.50	9.89	34.89
3	Castanea indica	Katus	2	66.67	14.29	66.67	7.14	1.00	6.59	28.02
4	Eurya cerasifolia	Jhyano	4	66.67	14.29	133.33	14.29	2.00	13.18	41.76
5	Myrica esculenta	Kafal	3	33.33	7.14	100.00	10.71	3.00	19.78	37.63
6	Diospyros malabarica	Teju	1	33.33	7.14	33.33	3.57	1.00	6.59	17.31
7	Rhododendron arboretum	Laliguras	6	66.67	14.29	200.00	21.43	3.00	19.78	55.49
Sapling/Adult Tree Species										
1	Schima wallichii	Chilaune	6	100.00	33.33	200.00	37.50	0.84	49.87	120.70
2	Ajuga bracteosa	Rat pate	1	33.33	11.11	33.33	6.25	0.08	4.68	22.04
3	Myrsine capitellata	Seti kath	1	33.33	11.11	33.33	6.25	0.09	5.57	22.94
4	Holarrhena antidysentrica	Khirro	1	33.33	11.11	33.33	6.25	0.08	4.68	22.04
5	Myrica esculenta	Kafal	5	33.33	11.11	166.67	31.25	0.17	9.91	52.27
6	Rhododendron arboretum	Laliguras	1	33.33	11.11	33.33	6.25	0.17	9.91	27.27

S.N.	Name of Species		Total number	F (%)	R F (%)	D (no./ ha.)	R D (%)	A/BA/C	R A/ R BA/ R C (%)	IVI
7	Fraxinus floribunda	Lakuri	1	33.33	11.11	33.33	6.25	0.26	15.48	32.84
Shrub Species										
1	Rubis ellipticus	Aiselu	2	16.67	6.67	416.67	0.47	208.33	0.57	7.71
Herb Species										
1	Arundinella nepalensis	Furke	130	58.33	23.33	27083.33	30.66	2208.33	6.02	60.01
2	Chrysopogon gryllus	Salim khar	46	25.00	10.00	9583.33	10.85	1625.00	4.43	25.28
3	Thysanalaena maxima	Amliso	7	25.00	10.00	1458.33	1.65	416.67	1.14	12.79
4	Eupatorium adenophorum	Banmara	75	25.00	10.00	15625.00	17.69	458.33	1.25	28.94
5	Nephroleplis cordifolia	Pani amala	30	8.33	3.33	6250.00	7.08	166.67	0.45	10.86
6	Unindentified 2	Dankirno	8	8.33	3.33	1666.67	1.89	41.67	0.11	5.33
7	Unindentified 4	Khari Banso	42	33.33	13.33	8750.00	9.91	333.33	0.91	24.15
8	Unindentified 5	Tite Ghas	71	33.33	13.33	14791.67	16.75	1166.67	3.18	33.26
9		Exposed soil/ rock	0	0.00	0.00	0.00	0.00	30000.00	81.73	81.73

A total number of 3 plots were laid down according to the area of IL-7. IL-7 was dominated by seedling and sapling/adult tree species of Schima wallichii. Altogether 7 different seedling tree species were found in IL-7. The IVI of seedling tree species ranged from 17.31 (Diospyros malabarica) to 67.58 (Schima wallichii). Similarly, altogether 7 different sapling/adult tree species were found in IL-7. The Importance Value Index (IVI) of sapling/adult tree species ranged from 22.04 (Ajuga bracteosa and Holarrhena antidysentrica) to 120.70 (Schima wallichii). Rubus ellipticus was only the shrub species of IL-7. The dominant herb species of IL-7 was Arundinella nepalensis. Altogether 9 different herb species were found in IL-7. The IVI of herb species ranged from 5.33 Unidentified 2 (Dankirno) to 60.01(Arundinella nepalensis).

Table 5: Shannon Diversity Index 'H'', Simpson's Dominance Index 'C' and Pielou's Evenness 'e' of plant species found in IL-7 in study area

Plant Species	H'	C	E
Tree	2.44	0.09	1.02
Shrub	0.00	1.00	Undefined
Herb	2.02	0.16	0.92

The diversity indices of plant species found in IL-7 were presented in Table 5. The Shannon Diversity index of tree species was higher in IL-7 (2.44). The Simpson's Dominance index was higher in shrub species (1.00) and lower in tree species (0.09). The Pielou's Evenness value was higher in tree species (1.02).

Inactive Landslide of 14 years (IL-14)

The quantitative status of plant species found in IL-14 was presented in Table 6.

Table 6: Quantitative status of plant species found in Inactive Landslide of 14 years in study area

S. N.	Name of Species		Total number	F (%)	R F (%)	D (no./ ha.)	R D (%)	A/ BA/C	R A/ R BA/ R C (%)	IVI
	Scientific Name	Local Name								
Seedling Tree Species										
1	Schima wallichii	Chilaune	94	100	87.50	1342.86	98.95	13.43	98.95	285.40
2	Alnus nepalensis	Utis	1	14.29	12.50	14.29	1.05	0.14	1.05	14.60
Sapling/Adult Tree Species										
1	Schima wallichii	Chilaune	32	57.14	100	457.14	100	0.34	100	300
Shrub Species										
1	Rubis ellipticus	Aiselu	1	3.57	1.61	89.29	0.12	125.00	0.19	1.92

S. N.	Name of Species		Total number	F (%)	R F (%)	D (no./ ha.)	R D (%)	A/ BA/C	R A/ R BA/ R C (%)	IVI
	Scientific Name	Local Name								
Herb Species										
1	Arundinella nepalensis	Furke	225	60.71	27.42	20089.29	27.41	8000.00	11.85	66.68
2	Chrysopogon gryllus	Salim Khar	176	50.00	22.58	15714.29	21.44	8250.00	12.22	56.24
3	Thysanalaena maxima	Amliso	10	10.71	4.84	892.86	1.22	1250.00	1.85	7.91
4	Andropogon pumilus	Kash	16	10.71	4.84	1428.57	1.95	625.00	0.93	7.71
5	Imperata cylindrical	Siru	7	7.14	3.23	625.00	0.85	250.00	0.37	4.45
6	Eupatorium adenophorum	Banmara	184	25.00	11.29	16428.57	22.41	1750.00	2.59	36.29
7	Unindentified 2	Dankirno	10	3.57	1.61	892.86	1.22	500.00	0.74	3.57
8	Unindentified 4	Khari Banso	192	50.00	22.58	17142.86	23.39	3750.00	5.56	51.52
9		Exposed soil/rock	0	0.00	0.00	0.00	0.00	43000.00	63.70	63.70

A total number of seven plots were laid down according to the area of IL-14. IL-14 was dominated by seedling tree species viz. Schima wallichii and Alnus nepalensis. Altogether two different seedling tree species were found in IL-14. The seedling tree species of Schima wallichii (285.40) had the highest IVI value. Schima wallichii was only the sapling/adult tree species found in IL-14. So, the IVI of sapling/adult tree species of Schima wallichii was found to be 300. Similarly, IL-14 was dominated by only shrub species viz. Rubus ellipticus. Altogether 8 different herb species were found in IL-14. The IVI ranged from 1.92(Rubus ellipticus) to 66.68(Arundinella nepalensis).

Table 7: Shannon Diversity Index 'H'', Simpson's Dominance Index 'C' and Pielou's Evenness 'e' of plant species found in IL-14 in study area

Plant Species	H'	C	E
Tree	0.79	0.48	1.14
Shrub	0.00	1	Undefined
Herb	1.85	0.18	0.89

The diversity indices of plant species found in IL-14 were presented in Tables 7. The

Shannon Diversity index of herb species was higher in IL-14 (1.85). The Simpson's Dominance index was higher in shrub species (1). The evenness value was higher in tree species (1.14).

Inactive Landslide of 34 years (IL-34)

The quantitative status of plant species found in IL-34 was presented in Table 8.

Table 8: Quantitative status of plant species found in Inactive Landslide of 34 years in study area

S. N.	Name of Species		Total number	F (%)	R F (%)	D (no./ ha.)	R D (%)	A/ BA/C	R A/ R BA/ R C (%)	IVI
	Scientific Name	Local Name								
Seedling Tree Species										
1	Schima wallichii	Chilaune	5	33.33	16.67	166.67	35.71	5.00	35.71	88.09
2	Rhus succedanae	Bhalayo	2	33.33	16.67	66.67	14.29	2.00	14.29	45.24
3	Ficus cunia	Khanyo	3	33.33	16.67	100.0	21.43	3.00	21.43	59.52
4	Streblus asper	Bedulo	2	33.33	16.67	66.67	14.29	2.00	14.29	45.24
5	Castanea indica	Katus	1	33.33	16.67	33.33	7.14	1.00	7.14	30.95
6	Psidium guajava	Amba	1	33.33	16.67	33.33	7.14	1.00	7.14	30.95
Sapling/Adult Tree Species										
1	Schima wallichii	Chilaune	40	100.00	25.00	13333.33	97.56	0.84	16.11	138.67
2	Diospyros malabarica	Teju	3	66.67	16.67	100.00	0.73	0.13	2.54	19.93

S. N.	Name of Species		Total number	F (%)	R F (%)	D (no./ ha.)	R D (%)	A/ BA/C	R A/ R BA/ R C (%)	IVI
	Scientific Name	Local Name								
3	Rhus succedanae	Bhalayo	2	66.67	16.66	66.67	0.49	0.16	3.04	20.19
4	Myrica esculenta	Kafal	1	33.33	8.33	33.33	0.24	1.27	24.21	32.78
5	Engelhardtia spicata	Mauwa	1	33.33	8.33	33.33	0.24	0.44	8.45	17.03
6	Unidentified 1	Ghokro	1	33.33	8.33	33.33	0.24	1.64	31.26	39.84
7	Psidium guajava	Amba	1	33.33	8.33	33.33	0.24	0.38	7.20	15.78
8	Bombax ceiba	Simal	1	33.33	8.33	33.33	0.24	0.38	7.20	15.78
Shrub Species										
1	Leucaena leucocephala	Ipil Ipil	2	8.33	4.00	416.67	0.36	225.00	1.16	5.52
2	Rubis ellipticus	Angeri	10	8.33	4.00	2083.33	1.78	400.00	2.07	7.84
Herb Species										
1	Arundinella nepalensis	Furke	196	66.67	32.00	40833.33	34.81	4437.50	22.91	89.72
2	Chrysopogon gryllus	Salim khar	10	16.67	8.00	2083.33	1.78	750.00	3.87	13.65
3	Eupatorium adenophorum	Banmara	48	16.67	8.00	10000.00	8.53	1300.00	6.71	23.24
4	Unindentified 2	Dankirno	7	8.33	4.00	1458.33	1.24	1000.00	5.16	10.41
5	Unindentified 3	Hadeunyu	116	25.00	12.00	24166.67	20.60	5250.00	27.11	59.71
6	Unindentified 4	Khari Banso	174	58.33	28.00	36250.00	30.91	3714.29	19.18	78.08
7		Exposed sol/rock	0	0.00	0.00	0.00	0.00	2291.67	11.83	11.83

A total number of 3 plots were laid down according to the area of IL-34. IL-34 was dominated by seedling tree species of Schima wallichii. Altogether 6 different seedling tree species were found in IL-34. The IVI of seedling tree species ranged from 30.95 (Psidium guajava and Castanea indica) to 88.09 (Schima wallichii). Schima wallichii and Diospyros malabarica were the dominant sapling/adult tree species found in IL-34.

Altogether 8 different sapling/adult tree species were found in IL-34. The IVI of sapling/adult tree species ranged from 15.78 (Psidium guajava and Bombax cibea) to 138.67 (Schima wallichii). Similarly, IL-34 dominated by shrub species viz. Rubus ellipticus and Leucaena leucocephala and herb species viz. Arundinella nepalensis and Unidentified 4 (Khari Banso). Altogether 6 different herb species were found in IL-34. The IVI of herb species ranged from 5.52 (Leucaena leucocephala) to 89.72 (Arundinella nepalensis).

Table 9: Shannon Diversity Index 'H'', Simpson's Dominance Index 'C' and Pielou's Evenness 'e' of plant species found in IL-34 in study area

Plant Species	H'	C	E
Tree	2.40	0.11	0.97
Shrub	0.64	0.55	0.98
Herb	1.65	0.23	0.92

The diversity indices of plant species found in IL-34 were presented in Table 9. The Shannon Diversity index of tree species was higher in IL-34 (2.40) and low shrub diversity (0.64). The Simpson's Dominance index was higher in shrub species (0.55) and lower in tree species (0.11). The Pielou's Evenness value was higher in shrub species (0.98) and lower in the herb species (0.92).

The Inactive Landslide of 7 years had 11 tree species belongs to 9 families, 1 shrub species belongs to 1 family and 9 herb species belongs to 2 families. Inactive Landslide of 14 years had 2 tree species belongs to 2 families, 1 shrub species belongs to 1 family and 8 herb species belongs to 2 families. Inactive Landslide of 34 years had 11 tree species belongs to 9 families, 2 shrub species belongs to 2 families and 6 herb species belongs to 2 families. The richness of herb species was found to be decreased simultaneously as the age of inactive landslides increases. The richness of shrub species of the inactive landslides was not found to be significant. Only 2 species of shrub species were found. The richness of tree species of IL-14 was very low or insignificant. Only 2 species of the tree were found. The older inactive landslide had higher sapling/adult tree density (13333.33 no. /ha.) with a higher IVI value (138.67) of Schima wallichii. The different landforms with varied climate and soil support, an array of a different form of vegetation. Vegetation composition is greatly affected by differences in the microclimate, aspect and altitude (Pande et al., 1996); size, degree and level of disturbance of established area (Levenson, 1981) and year of establishment of vegetation (Chen et al., 2014).

The past study indicates that Schima wallichii and Arundinella nepalensis were the ecologically important species to maintain an entire ecosystem of different ages of inactive landslides (Pande, 2001). These species had higher value of frequency, density and IVI; it may be due to adaptation of these species in any harsh condition of climate,

topography and soil characteristics. They presumably established soon after the landslide and retain an important place in the canopy for many years. After which it increasingly suppressed by emerging forest tree and ground cover.

The present study showed a higher herb diversity value in IL-7 (2.02) and a lower herb diversity value in IL-34 (1.65). The herb evenness value of the inactive landslide was almost similar ranges from 0.89 to 0.92. The study showed no value of shrub diversity in the inactive landslides. Reciprocally, higher shrub dominance was found in younger inactive landslides. The study showed higher tree diversity in IL-7 (2.44). Here, a higher herb diversity index was found in a younger inactive landslide. Likewise, higher tree diversity index was also found in a younger inactive landslide. There may be attribution of ecological succession process (Sundriyal and Sharma, 1996).

Vegetation Regeneration Status

Regeneration status according to seedling, sapling and adult tree density

Inactive Landslide of 7 years (IL-7)

The regeneration status of each tree species of IL-7 was presented in Table 10.

Table 10: Regeneration status of each tree species of IL-7 in study area

S.N.	Tree species	Density (Seedling/ ha.)	Density (Sapling/ ha.)	Density (Adult tree/ ha.)	Regeneration Status
1	Schima wallichii	266.67	200.00	-	New
2	Lyonia ovalifolia	100.00	-	-	New
3	Castanea indica	66.67	-	-	New
4	Eurya cerasifolia	133.33	-	-	New
5	Myrica esculenta	100.00	33.33	-	New
6	Diospyros malabarica	33.33	-	-	New
7	Rhododendron arboretum	200.00	166.67	-	New
8	Ajuga bracteosa	-	200.00	-	New
9	Myrsine capitellata	-	33.33	-	New
10	Holarrhena antidysentrica	-	33.33	-	New
11	Fraxinus floribunda	-	33.33	33.33	Poor

Schima wallichii, Lyonia ovalifolia, Castanea indica, Eurya cerasifolia, Myrica esculenta, Diospyros malabarica, Rhododendron arboretum, Ajuga bracteosa, Myrsine capitellata and Holarrhena antidysentrica showed new regeneration status in IL-7. Fraxinus floribunda showed poor regeneration as though the density of sapling species was equal to the density of adult tree species and there was an absence of seedling species in IL-7

Inactive Landslide of 14 years (IL-14)

The regeneration status of each tree species of IL-14 was presented in Table 11.

Table 11: Regeneration status of each tree species of IL-14 in study area

S.N.	Tree species	Density (Seedling/ ha.)	Density (Sapling/ ha.)	Density (Adult tree/ ha.)	Regeneration Status
1	Schima wallichii	1342.86	428.57	28.57	Good
2	Alnus nepalensis	14.29	-	-	New

Schima wallichii showed good regeneration status in IL-14. Alnus nepalensis showed new regeneration status in IL-14.

Inactive Landslide of 34 years (IL-34)

The regeneration status of each tree species of IL-34 was presented in Table 12.

Table 12: Regeneration status of tree species of IL-34 in study area

S.N.	Tree species	Density (Seedling/ ha.)	Density (Sapling/ ha.)	Density (Adult tree/ ha.)	Regeneration Status
1	Schima wallichii	166.67	966.67	366.67	Poor
2	Rhus succedanea	66.67	66.67	-	New
3	Ficus cunia	100	-	-	New
4	Streblus asper	66.67	-	-	New
5	Castanea indica	33.33	-	-	New
6	Psidium guajava	33.33	33.33	-	New
7	Diospyros malabarica	-	100.00	-	New
8	Myrica esculenta	-	-	33.33	None
9	Engelhardtia spicata	-	-	33.33	None
10	Bombax ceiba	-	-	33.33	None
11	Unidentified 1	-	-	33.33	None

Schima wallichii showed poor regeneration status in IL-34. Rhus succedanea, Ficus cunia, Streblus asper, Castanea indica, Psidium guajava, Diospyros malabarica and Rhus succedanea showed new regeneration status in IL-34. Myrica esculenta, Engelhardtia spicata, Bombax ceiba and Unidentified showed no regeneration status in IL-34 as there was an absence of density of seedling and sapling tree species and the presence of only adult tree species.

The present study showed the regeneration status of Schima wallichii was good in IL-14 as the density of seedling has increased then the density of sapling increased than the density of adult tree. The regeneration status of Schima wallichii was new in IL-7 and IL-34. Myrica esculenta, Engelhardtia spicata, Unidentified 1, Psidium guajava and Bombax ceiba of IL-34 showed no regeneration status as there was an absence of density of seedling and sapling species and the presence of only adult tree species. There were many new regenerated tree species in younger inactive landslides.

Many research revealed that the plant species in inactive landslide areas were dominated by herbaceous plants at the beginning stage. When surrounding forests and tree species gradually invaded grass-covered land over a few years, the area of grassland then decreased, and that of woody plants increased. The domination of woody plants resulted in the formation of shelter and changed soil conditions, reducing the area covered by herb species, thereby promoting forestation (Chen et al., 2014).

There were no regenerated tree species in the older inactive landslide of 34 years. The reason may be variation in the year of establishment of vegetation. As a function of time, all the seedlings were grown into saplings or adult tree stage in the older inactive landslide of 34 years (Chen et al., 2014).

Edaphic Parameter

The soil property of inactive landslides of Phedikhola Rural Municipality was shown in Table 13.

Table 13: Soil properties of inactive landslides in study area

Site	Avg. pH	Avg. Soil Moisture (%)	Avg. Bulk Density (gm/cm3)	Avg. Org. matter (%)	Avg. Carbon %	Avg. Nitrogen %
IL-7	6.78±0.08	34.83±12.19	0.55±0.23	11.09±1.39	6.45±0.81	0.19±0.07
IL-14	6.9±0.14	22.36±9.23	0.89±0.2	5.81±1.88	3.38±1.09	0.16±0.10
IL-34	6.9±0.12	16.57±4.21	0.98±0.12	5.74±1.11	3.34±0.64	0.14±0.09

The pH of the soil of older inactive landslides i.e.IL-34 and IL-14(6.9) showed slightly acidic. The pH of the soil of younger inactive landslide IL-7 (6.78) showed more acidic. The reason may be due to the avilability of higher soil moisture and nutrient content on younger inactive landslides. The other parameter such as soil moisture, organic matter, carbon and total nitrogen shows decreasing trend as the age of naturally stabilized inactive landslides increased. The reason may be due to the disturbance by wildlife or human for fuel or fodder collection. Overall, IL-7 had a higher amount of soil moisture, organic matter, carbon content and total nitrogen. The reason behind the high amount of soil moisture, organic matter, carbon content and total nitrogen may be due to change in aspect, topography and sunlight as well as disturbance by human and wildlife. As a result, there was also a high value of tree diversity index in IL-7.

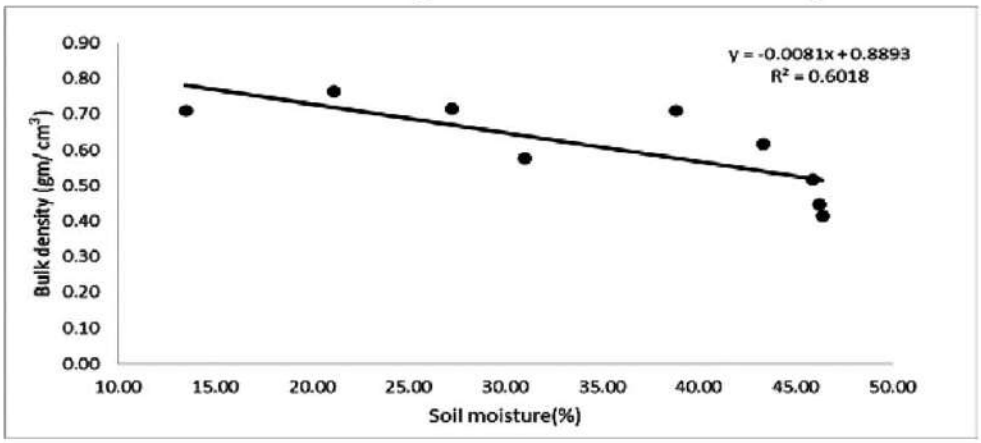

Fig 3: Scatter chart showing the relation between bulk density and soil moisture (IL-7)

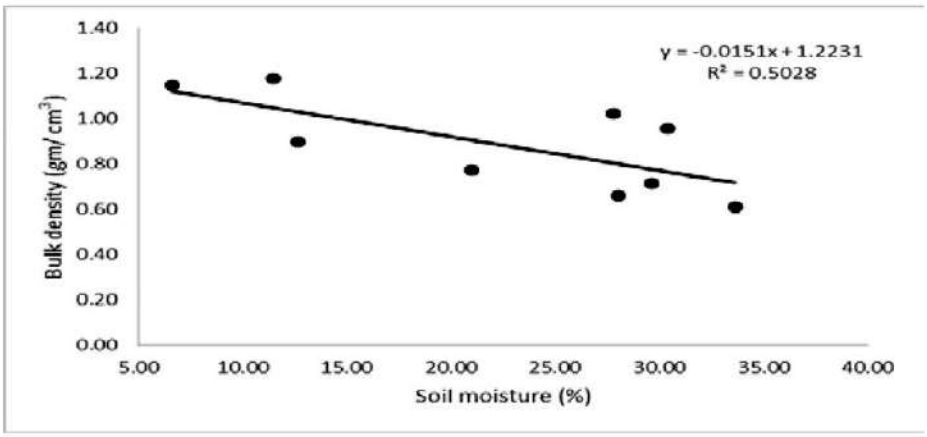

Fig 4: Scatter chart showing the relation between bulk density and soil moisture (IL-14)

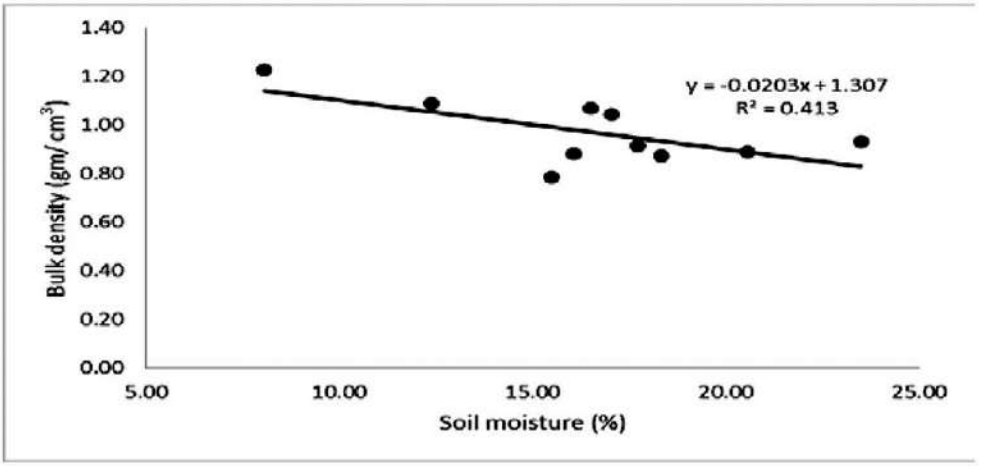

Fig 5: Scatter chart showing the relation between bulk density and soil moisture (IL-34)

The above figures (Fig 3, Fig 4 and Fig 5) showed the scatter chart of bulk density vs. soil moisture of different age of inactive landslides of Phedikhola Rural Municipality. It showed the increasing value of soil moisture according to decreasing the ages of inactive landslide. The Karl Pearson correlation coefficient test was used to show the relationship between edaphic parameters such as soil moisture and bulk density. It was found to be significant at 0.05 level in all ages of naturally stabilized inactive landslides and 0.01 level in a planted inactive landslide with a strong negative correlation to each other.

Conclusion

The present study revealed the composition and regeneration status of vegetation that developed on landslide area as a process of succession in Bhatkhola and Setikhola sub-watersheds of Phedikhola Rural Municipality of Syangja district in western Nepal. Schima wallichi and Arundinella nepalensis were the principal tree and herb species present in the inactive landslides. The younger inactive landslide had higher herb richness. The older inactive landslide had higher sapling/adult tree density. Knowledge of abundant tree, shrub and herb species reveal the natural bioengineering species that develop on the harsh condition of climate and topography after the occurrence of landslide. There were many new regenerating species in younger inactive landslide. As the landslide get older there was high compaction of soil layer revealing high bulk density that infiltrates and hold less amount water. High compaction and less moisture support higher sapling/adult tree species richness. Simultaneously, less compaction and high moisture support higher herb species richness. The composition and regeneration status of vegetation depends on topography, climate and soil parameters. Hence, it can be said that there is a great role of soil parameters, aspect, topography and climate in determining the composition

of vegetation of an area. These vegetation established through natural phenomena influence the role in ecosystem as well as society. The ecosystem based adaptation could be a suitable solution for the maintenance of diversified species presence in inactive landslide areas.

Acknowledgements

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Assessment of Nature Guide's Perception Towards Biodiversity Conservation in Chitwan National Park Using Knowledge, Attitude and Practice (KAP) Approach

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Abstract

Nature guide, a fast-growing green sector with good exposure motivation and incentives acts as a prominent component in biodiversity conservation. Nature guide working in close association with nature and its component is excellent form of safeguarding biodiversity in the protected areas as well as providing job opportunities assisting in nation's economy. The study has tried to assess the present scenario of nature guides working in Chitwan National Park and their perception towards biodiversity conservation using Knowledge, Attitude and Practice (KAP) approach. Among the 1,319 individuals who have received nature guide training, only 43.79% of them have been found to renew the license but still the one who renew the license are not actively engaged in their profession. The nature guides were found to have good to moderate knowedge and practice scores (n= 100% and n= 96.66%, respectively) and positive attitude (n=99.16 %). Strong positive correlation was seen in between knowledge and practice (r= 0.621, p value= 0.000), weak positive correlation in between knowledge and attitude (r= 0.300, p value =0.001) and very weak positive correlation in between attitude and practice (r=0.090, p value= 0.328). Significant association between knowledge, attitude and practice scores highlights to strengthen nature guide's knowledge to develop optimistic attitude and promote good practices for biodiversity conservation.

Keywords: *Biological diversity, Conservation economy, KAP Survey*

Introduction

Nepal's incredible topography as a result of changes in eco-climatic condition caused by changes in elevation within short horizontal span has given rise to exemplary biological diversity (Kindlmann et. al., 2011). Although the country occupies 0.1 percent of the global area, it is unique and rich in terms of biodiversity as proven by presence of 3.2 percent and 1.1 percent of world's known flora and fauna respectively. Nepal, the biodiversity hotspot of the world has a total 23.39% of the country's land area being

officially protected as National Parks, Wildlife Reserves, Conservation Areas, Hunting Reserve and Buffer Zones (MoFE, 2018).

Ever since Nepal has been a party to Convention of Biological Diversity (CBD), the country has made remarkable and notable changes in biodiversity conservation. As biodiversity is directly connected to the economic wellbeing and livelihood of Nepalese, biodiversity conservation has been given much priority in the country which is evidenced by a large number of success stories from across the country within 25 years of time after country became party to CBD in 1994 (MoFE, 2018). This triumph in biodiversity conservation has only been possible due to conjoint effort of Government of Nepal, conservationists, citizen scientists, conservation dedicated people from local level (Community Based Anti-Poaching Unit (CBAPU), buffer zone committee and nature guides with hand in hand cooperation from local community.

In absence of local community support and active engagement, the conservation efforts always fail. Out of the large groups of local communities, nature guide has been considered as next dimension for conservation achievement. A nature guide is a person who explains the natural prosperity of a specific site to local or international visitors and provides information of different aspects of that specific site. This excellent form of safeguarding protected areas through engagement of youths is magnificent way to keep the youths occupied in the country through job opportunity which not only directly helps in biodiversity conservation but also assists in the nation's economy. Nature guide act as ambassador of the tourism sector who can effectively contribute in nation's Gross Domestic Product (GDP). Nature guide is fast growing green sector with good exposure, motivations and incentive (NTNC-BCC, 2019).

Nature guide has act as salient component in biodiversity conservation as they work close in association with nature and have closely observed nature from various aspects. A large number of tourists annually visit Nepal for diverse purpose among which wildlife adventure (jungle safari, elephant ride, jungle walk) remains one of the utmost target. Nature guides are trained to have basic to advanced level knowledge about nature, biodiversity conservation, wildlife, wildlife behavior, plants and birds. Besides this, they possess various characteristics including leadership quality, facilitator skills etc. The professional, knowledgeable, and communicational behavior of nature guides eases the national and international tourists during his/her works.

Biodiversity conservation is not only utmost part of sustainable development but also of research and policy making process (Mahanta and Das, 2012). Attitude and perception of community people living within or near the protected areas like forest areas and their dependency on such resources for livelihood ultimately makes difference to biodiversity

conservation (Ninan et al., 2007). For successful biodiversity conservation, engagement of community people is very important but sometimes this key component i.e. community people can be a major threat to biodiversity (Gemeda et al., 2016). Understanding local community knowledge, attitude and perception (KAP) towards conservation is a pre requisite for any conservation action (Ebua et al., 2011).

Along with finding the present scenario of nature guide in Chitwan National Park (CNP), the study also explores the relationship developed by nature guide with biodiversity conservation of CNP through assessing their knowledge, attitude and practices. The study is important because assessment of such perception in terms of knowledge, attitude and practices can help policy makers in formulation and implementation of action plans and projects related to conservation that need support from biodiversity dependent communities (Gillingham and Lee, 1999). Moreover, the result can be used as educational tool to assess effectiveness of the training programs conduced to produce nature guide as well as achieve positive conservation results.

Materials and Methods

Study Area

Chitwan National Park located at geographical coordinate between 83"87' to 84"74' East longitudes and 27"34' to 27"68' North latitude in inner Terai region was established in 1973 and covers Chitwan, Makwanpur, Nawalpur, Parasi and Parsa districts of Nepal. Initially CNP covered an area of 544km2 with 750 km2 buffer zone (DNPWC, 1997) which served the needs of the local community with supplement habitat area for wildlife (HMG, 2001). The establishment of Chitwan National Park provided baseline for the people committed in conservation which rapidly spread throughout the nation resulting in the present scenario of conservation. Currently CNP covers an area of 952.63km2 with 729.37 km2 buffer zone and is one of the most popular destinations for tourists from national as well as international level. Chitwan National park and associated areas is one of the best destinations for the nature-based tourism where one can have pleasure of seeing endangered and vulnerable species like One-horned rhinoceros *(Rhinoceros unicornis),* Bengal Tiger *(Panthera tigris tigris),* Asian Elephant *(Elephas maximus),* Gaur *(Bos gaurus),* Gharial *(Gavialis gangeticus),* Python *(Pythonidae),* South Asian River Dolphin *(Platanista gangetica),* Sloth bear *(Melursus ursinus)* etc. and endangered bird species like Great Hornbill *(Buceros bicornis),* Bengan Florican *(Houbaropsis bengalensis),* Lesser florican *(Sypheotides indicus)* etc.

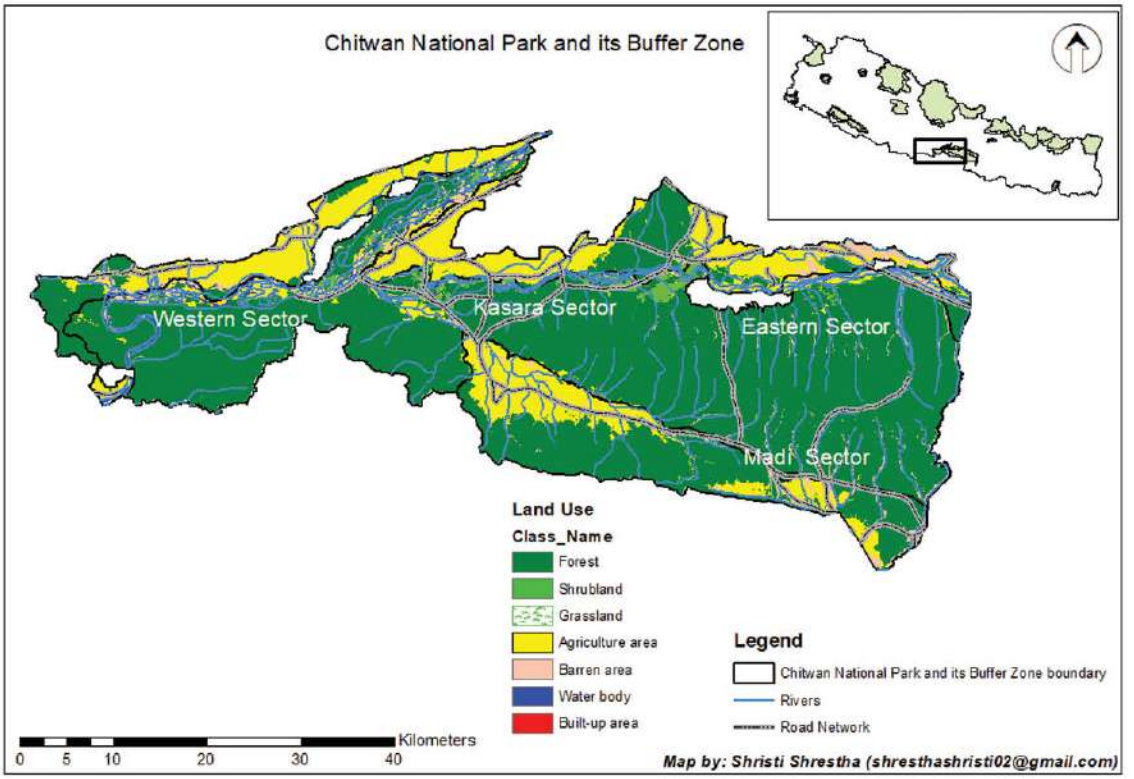


Figure 1. Study area

Respondent Sampling and Methods of Data Collection

During research, it was found that all the nature guide who renew their license were not fully working as nature guide. Therefore, 120 active nature guide were selected for the schedule survey. Respondents were selected based on the convenience sampling. Primary information was collected through KAP survey and focus group discussions (FGDs) (Rabiee, 2004). A total of 3 FGDs were carried out for this purpose. During this research, quantitative, qualitative and content analysis has been employed to gather all necessary information. The KAP survey was conducted by designing questionnaires which included information on nature guide's background, their knowledge, attitude and practices regarding environmental issues like importance of biodiversity conservation, loss of biodiversity, deforestation etc. in Chitwan National Park. Secondary information was collected from NTNC- BCC, CNP and Nature Guide Association (NGA).

Gumucio (2011) has considered knowledge, attitudes and practices (KAP) as a useful diagnostic tool in program evaluation. KAP studies are more cost effective and conserve resources than other social research methods as KAP is focussed and limited in the

scope (Eckman and Walker, 2008). KAP model suggests that knowledge about any practice determines how the person's attitude towards the behaviour then the attitude will display through the practices (Alzghoul and Abdullah, 2015). Here during the research, knowledge was considered to be the degree of understanding of nature guide on biodiversity conservation in Chitwan National Park. Attitude was considered to be a way of being: which referes to the feelings and perceptions of nature guide about the conservation activities. This is an intermediate variable between nature guide's knowledge of the biodiversity situation and their response to the situation. Practice was considered to be response of nature guide to a particular situation and refer how they demonstrate their knowlwdge and attitude through their action and behaviour.

Measures

Each correct answer, positive attitude and good/safe practice was scored 1 and incorrect answer, negative attitude and bad/unsafe practice was scored 0 points. An arbitrary system was used to classify scores: 0 to $< 50\%$ - poor, 50 to $< 75\%$ - moderate and $\geq 75\%$ - good scores. Attitude score of $\geq 50\%$ was taken as positive, and $< 50\%$ was taken as negative.

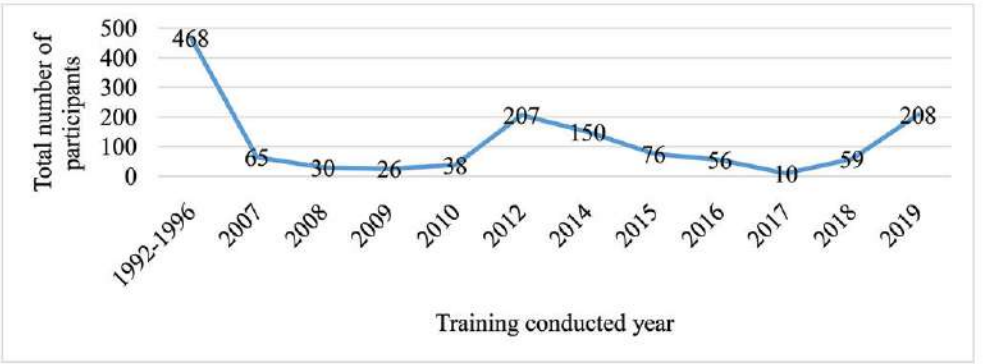
Statistical Analysis

Data analysis has been conducted through Statistical Package for Social Sciences (SPSS). All the neceessary inforamtion are presented in the form of bar graphs, pie charts and tables whereever necessary. Spearman correlation was done to determine relation between knowledge, attitude and practice. Bivariate analysis was done to determine the relationship between nature guide's knowledge, attitude and practice with different variables on biodiversity conservation in Chitwan National Park.

Results and Discussion

Present scenario of nature guide in Chitwan National Park

NTNC –BCC and CNP has been regularly providing nature guide training to youths from Chitwan and its surrounding areas. Other supporting organization to conduct the training successfully include Nepal Tourism Board, Buffer Zone Committee, Nature Guide Association and Local level government. Till now NTNC- BCC has given training to 1,393 people (Figure 2). Individual data from 1992 to 1996 was not found as the data was combined. Except that it was seen that in 2019, highest number of trainees has received the nature guide training and in 2017, lowest number of trainees has received the nature guide training.

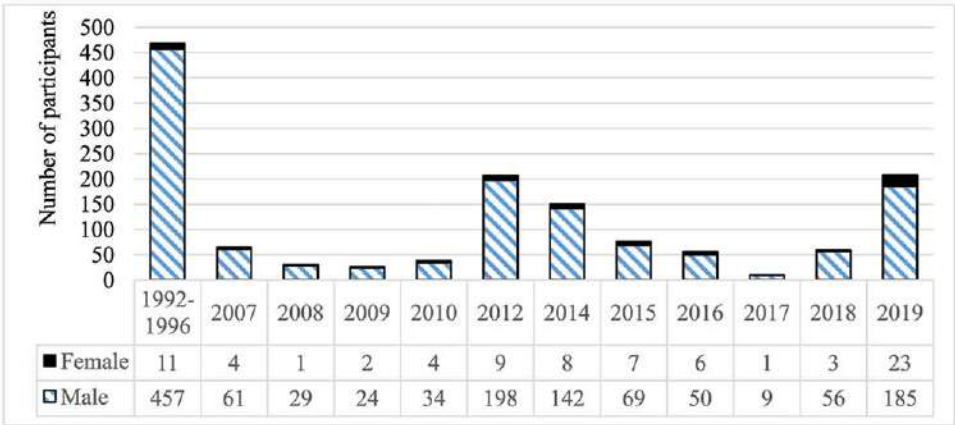


(Source : NTNC-BCC, 2020)

Figure 2: Graph showing total number of training participants

Higher number of males has received the training as compared to females (Figure 2). Though women in Nepal are not more negative towards biodiversity conservation and protected areas despite of having less knowledge regarding it (Carter and Allendorf, 2016), a smaller number of females are engaged as nature guide. A logical argument why a greater number of males have participated in the training might be due to the reason that the society in the developing countries is more patriarchal and women are considered to have traditional responsibilities as food growers, caretakers, and water and fuel gatherers.

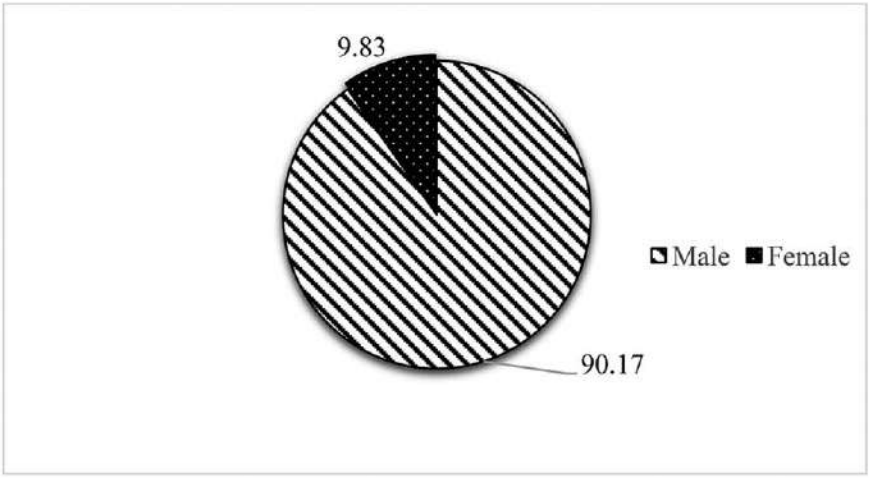
Among the 1,393 individuals (Figure 3) who received the training, a total of 610 trainees (43.79%) were found to renew their license but all of them were not actively engaged in nature guide profession. Among the trainee who timely renew license and work, 550 are male (90.17 %) and 60 are female (9.83%) (Figure 3).



	1992-1996	2007	2008	2009	2010	2012	2014	2015	2016	2017	2018	2019
Female	11	4	1	2	4	9	8	7	6	1	3	23
Male	457	61	29	24	34	198	142	69	50	9	56	185

(Source :NTNC-BCC, 2020)

Figure 3. Participation of people on training based on sex



(Source: NGA, 2020)

Figure 4: Actively working male and female population percentage

An interesting fact that has been observed was most of the female trainees are still working as nature guide while more than half of the male trainees have already left to work as nature guide.

Demographic Information

The demographic information regarding the age of the respondents reveals that about 85% of them were males and remaining 15% were females. The average age of the respondents varied from 19 to 64 years. All of the respondents were the permenent resident of the study area.

Education and occupation information (Table 1) revelas that nearly 12% of the respondents have received informal education, 30% have completed high school education level, 40% receiving higher secondary level and 22% with bachelors level of study. Besides working as nature guide, nearly 40% people were engaged in farming, 13% had hotel business, 22% were students and 37% were engaged in other occupations.

Nearly one third of the respondents have worked as nature guide for less than a year. But those working in between 1 to 5 years is nearly half of the respondents. Similarly, 20% of the respondents have worked in between 5 to 10 years and only 3% have worked for more than 10 years. The demographic profile of the sample is presented in the Table 1.

Table 1: Education and occupation information of the repondent

Variable	Subgroups	Percentage (%)
Age	16 to 29 years	65
	30 to 59 years	33.3
	60 years and above	1.7
Sex	Male	85
	Female	15
Education	Informal education	11.7
	High school	26.7
	Higher Secondary level	40
	Bachelors level	21.7
Occupation (except nature guide)	Farming	36.7
	Student	21.7
	Hotel business	13.3
	Others	36.7
Work experience	Less than 1 year	26.7
	1 to 5 years	50
	5 to 10 years	20
	More than 10 years	3.3

Field Visit, 2020

The work schedule of the nature guide has been presented in figures 5 and 6.

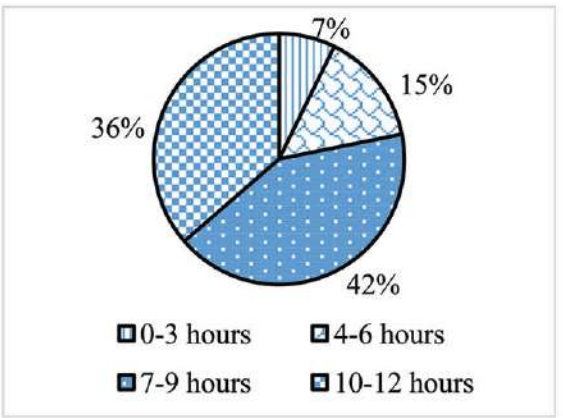


Figure 5. Working hours per day

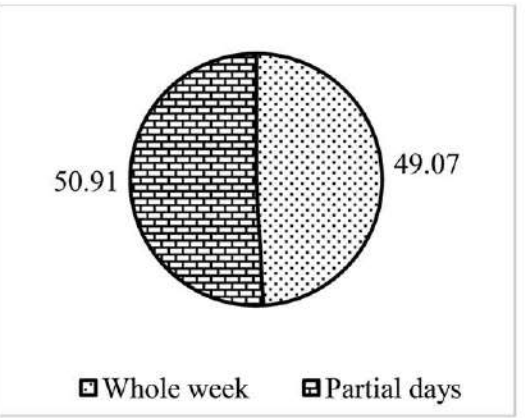


Figure 6. Working days per week

The distribution of knowledge, attitude and practice scores with obtained mean values are shown in table 2. The majority of the study sample showed good to moderate knowedge and practice scores (n= 100% and n= 96.66 % respectively) and positive attitude (n= 99.16 %).

The results of Spearman's correlation coefficient shows strong positive correlation between knowledge and practice (r= 0.621, *p value*= 0.000), weak positive correlation between knowledge and attitude (r= 0.300, *p value* =0.001) and very weak positive correlation in between attitude and practice (r=0.090, *p value*= 0.328) (Table 3).

Table 2: Knowledge, Attitude and Practice scores (N= 120).

Variables	Mean ± S.D	Good (%)	Moderate (%)	Poor (%)
Knowledge score	9.57±1.035	83.33	16.67	0
Attitude score	12.04±1.148	96.66	2.5	0.84
Practice score	5.89±1.242	64.16	32.5	3.34

Table 3: Analysis of KAP Scores using Spearman's Correlation Coefficient

Variables	Correlation	Knowledge	Attitude	Practice
Knowledge	Coefficient (r)	1.00	0.300**	0.621**
	p value		0.001	0.000
Attitude	Coefficient (r)	0.300**	1.000	0.090
	p value	0.001		0.328
Practice	Coefficient (r)	0.621**	0.090	1.000
	p value	0.000	0.328	

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

Bivariate analysis

Knowledge Score

Higher mean knowledge score was found in male as compared to female *(p value*= 0.301) and score was high within the age group of 30-59 years *(p value*= 0.994) (Table 4). Similarly the one with work experience 1-5 years and 5-10 years have had high mean knowledge score *(p value*= 0.942) and education level upto bachelor was found to have high mean knowledge score *(p value*= 0.958) (Table 4). A logical statement why these particular group had high mean knowledege score might be due to the reason that most of the participants were male and also the age group 30-59 contain energetic and active youths who try to keep all the possible information from various sources. Similar might be the reason with the working group 1-5 years and 5-10 years which mostly consist of active youths who try to update themselves with the latest news, new species found,

scientific names and many more. The one with experience more than 10 years seems to belong to age group more than 60 and have informal education which makes them a little difficult to grab the information with the updated technologies.

Attitude Score

Higher mean attitude score was found in males *(p value*= 0.029) and within the age group of 30-59 *(p value*= 0.670). Similarly, those who had work experience in between 5-10 years *(p value*= 0.39) and the one who had completed Intermediate education *(p value*= 0.772) had higher mean attitude score (Table 4).

Table 4: Bivariate analysis of different variables with KAP Scores

Variables	**Knowledge (Mean ± S.D)**	**Attitude (Mean ± S.D)**	**Practice (Mean ± S.D)**
Sex			
Male	9.61±1.055	12.14±1.025	5.85±1.254
Female	9.33±0.907	11.50±1.618	6.11±1.183
p-value	0.301	0.029	0.419
Age			
16-29	9.56±1.001	11.97±1.151	5.95±1.247
30-59	9.58±1.130	12.18±1.174	5.75±1.256
60 above	9.50±0.707	12±0.000	6.5±0.707
p-value	0.994	0.670	0.563
Work experience			
<1 year	9.56±0.948	11.81±1.378	6.19±1.120
1-5 years	9.58±1.094	12.13±0.911	5.77±1.240
5-10 years	9.58±1.060	12.33±1.090	5.83±1.308
> 10 years	9.25±0.957	10.75±1.893	5.75±1.893
p-value	0.942	0.39	0.475
Education			
Informal education	9.43±0.938	11.79±1.311	6.07±1.328
SLC/ SEE	9.56±1.076	12.09±0.928	5.88±1.185
Plus 2 or equivalent	9.60±1.106	12.13±1.282	6.00±1.149
Bachelor level	9.58±0.945	11.96±1.076	5.62±1.444
p-value	0.958	0.772	0.588

Practice Score

High mean practice score was not found in male. It was found in female *(p value=* 0.419). Also, the age group 60 plus had high mean practice score. The one with work experience less than a year had high mean practice score *(p value=* 0.475) and the one with informal education had high mean practice *(p value=* 6.07) (Table 4).

To the best of our understanding, this is the first KAP study regarding biodiversity conservation done among nature guides in Chitwan National Park. The study revealed that the extent of understanding, viewpoint and the way knowledge and viewpoint is applied varies from person to person based on the various factors. Majortiy of the nature guide had moderate to good knowledge and practice score (n=100% and n=96.66% respectively) and positive attitude (n= 99.16 %) towards biodiversity conservation. Comparing the results with the similar kind of researches conducted around the world revealed that majority of the respondents were relatively knowledgeable on issues like environmental/biodiversity conservation and had positive perceptions about components of biodiversity like wildlife (Kioko and Kiringe, 2010). Fenetahun and Eshetu (2018) found that the one with education level upto 10 had limited knowledge and perception in biodiversity and conservation which is similar to our finding where knowledge and practice score has been found less in the SLC/SEE groups as compared to its higher education.

The respondents had knowledge on biodiversity related to Chitwan National Park and were engaged in river cleaning, fireline maintainance, solid waste management campaign, human wildlife conflict awareness etc. As nature guide reach to diverse part of the forest, they witness various activities in the forest which some of them immediately share with the concerned authorities. The information sharing included mostly reporting dead and injured wildlife (mostly Rhinoceros unicornis, Panthera tigris tigris, Elephas maximus, Gavialis gangeticus etc.), illegal felling of trees and timbers, wild mammals movemnt and behaviour, illegal fishing and gharial hunting etc. In case of birds with minor injuries, they have been found to rescue in their natural habitat. Positive correlation was seen between knowledge and practice (r= 0.621, p value= 0.000), knowledge and attitude (r= 0.300, p value =0.001) and attitude and practice (r=0.090, p value= 0.328). The right knowledge along with right attitude eventually leads to good practices. The finding emphasizes on need to improve more on knowledge which eventually develops positive attitude and good practice measures.

Conclusion

Biodiversity loss mainly occurs by lack of knowledge and perception/ attitude of community people towards biodiversity conservation. To solve biodiversity conservation related issues community people/ youths who are actively engaged in nature conservation works stand as pillar and play important role in bringing positive changes. The nature guides working in Chitwan National Park had good to moderate knowledge and practice scores with positive attitude towards biodiversity conservation. Significant association between knowledge, attitude and practice scores highlights to strengthen nature guide's knowledge to develop optimistic attitude and promote good practices for biodiversity conservation.

Acknowledgements

The authors are highly grateful to all the respondents and NGA for their prompt response and active participation during survey.

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An Assessment of Soil Fertility Management Practices in Carrot Farming of Jurikhet Village, Makwanpur

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Abstract

With the rapid urbanization and population growth, the demand for vegetables is increasing day by day. It is forcing farmers to cultivate more in expenses of soil fertility. This study aims to assess soil fertility management practices in carrot farming in Jurikhet village, Makwanpur. A questionnaire survey with 40 farmers, two focused group discussions, and eight key informant interviews were conducted for data collection. The majority of the farmers used only FYM before sowing, followed by urea/ DAP, vermicompost and self-prepared compost manure. Most of the farmers (92%) use chemical fertilizer; and growth hormones like giberallic acid, boron to make carrot big and strong so that it doesn't get cracked. They use hexaconajol pesticides once in the season to protect the crop from pest attacks. Lack of knowledge on handling and disposal of fertilizer and pesticides threatened degradation of soil and water quality in and outside the farm. Only a few farmers use vegetative measures to control the pest and diseases. Thus study recommends there is a need for effective extension services for sustainable production and economic benefits from carrot farming.

Keywords: *Carrot, Soil Fertility, Commercial farming, Jurikhet, Makwanpur*

Introduction

Subsistence agriculture, mainly traditional agriculture, is the main source of occupation and livelihood strategy for the majority of Nepali people. With the urbanization and health consciousness of the people, the demand for vegetables has increased over the years (Tamang et al., 2014). To fulfill the increasing demand, the mode of farming is now changing from subsistence farming to commercial farming (Shrestha et al., 2018) where farmers produce vegetables not only for own consumption but also to sell in the market thereby improving their livelihoods (Shrestha & Karki, 2017). It has a great significance in improving the overall living standard of small farmers, through increased income and vegetable share in their diet (Acharya & Kafle, 2018).

Vegetable farming have high prospects of commercialization in order to enhance productivity in agriculture sector. Short growing cycle of vegetable and some what easy market availability compared to other agricultural product results vegetable farming as a good choice to the small-scale farmers for commercialization (Sapkota, 2004). Vegetable farming has been growing rapidly in recent years (CASA, 2020) as Government of Nepal has declared different pocket areas to get more benefit from vegetable farming. The area and production of vegetable has increased from merely 161048 ha. in 2001/02 to 244102 ha. in 2010/11 and production has raised from 1738086 MT to 3203563 MT respectively (Gurung et al., 2016). Nearly 15.2% of vegetable growers are considered commercial vegetable growers and only 4.3% vegetable growers perceive vegetable farming as their main source of income. The commercialization rate of vegetable sub sector is still low compared with livestock sub-sector specialized in milk and meat production (Ministry of Agricultural Development, 2016).

Vegetable farming has become an important part of agriculture in the surrounding cities (De Zeeuw et al., 2011) and a regular income source for farmers practicing agriculture even in a small plot of land (Bhatta & Doppler, 2010). It emerges as an important source of living for farmers near to cities area, especially those who have been migrated from different parts of the country in search of better livelihood (Rai et al., 2019) as vegetable farming provide almost 5 to 10 times higher economic returns per hectare than the traditional cereals (Gurung et al., 2016).

Vegetable farming also has different opportunities and constraints (Gurung et al., 2016). As vegetables are generally susceptible to a wide range of pests and diseases, it requires intensive effort in their management. The increased demand for food, particularly to feed the growing urban population, has necessitated an expansion and intensification of agriculture and horticulture and a concomitant increase in the use of synthetic pesticides for food production, particularly for the production of high-value cash crops and vegetables. According to CBS (2019), pesticides import in Nepal has increased from 404 tons in 2012 to 635 tons in 2018 where vegetable farming consume about 80% of the imported pesticides (Adhikari, 2017). Around 91% of commercial vegetable farmer are using pesticides and chemical fertilizers (Joshi and Piya, 2021). Similarly, the pesticide application rate is rising by 10-20% per year (Khanal and Singh, 2016). The average use of pesticide was 142g/ha (Shrestha et al., 2002), which increased to 396g/ha in 2014 (PPD, 2014). However, a much higher rate 1600g/ha is used in commercial vegetable production like Sarlahi, Kavre, Dhading and Tishtung, Palung of Makwanpur District and some other districts of Terai area. Previous studies have shown that misuse and overuse of pesticides occur in vegetable farming (Atreya et al., 2011; Chhetri et al., 2014) posing a serious risk to ecosystems (Bhandari et al., 2021, Dey, 2010) and human health due to consumption of vegetable (Bhandari et al., 2019). Farmers are getting exposed to pesticide hazards from the misuse and unsafe handling of pesticides which

have a long-term impact on the environment and human life (Pimental, 2005; Sharma et al., 2012). However, a greater proportion of farmers are unaware of pesticide types, poison level, safety precautions, and pesticide effects on health and the environment.

The high demand for vegetables in the market has forced the farmer to cultivate in more area and quantity in the expenses of soil fertility and proper water management. Farmers also lack appropriate technologies such as proper soil management practices (Tripathi, 2019) and pest management alternatives to chemical pesticides (Paudel et al., 2016; Rasul et al., 2019) impending its growth. Due to crop intensification and intensive tillage practices in vegetable farming, depletion of soil organic matter and soil loss due to soil erosion are growing (Paudel et al., 2016). Long time and imbalance use of chemical fertilizers and pesticides lead to declining yields and deteriorating physical quality of soils (Bajracharya and Sherchan, 2009). It consequently degrades the soil and water quality. There is increasing demand in improving soil health and production. Thus, this study tries to access soil management practices adopted by carrot farmers to maintain soil health and ensure sustainable production.

Materials and Methods

The study was carried out in Jurikhet village (pocket area for carrot production) ward no.6 of Bhimphedi rural municipality, Makawanpur district. It is located 30 km North-East from Hetauda on the way to Kathmandu. The altitude of this village ranges from 1100 metres to 1860 metres from the mean sea level. Altogether 40 households reside in the village and have been growing carrots instead of their usual crops viz. maize, millet and beans because of high returns rom the carrot. Carrot farming was introduced in the village around 21 years ago.

Both qualitative and quantitative research methods were used in this study. Primary data was collected through Participatory Rural Appraisal tools. For this, household questionnaire survey was conducted with all the 40 households engaged in carrot farming and two focused group discussions were conducted with female farmers. Also, eight key informant interviews were conducted with a pioneer farmer, current lead farmers, lead local sellers, DADO officer, agrovet owner at Hetauda etc. Research tools tried to capture the soil and water management measures adopted in carrot farming in relation to changing socio-economic and environmental conditions in the study area. Processing and analysis of quantitative data were done using SPSS; frequency, percentage, cross-tab were used and the results was presented in the form of tables, pie charts and bar diagrams. Qualitative and unstructured questions were logically interpreted and presented in descriptive form. Secondary data was collected from relevant journals, published and unpublished reports from concerned Government and Non-Government organizations.

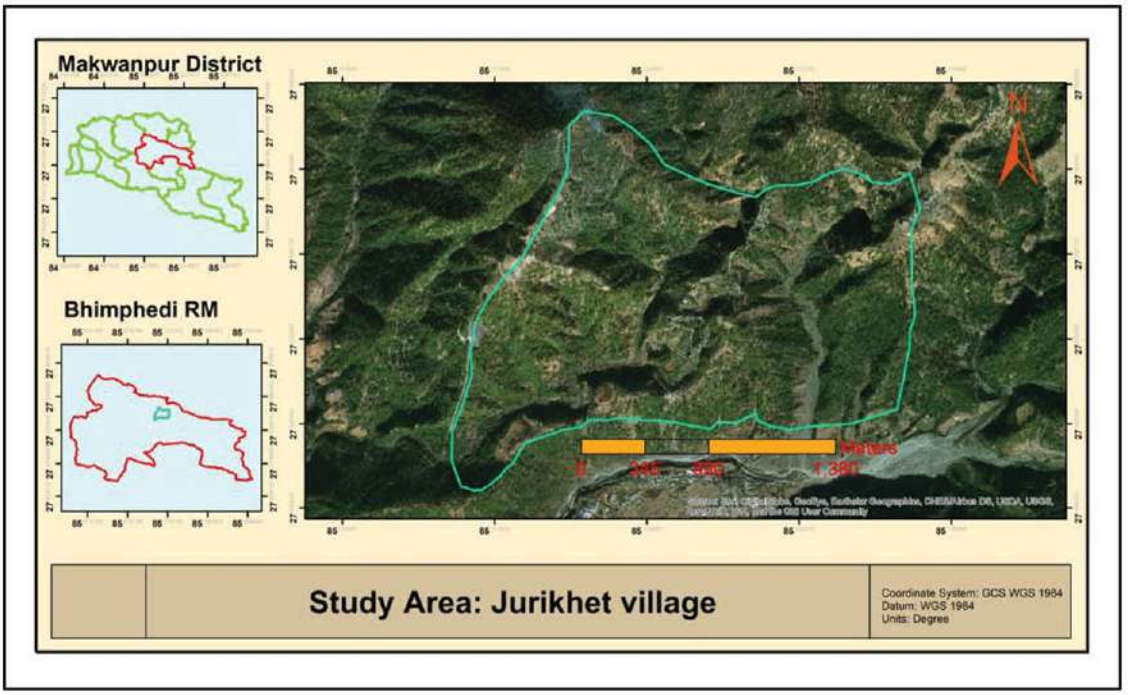

Figure 1: Location map of the study area

Results and Discussion

Socio-demographic characteristics of respondents

Various socio-demographic characteristics of the respondents such as gender, ethnicity, age, family size, household head, educational level, family occupation, farm size, household income in one season cropping were analysed/measured and then categorized. The frequency distribution of such information of the respondents has been presented in Table 1.

Table 1: Respondent profile

Social Categories			
Gender (%)		**Educational level**	
Male	9(22.5)	Illiterate	12(30)
Female	31(77.5)	Literate	13(32.5)
Ethnicity		Primary	9(22.5)
Chhetri	1(2.5)	Secondary	5(12.5)
Newar	4(10)	Higher secondary	1(2.5)

Tamang	3(7.5)		**Family occupation**	
Rai	1(2.5)		Agriculture only	14(35)
Magar	31(77.5)		Agriculture and business	4(10)
Age			Agriculture and services	2(5)
30 to 60 years	36(90)		Agriculture and outside employment	20(50)
> 60 years	4(10)		**Farm size**	
Family size			< 5 katha	12(30)
1 to 5	33(82.5)		5 to 10 katha	16(40)
6 to 10	7(17.5)		11 to 15 katha	11(27.5)
Household heads			> 15 katha	1(2.5)
Male	35(87.5)		**Household income in one season**	
Female	5(12.5)		< 50,000	6(15)
			50,000 to 100,000	25(62.5)
Note: Figure in parentheses indicates percentage			>100,000	9(22.5)
			Average: Rs. 90,000 Maximum: Rs. 400,000 Minimum: Rs. 25,000	

Jurikhet village is dominated by ethnic community, Magar where agriculture and employment outside the village are the major source of income of the respondents. Respondents have been engaged in commercial carrot farming from the last 2 decades. About 1/4th of them started farming after attending carrot farming training organized by the extension workers. Mostly male farmers had participated in such training. Rest followed their innovative neighbor footsteps while some just continued the family business but nearly 22% of respondents were motivated by extension officers for commercial farming.

Land holding is also a major component for the vegetable production in Nepalese agriclulture where small landholders and marginal farmers predominate with their average land holding size of 0.8 hectare and average area under vegetable crops per holding is 0.07 hectares (i.e., 1.4 ropani or 2.1 kattha). In the study area, more than 70% of farmers have less than 10 katha of land (0.33 hectare). And average household income of vegetable farmers in one cropping season is NRs. 90000 in study area.

Livestock

Farmers have been practicing vegetable farming along with small number of livestock as mixed agriculture-livestock based livelihood benefit the farmer and their field. Around 77% of the farmers rear livestock, mostly cows, buffaloes, goats and chickens.

Table 2: Average number of livestock per household before and now

Livestock type	LSU 5 years ago	LSU now
Cow	1.825	0.387
Buffalo	0.2	0.012
Goat	1.4	0.725

LSU: Livestock unit; Conversion factor: Cow (0.5), Buffalo (0.5), Goat (0.1)
(Source: Field Survey)

Table 2 reveals that the trend of livestock rearing has decreased as compared to 5 years ago. The livestock units have decreased for each of the domestic animals. But in the case of chickens/poultry, the trend is different. During FGD, participants reported that the decrement of livestock is due to diseases and lack of manpower. In the study site, about 60 percent of the household have one or more family members living outside of the house for either earning or study purposes. Along with this, increased interest of farmers in carrot farming is also stated as a reason for the decrease in livestock rearing. Another reason for having livestock is to get Farm Yard manure (FYM) for farming as FYM forms an integral part of soil fertility management for remote areas.

Soil and water management practices in commercial carrot farming

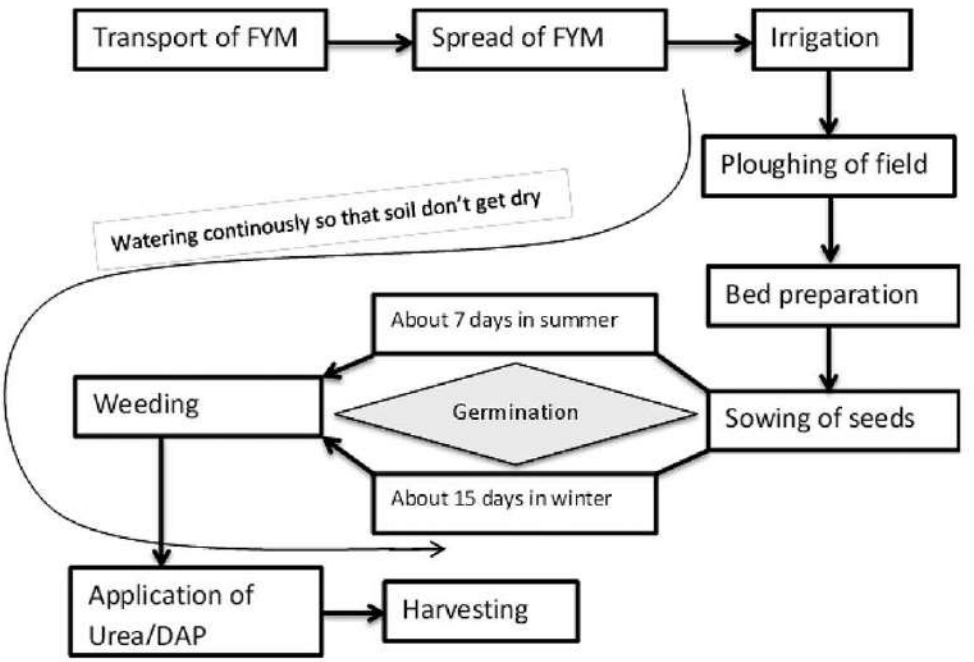

Figure 2: General steps of soil and water management in carrot farming

Soil management for the new season starts with transporting and spreading FYM to the field. More than 90 percent of the respondents transport FYM through bamboo baskets (doko) and make small heaps per basket. About 68 percent of farmers use only FYM before sowing, followed by 15 percent using FYM and urea/DAP. Along with this, 12% of farmers also use vermicompost manure, and self-prepared Compost Manure (CM) along with FYM and only 5% use all three fertilizers. After FYM is spread, about 65 percent of respondents irrigate the field just to make it moist. Most of the farmers (85%) use handheld tractor to plough their field and rest still use ox mostly in Gadeli height area. Most of the farmers use manual instruments like Kodalo, Chaade, Kodaali etc. to prepare a bed for sowing.

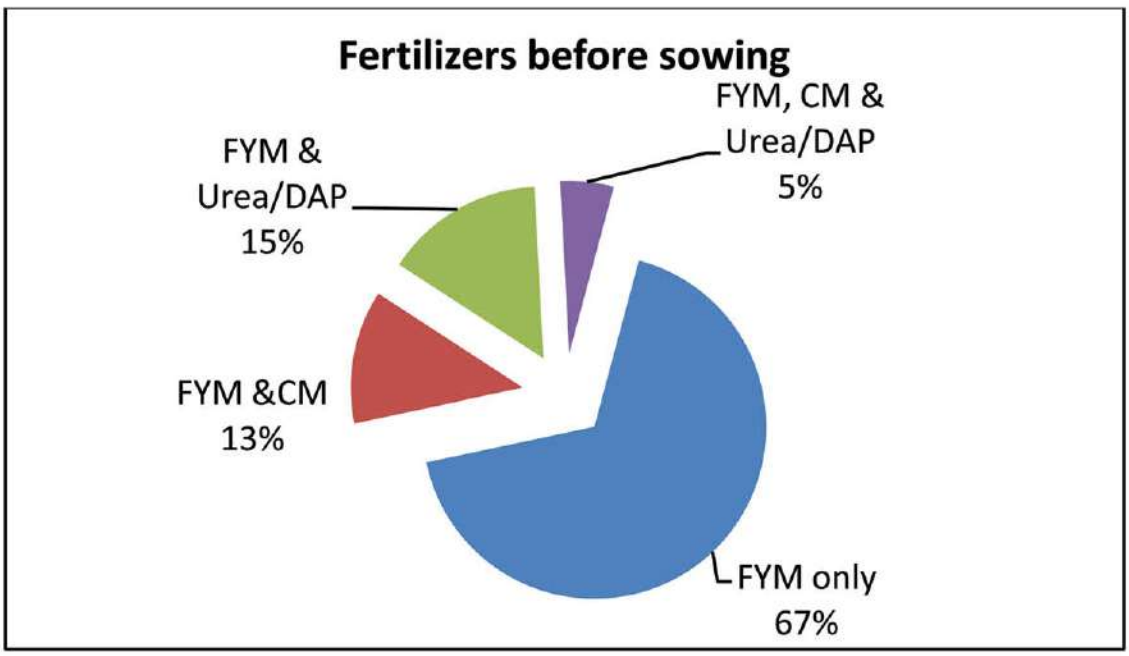

Figure 3: Fertilizers used before sowing

Sowing is done in line to line (row to row) pattern. About 1.5 inches to 2 inches depth is dug in a line using available instruments and sown accordingly. The distance between the two lines is 6 to 8 inches. The length of the bed varies according to the breadth of the terrace. The height of the bed was seen 6 to 8 inches during the field visit. According to the expert, the depth of sowing should be up to 3 inches, and line to line distance should be 6 to 8 inches. Also, it would be better if the seed is first soaked in water for one day and then sown. But none of the farmers reported soaking of seeds before sowing in the village.

Farmers generally cultivate two varieties of carrots. They are open-pollinated (OP)

and hybrid. Curoda, New Kuroda, Tokita etc., comes under OP and Sigma, Nantis etc., comes under hybrid variety. OP seeds are those which are improvised than local but not as good as a hybrid one. Hybrid are expensive than OP. The carrot of OP variety is generally yellowish, and the carrot of hybrid variety is generally bigger and reddish in colour. KI reported about 300 gm seed is required to sow for one katha of land. But on average, farmers use only 200 gm/katha in Jurikhet.

The germination period of carrots varies according to the season. In Jurikhet, in summer, it takes 7 to 10 days, and in winter, it takes 15 to 20 days to germinate. After the growth of the plant, about 80 percent of the farmers generally perform first weeding and thinning in 21 to 30 days intervals. Generally, weeding is performed manually using locally available instruments like kutto, kotaare etc., as needed. Generally, 2 to 3 times weeding is necessary for one season as per the appearance of weeds. Fifty percent of respondents preferred two times weeding, and the other 50 percent performs three times. Some of the weeds that generally appear and disturb the growth of carrots are:

Table 3: List of weeds

SN	Local name	Botanical name
1	Chitlange	Galinsoga parviflora
2	Banso	Eragrostis unioloides
3	Mothe	Cyperus difformis
4	Siruu	Imperata cylindrica
5	Dooboo	Cynodon dactylon
6	Chari amilo	Oxalis corniculata
7	Boke jhaar/Ganaune jhaar	Ageratum conyzoides
8	Lahare (Raato lahare)	Euphorbia hirta
9	Kuro	NA
10	Pothe	NA
11	Kodey jhaar	NA
12	Chane	NA

According to the respondents, these weeds disturb the growth of carrots by competing for nutrients, covering the carrots and inviting other insects. Seventy-five percent of respondents claimed that new weeds have been appearing in the area and might be induced due to seeds and chemical fertilizers. Along with the weeds, different kinds of pests and insects also attack carrots. About 77 percent of respondent observe different kinds of pest and insects. Some of the local names of insects and pest as recorded by respondents are:

Table 4: Insects and pests

SN	Local name	English name
1	Khumre kiraa	White grub
2	Lai kiraa	Aphid
3	Patero	Bug
4	Raato kamilo	Red ant
5	Dhaarke	Flea beetle
6	Jhusil kira	Larvae
7	Suire kiraa	NA
8	Dhamiraa	Termites

Exposure to pesticides is one of the most important occupational risks among farmer in developing countries (Bhandari et al., 2019). To protect carrot farms from pest attacks, about 80 percent of farmers use pesticides once in the season. According to KI at agrovet, most farmers use Hexaconajol for pest control, used in a ratio of 16L water and 30ml pesticides. Most of the farmers (92%) use chemical fertilizer after the first weeding. Most of them (78%) use urea only. And few use (3%) DAP only, and 5% use both Urea and DAP as well. They use, on average, one kg of urea/DAP/katha of farmland. According to experts, it is normal to use one kg of chemical fertilizer in one katha of land. But in the case of carrot farming, chemical fertilizers aren't necessary as FYM is enough for its growth. Along with the fertilizers, KI informed farmers also use growth hormones like giberallic acid, boron to make carrot big and strong so that they don't get cracked.

About 50 percent of farmers responded that carrot becomes ready to harvest in 90 to 100 days and rest reported 100 to 120 days, according to the field location. According to experts, it usually becomes ready to harvest within 3 months of sowing. All farmers harvest carrot manually when the soil is moist. From the period of sowing to harvesting, water is continuously applied through sprinkles. Most of the farmers irrigate the field in 2 days intervals at the rate of 1 hour at a time in one place.

Post harvesting

After harvesting, mostly farmers clean the carrot in the field. Crop residues are mostly fed to livestock; some use it for mulching and manuring as well. There is no storage facility available in the village. So, they pack it in the sack and bring it home for local selling or directly send it to the city market through the public vehicle. Generally, the harvested carrot is sold within one day. Also, some farmers along small roadside hotels offer carrot juice, which is a popular drink among passengers traveling along the Khulekhani-Hetauda road section.

Soil fertility management practices in carrot farming

Systematic collection and use of cattle urine

Cattle urine could be a major source of Nitrogen and an alternative to urea for vegetables and other cash crops. For a systematic collection of urine, the structure of the cattle shed need to be improved with a gently sloped floor. The floor is made as impermeable as possible using the available resources, e.g., stone slab, clay, cement, with a shallow gully to channelize urine to a collection pit. In Jurikhet, only 37 percent of the households practice a systematic collection of livestock urine. Farmers improved the shed by digging a hole and made it permeable by using sand. It helped efficient collection of urine, minimizes nitrogen volatilization and reduces loss of its fertilizer value. Collected urine after around three weeks of storage for decomposition is used as liquid fertilizer, particularly instead of urea in cash crops (Shrestha et al., 2014). Farmers had attained training organized by different agencies in the village and acquired knowledge on urine collection. About 20 percent of trained people use collected urine in carrot farming instead of Urea or DAP after weeding based on training knowledge.

Use of urine-based botanical pesticides

Around 20 percent of the farmers use local vegetative measures to control the pest and insects disturbing carrot growth. They use asuro (Justicia adhatoda), titepati (Artemisia vulgaris), banmaaraa (Eupatorium adenophorum), neem (Azidirachta indica) powder, chiuri cake brought from agrovet and livestock urine. Also, few use IPM technology. During FGD, it was reported that most of the farmer uses the biopesticides which they were taught during training. They use these vegetative measures only when pest arises, and they don't have time to go to the market to buy the chemical pesticides.

Urine-based botanical pesticide is effective in managing several insect pests with no or minimal damage to the local agro-ecosystem. These botanical pesticides often have to ameliorate effect on the plant-soil environment and beneficial organisms, supplying several essential nutrients and adding organic matter to the soil, and acting as a plant tonic (i.e., cattle urine can contain up to 1% nitrogen), enhancing better crop growth and production, especially in a stressful situation. It also reduces expenditure on the application of chemical pesticides (Bishwakarma et al ., 2014). Among those farmers who used biopesticides instead of chemical pesticides, half of them reported an increment in carrot production in that season compared to the earlier season, and the rest reported no change in the production.

Crop residue management

In Jurikhet, most of the farmer uses crop residues to feed the livestock. Some of them use it for mulching and making compost manure in their field. Compost is generally

prepared in the field and is an appropriate technology for those farmers who owe no or less livestock and/or whose farmland is very far to transport FYM. Along with reducing the farmers' production cost application of composting and mulching improves SOM and soil nutrient level. Generally, crop residues of the rainy season are used to mulch or prepare compost manure because livestock doesn't eat those residues in the rainy season. Mulching helps to add organic matter to the soil and increase the production capacity of the soil, decreasing the use of more chemical fertilizers. Though 50 percent of the farmers use compost manure in their field, only 37 percent of them prepare themself using household wastage and crop residues, and the rest of the farmers buy vermicompost manure from the agrovet.

Cropping system and leguminous plant

In Jurikhet, farmers practice crop rotation along with inter-cropping, mixed cropping. Mainly farmers practice two-season carrots, i.e., Bhadra (Aug/Sep) to Mangsir (Nov/Dec) and Falgun (Feb/March) to Asar (Jun/July) and one season maize in the mid-time. According to KI, the root penetration depth of maize and carrot is different. So, soil nutrient is properly utilized by the plant. In the spring season, more than 90 percent of the farm area is cultivated with carrots. Almost all the farmers adopt crop rotation and mix cropping in their field. Mix cropping isn't performed with carrots as it might disturb the maximum growth and production of the carrot. And mainly the crops cultivated in rotation are maize, cabbage, cauliflower, coriander, garlic, spinach, leguminous plants, bean, pea, cowpea, soybean, lentil etc. are included in the cropping system in several ways: mixed or relay cropping system with cereals, vegetables as grain, vegetables for household consumption and generating additional cash income, soil improver, cover and green manuring crop, and as a forage crop to improve livestock nutrition. Legumes can withstand adverse climatic conditions (e.g., drought) and incidence of insect pests and disease(Shrestha et al., 2014). More than 82 percent of the farmers cultivate leguminous plants in their field.

Soil fertility test and experience

Soil health is important determinant of quality and quantity of food production (Bhandari et al., 2021). In Jurikhet village, the majority of farmers (58%) have done soil fertility tests. Among them, 60 percent of them have done soil tests just one time till now, and the rest had their soil tested once a year. It is recommended that soil and water quality analysis should be done prior to carrot farming. This will ensure the status of pH is taken into account, thereby reducing fertilizer waste and eliminating the risk of oversupply and possible risk of fertilizer burn of the crop. Most of them have done soil tests when a technician comes to visit the village, and 22% have done soil tests in a government soil test lab. According to the expert, the soil of Jurikhet is so fertile, full of OMs, and is suitable for the production of the carrot. So, serious treatment isn't needed for the soil.

But, when farmers are queried about their perception of the soil fertility loss, 35% of them reported loss in soil fertility in recent years resulting decrease in carrot production.

Management of inorganic farm wastage

When farmers are queried about inorganic farm wastage including chemical fertilizers sacks, pesticides bottles, and others that don't get decayed, about half of the farmers reported they throw out the wastage randomly, and about 47% burn the waste. And very few, only 5% reported they reuse the things that are reusable. It shows that most farmers are not concerned about the potential impact of their behavior in degradation of soil and water quality, and ultimately posing adverse impacts on the environment and human health.

Trend of using chemicals and production of carrot

From the questionnaire survey, it was reported that 57% of the farmers perceive that the use of chemical fertilizer increases the fertility of the soil. Table 5 shows that the maximum of the respondent said the trend of production of the carrot is the same and equal frequencies of respondent claimed that the use of chemical fertilizer is increasing as well as decreasing the production. But majority of the respondents who have an increasing trend of using chemicals reported to have decreasing trend of production. Majority of respondents who have been decreasing the use of chemicals still have the same trend of production. And majority of the respondents who uses the chemicals in the same trend as previous have the same trend of production as well.

Table 5: Trend of using chemicals and carrot production

The trend of using chemical fertilizer	The trend of carrot production				Total
	Increasing	Decreasing	Same	Don't know	
Increasing	2	7	3	0	12
Decreasing	3	1	8	0	12
Same	4	0	7	0	11
Don't know	0	0	3	2	5
Total	**9**	**8**	**21**	**2**	**40**

Water supply and management

Affordable irrigation is the first step to wealth creation for poor rural farmers (Upadhyay et al., 2005). Farmers have perceived a significant change in rainfall pattern with either a complete lack of or late occurrence of winter rain and more intense but less frequent rain in summer (SSMP, 2010). But in Jurikhet, all of the households are benefited from the water supply through pipeline from distant rivers. Most of them, about 70%, have had provision of water in a group, and 30% of them laid their private pipeline from

river source to house. They are practicing this system of water supply since 1996. From FGD, it was reported that people getting water from the community water supply, invest less than NRs 10,000 at the beginning of the supply system, whereas farmers who are using private water supply system cost about NRs. 70,000 to 90,000 each household. The local government had support villagers to initiate community water supply by providing the required pipe at the beginning. Currently, the community water supply is managed by collecting NRs. 50/HH per month for maintenance of water supply system. All the farmers use a sprinkling system of irrigation in the field. The water supply in the village has no problem to date, and farmers perceived there is no effect of climate change in water availability in the village. None of the farmers have constructed a water conservation pond in the village.

Water management

The Table 6 shows the cross-tabulation result of the interval of water supply and time of water supply in the carrot field by the farmers. It is revealed that most of the respondents (15) supply water to their field once in two days, and they supply for about 1 hour at a time in one place. Similarly, 28 respondents supply water to their field at the rate of about 1 hour at a time. The cross-tabulation shows that most of the respondents supply water once in two days and about one hour at a time. This practice matches with the expert opinion, as the carrot field required continuous moisture in the soil so that soil does not get dry out.

Table 6: Water supply system observed in the study area

Interval of water supply	Respondents			Total
	about 1 hour	about 1.5 hour	about half an hour	
Once a day	8	1	3	12
Once in two days	15	0	0	15
Once in three days	5	7	1	13
Total	**28**	**8**	**4**	**40**

Conclusion

In Jurikhet, farmers have long experience of carrot farming and they pay great attention towards its commercialization because of favourable climate, soil and easy access to market. Vegetable farming is labour intensive where almost all the farming activities are carried out manually. They apply FYM along with vermicompost manure for bed preparation, and after first weeding, 92% of farmer apply chemical fertilizer like urea/DAP in the field and growth hormones. Few farmers have realized soil fertility

is declining compared to past decades. Lack of knowledge on pesticides handling and disposal threatened degradation of soil and water quality in and outside the farm. Only a few farmers use vegetative measures to control the pest and disease. However, majority of farmer are constrained by a low literacy, low rates of technology adoption, and an inefficient use of resources. Study recommends that there is a need of effective extension services for technical assistance on farming practices, fertilizer and pesticides application, facilitation in the accessibility to finance, market and improved seeds for sustainable production and economic benefits from carrot farming in Jurikhet village.

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Cumulative Impact Assessment of Hospitals: A Study in Two Major Cities of Nepal, Biratnagar and Janakpur

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Abstract

This study focuses on the status of healthcare waste management in hospitals and its cumulative impact. Biratnagar and Janakpur were selected for the purpose of the study. The study was conducted in 2016 and partially in 2017. For the study, nine hospitals were randomly sampled in Janakpur whereas eight hospitals in Biratnagar. Questionnaire was provided to each hospital for filling up the waste inventory of the hospital. Wastewater sample from the release point of hospitals was collected. Biological Oxygen Demand, Chemical Oxygen Demand, Mercury, total Chromium, Total Suspended Solids, Total Dissolved Solids, Phenolic Compound, Oil and grease and Total Residual Chlorine was analyzed. Biological Oxygen Demand and Chemical Oxygen Demand was found very high in two sites. Healthcare waste management issue has been neglected by most of the healthcare institutes in both the cities. Majority of hospitals lack segregation practice, treatment, proper disposal and wastewater management. None of the hospitals had practiced sterilization of healthcare. They depend upon municipal landfill site or burn openly to dispose hospital wastes. Wastewater was found direct released into municipal drainage without being treated. Overall condition was found to be worse. Such negligent practice draws whole city at risk.

Keywords: *Bio-medical waste, Hazardous waste, Radiation, Segregation, Sterilization*

Introduction

Nepal in the phase of development has many challenges of safeguarding a clean environment. The development works are being carried out at rapid rate and so is the urbanization growing (NPC, 2011). And to meet these people needs for health services, health care institute are also multiplying rapidly. Healthcare institutions generate large amounts of diverse wastes that require disposal. Much of the waste is hazardous and must therefore be collected, transferred, and disposed of properly to protect both the persons handling it and the environment. It affects not the two generators of waste but also the operators and general public (NHRC, 2002). The combined, incremental effects of human activity, referred to as cumulative impacts, pose a serious threat to

the environment. While they may be insignificant by themselves, cumulative impacts accumulate over time, from one or more sources and can result in the degradation of important resources (USEPA, 1999). The problem exists everywhere in world even in developed countries. Health care institutes including clinic, poly clinic, nursing homes, laboratory and hospitals generate waste which are very risky. Health care centers generate waste like healthcare, household and administrative waste. Every individual who gets exposed to the hazardous healthcare waste becomes susceptible to infection. More the carelessness, the more vulnerable becomes the situation. And concern over the hospital is they produce bulk of healthcare waste (UNEP, 2012). The disposal of hospital waste can be very hazardous particularly when it gets mixed with municipal solid waste and is dumped in uncontrolled or illegal landfills such as vacant lots in neighboring residential areas and slums. This can lead to a higher degree of environmental pollution, apart from posing serious public health risks such as AIDS, Hepatitis, Plague, Cholera, etc. (Acharya & Meeta, 2000). Though solid waste management act focuses on managing the hazardous waste by the producer itself, there is no guideline that specifically tells the polluter the method, and technology to use for treating such specific hazardous waste. So, there is a lot of confusion with the problem among the generators, decision-makers and the general community about the safe management of bio-medical waste (Patan & Mathur, 2015). The medical waste, if not properly managed can cause dangerous infection and possess a potential threat to the surrounding environment the persons handling it and to the public (Radha, Kalaivani & Lavanya, 2009).

Establishment of any health institution in Nepal is guided by Health Institution establishment, operation and upgrading related guideline 2013. Clause 3 of this guideline clearly mentions that any health institution can operate after taking permission from the concerned agency once it makes the provision of managing health institute waste. Solid waste management Act promulgated in 2011 on the same issue points out that the local government is the responsible agency for managing the solid waste however the responsibility for the processing and management within the set standard of harmful waste, health institution related waste lies within individual or body producing such solid waste. The environment protection act 2019 and regulation 2020, prohibits on pollution and sets the criteria for conducting Environmental Impact Assessment (EIA) and Initial Environmental Examination (IEE) for health sector. Rule 3, Annex-2 of Environment Protection Act, 2019 ensures that IEE is mandatory for the establishment of hospitals providing its services from 26 beds to 100 beds whereas Rule 3, Annex-3 EIA is mandatory for the hospitals operating with more than 100 beds. Rule 3, annex-2 of EPA, 2019 facilitates managing wastes including segregation, storage, landfill site, treatment plants, recycling plant. Nepal has 104 public hospitals and 303 private hospitals (then), providing basic services to the people. There were 16 private hospitals in Nepal in 1990 AD. By 2006 their numbers increased to 190 hospitals and as of 2014,

there are 301 registered private hospitals in Nepal. In fact, data collected in 2012 show that the number of beds (19,580) in private hospitals far surpasses those in the public hospitals (5,644). Most of these private hospitals are concentrated in urban areas (67 of them are in Kathmandu valley). In the year 1963, there were 32 hospitals in the public sector with the regionalization of health services zonal hospitals were established in 1964 (Marasini, 2003).

Materials and Methods

The study is based on field visits, questionnaire survey and observations. The study was conducted in two major cities of Nepal, Biratnagar and Janakpur. The two cities were visited for study in two different time. The first field visit was conducted in the month of December, 2016 followed by second field visit in June, 2017. List of hospitals was taken from District Public Health Office (DPHO) in both the cities in which 20 hospitals were identified in Janakpur whereas 27 hospitals were identified in Biratnagar. Among the listed hospitals, 9 hospitals were randomly sampled in Janakpur whereas 8 hospitals in Biratnagar. Each hospital was provided with 16 sets of questionnaires for filling up the waste inventory of the hospital. Questionnaires were based on number of beds in operation, their occupancy rate, available medical services, hospital's solid waste handling, liquid waste management, radiation hazard, alternative source of energy and their management, occupational health and safety, open space and greeneries maintenance, fire hazard and building codes, etc. Waste water sample from the release point of hospitals was taken. The collected waste water samples were sent for laboratory analysis of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Mercury (Hg), total Chromium, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Phenolic Compound, Oil and grease and Total Residual Chlorine. The level of these parameters was noted and plotted in graph. In each field visit, interaction and consultation was conducted with the hospital management team. The concerned government agencies, District Public Health Office (DPHO) and Municipality office were visited to collect list of hospitals registered and information related to healthcare waste management in both the cities. GIS Mapping (Version 3.10) was used to locate the study area.

These two cities are in topographically similar location; sub-tropical region Terai adjoining to Indian state Bihar. Janakpur lies in 26° 44' N and 85° 56' E, and 90 m above the sea level. The average annual temperature is 24.3° C and annual rainfall is 1271 mm whereas Biratnagar lies at 62 m to 78 m above mean sea level. The metropolitan city lies at 26° 23'10" to 26°30'44" N and 87°14'27" to 87 o 18' 29" E.

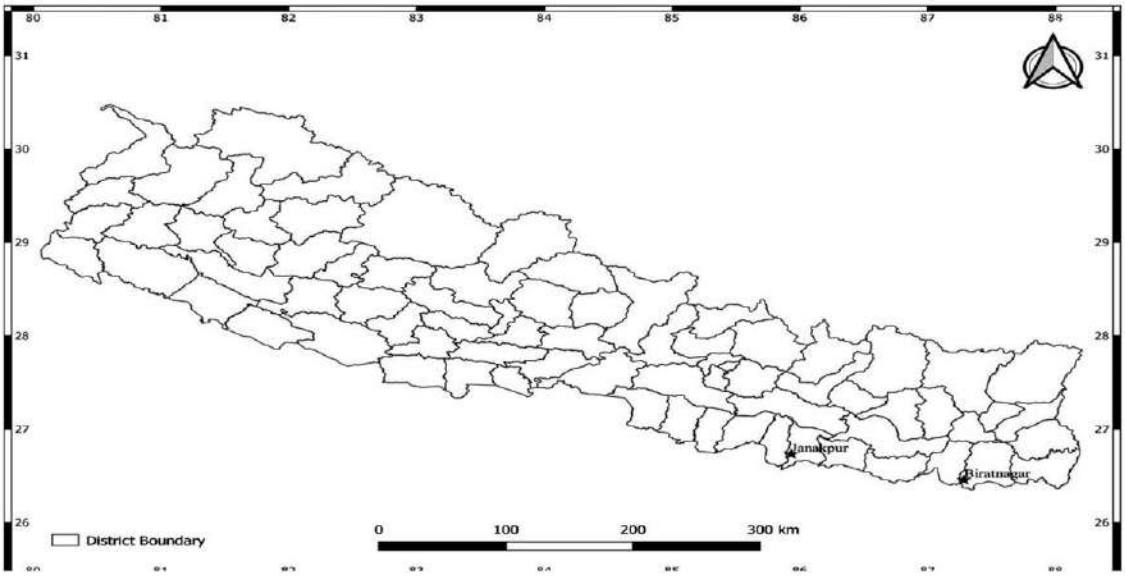

Fig 1: GIS mapping of study areas

Results and Discussion

Results

Healthcare Solid waste management

Most of the hospitals lack waste management committee for managing the hospital waste. Most of them depend upon municipality services for disposal along with practice of open burning and burying in the hospital premises. Hospitals lack adequate segregation bins, bins without label and without color coding. The number of buckets kept for segregation found varied in number with every hospital. It was observed that even the equipment used by health professionals were randomly thrown into the bucket. This indicates the negligence of health professionals towards the waste segregation or they are untrained. The central waste collection area found lacking in most of the hospitals. But some hospital has still managed to differentiate the waste in storage area as well. The human body parts, sharps and needles do not make part of the above-mentioned waste. Human placenta and other body parts were collected differently and even disposal process is also done in a different manner. Needles were destroyed in needle destroyer and stored in closed container. Quantification of waste generated per day has not been practiced by any hospital except one hospital in Biratnagar metropolitan city. A private organization is given the responsibility of collecting most of the hospital's waste and disposing it to the landfill site in Biratnagar municipality. The condition was more pathetic in Janakpur. Janakpur municipality disposes the waste at riverside. Some of the hospitals even burn their waste in the open space. Disposing the waste to open neighboring areas and even in

roadside had been practiced by few of them. One of the hospitals of Janakpur, biogas is manufactured from the hospital waste which is used in hospital. The waste segregation practice to the waste storage and disposal found worse even in Government hospitals. The visit to 17 hospitals from two different cities of Nepal shows that the health care institute has high level of negligence in managing such waste. A small amount of hazardous waste mixed with a large amount of general waste turns the whole quantity into hazardous waste. This is observed in almost all hospital. The level of awareness with the patient and the visitors is very low. Out of 17 hospitals visited, only 2 hospitals had Environmental Impact Assessment (EIA) approval whereas 7 hospitals had their Initial Environment Examination (IEE) approval and two are government regional hospitals.

Waste water management

Since the study area lies in Terai region, ground water is the source for meeting the needs. None of the hospitals had facility of the water treatment plant. They practice the soak pit or either draining to the municipal drainage. Though the government has brought the legal provision of running the hospital in their own building and not in rented one, the treatment plant has not been envisioned by any of them. The wastewater outlet of the sewage found running through hospital department. The sampling of wastewater taken from different hospital from two sites showed that the biological oxygen demand (BOD) and chemical oxygen demand (COD) to be very high.

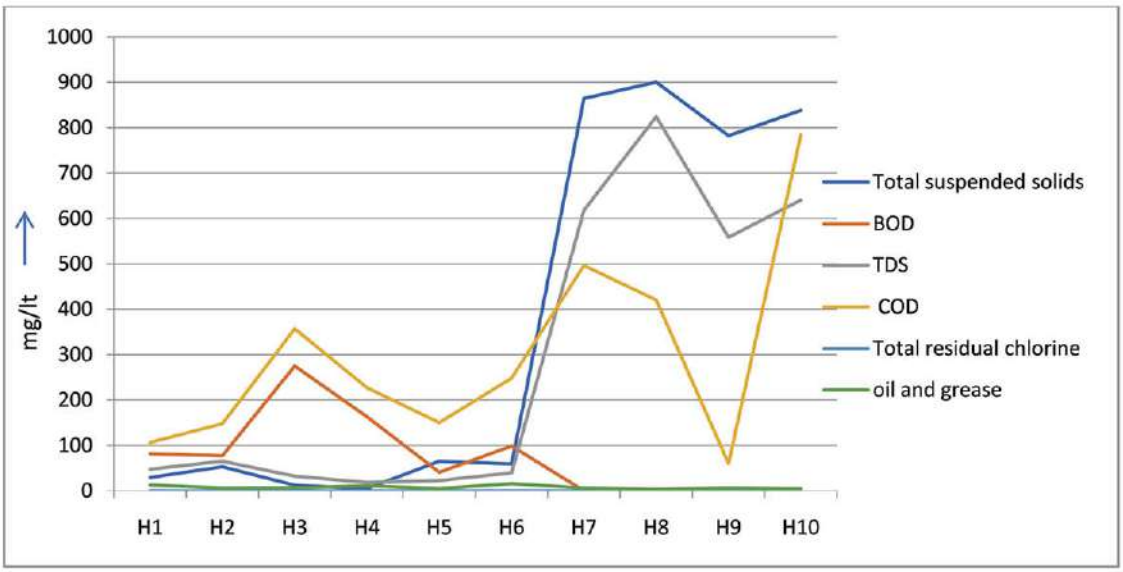

Fig 2: Waste water database from the samples taken from hospitals

Occupational Health and Safety

The hospital management lacks the sensitivity towards effect of waste generated. The waste handlers found working without any protective equipment. The use of safety measures viz. boot, mask and gloves were not observed in use. Rag pickers were also seen scavenging waste to collect recyclable items at waste transfer sites and storage. Situation of some Government hospitals are pathetic than some of the private hospitals. Hospital cleanliness, waste segregation, storage and disposal; every aspect is mismanaged and hype of carelessness could be observed. Most of the hospitals had open X-ray room i.e., without lead coated door and barium sulfate coating walls. The operators found working without lead apron. This situation can cause radiation hazard.

Discussion

There seems a challenge in healthcare waste estimation and planning. There is no exact record of hospitals and healthcare centers established and the license renewal system seems questionable. Segregation at source is most important step to manage the waste. The National Healthcare Waste Management Guideline 2014 mentions on wherever possible the waste should be categorized as per WHO/UNEP and if not possible then at least by the recommendation provided by guideline; however, the recommended categorization by the guideline has not been followed. The process of institutionalization of a good healthcare waste management system entails a waste assessment. Healthcare waste handling is a hazardous activity which requires a high standard of training. It needs specific training that depends on the nature of the work in the hospital, the hazards and possibility of worker exposure, and the responsibilities of individual workers. Nepal lacks sufficient recorded information on healthcare waste management methods and technologies and this fact hinders the planning for better management of healthcare waste. And many hospitals operating in a single city without proper waste management plan, the situation could be very devastating. As the waste is dumped so close to the river, there is a risk that the infectious waste gets mixed into the river when the water level rises, hence spreading infectious agents in the river stream. This eventually can contaminate the drinking water system of nearby inhabitants. Rivers also get contaminated from the liquid discharged to the municipal sewers which can further affect aquatic biodiversity. Soil gets contaminated from healthcare waste in the municipal landfills due to non-availability of separate sanitary landfill, is another concern.

Conclusion

Healthcare waste generation depends on numerous factors such as type and level of health care institutes, hospital specialization, segregation practices, seasonal variation, location, the number of hospital beds, and proportion of patients treated on a daily basis, extent of recycling, extent of use of disposable materials, procurement policies and

inventory control and other waste minimization activities. But as a whole it is affected by regulations or policies on waste classification, monitoring and enforcement by local or national authorities and level of development of the country. Hence the stringent policy with feasible solution on waste segregation should be implemented. The Government should come up with the solution on treating hazardous/infectious waste and should develop a particular procedure for it. All health care institutes strictly following the same set of rules on managing the healthcare waste will minimize the existing problem or else the situation is going to be more severe as it might create havoc in the future. Private hospitals take government hospital as their model, (as stated by many private hospitals), it is high time that government hospital approach on waste management and cleanliness be changed. The sensitization to all visitors and patient should be carried out. Frequent training should be launched for staffs. But above all, the strong workable policy and stringent monitoring is requisite.

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Subsidy Support and Funding for Sustainable Agriculture Development in Nepal

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Abstract

Series of interactions were made with farmer's groups/cooperatives (N=60) and experts (N=30) in Chitwan, followed by a desk review in 2020, to know the status of agriculture subsidy, funding and needed strategy in Nepal. The study revealed that the partnership on agriculture funding is in declining trend (35.6%). Subsidies are out of farmer's access (66.7%), subsidy leakages with large administrative cost, bureaucratic waste and recipient fraud are common (64.4%), and the role of cooperative and private sector on distribution is negligible (42.2%). There is an immense need for increasing public investment (34.4%), the attraction of private funds (50.0%) and the use of foreign add (41.1%)in specific fields. It is demanded to reform subsidy and extension policies (40.0%), ensuring participation of stakeholders (42.2%), prioritized subsidy (97.8%) and distribute it based on output/production/marketing (62.2%). Continuation of the short-term farm subsidies for few years (85.6%), substitute it with the long term subsidies (97.8%) with the programs for agriculture risk reduction, insurance and farmer's welfare scheme (61.1% respondents) are demanded for the sustainability of agriculture in Nepal.

Keywords: *Extension, Farmer, Leakage, Partnership, Public*

Introduction

The agricultural development is the fundamental for sustainable development and poverty alleviation in the developing countries like Nepal. Besides being the primary source of food and contribution to the household economy, agriculture holds the major share in providing the raw materials for industries and the national economy. Increased productivity increases farm incomes and fuels the linkages between farm and non-farm poverty reduction programs, which are the consequences of agricultural growth (Dhital, 2017). Recent commitments by African countries to re-introduce Input Subsidy Programs (ISPs) in the mid-2000s accounted for up to 60 percent of governments' expenditures on agriculture each year. Ghana, Ethiopia, and Rwanda devoted larger shares of government agricultural budgets to public investments and benefited from greater long-term impacts, including attracting new private investment. The ISPs have raised the rate of purchasing agriculture inputs, including fertilizer, in prior seasons and have improved national food production and farmer income (Food Tank, 2018).

Nepal is agrarian country with more than two third population engaged on farming. About one third (28.8%) total area is under cultivation (World Factbook, 2021). Agriculture extension and educational program in Nepal was started in the 1920s. The extension network has been established with 75 District Agriculture Development Offices and an equal number of District Livestock Service Offices and the network of Agriculture/ Livestock service centers, with the concept of co-financing between the government and other stakeholders (K.C., 2001). Since the first effort of extension service, Training and visit, Integrated Rural Development Approach, Tuki Approach, Farming System Research and Extension Approach, Block Production Program were the approaches used in the past. Conventional Educational Approach, Pocket Package Approach, Projectization Approach, Farmers Group Approach, Farmers Field School Approach and the Public-Private-Cooperative Partnership Approach are the approaches being followed presently in agricultural extension in Nepal (Dhital, 2017). The extension efforts in the country are guided by the National Agricultural Extension Strategy. Department of Agriculture and Department of Livestock Services under the Ministry of Agriculture and Livestock Development are responsible for providing public extension service via their District level offices and their Service Centers, Contact Center, and Community Agriculture Service Center at the farmer's level. Farmer's Group and Cooperatives, International and National Nongovernmental organizations, Community Based Organizations and few private entities provide private extension services (Dhital, 2017).

As an agrarian nation, Nepal's agriculture policies prioritize subsidies to boost production, improve food security and reduce poverty. Currently, the government has been allocating around Rs 18 billion to provide subsidies each year. However, there is considerable debate regarding the effectiveness and efficiency of their uses (Timsina, 2019). However, the results and objectives of the agricultural subsidy program do not converge very well as a big chunk of it is spent in covering the administrative costs in Nepal. Access of agriculture subsidies for the poor or non-poor is needed to calculate. The marginalized people are unable to utilize subsidies in a system of co-payment. One of the major issues found in public extension systems is lack of motivation among the rural youths and farmers because of low level of need-based extension coverage, particularly for small farmers, insufficient budget and investment for extension activities, domination of supply driven approaches rather than demand driven and inadequate extension services in parts of value addition and market exposure. On the other hand, insufficient budget and investment for extension activities is another important issue where the trend of the share of the budget in the agricultural development is very low as compared to other nations of the world. The government expenditure has fallen from 30 percent in the eighties to below 5 percent to the current time. Though the share of the agricultural budget reached 3.11% in 2010 from 2.45% in 2005, the AGDP has around one-third of the national GDP (SAAPE, 2011). The figure clarifies that the field of agriculture and specific agricultural extension is extremely neglected. For overall

national development, there is a need for huge investment in the field of agriculture development. Domination of supply driven approaches rather than demand driven is another major issue that should cover well managed effective and accountable agricultural extension services, which can address the demand or need of millions of farmers engaged in diverse and complex farming system in the country (Birner & Anderson, 2007). The concept of the demand driven extension to provide the farmers with extension services based on the need of the farmers. The extension services in Nepal are more based on the donor's interest and are less concerned on the demand of farmers. The practice of privatization of the extension is not seen in the country. A good demand driven extension service is possible when there is commercialization and privatization of the extension services (Birner & Anderson, 2007, Dhital, 2017).

The Subsidy Management Procedure-2019 aims to distribute subsidy transparent by maintaining good governance (Timsina, 2019). The subsidy support until the present time is only NPR 10-15 thousand million annually, which is very low to support the large farming communities to grow sufficient food to feed 28 million people in the country. The government is distributing the subsidy to farmers for crop and livestock production. However, it is frequently questioning whether the subsidy is reaching right farmers at the right time without licking? On the other hand, the monitoring of the subsidy distribution is also carried by the government itself, which seems controversial. That is why the citizens are blaming misuse and corruption held on subsidy distribution. It shows the need for the inclusion of cooperatives and the private sector on subsidy distribution (Pokhrel, 2019). Until this time, the subsidy is giving on food production but not in export expect it was tried with lentil and cardamom in the past. However, the participation of the private sector and cooperatives in this process was ignored. Leakage of subsidy with large administrative cost has decreases the role of subsidy on food production (Pokhrel, 2020). It is essential to have a quick look at where the subsidies go and how they are being used. It has been reported that the bulk of the subsidies is benefitting the largest and wealthiest farm households, and there are many startups with the announcement of subsidies. There are also ample subsidy programs being subjected to bureaucratic waste and recipient fraud (Timsina, 2019). In this context, it was necessary to study the funding sources and the role of subsidies on food production in Nepal.

Materials and Methods

A detailed desk review was made by the available relevant literature through the discussion paper of IFPRI, publications of Food Tank and the World Factbook, available Journals, Newspapers related to agricultural extension and research systems, agriculture extension and subsidy policies and issues on agricultural development in the year 2020. Web pages were visited to collect information on agriculture subsidies in Nepal. Series

of comprehensive discussions were made with agricultural extension experts and the academicians (N=30). Interactions were made with the farmers' groups and cooperatives through visiting different locations in Chitwan Nepal (N=60) in the same year. The qualitative information collected from desk review, expert discussions, interactions with farmer's organizations and field visits were synthesized, and results were presented.

Results and Discussion

Historical perspective of agriculture subsidies in Nepal

Subsidy started in the 1970s with the establishment of District Agriculture/livestock Offices and Agriculture/Livestock Service centers, while the agriculture in Nepal was fully traditional subsistence and organic. Subsidy in agriculture started with India's green revolution. The concept was carried out by the old agriculturists having education from India (Pokhrel, 2019).

The kind subsidy, 1970-1990

During the initial time, the subsidy was mainly on free distribution of small seed kits (mini kits), fruit saplings, demonstration kits, breeding buck/bulls/birds and trainings (47.8% respondents) (Table-1, Figure-1). However, there was not provision of a cash subsidy. Subsidized large-scale demonstration, block production programs, fertilizer and seed subsidy, subsidy on farm irrigation and farm machinery/equipment were initiated in the 1990s. The government was the sole authority for the purchase and supply of the materials on subsidy (Pokhrel, 2019). Agriculture subsidy became very common during the late 1950s and early 1970s (Timsina, 2019).

Cash and kind subsidy, 1990-2019

Later in the 2000s, the concept of agriculture commercialization developed. Agriculture loans and insurance programs were tied up with the government subsidy, mainly with livestock. Partial subsidy (certain percentages) program for larger machinery/tractors, irrigation started simultaneously. Agriculture subsidy was seriously declined in the late 1990s (Pokhrel, 2019). Finally, with the demand for agriculture entrepreneurship, commercial agriculture began with donor-supported projectization with cash subsidy. This model was more attractive than only minikit distribution. However, the cash and kind subsidies in the early 20s were not sufficient for agriculture commercialization (38.9% respondent) (Table-1, Figure-1). The examples of donor-supported projects during 2019s providing both cash and kind supports were CADP, PACT, RISMFP, KUBK, KISSAN, HIMALI, etc., with cash subsidy (Pokhrel, 2019). Agriculture subsidy was again boosted by the federal, state and local governments after the political transformation in Nepal (Timsina, 2019).

Credit/loan/loan interest subsidy, 2019-2020

Earmarking agricultural credits to support agriculture development objectives felt necessary in Nepal. The government raised interest subsidy on agriculture loans to 5 percent, waiving 50 percent on interest rates for those who seek bank credits to engage in commercial agriculture. It was spent Rs 758.2 million on subsidizing the interest and had a plan to provide 10,000 youths Rs 14.39 billion in concessional loans in five years to prevent their exodus. The government must, however, closely monitor the progress before this invites a fiscal crisis (Timsina, 2019). However, the credit/loan/loan interest subsidy has been just initiated, and the coverage was too little (54.4% respondents) (Table-1, Figure-1).

Table-1: Weaknesses in agriculture funding and subsidy distribution in Nepal (Nos respondents)

SN	Responses	Agri. Ext. experts (N=30)	Farmers (N=60)	Total (N=90)
1	Partnership funding on agriculture is in a declining trend.	14(46.7)	18(30.0)	32(35.6)
2	There lacks public-public partnership.	20(66.7)	29(48.3)	49(54.4)
3	The majority of private funds are mobilizing separately against the public-private partnership.	17(56.7)	21(35.0)	38(42.2)
4	Private-private partnership is not materialized	8(26.7)	12(20.0)	20(22.2)
5	Free distribution of small seed kits/ minikits and trainings before the 1990s were not sufficient	11(36.7)	32(53.3)	43(47.8)
6	Cash and kind subsidies in the early 20s were not sufficient for agriculture commercialization.	14(46.7)	21(35.0)	35(38.9)
7	Agriculture subsidies are leading farmers to addict in the long run.	7(23.3)	12(20.0)	19(21.1)
8	Credit/loan/loan interest subsidy just initiated, and the coverage is too little.	18(60.0)	31(51.7)	49(54.4)
9	Farmer's access on subsidy is very poor.	5(16.7)	55(91.7)	60(66.7)
10	Leakage of subsidy with large administrative cost, bureaucratic waste and recipient fraud is common.	7(23.3)	51(85.0)	58(64.4)
	The role of cooperative and private sector on subsidy distribution is negligible.	2(6.7)	36(60.0)	38(42.2)

Note: Figures in parenthesis are the percentage

Weaknesses in agriculture funding

The participatory funding in agriculture enterprise development in Nepal was assumed to be enhanced accountability among the partners for public-public partnership, public-private partnership and private-private partnership. However, the partnership was not stronger as projected by the Agriculture Development Strategy. Partnership funding on agriculture is declining (35.6% respondents) (Table-1, Figure-1).

Public-public partnership on agriculture development

The funding on public-public partnerships was not materialized enough. The linkages and coordination mechanism between the public institutions was very weak, and there was a lacking integrated approach resulted from overlapping and duplication of the programs (54.4% respondents). That is why the misuse and wastage of the resources were happening (Table-1, Figure-1). It was one of the causes of the failure of the Agriculture Perspective Plan (APP), 1995-2015 in Nepal.

Public-private partnership on agriculture development

Under the public-private partnership, the "One Village One Product" (OVOP) and One District One Product (ODOP) mode of the partnership between the Government of Nepal (GoN) and Federation of Nepalese Chamber of Commerce and Industries (FNCCI) were launched. There was a clear set of financial and management roles of the public-private organizations defined for the development of certain products like rainbow trout fish, sweet oranges, orchids, wood apple (bel), and Nepalese hog plum/mombin from production, processing, quality control and ultimately their marketing. However, the funding from the private sector was too weak, and ownership of the private sector was found not satisfactory in many of the schemes. Moreover, there were no more examples of agriculture funding on public-private partnerships, and all the stakeholders were mobilizing their funds separately (42.2% respondents) (Table-1, Figure-1).

Private-private partnership

There were several agro-based industries and companies working in Nepal. Some of them were working on joint ventures. They were not progressing up because of unfavorable policies and poor linkages with resource-poor small farmers. However, agriculture funding on private-private partnerships was not materialized enough (22.2% respondents) (Table-1, Figure-1).

Public, private and foreign investment

On the other hand, the public investment in agriculture is too little and need to increase significantly (34.4% respondents), the attraction of the private fund for agriculture development is important (50.0% of respondents), where the foreign investment in

agriculture mainly on product marketing is very important (41.1% respondents) (Table-2, Figure-2).

Weaknesses in agriculture subsidy distribution in Nepal

Agriculture was no more attractive job in Nepal. It was because of the high production cost and low agriculture profits. The cost of fertilizers, quality seeds, machinery and irrigation found financially unaffordable to many poor farmers. That is why agriculture productivity in recent decades has been fallen increasingly behind.

Effect of foreign subsidy policy

Farm subsidies and trade protections in neighboring countries China and India were harming Nepalese agriculture, hindering commercialization and competitiveness. It undermined Nepalese efforts on economic reform. Indian subsidies made their products cheaper, causing them to flood in Nepali market. This has led to increased imports of agricultural products in the total commodity trade. The subsidies and protection given to Nepali farmers are insufficient in this context (Paudel, 2020).

Farmer's access on subsidy

The involvement of local government in subsidy distribution seemed very crucial. Government extension coverage was claimed to be only 16-17% farmers, and the rest of the farming communities were out of the extension access in Nepal. The subsidy distribution model until this time was on demand-based rather than process-based. The constraint of access to economic opportunity by the farmers, especially the smallholder farmers, women, and disadvantaged groups, was lacking (66.7% of respondents) (Table-1, Figure-1). So that, about half (40.0%) respondents demanded the extension reforms for the attraction of youth workforce for gainful employment in agriculture and rural development, jeopardizing agricultural development in Nepal (Table-2, Figure-2).

Role of stakeholders on subsidy distribution

The agriculture subsidies should be available in groups and cooperatives or to firms' rather individual access (Table-1, Figure-1). It needs identification of beneficiaries by the Local Governments, social mobilization through CBO/NGOs, involvement of all stakeholders including industries on subsidy distribution, involvement of private sector on monitoring, contract farming, and market promotion from cooperative/private and regulation from the government sector. Micro-finance intermediaries should be expanded. Government should give due attention to the allocation of public investment to the prioritized agriculture sector and tuned it for the attraction of private funds to meet the developmental goals (Table-2, Figure-2). However, no direct role of cooperative and private sector on subsidy distribution, and the public sector was mainly involved in it (42.2% respondents) (Table 1).

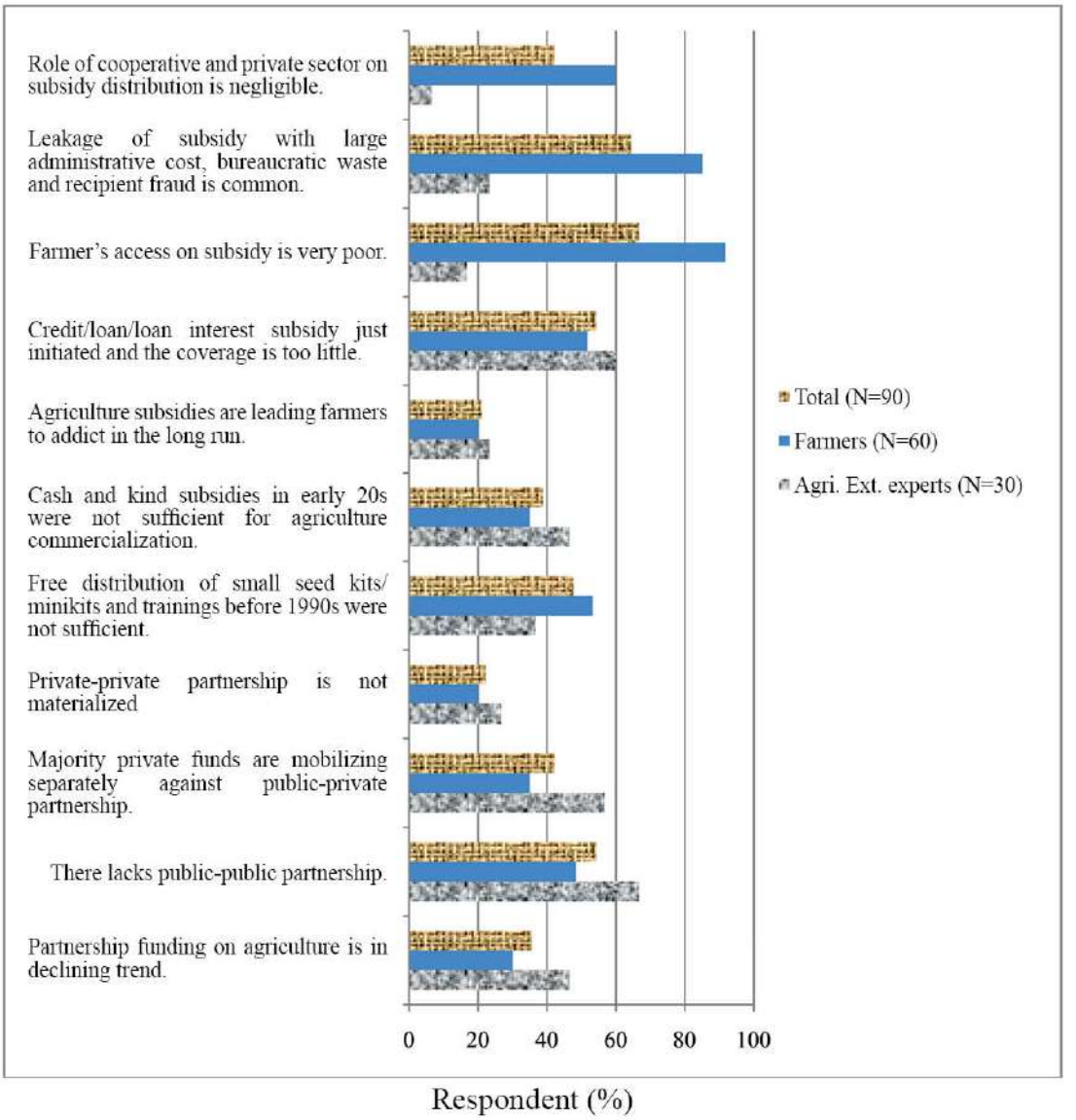

Figure-1: Weaknesses in agriculture funding and subsidy distribution in Nepal (%respondents)

Other problems associated with subsidy distribution

Most of the subsidies in Nepal were channeled through local governments without exactly focusing on fertilizers, quality seeds, machinery, irrigation, farmer's welfare scheme, insurance and agriculture risk reduction. On the other hand, there were many leakages on the subsidy with large administrative cost, bureaucratic waste and recipient fraud and access of needy, small and marginalized farmers and rural youths on agriculture fund/ finance and subsidy were frequently questioned (64.4% respondents) (Table-1, Figure-1).

The direct and indirect agriculture subsidy in Nepal

The agriculture subsidies provided in Nepal in the different time periods were in kind or cash or both. The direct/short-term farm subsidy provided was on fertilizers, quality seeds/breeds, machinery and irrigation and the long-term subsidies on overall support on infrastructure, research, knowledge dissemination, capacity building, and market support provision. However, all these efforts were insufficient for agriculture commercialization.

The direct/short term farm subsidy

The agriculture subsidies in Nepal were more focused on direct subsidies. It is also called short-term farm subsidies. This short of subsidies seemed important for the smallholder resource-poor farmers for boosting their production. In the past, the short-term farm subsidies were distributed on the production inputs like fertilizer, manure, chemicals, seeds, breeds, machinery/equipment, etc. but were not well distributed to all farmers throughout the production sites (Table-1, Figure-1).

There were maize and onion mission programs for import substitution. Lentil production under Nepal Agriculture Trade Promotion Program was implemented for export promotion. However, the subsidies were not targeted for producing of the rest of other industrial raw materials like sugarcane, oilseeds; for import substitution like sugar, oilseeds, pulses and fruits and export promotion like tea, coffee, honey, etc. The maize mission program was not fully able to substitute the maize import. The onion mission program was almost a failure, and the lentil promotion program was not able to produce the lentil in full exportable volume. The subsidies under these programs were not output/production/marketing based but were on ad hock basis. The direct/short-term/farm subsidies were not tied up with farmer's welfare schemes like crop/livestock/fishery insurance and agriculture risk reduction programs (Table-2, Figure-2). On the other hand, these subsidies led farmers to addict in the long run (21.1% respondents) (Table-1, Figure-1). However, the lower chemical fertilizer price seems to increase the per capita incomes of farm households in Nepal (Takeshima et.al. 2016a). Nepal, being the net importer of chemical fertilizers, the lack of access to this vital farm input in the time of crisis has exacerbated the threat of food crisis (Sambridi Foundation, 2021). Nepal is facing the massive criticism each year for not being able to supply enough chemical fertilizer during the peak paddy transplantation season and need to be resolved (The Kathmandu Post, 2021). In the other hand, the government should continue to promote custom-hired tractor services and farm mechanization not only for medium to large farmers but also for smallholders in Nepal (Takeshima et.al, 2016b). Thus, the short-term farm subsidies are very important for raising farm income in Nepal. However, the Federal Government has been allocated only Rs 70 billion for subsidized chemical fertilizers (AICL, 2020), though the budget was not sufficient for farm mechanization and other farm subsidies in 2020.

Indirect /long term subsidy

The long-term agriculture subsidies occupy a more important role to address national food security, also called indirect subsidies. They were stepping ahead in Nepal, covering overall support framework, better market infrastructures, irrigation, agriculture research, extension education, farmer's training and capacity building, strengthening diagnostic services, crop, livestock, honeybee and fishery insurance and agriculture risk reduction. However, the coverage of the indirect subsidies was very low in terms of farmer's number, which was less than 16-17% (Pokhrel, 2019) and in terms of volume of the subsidy, which was about Rs 18 billion each year as reported by Timsina (2019). The farmer's welfare programs were almost nil except for the crop and livestock insurance (Table-1, 2).

National priorities and the agriculture subsidy

The national priorities for the agriculture subsidies were not fixed yet. There were not any linkages between the distributed subsidies and their purpose. It was not clearly spelled out whether the subsidies given for the agriculture production were for the national food/fiber self-sufficiency? Was it for import substitution or the export? Was it for the supply of industrial raw material or the domestic consumption? The commodity-wise national priority setting was most necessary behind distributing any subsidies in correspondence to target, but it was absent. The subsidy target should have clear-cut answers against what kind of the agriculture subsidy needs to provide the farmers and what are the prioritized crop/livestock and what is the guideline procedure for it? For example, 'irrigation subsidy to what commodities?' 'fertilizer and seed subsidies on which crops/varieties?' 'livestock farm subsidy to produce what product like meat, wool or fish?', and 'infrastructure support for what?', etc. (Table-2, Figure-2).

Table 2: Suggestions on subsidy distribution in Nepal (Nos respondents)

SN	Responses	Agri. Ext. experts (N=30)	Farmers (N=60)	Total (N=90)
1	Need of increasing public investment	13(43.3)	18(30.0)	31(34.4)
2	Attraction of the private fund for agriculture development	17(56.7)	28(46.7)	45(50.0)
3	Foreign investment on agriculture	13(43.3)	24(40.0)	37(41.1)
4	Continuation of farm subsidies on fertilizers, quality seeds, machinery and small/micro irrigation	25(83.3)	52(86.7)	77(85.6)
5	Long term agriculture subsidies on overall support framework, infrastructure, research, extension, market supports and institutional strengthening	28(93.3)	60(100.0)	88(97.8)

SN	Responses	Agri. Ext. experts (N=30)	Farmers (N=60)	Total (N=90)
6	Agriculture risk reduction, insurance and farmer's welfare scheme.	15(50.0)	40(66.7)	55(61.1)
7	Output/production/marketing based subsidies on production, collection, processing and marketing	12(40.0)	44(73.3)	56(62.2)
8	Define subsidy on the production of industrial raw materials, import-substitution, domestic needs or export promotion	17(56.7)	26(43.3)	43(47.8)
9	Reform agriculture extension with defined role and responsibilities of stakeholders	11(36.7)	25(41.7)	36(40.0)

Note: Figures in parenthesis are the percentage

Way out for the effectiveness of agriculture subsidy in Nepal

Agricultural development is fundamental for sustainable development and poverty alleviation in developing countries. The input subsidy programs have raised farmers' purchasing rate on agriculture inputs and have improved national food production and farmer income. However, there was an insufficient budget and investment with inadequate agriculture extension in Nepal. The entire farmers respondent (N=60) and majority agriculture extensionist (N=28) demanded long-term agriculture subsidies on overall support framework, infrastructure, research, extension, market supports and institutional strengthening. However, more than two-third (85.6%, N=77) respondents said it is needed for the continuation of farm subsidies on fertilizers, quality seeds, machineries and small/ micro irrigation for the protection of small and resource poor producers. They said the agriculture subsidies should be output/production /marketing based on production, collection, processing and marketing (62.2%, N=56). There is a higher risk on agriculture production and marketing from the natural calamities and brokers; therefore agriculture risk reduction, insurance and farmer's welfare scheme is equally important (61.1, N=55) (Table-2, Figure-2). The agriculture extension programs are dominated by supply-driven approaches rather need based extension coverage in Nepal,

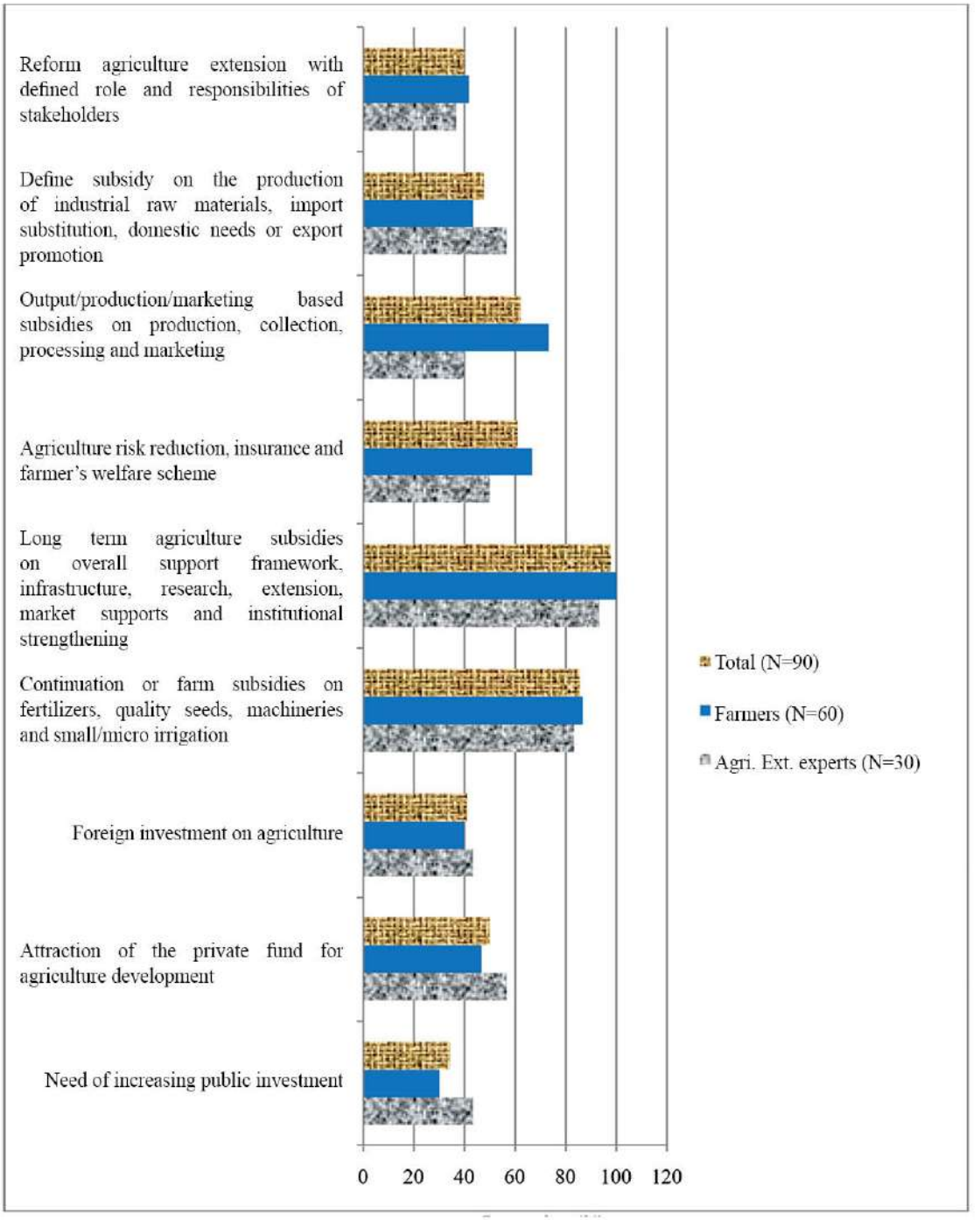

Figure-2: Suggestions on subsidy distribution in Nepal (% respondents)

where the effectiveness and efficiency of subsidy and partnership on agriculture funding in Nepal are debatable. The majority (64.4% respondents) raised the problem of leakage of subsidy with large administrative cost, bureaucratic waste, and recipient fraud has decreased the role of subsidy/funding on food production. Access of needy, small and marginalized farmers and rural youths on agriculture fund/finance and subsidy was frequently questioned (Table-1, Figure-1). Thus, there is an immense need for increasing public investment (34.4%, N=31) and attraction of the private fund (50.0%, N=45) for primary production and also use foreign investment (41.1%, N=37) on agriculture marketing and processing in Nepal. Moreover, it should be defined the agriculture subsidy, whether for the production of industrial raw materials or import substitution or for domestic needs/consumption or export promotion (47.8%, N=43) and application of subsidy on agriculture. Also, it needs to reform agriculture extension with defined role and responsibilities of stakeholders (40.0% respondents, N=36) for the effectiveness of subsidy and funding for agriculture development in Nepal (Table-2, Figure-2).

Conclusion and Recommendation

There is overlapping and duplication on the programs. The agriculture funding is insufficient. The partnership on funding lacks an integrated approach. The agriculture extension programs are dominated by supply-driven approaches rather than need-based extension coverage. The majority of respondents raised the problem of leakage of subsidy with large administrative cost and bureaucratic waste, and recipient fraud has decreased the role of subsidy/funding on food production. Access of needy, small and marginalized farmers and rural youths on agriculture fund/finance and subsidy was frequently questioned. Thus, there is an immense need to increase public investment and attraction of the private fund for primary production and use foreign investment in agriculture marketing and processing. Moreover, the agriculture subsidy should be prioritized to produce industrial raw materials or import substitution or for domestic needs/consumption or export promotion. Also, it needs to reform agriculture extension with defined roles and responsibilities of stakeholders. However, the long-term agriculture subsidies on overall support framework, infrastructure, research, extension, market supports, and institutional strengthening are most demanded. Continuation of farm subsidies on fertilizers, quality seeds, machineries and small/micro irrigation on output/production/marketing based on production, collection, processing and marketing are also demanded to protect small and resource-poor producers. The increasing risk on agriculture production and marketing from the natural calamities and brokers should be minimized through insurance and farmer's welfare scheme.

Based on the study, the following recommendations are made:

1. It is recommended to distribute the direct/short term farm subsidies on fertilizers, quality seeds, machinery and micro-irrigation by the local governments and the indirect/long term agriculture subsidies on overall support framework, better infrastructure, research, knowledge dissemination, capacity building, market support provision, institutional strengthening and agriculture risk reduction with farmer's welfare scheme and insurance by the provincial and federal governments.
2. The direct/short-term farm subsidy on agri-production inputs should be output based either on production or marketing based.
3. There should be a clear-cut strategy to minimizing the direct/short-term farm subsidies and emphasized indirect/long-term subsidies. Because the short-term farm subsidies make farmers addict to them in the long run.
4. The commodity-wise national priorities should be fixed to distribute the direct/ short term and indirect/long term agriculture subsidies. The priority can be for the food self-sufficiency, supply of the industrial raw materials, import substitution, domestic need or for the export.
5. The extension reform for the integrated approach for the attraction of youth for their gainful employment in agriculture, allocation of public investment to the prioritized agriculture sector, and tuned it to attract private fund to meet the developmental goals is needed.
6. There should be a clear-cut role and responsibilities of all stakeholders, including the public, private, cooperative and community on identifying beneficiaries, social mobilization, subsidy distribution and funding, monitoring, contract farming and market promotion.

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Waste Generation and Management Practices: A Case of Icchumati Community Agricultural Market, Bagbazar, Kathmandu

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Abstract

Biodegradable waste is any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard. This study mainly focuses on providing information about biodegradable waste generated in Icchumati Community Agricultural Market (ICAM). It also estimates manure generating capacity from the wastes. Waste management practices and people's perception towards waste management practices at ICAM. Collection and analysis of data were performed through the survey and field visit. The biodegradable fraction of waste comprising agricultural residue carried a higher density than other wastes. The daily waste generated inside ICAM ranged from 490 Kg to 561.8 Kg. The amount waste generation varies with flow of vendors. Composting is regarded as an effective method to convert "Garbage to Gold". Different composting methods can be adopted to utilize the wastes generated from the market into valuable compost manure. Among different methods of compost, vermin-composting is regarded as the best, most of the surveyed sellers and costumers were satisfied with the waste management practices in the ICAM. Biodegradable wastes are the source of large amount of nutrients; it is recommended that if these wastes are utilized in proper manner they can beused as a valuable material like compost or biogas which in addition also reduces theenvironmental problems. If the wastes are recycled and reduced almost all types of solid waste could be managed and utilized properly. Also, awareness program regarding sanitation, waste segregation, collection and storage should be conducted, and better waste management plans should be made with co-ordination with shop owners of ICAM.

Keywords: *Biodegradable waste, Composting, Solid waste, People's perception, waste management practices.*

Introduction

"Wastes" are substance or objects, which are disposed of or are intended to be

disposedof or are required to be disposed of by the provisions of national law"(Voinov Kohler, 2017). Waste is also defined as, "materials that are not prime products (that is, productsproduced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose. Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals recycled or reused at the place of generation are excluded "(Shah, 2007).

Solid waste

"Solid waste" means any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, resulting from industrial, commercial, mining, and agricultural operations, and from community activities. Nearly everything we do leaves behind some kind of waste. It is important to note that the definition of solid waste is not limited to wastes that are physically solid. Many solid wastes are liquid, semi-solid, or contained gaseous material (EPA, 2017).

Solid waste often called the third pollution after air and water pollution (Rao, 1985), is that material, which often rises from various human activities and is normally discarded as useless or unwanted. Solid waste is defined as "any unwanted or discarded materials that is not liquid or gas (Miller, 2002). It consists of highly heterogeneous mass ofunwanted materials from the urban community as well as homogenous accumulationsfrom agriculture, industries and wastes from mine.

The major sources of solid wastes can be domestic wastes that results from household activities, commercial wastes from shops, hotels, offices, hospitals, construction activities, mining wastes etc. Nowadays, solid wastes are growing rapidly with urbanization and high population growths.The composition and quantity of waste depends on various factors such as population growth, socio-economic factors and also GDP growth(Senzige, 2014).

Solid waste management

The process of collecting, treating and disposing of solid materials those are discarded after they have served its purpose and are no longer useful is called solid waste management. Improper disposal of solid waste can create unsanitary conditions, and these conditions in turn can lead to pollution of the environment and to outbreaks of vector-borne disease—that is, diseases spread by rodents and insects. The tasks of solid-waste management present complex technical challenges. They also pose a wide variety of administrative, economic, and social problems that must be managed and solved (Nathanson, 2018).

Reducing and eliminating adverse impacts of waste materials on human health and environment to support economic development and superior quality of life is the primary goal of solid waste management (the balance small business, 2018).

There are six functional components of the waste management system as outlined below (http:||cpheeo.gov.in>chap2 (pdf)

1. **Waste generation** refers to activities involved in identifying materials which areno longer usable and are either gathered for systematic disposal or thrown away.
2. **Onsite handling, storage, and processing** are the activities at the point of waste generation which facilitate easier collection. For example, waste bins are placed
3. **Waste collection**, a crucial phase of waste management, includes activities suchas placing waste collection bins, collecting waste from those bins and accumulating trash in the location where the collection vehicles are emptied. Although the collection phase involves transportation, this is typically not the main stage of waste transportation.
4. **Waste transfer and transport** are the activities involved in moving waste fromthe local waste collection locations to the regional waste disposal site in large waste transport vehicles.
5. **Waste processing and recovery** refer to the facilities, equipment, and techniquesemployed both to recover reusable or recyclable materials from the waste streamand to improve the effectiveness of other functional elements of waste
6. **Disposal** is the final stage of waste management. It involves the activities aimedat the systematic disposal of waste materials in locations such as landfills or waste-to-energy facilities.

Materials and Methods

Study Area

The study was carried out in Icchumati Community Agricultural Market which lies within Bagbazar of Kathmandu Metropolitan City, ward number 32. It spread over 3 ropanies and 12 anas(0.19077638 ha) It lies at 27.702767 latitude,85.321025 longitude and 1305m elevation.

Icchumati Community Agricultural Market is an organized vegetable market established in 2054 and has 206 vegetable stalls. Here retailers, institutional consumers and other bulk consumers obtain their commodities. In order to provide organized shape to the marketing of agricultural products, especially vegetable products in Kathmandu Valley, Icchumati vegetable market(IVM) was set up by Harit Agricultural Co-operative Ltd. (HACOL).

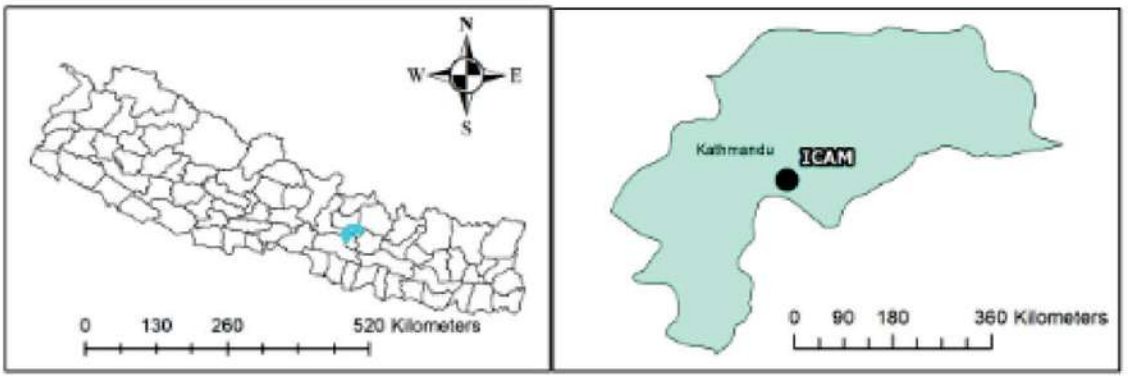

Figure 1: Map of Nepal with study area, ICAM, Bagbazaar, Kathmandu,

Methods of data collection

Collection of Primary Data

In order to achieve the objective of the study, the study area was fixed i.e. Icchumati Community Agricultural Market. The waste generation of the vegetable market was measured (in kilogram) for a week at morning and evening time. For this, a portable weighing scale having a capacity up to 50 kg was used. The data were collected by stall to stall basis. Along with this, various waste management practices were analyzed whichincluded existing waste management practices such as waste collection, transportation,storage, disposal etc.

Questionnaire Survey

Questionnaire survey was conducted amongst the shopkeepers and consumers of the Icchumati Community Agricultural Market. There were total 206 stalls. Out of them 65 stalls and 10 public consumers were surveyed randomly during the field work. Stall based and consumer-based questionnaire was developed which contained the socio-economic information as well as their waste management practices and their perception on waste management of the market. For the survey, the required number of stalls sample was determined as follows;

Sampling design

The sample size was determined using Arkin and Colten (1963) formula which is as follows;

Where,

$$n = \frac{NZ^2 * p * (1-p)}{Nd^2 + Z^2 * p(1-p)}$$

n= sample size

N= Total number of stalls

Z= Confidence level (at 95% level Z=1.96)

p= Estimated population proportion (0.5, this maximizes the sample size)

d =Error limit of 10% (0.1)

Secondary Data

Secondary Data was taken from a published thesis of Maharjan(2004) as a reference and used simple unitary method to estimate the amount of compost that can be generated from the vegetable market. The reference weight of compost production in Kalimati vegetable market (Maharjan, 2004) is as follows.

Table1: Reference values of compost fromKalimati vegetable market (Mahajan, 2004)

S.N	Composting method	Weight of vegetables (kg)	Weight of Compost (kg)
1.	Pile Composting	979.16	362.29
2.	Bin Composting (anaerobic)	60	29.5
3.	Bin Composting (aerobic)	45	19
4.	Bag composting	38	17.3
5.	Vermi-composting	6	1.9

Results and Discussion

Results

Status of waste generation

The total amount of biodegradable waste generated on ICAM in a week from sampled stalls was 3710.1 Kg giving 530.01 Kg/day (0.53 tons/day). The daily waste generated inside the ICAM ranges from 490 kgs to 561.8 kgs as shown in figure 1. There was fluctuation on the amount of waste generated. The highest amount of weight was found to be generated on day 7(Saturday) i.e. 591.8 kg (0.59 tons) and lowest amount of waste was generated on day 1(Sunday) i.e. 490 kg. The total number of stalls (206 stalls) of ICAM is supposed to generate 11758.4 Kg/week (11.75 tons/ week) and 1680 Kg/day (1.68 tons/ day).

Table 2: Waste generation by sampled stalls and total stalls

Waste Generation by 65 sample stalls	3710.1kg/week	3.71 tons/week	0.53 tons/day
Waste Generation by total 206 stalls	11758.4 Kg/week	11.75 tons/week	1.68 tons/day

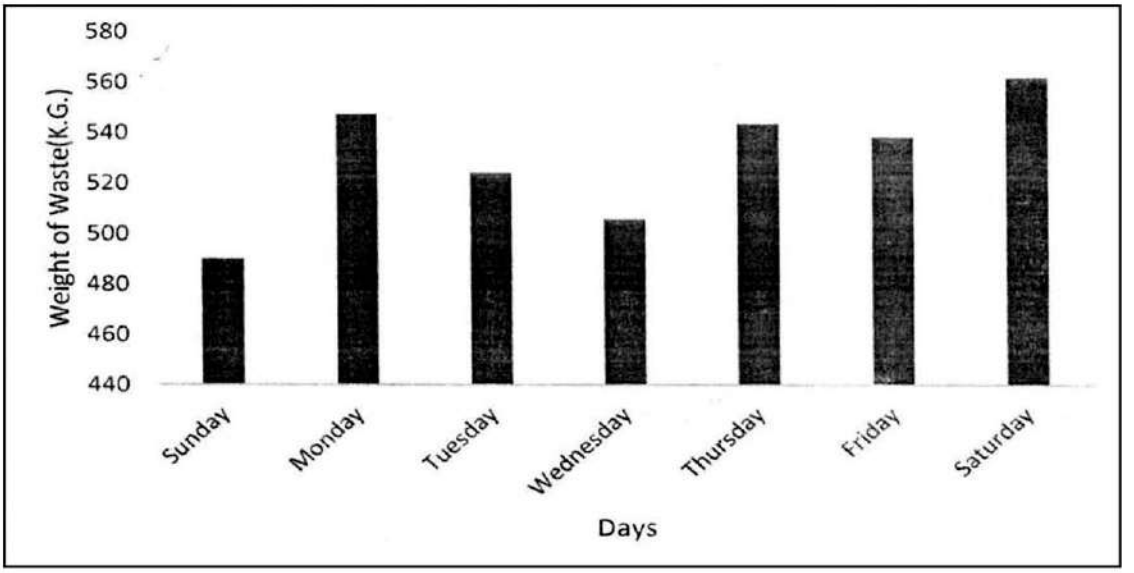

Figure2: Daily waste generation in week long duration

Table 3: Waste generation and standard deviation for a week

The per day waste generation vary 25 kg to the average waste generation 530kg at ICAM (Table 3).

Day	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Total	Mean	SD
Waste(kg)	490	547.2	523.8	505.7	543.5	538.1	561.1	3710.1	530.01	25.11

Association between waste generation and years of trading

There is no significant difference between years of trading and waste generation. ($\chi 2$=0.822, p= 0.66). The shops were trading from long time were observed to generate high amount of waste than other shops (Figure 3).

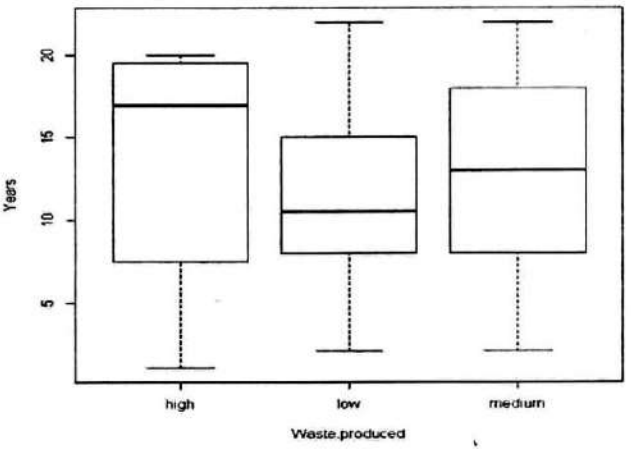

Figure 3: Relationship between years of trading and waste production

There is no significant difference between shop duration and waste generation. (X=1.7184, P Value=0.4235). The shops with high shop open duration were observed to have higher waste generation than other shops with less shop open duration. (Figure 4)

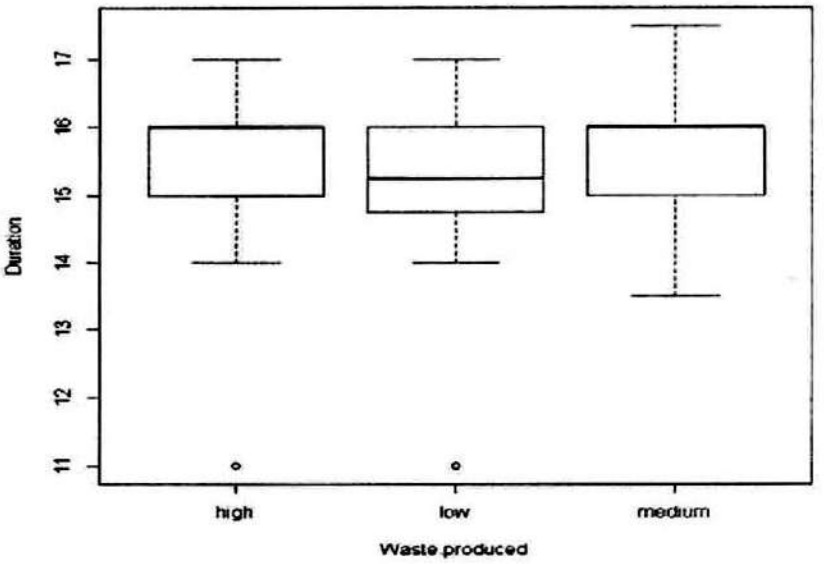

Figure 4: Relationship between duration of shop and waste production

Association between waste generation and rent

There is no significant difference between rent of stalls and waste generated. ($\chi 2$ =0.804, p= 0.668). The stalls having higher rent were bigger in size and generated higher waste than the stalls having lower rent (Figure 5).

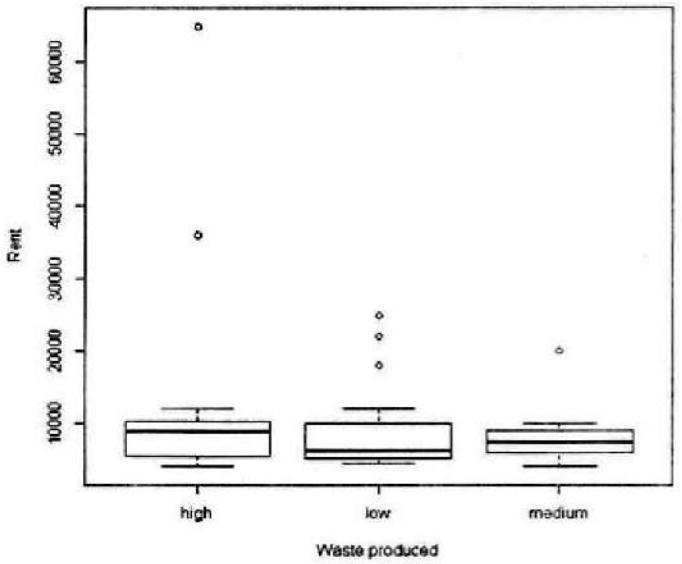

Figure 5: Relationship between shop rent and waste produced

Compost Estimation

The weight of compost generation varies with the variation in the method of composting (Figure 6 and Table 4). The highest amount of compost would be generated from Bin Compost (anaerobic) and the lowest amount of compost would be generated from Vermi-composting (Figure 6; Table 4). In anaerobic bin compost out of 3710.6 kg (3.71 tons) of weekly waste 1821.65 kg (1.82 tons) of compost is supposed to be generated while in vermin compost out of 3710.6 kg of weekly waste 1172.39 kg (1.17 tons) of compost is supposed to be generated.

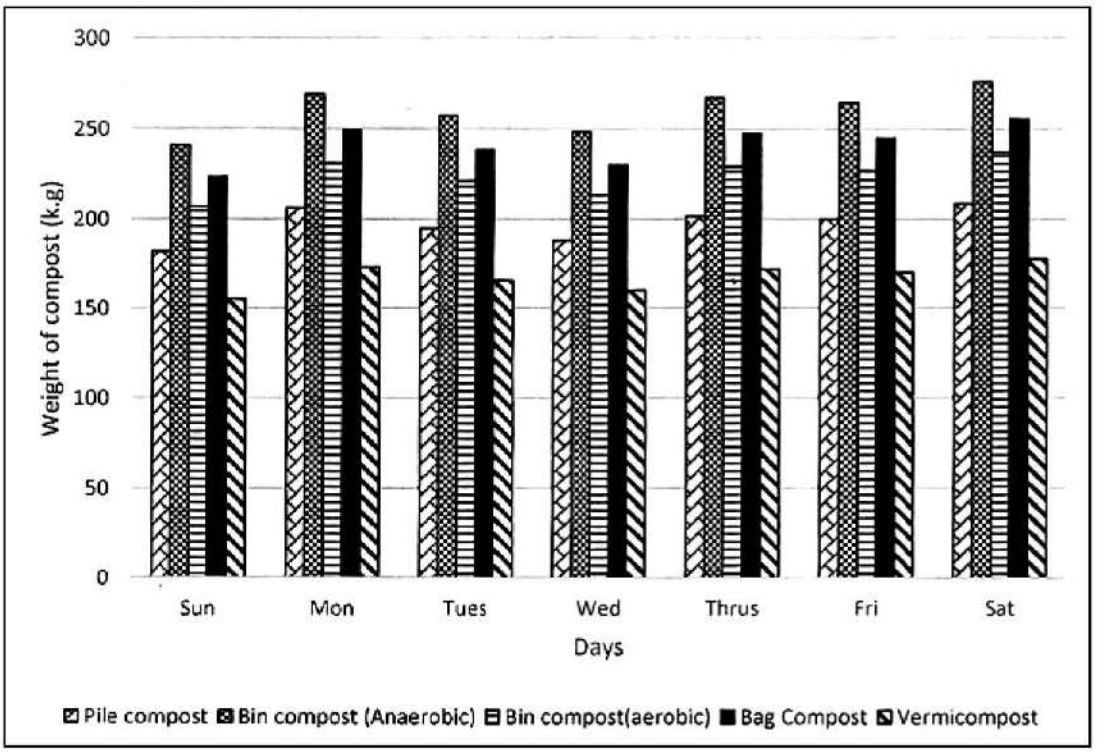

Figure 6: Daily generation of compost

Table 4: Estimated weekly generation of compost using reference valued of Maharjan (2004)

Waste (tons/week)	Estimated compost generation (tons/week)				
	Pile compost	Anaerobic Bin compost	Aerobic Bin compost	Bag compost	Vermi-compost
3.71	1.37	1.82	1.56	1.68	1.17

People's Perception

Seller's Point of View

In ICAM, out of total surveyed shop owners 51% of them were female and 49% were male. It was observed that burning was not considered appropriate by 91% of the shop owners while 6% of the total surveyed sellers practiced burning (Figure 8).73% of the respondents were satisfied with the waste management services while 27% of them were unsatisfied (Figure 7) and had complains as well as suggestions for the betterment of waste management in ICAM.

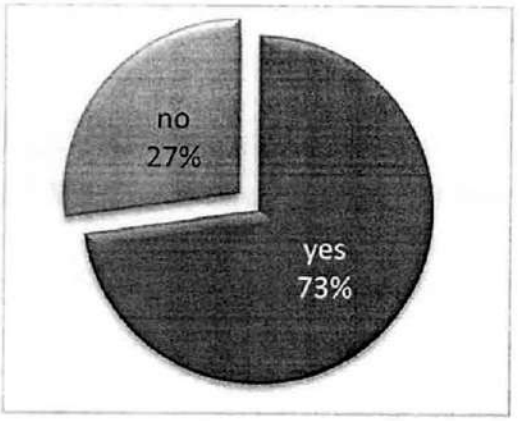

Figure 7: Satisfaction of sellers withmanagement of ICAM&Figure

Figure 8: Waste burning practices among sellers

Consumer's Point of View

Out of total surveyed consumers 70% were female and 30% were male. 60% of them were regular customers and 40% of them visited occasionally. 70% of the surveyed consumers lived within 10 minutes (walking distance) from the vegetable market. Also, 70% of the surveyed consumers (Figure 9) were found to be satisfied with themanagement of ICAM.

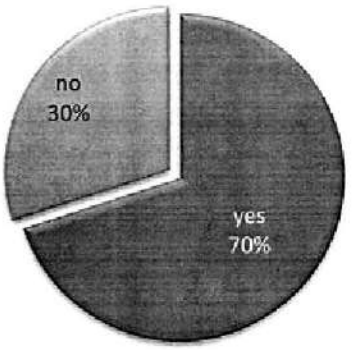

Figure 9: Satisfaction of consumers with the management of ICAM.

Existing Waste Management Practices

HaritKrishi is responsible for the management of wastes in Icchumati Community Agricultural Market. The waste management practices such as waste collection, waste storage, waste transportation and disposal are practiced.

Onsite separation of wastes

It was observed that there isn't any provision for onsite separation of wastes in ICAM.

Waste Collection

The wastes were collected once daily. The wastes are kept in different containers outside the stall by the shopkeepers so that the waste collectors can collect it easily. There were about 7 waste handlers who collect the wastes from stall to stall of the vegetable market and store the wastes in a big storage area. Sweeping was done once a day as one of the process of waste collection.

Waste Storage

In ICAM, the waste storage area is open and non-restricted area to visit. The storage area is within the market premises and is near some vegetable stalls. There isn't any provision of segregation of collected waste.

Waste Transportation

The transportation of waste from the collected area to the dumping site is crucial part of SWM. The vegetable market has been involved in transporting waste collected by them using tractors from the collected area. The wastes from the market premises were collected timely and transported once daily.

In case of public holidays, the wastes were transported on another day.

Waste Disposal

For the disposal of wastes, the wastes were transported directly to the dumping site which is Okharpauwa.

Discussion

Overview of waste on ICAM

Waste generation is an outcome of economic activity inside the vegetable market. Most of the waste generated inside the vegetable market are organic and has a great potential of being recycled as compost. At present, these wastes are not being properly utilized as they are mostly thrown away and dumped with other in- organic wastes and very less of them are utilized by farmers as food for livestock.

Waste Generation

The total number of stalls i.e. 206 stalls of ICAM is supposed to generate 11758.4 Kg/ week (11.75 tons/ week) and 1680 Kg/day (1.68 tons/ day).The daily waste generation of sampled stalls (65 stalls) inside the ICAM ranged from 490 Kg (0.49 tons) to 561.8 Kg (0.56 tons) on the month of Jestha. After Saturday the highest amount of waste was generated on Monday i.e. 547.2. Waste generation was high on this day because most of the shop owners had cleaned their shops on that day. The waste generations of ICAM

are something very low than these calculated wastes, because a significant amount of waste is sometimes given to farmers for their livestock. This study is similar with the study of (Maharjan, 2004) which showed that the daily waste in Kalimati vegetable market ranged from 2.72 MT to 10.86 MT. The amount of waste generation in Kalimati vegetable market was humongous i.e.45 ropanies as compared to this study area of ICAM i.e. 3 ropanies and 25 anas. It was because of the fact that Kalimati vegetable market is one of the biggest vegetable wholesale markets of Nepal. The seasons of the year also causes variation in the amount of waste generation.

Estimated compost and different compost influencing factors

The highest amount of compost is supposed to be generated from anaerobic pile composting (1.82 tons/week) and lowest amount of compost is supposed to be generated from vermin composting (1.17 tons/ week). This variation in the amount of compost was due to various factors like temperature, moisture content, pH etc. Different methods of composting generate different amount of compost at different time period. The time requirement for maturation of compost was different for different compost method. The time requirement for aerobic composting method is short as compared to other methodsof composting techniques i.e. only 2 and half months. It may be due to the constant supply of oxygen for the micro-organisms from the holes present in the compost bin. But the maturation time of anaerobic composting takes more than 4 months. It might be due to absence of oxygen for the micro-organisms. Likewise, pile composting and bag composting method requires about 3 and half months (Maharjan, 2004).

Temperature also indicates the amount of biological activities taking place in composting. Temperature also indicates the amount of biological activities taking place in composting. Extent of rise in temperature of compost will depend upon the type of waste material being compost and also on the size of the heap (Gaur, Sadasivam, Magu, &Mathur, 1990). The maximum amount temperature could be observed in pile composting at the thermophilic stage. At this stage most of the pathogens are killed. After this stage temperature will be cooled and the population of mesophilic microorganism becomes active during decomposition process. (Maskey, Bhattrai, Gami, &Shrestha, 2001).

Decomposition rate of organic matter also depends on moisture content of the waste material as well as the relative humidity of air and ambient temperature. Higher the moisture content, greater is the chance of growth of microorganisms. But excessivemoisture above 60% can lower the internal temperature, as a result oxygen flow getsinhibited (Sharma, 2001).

Similarly, pH value changes during decomposition process. In the beginning the pH of wastes are acidic in nature and then becomes basic in nature when the composts are fully matured.

According to the study done byMaharjan, (2004) on Kalimati Vegetable Market high concentration of compost doesn't support higher productivity but causes suppression of plants.

People's Perception

From the surveyed sellers of ICAM, 73% of the shop owners were satisfied with the waste management practices and had a perception that the management practices are satisfactory in context of our country. The market area was mostly clean, and the wastes were also collected timely. But 27% of the shop owners were unsatisfied with the waste management. According to them plan on waste management is made but isn't implemented. Generally, difficulty was faced by both sellers and costumers during rainyseason. The market area gets smelly when wastes are not properly managed and stored. Also the pathway of the market is not proper and has potholes due to which the market becomes muddy during rainy season. According to them generating compost manure from the degradable wastes of the market can be a very effective method to minimize the wastes from the market area. Also, the separation of waste at the source can be done, proper disposal facilities can be provided, awareness and cleanliness program can be initiated, and proper concern must be given to the ICAM by government.

Existing Waste Management Practices

Onsite Separation of Wastes

It was observed that the onsite separation of wastes wasn't practiced in ICAM. This could be the result of ignorance, also due to unawareness of shop owners and waste handlers and low budget. The sellers have a little knowledge about separating inorganic and organic wastes.

Collection Practices

Stall to stall waste collection system was practiced in ICAM once a day and stored in a storage area. The stallholders used their own container, sac or plastic bags to collect their waste. Sweeping was done once a day as a result the pathways of the market area wasclean. Unlike our study area different metallic containers were provided for waste collection in Kalimati Vegetable market according to KFVWM development board but the stallholders didn't contribute in waste segregation and did not use the container service so the system failed. (Wagle&Gautam, 2007)

Waste Storage Area

ICAM vegetable market has an open storage area with easy access to people, animals and scavengers. Due to the open storage area, the sellers and costumers face problem during rainy season.

Waste Transportation

The wastes of ICAM were transported directly to the disposal area i.e. Okharpauwa. Thewaste was transported once a day at afternoon which was found to be sufficient for the amount of waste generated in the market. While according to (Wagle&Gautam, 2007)about two to three trips of solid wastes were transported daily in winter season while in summer eight to twelve trips of wastes were transported in Kalimati Vegetable Market due to the massive area.

Waste Disposal

The final step of the waste management is to safely dispose them in a proper manner. The final destination of the wastes was Okharpauwa landfill site which is located in Nuwakot district. The landfill covers an area of 15 hectares. From our study it was found that the final destination of waste disposal was Okharpauwa landfill site which was similar to (Wagle&Gautam, 2007) that was found thatthe disposal site of Kalimati Vegetable market was found to be Balkhu riverbank and Okharpauwa landfill site. Therefore this study is justifiable.

Conclusion

Among different sectors of waste generation Icchumati Community Agricultural Market (ICAM) is one of the sectors that has been generating a remarkable amount of biodegradable waste in present. During the study it was observed that the daily waste generation inside the vegetable market ranged from 490 kgs to 561.8 Kg. From the analysis it was clear that the waste generated was directly proportional to the size of the stall and flow of vendors.

Composting is a process of biological decomposition of organic wastes by bacteria, fungi, worms or other micro-organisms. Among different methods of composting such as Pile composting, Aerobic Bin composting, Anaerobic Bin composting, Bag composting and Vermicomposting, Vermicomposting method is supposed to give best result on the basis of nutrient quality. The time requirement for Aerobic Bin composting is supposed to be comparatively shorter than other methods of composting.

The study also revealed that most of the shop owners inside ICAM were satisfied with the waste management practices of the vegetable market. There were sufficient waste handlers and vehicle as a result of which cleanliness wasn't a big problem within the market.

The wastes generated inside ICAM are mostly organic and can be easily recycled. These wastes can be cheap source for recycling through various methods of composting and the

final product can be used as compost manure. The compost can be used as supplement for expensive chemical fertilizers. But such practices are not in practiced by ICAM as a result such valuable resources are being wastes. Effective management of these wastes can produce "Gold from Garbage".

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Status of Hazardous Waste and Chemical Management in Some Selected Industries, Hospitals and Health Laboratories in Nepal

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Abstract

Hazardous waste if not managed properly poses serious threat to the human health and environment. Moreover, developing countries lack proper resources for the proper management of such waste. Hence, a study has been carried out by Department of Environment regarding the hazardous chemical and waste management practices adopted by some industries and hospitals in Nepal. The overall objective of the study is to assess the nature of chemical used and hazardous waste generated as well as their management in industries (different types) and hospitals in Nepal. Altogether seventeen industries, hospitals and health laboratories were selected from different parts of Nepal for this study. For the study, a checklist was developed and information was collected from the sampled industries, hospitals and laboratories about the use of chemicals and hazardous materials, hazardous waste generation along with their management. It was found that various types of hazardous and non hazardous wastes were found to be generated from different industries and institution. The average amount of hazardous waste generated from the selected institutions for this study was found to be 80 kg per day. Also, hazardous chemicals and hazardous waste were not properly handled in those institutions. And, institutions were found lacking proper facilities for the management of the hazardous wastes.

Keywords: *Hazardous waste management, Chemical management, Healthcare waste*

Introduction

Resource Conservation and Recovery Act (RCRA) of United states of America defines hazardous waste as "A solid waste, or combination of solid waste, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (a) cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed"(US EPA, 2019). In many developing countries, waste is scattered in urban centers or disposed of in open dump sites. The lack

of infrastructure for collection, transportation, treatment and final disposal, management planning, financial resources, know-how and public attitude reduces the chances of improvement (Ferronato and Torretta, 2019).

Various types of hazardous wastes are produced from different types of industries (Liu et al 2016, Misra and Pandy 2005). Hazardous waste poses risk to the environment and the human health and have negative impact on air, water and soil (Misra and Panday 2005, Li et al 2015).

Besides surface water, the ground water may also be contaminated due to the open dumping of the hazardous and non hazardous wastes from industries posing serious public health threat to the population nearby such sites (Rao et. al. 2011, Carvalho et al 2018, Mbuligwe et al 2006, Damalas et al 2008). The major problems faced by developing countries for the management of the hazardous waste are lack of the comprehensive legislation, unauthorized scrap dealers, poor and inappropriate disposal methods and the significant health hazards and environmental pollution etc. (Gu et al 2014).

Also, in developing countries the quantities of hazardous wastes have not been documented because waste streams are incorrectly managed thereby posing greater environmental impacts (Mmereki et al 2016). Like other developing countries, there have been very few research conducted on hazardous waste in Nepal as well. The aim of this research is to assess the hazardous waste generation and their management in some selected industries, hospitals and health laboratories of Nepal. Though the findings of this research may not be generalized to the whole country, this will definitely demonstrate the scenario of the hazardous waste management in Nepal.

Methodolgy

This study was carried out by Department of Environment from February to June 2019. Different industries, hospitals and health laboratories of Kathmandu Valley, Rupandehi, Nawalparasi, Morang and Sunsari districts were selected for this study. A total 17 institutions were selected for the study. Out of those 17 institutions, 12 were industries and the remaining 5 were hospitals and health laboratories. The type of institution selected for the study and their location has been presented in Table 1. A checklist was also developed to acquire the required information for the study. Through the checklist, general information of institutions, major chemicals used, waste water generation process and its treatment, hazardous waste (type and amount) and their management, solid waste generation and their management was acquired. The checklist was filled up by the study team through the consultation with the senior staff as well as the personnel involved in such processes. Apart from the checklist, direct observation was used as vital approach

of information collection. For this, various facilities of hospitals, industries and health laboratories were visited in order to gather the information regarding the storage of chemicals, collection and storage of waste materials, management of waste water.

Table 1: No. of different type of Institutions selected for the study

S N	Type of Institution	No.	Location
1	Hospital	4	Two from Kathmandu Valley, One from Morang and one from Rupandehi Districts
2	Health Laboratories	1	Kathmandu District
3	Iron and steel industries	4	Two from Morang and Two from Rupandehi Districts
4	Lead acid battery industry	1	Morang District
5	Pharmaceutical industry	1	Nawalparasi District
6	Plastic industry	1	Morang District
7	Spinning industry	1	Sunsari District
8	Rubber industry	1	Kathmandu District
9	Fiber industry	1	Chitwan District
10	Tyre industry	1	Rupandehi District
11	Lubrication industry	1	Kathmandu District
Total		**17**	

Results and Discussion

Chemicals used in different industries, hospitals and health laboratories

Different chemicals and raw materials are found to be used in different industries and institutions. The major chemicals used in different industries and institution has been summarized below.

Table 2: Major Chemical used in different Institutions

S N	Type of Institution	Major chemicals used
1	Iron and steel industries	Hydrochloric acid, Sulfuric acid, Ammonium chloride, Zinc chloride, Diesel (used in diesel generator)
2	Hospital and Health laboratories	Hydrochloric acid, Sulfuric acid, Acetic acid, Potassium hydroxide, Sodium hydroxide, Propanol, Ammonium hydroxide and many chemicals used in laboratories and as cleaning chemicals, Diesel (used in diesel generator)

S N	Type of Institution	Major chemicals used
3	Lead acid battery industry	Sulfuric acid (Conc.), Hydrochloric acid (Conc.) Lead alloy, Red oxide ($Pb_3O_4.PbO_2$), Grey oxide ($PbO_2.PbO$), Diesel (used in diesel generator)
4	Pharmaceutical industry	Hydrochloric acid, Nitric acid, Sulfuric acid, Sodium hydroxide, Potassium hydroxide etc, Diesel (used in diesel generator)
5	Plastic industry	LLDPE Master batch, kerosene (used in painting), Diesel (used in diesel generator)
6	Spinning Industry	Aayo salt, Acetic acid, Ammonium sulfate, Caustic soda, Nitric acid, Sodium chlorite, Sodium hydro sulfate, Sulfuric acid and different dying chemicals, diesel (used in diesel generator), petrol(used in cleaning)
7	Rubber industry	Synthetic rubber, Precipitated Silica, Zinc Oxide, Pf resin etc
8	Fiber industry	Glass fiber, Resin, Catalyst, Polyurethen, Resin, Thinner, Cleaning solvent, Adhesive and other organic compounds.
9	Tyre industry	Adhesive solution and tyre powder, Diesel (used in diesel generator)
10	Lubrication industry	Base Oil, Additives, Black Mobil, Diesel (used in diesel generator)

Chemical management

The chemical management procedure in the industries and institution was also assessed by the study. From this, none of the institutions was found aware in the proper management of the hazardous and other chemicals. The major problems identified were as follows.

- Chemicals were not classified as hazardous and non- hazardous in any of the institutions.
- Most of the chemicals used were identified by trade name and none of the industries and institutions were found aware of the exact chemical constituent.
- None of the institution had acquainted workers with the knowledge about handling and health hazard of hazardous chemicals/wastes though formal/informal trainings.
- In all of the studied industries, workers were not found to use the personal protective equipment. However, in all of the hospitals and health laboratories, employees were found to use mask and gloves.
- Out of 17 institutions selected for the study, 16 institutions were not found to keep records of waste generated. Only one hospital was found to have kept the records.

Waste water treatment in the industries and institutions

Chemical are used in industries in different processes from where they are released in to air, water and soil through different means. In industries, hospitals and health laboratories, waste are released from production process as well as from the cleaning process. Large amount of waste water (>5,000 liters per day from production process) was found to be released from Iron and steel industry, Pharmaceutical industry, Hospital, Health laboratories and spinning industries while nominal amount of waste water was found to be released from Fiber industry, Tyre industry, Lubricant industry, Plastic and Rubber industry. Out of the 17 institutions, 12 institutions are found to discharge significant amount of waste water (>5,000 liters of waste water per day). The average amount of waste water generated from all the 17 institutions was found to be around 75,000 liters per day. The largest amount of waste water generated from an institution was found to be 400,000 per day. Figure 1 shows the amount of waste water generated from the sampled industries.

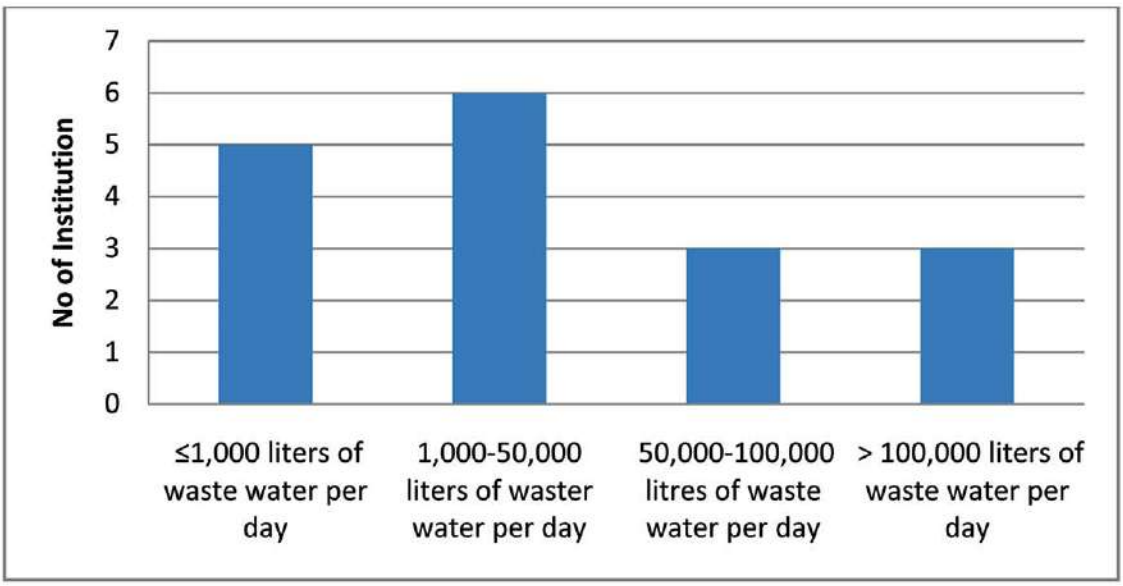

Fig 1. Waste water generation from different institutions.

Out of the 12 industries and institution that generate significant amount of waste water, only 3 industries and institution were found treating waste water up to secondary level. While 4 industries and institutions were found having partial treatment. Out of those four institutions, two institutions were found adding lime in waste water for pH adjustment and two institutions were found using sedimentation technology for settling solids from waste water. Rest of the industry and institution were not found treating waste water at all. Out of those 12 institutions that generate significant amount of waste

water, 10 institutions discharge waste water into public drains while 2 of them collect it in ponds within their premises. Figure 2 depicts the type of treatment done by the sampled institutions for the waste water.

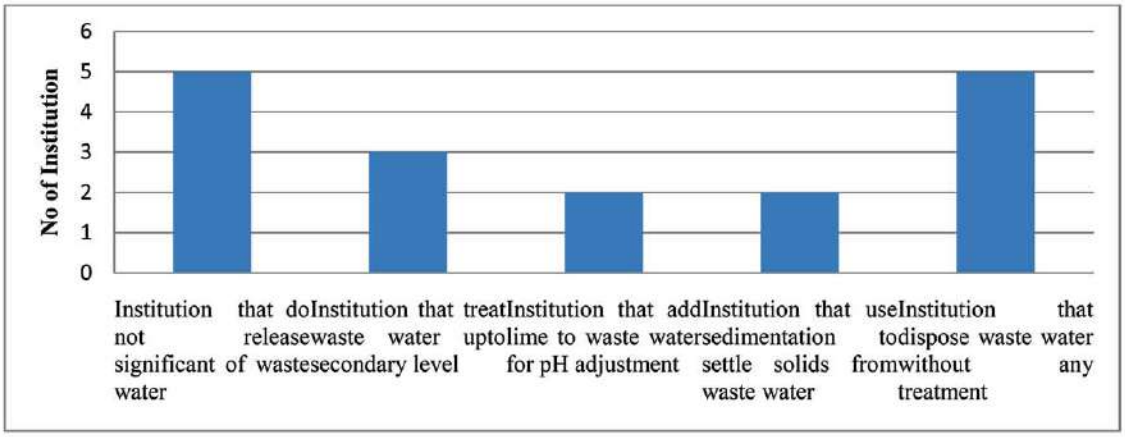

Fig 2: Waste water management in different industries

Hazardous waste material from different industries and Institution

Different industries and institutions were found to release different type of hazardous waste material. The major hazardous waste material emitted from the studied institutions has been presented in table 3.

Table 3: Major type of hazardous wastes from various institutions

S N	Type of institution	Major type of hazardous waste
1	Iron and steel industries	Spent mobil, Spent grease, Sludge, Chemical packaging material
2	Hospital and Health laboratories	Infectious waste, Sharps, Needle, Pharmaceutical waste, Chemical waste etc
3	Lead acid battery industry	Sludge, Scarp material contaminated with lead, Expired raw material, Dust contaminated with lead and other chemical, Chemical packaging material
4	Pharmaceutical industry	Sludge, Expired raw material, Expired products, Chemical packaging material
5	Plastic industry	Material contaminated with kerosene
6	Spinning industry	Spent mobil, Spent grease, sludge, cleaning material (used for cleaning machine), chemical packaging material
7	Rubber industry	Spent mobil, Spent grease, dust, chemical packaging material

S N	Type of institution	Major type of hazardous waste
8	Fiber industry	Spent mobil, Spent grease, chemical packaging material
9	Tyre industry	Spent mobil, Spent grease, chemical packaging material
10	Lubrication industry	Spent mobil, Spent grease, chemical packaging material

The average amount of hazardous waste generated was found to be 80 kg per day. The maximum amount of hazardous waste generation from an institution was found to be 350 kg per day.

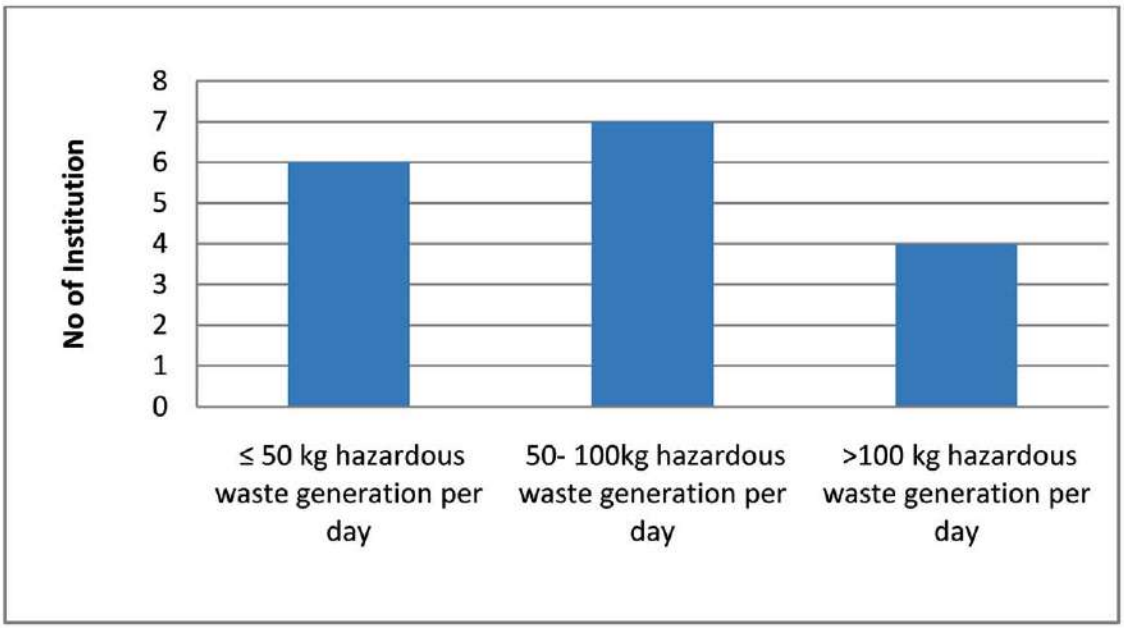

Fig 3. Hazardous waste generation from different Institution

Out of 17 institutions, 6 institutions were found to generate 50 or less than 50 kg of hazardous waste per day while 7 institutions were found to generate 50 to 100 kg of hazardous waste per day and 4 institutions were found to generate more than 100 kg of hazardous waste per day. The type of hazard from hazardous waste identified from selected institutions has been presented in Table 4.

Table 4: Type of Hazard associated with the different hazardous waste identified in the study

S.N.	Hazardous waste	Type of Hazard associate with
1	Spent mobil, Spent grease, Material contaminated with kerosene,	Fire Hazard
2	Sludge, Scrap material contaminated with lead, dust contaminated with lead and other heavy material, expired raw material from lead acid battery industry, dust from rubber industry, chemical packaging materials, expired raw material and expired products from pharmaceutical industries, pharmaceutical waste from hospitals.	Toxic
3	Infectious waste from hospitals and health laboratories	Health Hazard(infection)
4	Sharps and Needles from hospitals and health laboratories	Physical Hazard (can cause injuries) and also may cause infection

Segregation of waste

Out of 17 institutions, only two hospitals and one health laboratory were found segregating wastes properly. Those three institutions were found to segregate infectious waste, sharps and needles, plastic and paper and general biodegradable waste in the source. Rest of the institutions were not found segregating wastes properly.

Management of Hazardous waste by institutions

Management of chemical packaging materials

Major packaging materials found in different institution were sacks, drums and jars. Sacks are mainly used for storing solid materials while jars and drums are used for storing liquid chemicals. Out of 17 institutions, 12 institutions reported that sacks are released from chemicals packaging and 6 industries reported that drums and jars are released from chemical packaging. Out of 12 institutions, 3 institutions reported that sacks are used to collect waste and rest of the institutions reported that they sold it to the vendors. Most of the drums and jars released are also sold to the vendors. One industry was found releasing glass fiber and wood dust from the packaging material and it was reported that these wastes are sent to municipalities for further management.

Management of Expired chemicals

Out of 17 institutions, one pharmaceutical and one lead acid battery industry were found to be having significant stock of expired raw material and products. Those industries are storing expired material for long time and looking for better management options because they lack the proper management procedure. Some hospitals were also found having expired pharmaceuticals and it was said that they return the expired medicine to the supplier or the manufacturer.

Management of Healthcare waste

Four hospitals and one health laboratory were included for this purpose. Out of these five institutions, three institutions were found treating infectious waste. Two institutions were using autoclave while one was using autoclave and sodium hypochlorite solution for the disinfection of the infectious waste. Remaining two institutions were not using any treatment methods. Out of those two institutions, one institution was found openly burning such healthcare waste in its own premises while the another organization was dumping its healthcare waste in the landfill site managed by the municipality.

Management of Sludge

Sludge is produced as a by-product from waste water treatment plant. Beside this, sludge is also produced during production process in some industries. Out of 17 institutions studied, 6 institutions were found to be producing sludge. In three institutions which treat waste water to secondary level and two institutions which use sedimentation to partially treat waste water, sludge is produced during waste water treatment process. In one industry, sludge is produced during the production process also. The method of sludge disposal has been depicted in figure 4.

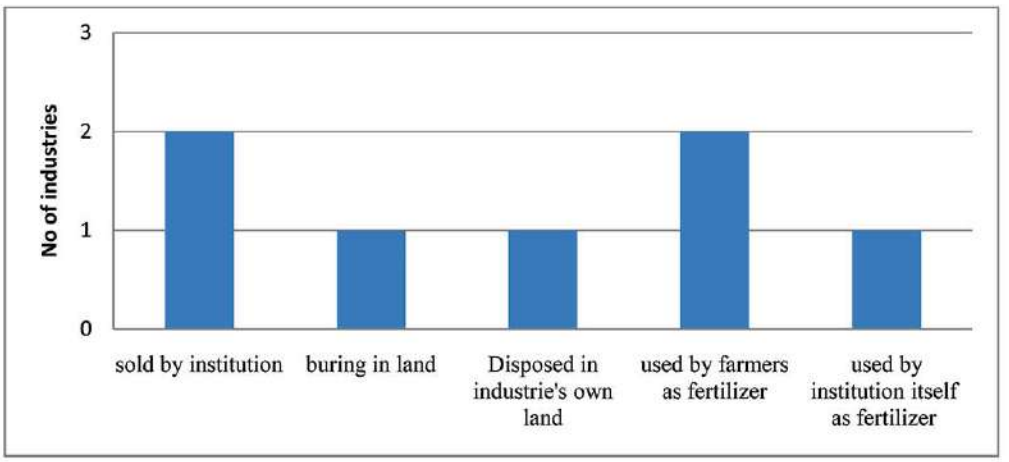

Fig 4. Sludge Management in different Industries

Solid waste management techniques used by the Institution

Institutions were found to be using various management options for the solid waste. Only some hospitals and health laboratories were found using different management option for the treatment of infectious waste. Institutions especially industries were not found segregating and treating hazardous waste and they were found treating hazardous waste as common waste. Most of the industries and institutions were found using more than one management technique/practices. The common management techniques which were found being adopted has been presented in the figure 5.

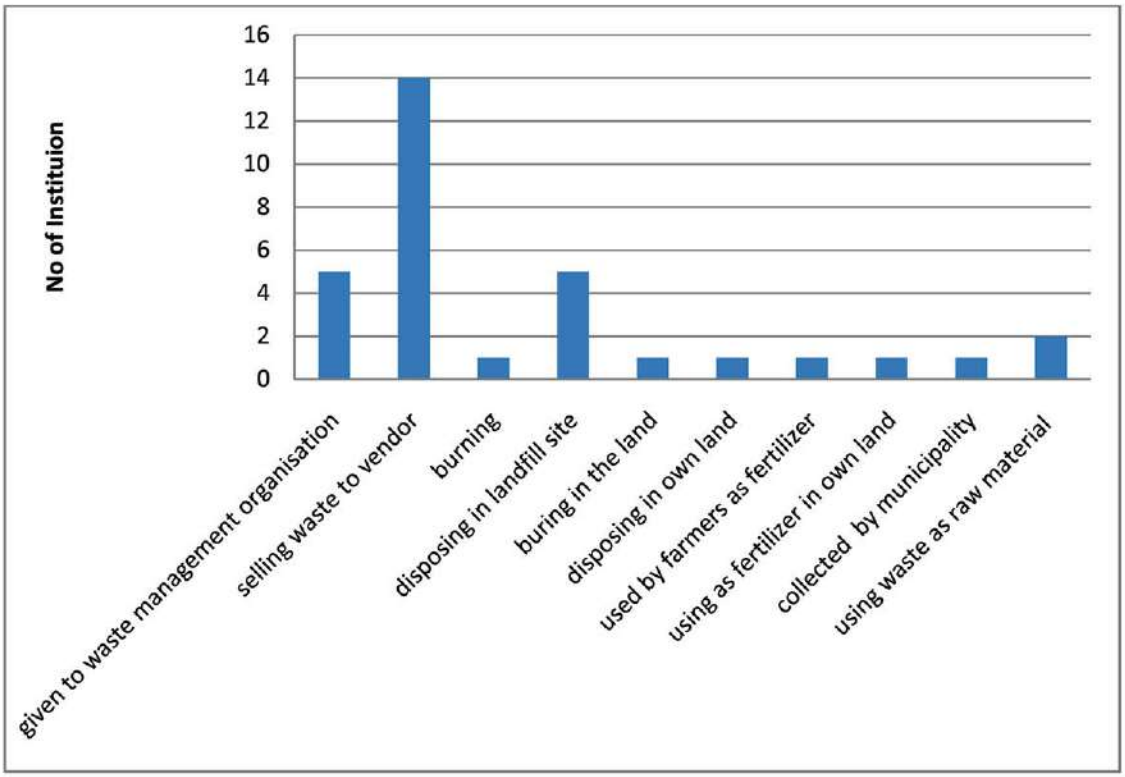

Fig 5. Waste management techniques adopted in different institutions

Some industries and institutions were found selling some of the recyclable waste materials to the vendors. Both hazardous and non-hazardous waste materials were found to be sold to the vendors. The major ones sold to the vendors are sacks, plastics, waste mobil, drums, jars, metal scraps etc. Out of seventeen, five industries and institutions were found disposing their hazardous and general wastes in the municipal landfill site.

Hence significant amount of hazardous waste was found to be generated from different sampled institutions. However, the hazardous wastes were managed similar to general

waste. In some cases, hazardous waste material even goes to the general landfill site. There has been absence of facilities like hazardous waste landfill as well for the management of the hazardous waste. Similarly, different chemicals used by institutions are also released to surface water bodies but all institutions were not found to treat waste water properly. Hence the present method of waste water and hazardous waste management seem to pose serious threat to human health and environment.

Conclusion

The study concluded that various categories of hazardous and non hazardous chemicals / materials were found to be used by different industries, hospitals and health laboratories. Likewise, various types of hazardous and non hazardous waste were found to be generated from those institutions. Also, management of chemical packaging materials and expired chemicals was found to be poor. Segregation and treatment of infectious waste by hospitals and healthcare facilities was not found to be satisfactory either. Out of seventeen institutions, only two hospitals and one health laboratory were found segregating their wastes in proper ways. They were found lacking facilities for the proper management of the hazardous waste. Some industries were found to be storing expired chemicals because of lack of facilities for the management of those chemicals. Thus, the management of hazardous wastes and chemicals generated and used by industries, hospitals and health laboratories was found to be an issue of serious concern.

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Forest Structure and Carbon Stock in Aadarsha Namuna Community Forest of Jhapa Province One Nepal

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Abstract

Carbon stock related studies in the forest are gaining attention these days as it is essential for climate regulation. We conducted a study in the Aadarsha Namuna community forest, Buddhashanti Rural Municipality, Jhapa, to estimate the carbon stock in this forest. For this purpose, we recorded data from a total of 35 circular plots (each of 250m2), adopting systematic sampling to collect the biophysical data of trees, sapling, seedling and leaf litter, herb, and grass. The studied forest was species-poor with Shorea robusta forests with importance Value Index 238.33 with 204.19 ton/ha of carbon. Based on the number of seedlings, saplings, and adult trees, the regeneration status was good. The DBH size class diagram was skewed towards the younger DBH class, indicating good regeneration and good carbon stock in the future. This study recommends that this community forest conserving higher DBH-sized adults maintain sustainable regeneration and maintain stable carbon stock in this forest.

Keywords: *Biomass; Carbon stock; Climate regulation; Forest; Regeneration; Trees*

Introduction

The carbon stock related studies in forests are getting attention as it is essential for regulating climate change (Fernandes et al., 2020). Forests are the reservoir of carbon. The terrestrial ecosystem stores 60% of all carbon (Ong et al., 2020). Forest plays a vital role in reducing ambient CO2 levels by sequestering atmospheric carbon into woody biomass growth through photosynthesis and increasing soil organic carbon(SOC) content (Brown et al., 1994). Trees of forest stock the carbon to maintain the carbon pool of the forest ecosystem. Carbon stock refers to the absolute quantity of carbon stored in a pool at a specific time, whereas carbon sequestration is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide in the biosphere (FAO, 2011).

The carbon of trees remains stock in three forms of trees, i.e., seedling, saplings and trees, and litter and soil. The above-ground carbon stock is the largest pool and the most directly impacted by deforestation. Above-ground carbon storage in natural forests is higher than that in any other vegetation. Above-ground tree biomass variation is based on climate and forest stands types.

Phytosociological character and population structure have a significant role in the carbon storage system in the forest.Phytosociologymeans the floristic composition, structure, development, and distribution of plants (Poore, 1955). The phytosociological character of the forests to know about the community status of species (Harper et al., 1965; Lykke, 1998). The phytosociological character can be assessed by calculating density, relative density, frequency, relative frequency, and importance value index (IVI)(Sheikh, 2017). The measure of the structural parameter of trees DBH and height is essential to know the structural attribute of the forests (Hu et al., 2015). Population structure can be assessed by making a DBH density diameter curve.The number of seedling, sapling, and tree counts gives the idea of the status of regeneration of trees (Pokhriyal et al., 2010). The successful regeneration of plants depends upon the survival and growth of seedlings and saplings (Good and Good, 1972).

Community Forestry Programme accounts for almost four decades of history is one of the major national forest management strategies of the Government of Nepal (GoN) (Bartlett, 1992; Gautam et al., 2004;Gilmour, 2016;Maryudi et al., 2011). However, the handing over of forests to local communities gained momentum after the endorsement of the Forest Act 1993 and the Forest Regulation 1995 (Dahal and Chapagain 2008; Gilmour, 2016; Pokharel et al., 2007; Springate-Baginski et al., 2003). By 17 July 2017, 1,813,478 ha of the total national forest has been handed to 19,361 community forestry user groups (CFUGs) (DoF, 2017). About 1.45 million households, or 35 percent of the population of Nepal, are involved in community-based forest management programs by forming 17,685 Community Forest User Groups (CFUGs) who manage 1,652,654 hectares of national forest handed over to them (DOF, 2015).

Forest is essential in mitigating greenhouse gas emissions. Reducing carbon emissions from deforestation and forest degradation in developing countries is central to combat climate change (Gibbs et al., 2007). It seems that carbon sequestration in developing countries may be more cost-effective than developed countries (Richards and Stokes, 2004). The national forest inventory of Nepal has shown that carbon stock in the forests of Nepal stores 897 million metric tonnes of carbon in the year 2005 (FAO, 2006). Likewise, the total carbon stock in Nepal's Forest was recorded to be 1,054.97 million tonnes (176.95 t/ha). Out of this total, tree components (live, dead standing, dead wood, and below-ground biomass), forest soils, and litter and debris constitute 61.53%, 37.80 %, and 0.67%, respectively (DFRS, 2015).

However, this data is quite old and is not specifically focused on one particular forest like the Aadarsha Namuna community forest.Therefore it is necessary to estimate the carbon stocks to understand the potential role of forests in carbon sequestration in our community. Therefore, this study has been aimed in order to assess the structure and above-ground and below-ground carbon level of the Aadarsha Namuna community of Jhapa (Province.1), Nepal.

Materials and Methods

Study Area

We conducted this study in the Aadarsha Namuna community forest located in the Buddhashanti Rural Municipality, Ward no.4, Province no.1, Jhapa District. The total area of this forest is 178.46 ha. It is located between 26o41'.30" and 26042'.30" north latitude and 8803'.0"and 88005'.0"east longitude (Figure 1).

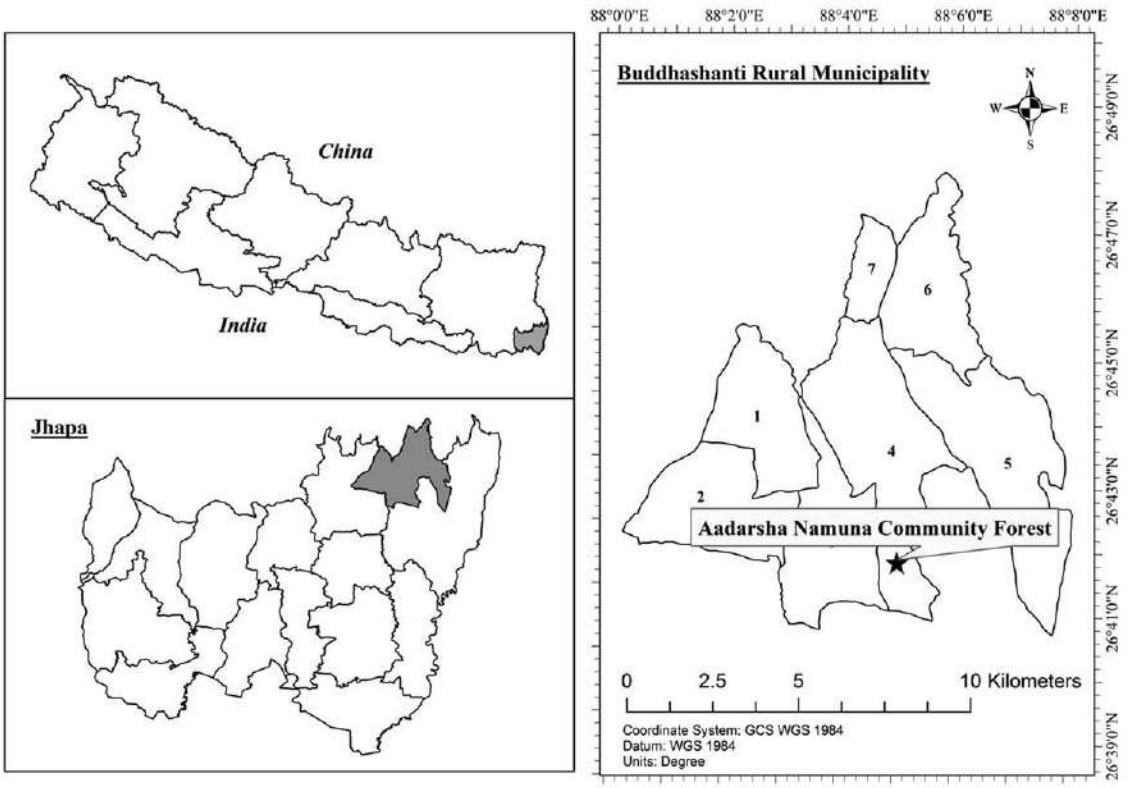

Fig 1: Study area map of Aadarsha Namuna Community Forest, Jhapa

Sampling

We laid a total of 35 plots applying a systematic sampling method with 220 m distance from each plot using Arc GIS software. Inside the circular plots of 250m2, the adult trees were counted in the whole area, a sapling in 100m2, seedling leaf litter, herb, and grass in 1m2.The DBH (at 1.3m) and the height of an individual tree greater than or equal to 5cm DBH were measured using diameter tape and a range finder. For the saplings (1-5cm), only the DBH at 1.3m above ground level were measured. Finally, the sub-sample of leaf litter, herb, and grasses was collected and carried out in the laboratory to determine the oven-dry weight of the biomass.

Data Analysis

Forest Area

Community Structure analysis

We followed Zobelet al., (1987)to analyze the community structure of forests.

$$\text{Density} = \frac{(\text{Total number of individual species in all sampling plot})}{(\text{Total number of sample plot} \times \text{size of sample plot})} \times (10000)$$

Importance Value Index (IVI)= Relative Density + Relative Frequency+ Relative Basal Area

Regeneration Status of Trees

The regeneration status was determined following Shankar (2001):

a) 'Good', if seedling > sapling >adult

b) 'Fair', if seedling or sapling > adult

c) 'Poor', if species survives in only sapling stage but not as seedling

d) 'None', if a species is an absence in both in sapling and seedling stage

e) 'New', if a species has no adult but only sapling or seedling or both.

DBH size Class Diagram

The diameter size class diagram was made, keeping DBH >5-10cm in one class and the other in a gap of 10cm.

Carbon Stock Analysis

Chave et al. (2005) developed the allometric equation for moist forest stand to estimate above-ground tree biomass.We followed Tamrakar (2000) to find above-ground sapling biomass. Moreover, the samples of leaf litter, herb, and grasses were dried to get the biomass. The below-ground biomass was estimated at 20% of the above-ground

biomass (MacDicken, 1997). Then, the biomass stock was converted to carbon stock after multiplication with a default carbon fraction of 0.47(IPCC, 2006).

The total carbon stock was calculated by summing the carbon stock of the individual carbon pools.

Total Carbon stock:
C (LU) = C (ABTG) + C (AGSB) + C (BB) + C (LHG)
Where,
C (LU) = Carbon stock for a land use category (t C/ha)
C (ABTB) = Carbon in above ground tree biomass (t C/ha)
C (AGSB) = Carbon in above ground sapling biomass (t C/ha)
C (BB) = Carbon in below ground biomass (t C/ha)
C (LHG) = Carbon in litter, herb and grass (t C/ha)

Results & Discussion

Results

Phytosociological Character of Trees

We recorded a total of nine species of trees in which Shorea robusta was the dominant species with an IVI value of 238.33, followed by Schima wallichii(Figure 2).

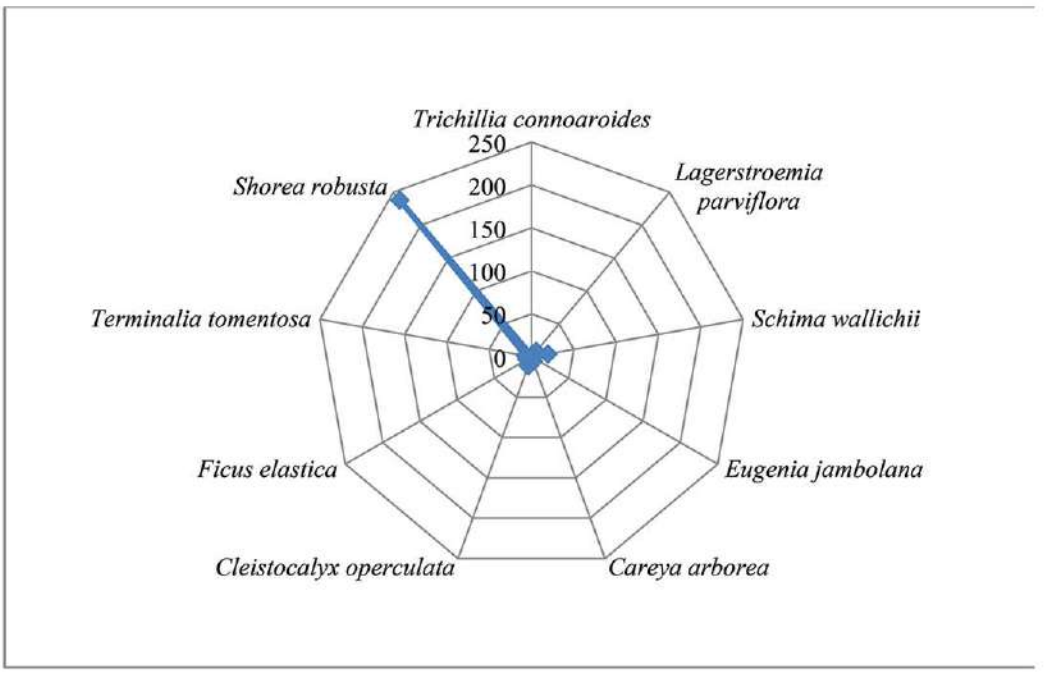

Figure 2: IVI of recorded adult trees.

Regeneration and Population Status of Trees

We recorded 781 / ha of adult trees, 1380 / ha of the sapling, and 26297 / ha of the seedling. The average minimum and maximum DBH were 5.99cmand43.42cm, respectively. The highest number of adult treeswere recorded in DBH size class 10-20cm, followed by >5-10 cm (Figure 3).

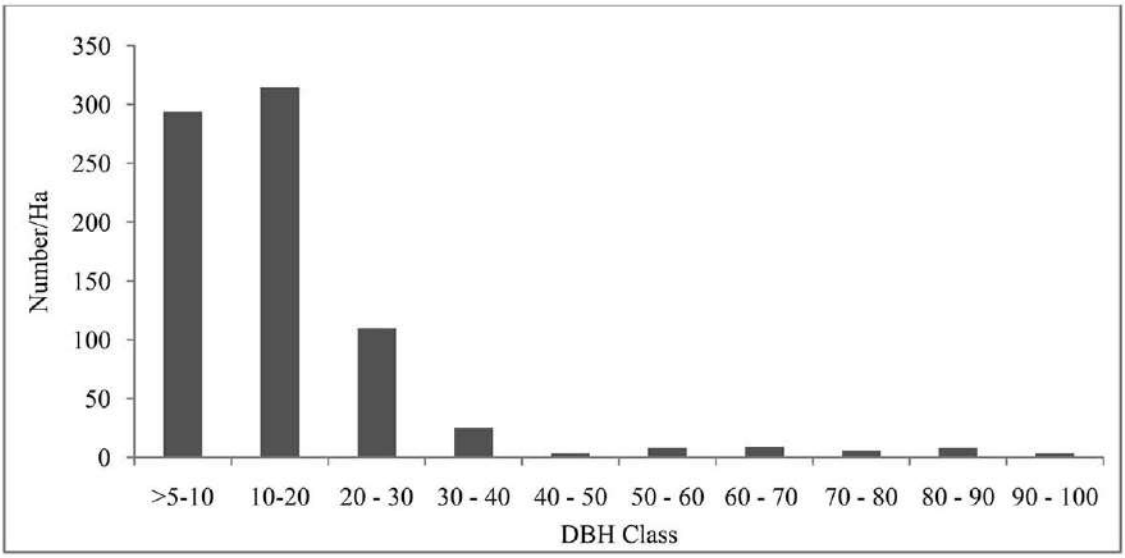

Figure3: DBH size class diagram of Trees.

Carbon Stock

We recorded 204.19 ton/ha of carbon in this forest. The estimated total amount of carbon in the forest was36440.05 tons in 178.46 ha.

Table 1:Carbon stocks present in the studied forest (in tons)

	C (AGTC) t/ha	C (AGSB) t/ha	C (BB) t/ha	C (LHG) t/ha	C(LU (Total)
Actual	168.60	1.87	33.72	0.000013	204.19 t/ha
Estimated	30088.68	333.63	6017.74	0.002251	36440.05 tons

Species wise Tree carbon Stock

The carbon stock in Shorea robusta species was highest (160.41 ton/ha), followed by Terminalia tomentosa 3.07 ton/ha and Ficus elastica 1.8 ton/ha (Figure 4).

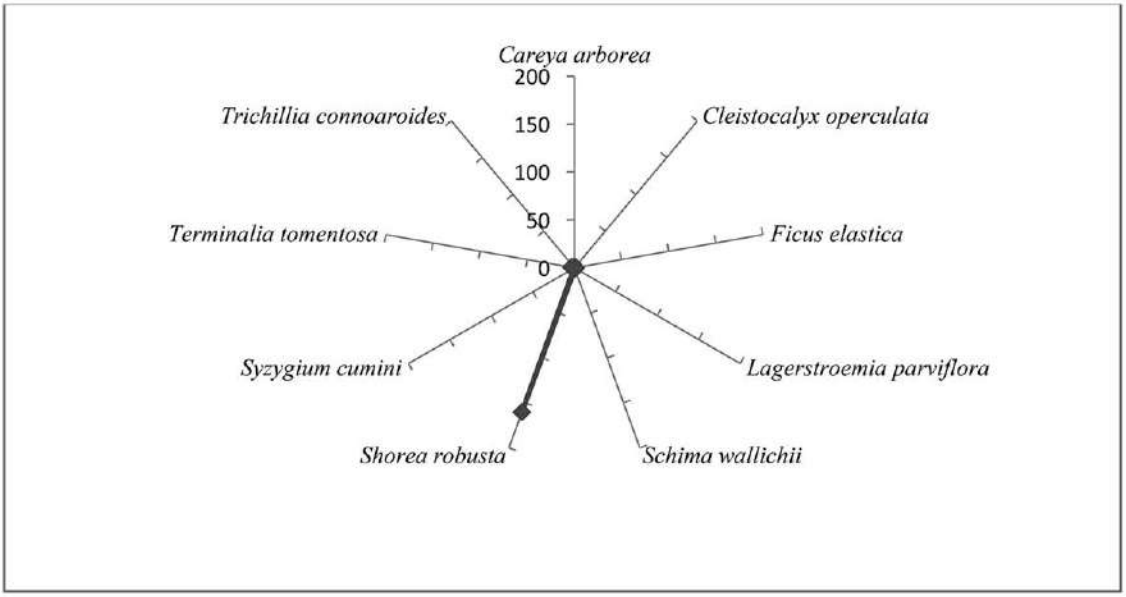

Figure4: Species wise tree carbon (ton/ha)

Discussion

Phytosociological Character of Trees

Shorea robusta dominated the forest, while Schima wallichii, Cleistocalyx operculata, and Lagerstroemia parviflora were commonly available. This analysis goes in line with the study by Joshi et al. (2019). The vegetation analysis of the community forests of the Terai region in Nepal is dominated by monospecies, with the most common dominating species being Shorea robusta (Joshi et al., 2019). The disappearance of other dominating tree species has been observed due to forest degradation or disturbances allocated as grazing or browsing pressure (Onaindia et al., 2004). On the contrary, Malla, and Acharya (2018), in their study, have found that Shorea robusta forests in the Terai region of Nepal has been rapidly degrading due to heavy grazing, fire, and lopping. In order to increase the species diversity in the study, it is recommended that anthropogenic degradation and disturbances within the community forest should be reduced or regulated, which might allow the fostering of lesser dominant species (Pain et al., 2020).

Regeneration and Population Status of Trees

The number of seedlings and saplings were recorded more than adult trees indicating fair regeneration status similar to other Shorea robusta dominated forests of Nepal (Mishra & Garkoti 2016; Sapkota & Oden, 2009). This indicated the good regeneration status of trees in this forest (Shankar, 2001).The DBH size was made to understand the regeneration sustainability and study found that the DBH class within the range of 10-20cm was more. Thus, the DBH density class diagrams of tree species are progressing

towards reverse J shaped, indicating forests will attend sustainable regeneration in the future (Vetaas, 2000). This result could be interpreted with the people's behavioral characters and comprehended that the region's local people are more willing to allow the small-habit trees to grow(Pokhrel et al., 2020). The result also goes in line with the study done by Timilsina et al. (2007) in Shorea robusta-dominated western Terai forests of Nepal. Despite large trees in the study region, this DBH range is considered low as they result from low stocking among mid-size classes (10-20cm) (Timilsina et al., 2007).

Carbon Stock

We recorded 204.19 ton/ha of carbon in studied forest. Therefore, the estimated total amount of carbon in the studied forest was 36440.05tons in the coverage area of 178.46 ha. The result goes in line with the study done by Pandey and Bhusal (2016) in Shorea robusta dominated Terai forest of Chitwan district, with total carbon stock calculated to be 234.54 ton/ha. However, Shorea robusta dominated forests in the mid-hills of Nepal are found to have lower carbon stock values. In the mid-hills of Nepal, the carbon stock was around 120 tons/ha (Thapa-Magar & Shrestha, 2015). In the Terai region, Shorea robusta dominated forests have a much higher presence of average diameter and height than the Shorea robusta-dominated forests in the mid-hills of Nepal.

Species wise Tree Carbon Stock

The carbon stock in Shorea robusta species was highest (160.41 ton/ha), followed by Terminalia tomentosa (3.07 ton/ha) and Ficus elastica (1.8 ton/ha), similar to Aryal et al. (2018). However, this result hugely varied with the study of Pandey et al. (2014) and Ghimire et al. (2018), which showed the carbon stock of the dominant tree to be more than 320 tons/ha and 229.57 tons/ha, respectively. The availability of carbon stock in forests depends on their geographical location, species diversity, age of the stand, decomposition rate, amount of litter, and other disturbances such as fire, lopping, grazing, and tillage(Noordwijk et al., 1997).

This study has revealed that this forest has good regeneration status and a good amount of carbon that provides ecological and economic benefits (Pandey & Bhusal, 2016). For instance, an ecological benefit includes global climate change regulation. The forests' ability to naturally sequester carbon out of the atmosphere is vital for climate change mitigation and has thus been recognized by international climate change agreements (Zhang et al., 2020). Likewise, how the forests respond to growing carbon dioxide (CO2) concentration in the atmosphere is essential for the global carbon cycle as forests sequester carbon comparatively more than any other terrestrial ecosystem (Abere et al., 2017). We recommend timely assessment of forest regeneration and carbon stock assessment in different areas of Nepal so that important inferences can be made for sound management of the forest.

Conclusion

The study on forest structure and carbon stock was done in Aadarsha Namuna Community Forest of Jhapa district province one Nepal. The forest was species-poor with more seedling and sapling than adult trees indicating good regeneration of trees. The DBH size class diagram was right skewed, indicating sustainable regeneration. This study recorded 204.19 ton/ha of carbon stock in this forest. Shorea robusta had stock highest carbon (160.41 ton/ha). The population status of trees in this forest indicated a need to conserve higher DBH class trees to maintain sustainable tree regeneration and increase carbon stock. The data obtained from this study might be taken as baseline data and future research on forest regeneration and carbon stock change dynamics in this forest.

Conflict of interest

None

Acknowledgments

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Physico-Chemical and Bacteriological Assessment of Groundwater Quality of Boring Sites of KUKL; (A Case Study of Kathmandu Valley)

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Abstract

Presented research has assessed physicochemical and microbiological parameters of deep boring groundwater quality from different sites in Kathmandu Metropolitan city. In the study sites, north direction includes Balaju, Makalu-7, BB-0, BB-1; south direction includes Chapagaun, Charghre, Muldol, Khokana area, east direction includes Gokarna-1, Gokarna-3, Lokanthali, Bode area and west direction includes Chobar, Kirtipur, Sim, Dudhpokhari area. Twelve different physicochemical and bacteriological parameters those influence water quality were evaluated and analyzed from 16 separate boring sites with total 32 samples of water in the monsoon season (September, 2020). The physiochemical parameters like pH, turbidity, temperature, electrical conductivity, total dissolved solids, chloride, iron, ammonia, phosphate, total hardness, and total alkalinity were tested using standard methods. For bacteriological parameters total coliform were tested using the standard methods. The main objective of the study was to analyze the physicochemical and microbiological parameters of deep boring water and compare values with NDWQS (National Drinking water Quality Standard). From the laboratory work and analysis, it was found that all the parameters were within the range except the concentration of iron. Therefore, the deep boring water distributed by KUKL (Kathmandu Upatyaka Khanepani Limited) from sampled and studied sites was safe for drinking purposes.

Keywords: *Deep Boring, KUKL, NDWQS, Parameters, Water Quality*

Introduction

Water below the earth surface raised up to water table refers to groundwater. Ground water is being used primarily for drinking, livestock, irrigation, manufacturing, and other commercial purposes. The quality of the groundwater depends on different physicochemical constituents and their concentration, which are mostly derived from the region's geological records (Koivunen et al., 2003). Groundwater is the primary source of drinking water for urban as well as rural areas. The importance of groundwater quality is to obtain water quality that is deprived of to humans, the availability of clean water is

vital to the growth of mankind in many important aspects and also a major economic and political problem in the future. Near the edge of river systems, groundwater receives various contaminations from pathogenic bacteria, pesticides, nitrates, industrial effluents and domestic sewage by inlets and changes the overall quality of groundwater(K C et al., 2018). Study has reported that various waterborne epidemics, such as typhoid, jaundice, cholera, etc., causing significant death too. Much of the valley's drinking water supplies do not fall under WHO standards. Near the edge of river systems, groundwater receives various contaminations from pathogenic bacteria, pesticides, nitrates, industrial effluents and domestic sewage by inlets and changes the overall quality of groundwater. During the monsoon season, the government's authentic water supplier, Kathmandu Upatyaka Khanepani Limited (KUKL), supplies almost 50 % of the total water for drinking purposes in the Kathmandu Valley. During the dry season, however, 60-70 % of total water demand is met from groundwater sources. In our condition potable drinking water supply is a major concern so monitoring of water quality status at regular intervals is needed. Therefore, the present study has assessed the current status of drinking water supply in Kathmandu and tests its suitability for drinking with respect to Nepal's drinking water quality [National Drinking Water Quality Standard (NDWQS)(Chapagain et al., 2010)]. Groundwater, the largest source of fresh water available, is also considered as best source of raw water because it is naturally filtered and has a low concentration of bacteria and other organic contaminants(Shova& Raj, 2013). A substantial percentage of groundwater in the valley is contaminated with fecal indicators as well as other Asian cities and human pathogens(Shrestha et al., 2015).

The mineralogy and reactivity of geological formations in aquifers, the effects of human activities, and environmental parameters that may influence the geochemical mobility of certain constituents all play a role in groundwater quality(Kouras et al., 2007). According to the UN, for example, diarrhea accounts for 80% of all diseases and more than one third of deaths in developing countries caused by poor water quality patients(Mostafa et al., 2013). The study has shown high concentrations of iron and manganese in the deep groundwater. The occurrence of elevated heavy metal concentrations was identified in underground water in the field(Shrestha et al., 2016). Low availability of reliable and potable water in the valley is due to rapid population growth and largely unplanned urban area. There is a lack of reliable water supplies due to, drastic land use changes, socioeconomic transition, and a weak management system(Udmale et al., 2016). By 2025, the government of Nepal's capital investment and asset management program aims to provide 135 liters per capita per day (lpcd) as domestic water to valley residents(Asian Development Bank, 2015). The increasing number of extractions cases of groundwater, uncontrolled and unregulated usage for private and commercial water use has challenged the use of common pool water resource and traditional social environment related to water use(Shrestha, 2017). The similar investigation studying the physicochemical

parameters of drinking water supply for the residents of metropolitan city of Kathmandu was completed(Subedi et al., 2018).

Materials and Methods

Study area

Kathmandu, Nepal is located in the Cities group in Nepal with 27° 42' 2.7684" N and 85° 18' 0.5040" E GPS co-ordinates. The valley is east-westelongated, with an average elevation of about 1350 meters above mean sea level and surrounded by hills of about 2800 meters. The region's climate is semi-tropical, humid, and temperate. The valley receives an average of 2,000 mm of precipitation per year, with around 80% of that falling during the monsoon season in from June to september. The research was carried out four directions, inside the valley. The north direction includes is represented by (Balaju, Makalu-7, BB-0, BB-1), south direction includes (Chapagaun, Charghre, Muldol, Khokana) area, east direction includes (Gokarna-1, Gokarna-3, Lokanthali, Bode) area and west direction includes (Chobar, Kirtipur, Sim, Dudhpokhari) area. The research area carried out the study of deep boring through which KUKL distributes the water which represents the whole valley. There are 80 deep well where KUKL distributes its water inside the valley.

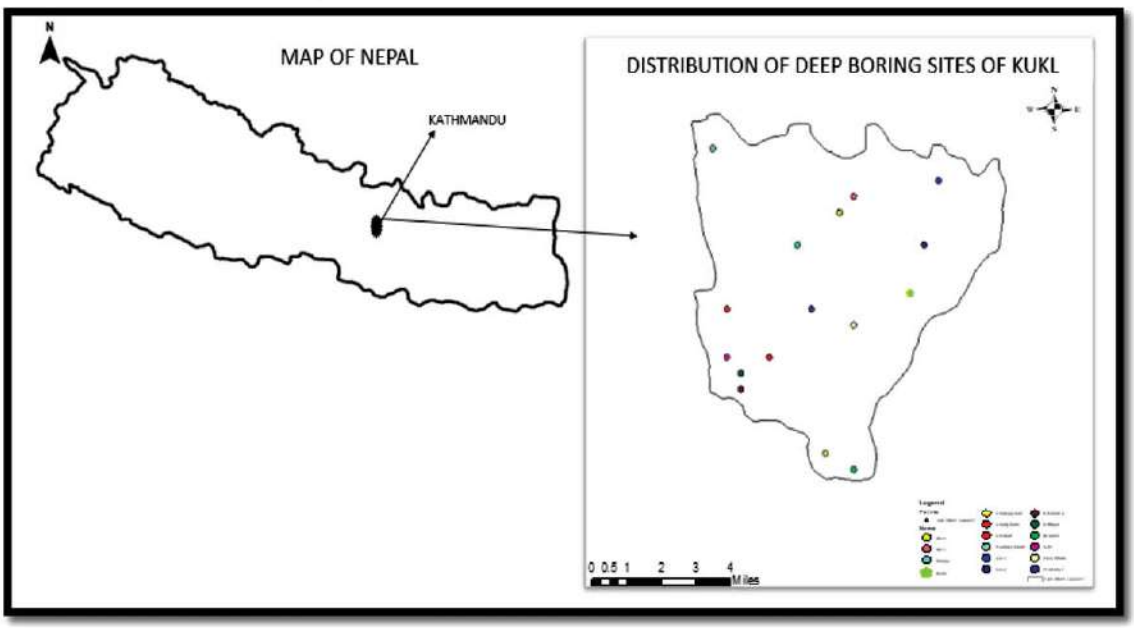
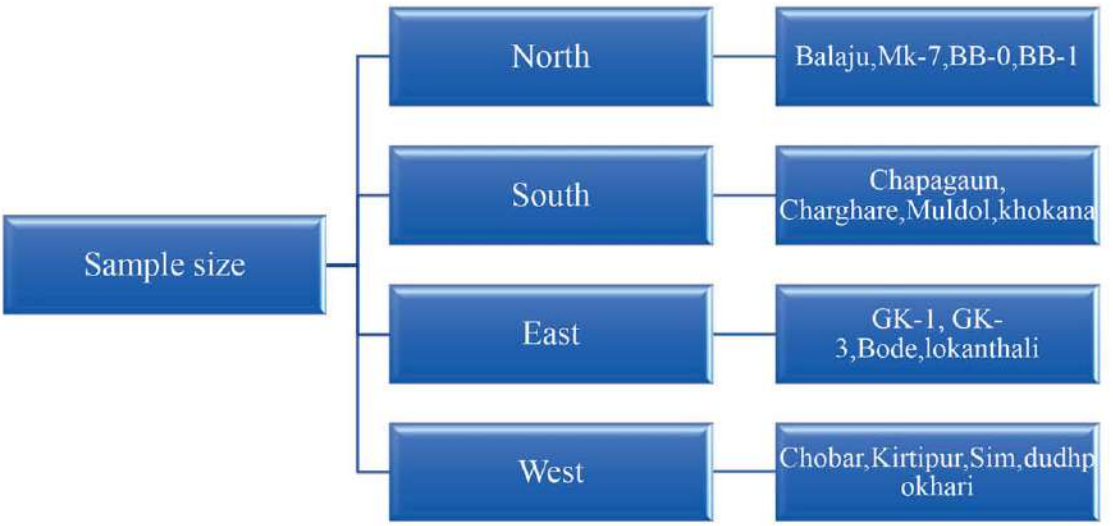


Fig. 1 Study area map showing deep boring sites of KUKL

Groundwater sampling: A systematic sampling was done at 16 groundwater sources sites from different sites of Kathmandu valley.Sampling and testing of water quality

at north site, south site, east site, and west site were performed from 32 groundwater sources sites. The samples collected for groundwater quality analysis of physiochemical and bacteriological parameters were performed in field level as well as in the laboratory too depending on parameters. The sampling locations and groundwater sources are also shown in provided map.



The investigation was focused on analysis of quality of groundwater, collected from depth of 170-250 meters. The water samples were collected during the monsoon season (September 2020).

In presented study to obtain representative samples from each study site, the samples were collected in sterilized sampling bottles after pumping water for five minutes prior to sampling. The sample area was labeled on the sampling bottles with the help of permanent marker. All of the samples were carried to the laboratory on the same day. Until processing and analysis, all samples were stored at 4°C.

The first sample drawn using the simple random sampling technique dividing the total sampling size by sample size(i.e., k=N/n).

Where, K = constant

N= Population size and 'n' = Sample size

The remaining samples are drawn automatically by adding the sampling intervals as follows:

X

X+k,

x+2k,

x+3k ...x+nk.

16/80;so, first sample taken from sample no 20 followed by X+20 and so on.

Deep boring water quality analysis:

For determining the water quality status, the collected groundwater samples were subjected to a variety of physicochemical and microbiological tests [Trivedi and Goel (1995)]. Subsequent physicochemical and microbiological analyzes were performed using standard methods (APHA 1998). The research was carried out in accordance with presented standards water analysis techniques.For accuracy each sites and water sample were tested three times to get concurrent reading. During the sampling period temperature, pH, turbidity, EC and water samples were obtained at the site. Other parameters were analyzed in the laboratory. Turbidity was measured by using the model number LT-33 of the wireless turbidity meter. The concentration of hydrogen ions in the sample water was measured using pH meter model HI98129. The electrical conductivity was measured by the same instrument used to measure the pH. TDS was measured by dipping into the water and reading from the same instrument used for pH should be taken as above. The same instrument gave us reading about the measured water temperature, HI98129 for different water sample's physical parameters. The samples were stored at 4 degrees Celsius for laboratory analysis of different necessary parameters. Phenanthroline method was used for determination of iron from taken sample. Ammonia was measured through the use of Phenatemethod. For chlorine, Argentometric titration method was used for which 50 ml of sample water was taken in a conical flask and 2 ml of K2CrO4 added. The material titrated against 0.02 N AgNO3 until there is a persistent red tinge. Stannous chloridemethod was used to determine phosphate. A 50 ml water sample was taken in a beaker, and 2 ml of ammonium molybdate inserted, accompanied by 5 drops of SnCl2. For total hardness Eriochrome Black T, EDTA method was used;50ml of sample water was taken in conical flask and 2ml of hardness buffer solution was added, a pinch of dry Eriochrome Black T was added in the same content. The color of the solution changed to wine red. The sample was then titrated with EDTA solution until the color changedfrom wine red to blue.

For total alkalinity,50 ml of sample water was taken in a conical flask then 2 drops of phenolphthalein indicator was added. The sample remained colorless, after that, 2 drops of methyl orange was added in the same content, which change the sample into yellow color. The sample was then titrated with 0.1N HCL until the yellow color changed to pink. Membrane filtersmethod count total coliform. For this, alcohol was used to sterilize the equipment before the experiment was performed. Using MacConkey.

Descriptive statistics reveal details about a population's distribution and characteristics. Hypothesis testing was done with the means and variances (1st and 2nd statistical moments) of a normally distributed population from the analyzed parameters using SPSS. In order to compare the data t-test for paired two samples was done to prove the quality of deep boring water. The summary of this is written in table 2 with p-value.

Results and Discussion

The average concurrent values of all tested water quality parameters as well as the elemental concentration of water samples obtained from sixteen sampling sites are shown in table 1. The findings are compared with Nepal's National Drinking Water Quality Standard (NDWQS).

Table1: Measured Physiochemical and microbiological parameters and national drinking water quality standard

S. N.	Tested Parameters	Used Methods/ Instrument &Unit	North site (Balaju, Makalu-7, BB-0, BB-1)	South site (Chapagaun, Charghare, Muldol, Khokana)	East site (Gokarna-1, Gokarna-3, Lokanthali, Bode)	West site (Chobar, Kirtipur, Sim, Dudhpokhari)	National drinking water standard
1	pH	pH meter model HI98129	7.31	7.36	6.94	7.23	6.5-8.5*
2	Electrical conductivity	Multi-purpose Meter model HI98129 (µs/cm)	389.6	314.25	234.13	296.13	1500
3	Total dissolved solid	Multi-purpose Meter model HI98129 (mg/l)	195.75	160	113.21	155.37	1000
4	Turbidity	LT-33 Turbidity meter(NTU)	2.26	0.52	1.84	10.55	5(10)
5	Iron	Phenanthroline (mg/l)	0.36	0.5	0.21	1.18	0.3(3)
6	Ammonia	Phenate(mg/l)	0.04	0.23	0.16	0.07	1.5

S. N.	Tested Parameters	Used Methods/ Instrument &Unit	North site (Balaju, Makalu-7, BB-0, BB-1)	South site (Chapagaun, Charghare, Muldol, Khokana)	East site (Gokarna-1, Gokarna-3, Lokanthali, Bode)	West site (Chobar, Kirtipur, Sim, Dudhpokhari)	National drinking water standard
7	Chloride	Argentometric (mg/l)	19.03	8.4	14.09	9.95	250
8	Phosphorus (Orthophosphate)	Stannous chloride (mg/l)	0.44	0.53	0.43	0.31	0.3
10	Total alkalinity	Phenolphthalein: Methyl Orange (mg/l)	134.5	111.5	99.25	87.87	200
11	Total hardness	Eriochrome Black T, EDTA (mg/l)	151.13	111.62	80.65	69.13	500
12	Total coliform	Membrane filters MPN/100ml	0	0	0	0	0 in 95% samples

Results presented in Table 1 shows that mean pH values of (north site, south site, east site, west site) different sites were: 7.31, 7.36, 6.9, and 7.23 respectively. The values were found to be within the range as compared to NDWQS, as the pH value ranges between 6.5 to 8.5. The strength of the acidic or basic character, or the degree of hydrogen ion activity in water, is measured by pH (Rajbhandari, Rajbhandari & Pradhananga, 2012). The pH scale is used to determine the sensitivity of acidity and alkalinity. A pH of less than 6.5 and greater than 8.5 may be detrimental to one's health. There are reports that pH has no direct effect on humans but this is a significant water quality parameter. To ensure satisfactory water quality and disinfection, pH control must be carefully monitored at all stages of water treatment. (World Health Organization, 2007).The electrical conductivity value of (north site, south site, east site, west site) water samples were 389.6, 314.25, 234.13, and 296.13µs/cm, respectively. The value for electrical conductivity was found to be within the range of NDWQS 1500µs/cm.Considering these parameters water was potable. Locals in Kathmandu use deep boring groundwater for drinking and other domestic purposes(Shrestha, 2017).

The total dissolved solids (north site, south site, east site, west site) in water samples were 195.75, 160, 113.21, and 155.37 mg/l respectively. The value for total dissolved solids was found to be within the range as compared to NDWQS, 1000 mg/l. The turbidity values of (north site, south site, east site, west site) water samples were 2.26, 0.52, 1.84, and 10.55, NTU respectively. The value for turbidity was found to be within the range as compared to NDWQS, 5(10) NTU. Uthayashangar, Nanthakumaran, and Devaisy (2019) reported that EC in the range of 0-800 and even 0-2500 is suitable for human

consumption; however, EC up to 2500 is not recommended for human consumption.

The values of iron from north site, south site, east site, west site water sample were found to be 0.36, 0.5, 0.21, and 1.18, mg/l respectively. The value of iron was found to be higher as compared to NDWQS, 0.3 mg/l, from the water sample in south and west site because of geological structure. Study by Shrestha et al. (2016) has reported that high concentrations of iron and manganese were found in the deep groundwater. The occurrence of elevated heavy metal concentrations was identified in broad water in the field. Furthermore, high Fe concentrations may be due to high dissolved iron, particularly in deep groundwater. The exact mechanism of iron release is unknown, but it may be due to the reducing environment, in which iron oxides dissolve into soluble form. The value of iron from north and east site was found to be within the range. Iron concentrations greater than 1.0 mg/l. According to the WHO International Standards for Drinking Water published in 1958, iron would greatly degrade the water's consistency. At iron concentrations of less than 0.3 mg/liter, there is typically no discernible taste. The main source of iron in natural water are the processes of chemical weathering of geological materials which lead to their destruction and transformation of Fe from solid compounds to soluble and/or colloidal form. In groundwater, in addition to corrosion problems of distribution system, high content of iron can be encountered due to frequency of elevated iron in the earth strata. The different values of ammonia from (north site, south site, east site, west site) water samples were found to be 0.04, 0.23, 0.14, and 0.67 mg/l respectively.

The value for ammonia was found to be within the range as compared to NDWQS, 1.5mg/l. Relevant studies reports that when ammonia consumed in large amounts, it has a detrimental effect on humans.Ammonia present in drinking water,does not pose a direct threat to human health. When the consumption of ammonia exceeds the detoxification potential of healthy humans does it become harmful. Water security Agency (2012) reported that most of the natural water have a pH range where nitrogen is mostly found as NH4+. Ammonia can be found in groundwater as a result of the breakdown of naturally occurring organic matter or man-made sources. Natural ammonia levels in groundwater and surface water are typically less than 0.2 mg/L, but naturally occurring ammonia levels are elevated in many parts of the world. Nitrogen fertilizer application, livestock operations, manufacturing processes, sewage penetration, and cement mortar pipe lining are all sources of ammonia.

The values of chloride from (north site, south site, east site, west site) water samples were found to be 19.03, 8.4, 14.09, and 9.95 mg/l respectively. The value of chloride was found to be within the range of NDWQS, 250mg/l. For chloride in drinking water, no health-based guideline value has been suggested. Chloride concentration greater than

250 mg/liter can cause a noticeable taste effect in water (WHO, 2004).

The values of phosphorus from (north site, south site, east site, west site) water samples were found to be 0.44, 0.53, 0.43, and 0.31 mg/l respectively. There is no standard value of phosphorus mentioned in NDWQS as phosphorus is not toxic to people unless they are present in very high amount. Relevant studies have reported that Phosphates are not harmful to humans or animals unless they are in very high concentrations. Extremely high phosphate levels can cause digestive problems. It is naturally present in water, but it may be applied during water treatment to reduce lead contamination from lead pipework. Phosphate does not have a norm in the NDWQS. The value of total alkalinity from different (north site, south site, east site, west site) were found to be 134.5, 111.5, 99.25, 87.87 mg/l respectively.

The value for total alkalinity was found to be within the range as compared to NDWQS, 200mg/l. The value of total hardness of water samples from north site, south site, east site and west site were found to be 151.13, 111.62, 80.25, 69.13 mg/l respectively. All the values for total hardness were found to be within the range as compared to NDWQS, 500mg/l. Different Studies have reported that hard water is less danger of corrosives and within certain limits, a better taste.

The microbiological parameters of total coliform were tested inside the laboratory and the value from (north site, south site, east site, west site) were found to be 0 from respective sites, which was within the range as compared to NDWQS. APHA (1998) reported that coliform species are known as a good microbial predictor of drinking-water quality, owing to their ease of detection and quantification in water. Total coliforms should be absent immediately after disinfection. The presence of total coliforms in distribution systems and stored water supplies can reveal regrowth and possible biofilm formation or contamination through ingress of foreign material, including soil or plants. Potential health effects of coliform include assorted gastroenteric infections and diseases and these are usually susceptible to people that have weak immune system.

Data analysis

Statistical value of physiochemical and microbiological parameters of deep boring water in Kathmandu was done by using SPSS, which scientifically proves that the quality of deep boring water provided by KUKL is good for drinking purposes. Descriptive statistics reveal details about a population's distribution and characteristics. Hypothesis test was done with the means and variances (1st and 2nd statistical moments) of a normally distributed population (provided in table 2). Means, such as the Health Risk Limits, are also useful for comparing ground water quality.

Table2: Statistically calculated p-value of physiochemical and microbiological parameters of deep boring water sampled in Kathmandu with taken decision.

S.N.	Parameters	North site : p-value	South site: p-value	East site : p-value	West site : p-value	Decision
1.	pH	0.84	0.36	0.94	0.05	Not contaminated
2.	Electrical conductivity	0.74	0.41	0.27	0.42	Not contaminated
3.	Total dissolved solid	0.63	0.22	0.44	0.62	Not contaminated
4.	Turbidity	0.38	0.38	0.34	0.37	Not contaminated
5.	Iron	0.18	0.27	0.32	0.48	Not contaminated
6.	Ammonia	0.36	0.33	0.63	0.74	Not contaminated
7.	Chloride	0.4	0.54	0.23	0.24	Not contaminated
8.	Phosphorus	0.32	0.6	0.67	0.51	Not contaminated
9.	Total alkalinity	0.25	1	0.10	0.48	Not contaminated
10.	Total hardness	0.42	0.67	0.42	0.63	Not contaminated

Groundwater is an important source of water for drinking purpose in Kathmandu as it serves 50-70 percent population. The supply of surface water becomes restricted to the limited people living in the Kathmandu valley (KUKL 2015). Due to insufficient availability of surface water, it resulted to massive extraction of groundwater which has led to decline in groundwater level and its quality. The physical, chemical, and biological conditions of water are characterized by anthropogenic activities such as solid waste disposal, sewage, untreated / partially treated wastewater, excessive use of pesticides and fertilizers, all of which directly pose a significant threat to human health and other living organisms, economic development, and social effect. The data were taken in the monsoon region to analysis the ground water. Among the tested physical parameters pH, temperature, electrical conductivity, total dissolved solids, turbidity are all within the range that implies that the water is in good quality as compared to

NDWQS. Similarly, the chemical parameters ammonia, iron, chloride, total hardness, total alkalinity, phosphate were taken for groundwater quality from the four site of Kathmandu valley, it was found that the level of ammonia and iron are high in two sites. The reason for high ammonia in groundwater in south and east region is due to result degradation of naturally occurring organic matter or 34 manmade sources. A broad lake once existed in the Kathmandu Valley millions of years ago, organic material from the lake settled out and created lacustrine material beds, which were gradually buried by sediment over time. As the lake began to recede and settle, these organic deposits were interlaced with peat. There is a lot of ammonia in these soils. But it can't be nitrified because there isn't any oxygen. Similarly, the amount of iron concentration is high in south and west site. Small amount of iron concentration is frequently present in water because of large amount of iron present geological materials. Little amount of iron is good for health but the presence of large amount of iron in water is objectionable as it imparts a brownish color. Similarly, the presence of microbiological parameters is under NDWQS. So, from all findings after water sample test and discussion we can draw a view that the ground water quality is within the range of NDWQS and found to be within acceptable limit.

Conclusion

Present study about deep boring water quality assessment at Kathmandu valley in 16 different wells of KUKL deep well water was conducted by sample collection and testing in the SchEMS laboratory and KUKL laboratory. In the 32 samples from 16 wells, physiochemical parameters (pH, temperature, turbidity, electrical conductivity, total dissolved solids, chloride, iron, ammonia, phosphate, total hardness, and total alkalinity) and microbiological parameters (total coliform) were analyzed. The pH, Turbidity, Electrical conductivity, Temperature, Total dissolved solids, Ammonia, Chloride, Total hardness, Total alkalinity, Total coliform were within the NDWQS.

After laboratory testing it was found that the amount of iron concentration was somehow high in the south site and west site. The values of iron from water sample of different sites (north site, south site, east site, west site) were found to be 0.36, 0.5, 0.21, and 1.18 mg/l respectively. The value of iron was found to be out of the range as compared to NDWQS (0.3 mg/l). The value from the south and west site was found to be slightly high because of geological structure of that area. The water was found to be within national standards except iron and can be used for different domestic purposes. Although the number of samples can be tested in different seasons too for better idea but the present study was conducted only in monsoon season. This gave us a general idea of the deep boring water over the Kathmandu valley within studied sites. There may be poor water quality due to different factors in different seasons. If water distributing agency treats it

and distributes, then residents in those areas will be able to drink it directly. Otherwise supplied water may be harmful for human consumption.

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Impact of Climate Change on Indigenous Tharu People: A Case Study from Parsa District of Nepal

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Abstract

Tharu is the ancient indigenous community of Terai region of Nepal comprising 6.6% of the country's population. They are found living in the entire Terai belt of Nepal from West to East, most of them living near forests, steep hills, and riverbanks. This study deals with the impact of climate change on Indigenous Tharu people of Parsa distict, Nepal during the last two decades. The study is based on qualitative and quantitative approach. Qualitative data was collected through key informant interviews and field observation whereas quantitative data were collected through the household survey, field visit and Government Offices. Temperature and precipitation data of Simara station from Department of Hydrology and Meteorology (DHM) between the years 1998 to 2018 was used to analyze the climatic trends. Perception of Tharu people clearly reflects that they have been experiencing changes in climatic conditions and its impact on local natural resources over few decades while the statistical data analysis of temperature reveals that no significant change exists in the climate of the study area, but precipitation is in decreasing trend for each year in the station. The impact faced by Tharu people of this region on forests and culture is comparatively human induced whereas agriculture and water resources seem more affected by climate change. The statistical data was taken from a single meteorological station that might be insufficient to check the yearly trend of changing climate over the area.

Keywords: *Biodiversity, Livelihood, Morphology, Perception, Sustainable, Vulnerability*

Introduction

Nepal is one of the least developed countries in the world ranking 4th most vulnerable country to climate change though it is one of the least contributors to global Greenhouse gases emissions, emitting 0.027 % of global total (MoPE, 2016). The impact of climate change has been observed in various sectors such as water, forestry, biodiversity, agriculture, and cryosphere. Impact on these sectors is very likely to affect the livelihood of local communities (MoFE, 2019). Under various climate change scenarios for Nepal, mean annual temperature is increasing while annual precipitation is in

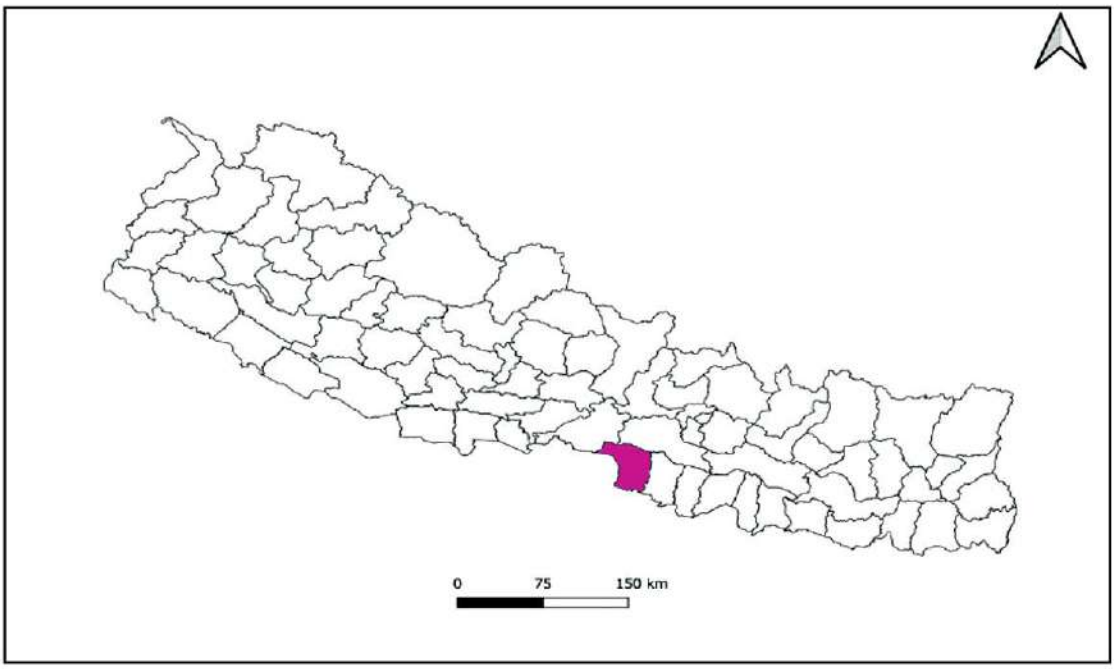
reducing phase (MoPE, 2010). Data on temperature trends from 1976 to 2015 showed that on the average and across the entire country, maximum air temperature increased (+0.045)0C y-1, p<.001) more than minimum temperature (+0.0090C y-1, p< .5) and, as a consequence, diurnal temperature range also increased significantly (+0.0340C y-1, p< 0.05). Maximum temperature increases have been observed during all seasons of the year (Thakuri, et. Al. 2019). Nepal is a multi-ethnic, multi-religious, multi-lingual and multi-cultural nation. This country is a home of 125 castes and ethnic groups speaking 123 languages as their mother tongue, maximum of which are spoken by indigenous peoples (CBS, 2011). The Government of Nepal has officially recognized 59 Indigenous Groups in the country covering 35.6% of the country's total population (CBS, 2011). Tharus are one of the oldest and unique indigenous tribal people scattered all along the Southern foot-hills of the Himalaya from a long time ago. They usually live very close to the heavily forested regions (Bista, 1967). Tharu is categorized as marginalized group of Nepal (NEFIN, 2004). Indigenous Tharu people traditionally live close to the nature. They prefer living in remote area than in urban cities. They depend on farming, forests products and natural resources. The dependency in natural resources for livelihood and closure to nature makes them vulnerable to climate change and natural disaster. Though this community is comparatively less responsible for the cause of greenhouse emission, they are equally facing consequences of climate change. Parsa district is categorized as highly vulnerable to climate change (NAPA, 2010). This study focuses on impacts of climate change on Indigenous Tharu people of Parsa distict.

Materials and Methods

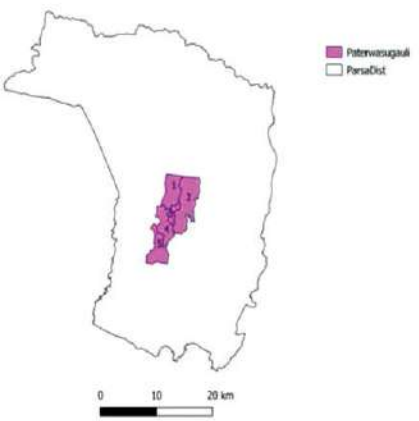
This study is based on descriptive as well as explanatory research design. Primary sources for information collection based on questionnaire were Key Informant Interview, household survey, field observation, interview with farmers and stakeholders whereas secondary sources for data collection were literatures review, articles and government offices. Interview of 50 households combinedly on two wards of Paterwa-Sugauli Rural Municipality of Parsa district was taken to know vulnerability level. Semi structured interview with related personal was carried out to acquire answers to the research questions. Locally elected personals, bureaucrats (working on the field), ward members and Rural Municipality office were the key informants. A time series of meteorological data (temperature and precipitation) of Simara station for 20 years of period (1998-2018) was purchased from Department of Hydrology and Meteorology (DHM), Government of Nepal to compare the trend of climate change in the region. Quantitative data were analyzed through descriptive statistics. Geographic Information System (GIS) mapping was used to locate the study area.

Study area

Paterwa Sugauli Rural Municipality is located in Parsa district of Province 2. It occupies an area of 103.11 sq. km with total households 4,201 and total population of 23,038. Average literacy rate of this Rural Municipality is 56.5% (field work). The study was conducted in two wards (Ward no. 1 & 2) of this Rural Municipality. This area is located approximately 30 kms north-west from Birgunj, the district headquarters. This area is a residence of Tharu, Tamang, Chamar, Dusad, Musahar, etc. whereas Tharu is the dominating community in both wards. Major occupation of the people is agriculture.



Parsa district and Paterwasugauli rural municipality



Paterwasugauli and Study area (ward 1 and 2)

Fig 1: GIS Map of Study area

Results and Discussion

Climatic trends of the Study Area

Data of DHM for 20 years of period of the study area was used to analyze climate from atmospheric observations. The observed climate trend analysis was performed using temperature and precipitation data for the period from 1998 to 2018 through descriptive statistics.

Table1: Rainfall Patterns (Data Source: Simara Station, Bara)

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
January	5.2	0	8.9	1.4	51.3	40.4	13.8	22.5	0	0	4.8	0	0	0	18.4	4.2	8.9	1.7	15.8	19.7	0
February	17.8	0	18.3	0.8	48.2	48.9	0	3.2	0	47	0	1	4	25.2	1.1	34.4	21.8	6.7	2.4	0	0
March	60.4	0	0.4	2	1.2	93	0	21.2	5.5	30.8	18.6	0	0	8.6	0	2.2	0	16.8	27.9	52.7	8.3
April	70.5	14	90.8	21.6	50	20.4	43.8	72.9	119	14.8	9.4	0	41.2	20.6	17.6	44.2	2	136	5.4	40.2	42.9
May	164	115	355	307	273	135	146	25.6	142	66	91.8	102	48.8	235	85.8	244	204	58.1	160.7	152	103
June	166	535	305	300	223	451	331	229	318	404	464	115	275	167	151	332	215	234	226.8	296	210
July	1116	664	601	555	795	721	822	415	537	858	571	304	413	719	370	374	335	121	679.8	287	501
August	828	423	561	664	142	325	207	898	189	654	260	654	365	429	0	351	433	609	51.9	839	587
September	280	192	180	363	273	245	235	108	463	739	153	90.5	269	221	244	130	245	133	388	146	263
October	78.9	103	3	81.3	78.4	70.2	136	67.4	72.2	78.4	70.9	40.5	165	0	4.6	149	133	19.8	26.6	134	0
November	9.4	0	0	0	9.8	0	30	0	1	5	0	0	0	5	0	0	0	0	0	0	0
December	1.5	0	0	0	3.6	1	0	2	14.2	0	0	6.4	0	0	0	0	7.6	0	2.2	0	0
TOTAL (mm)	2797	2046	2123	2297	1949	2150	1965	1864	1861	2897	1643	1312	1580	1832	893	1664	1604	1335	1588	1967	1715

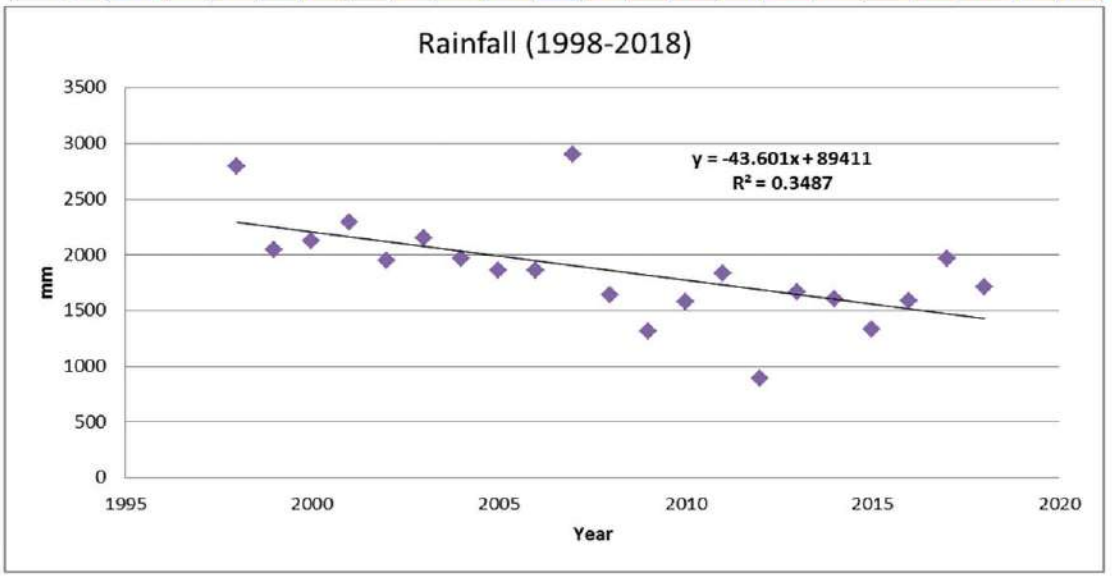
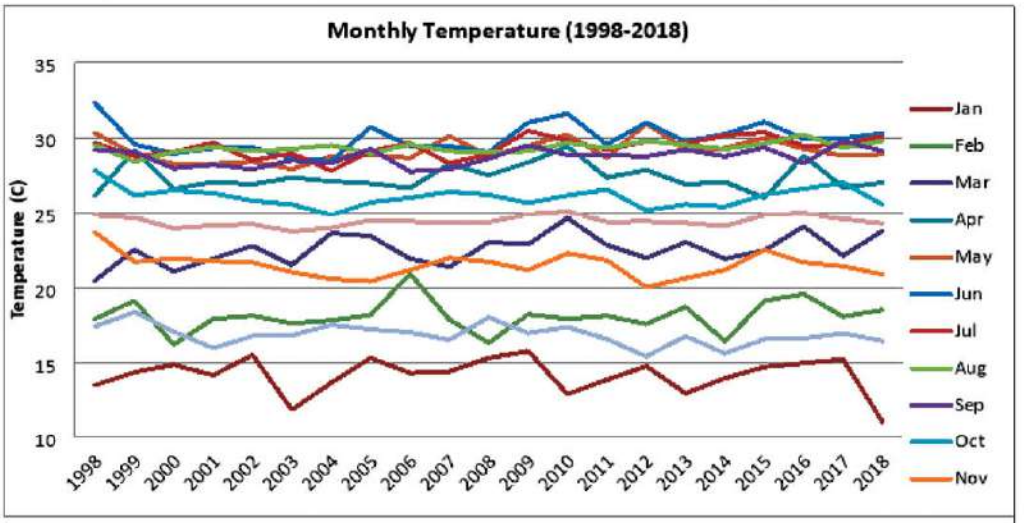
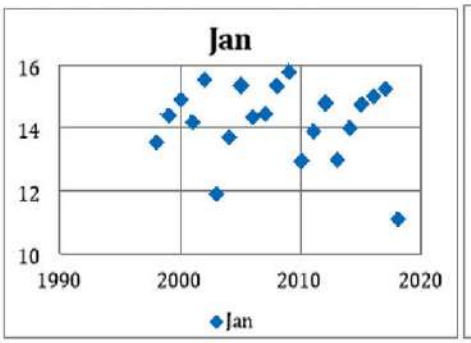


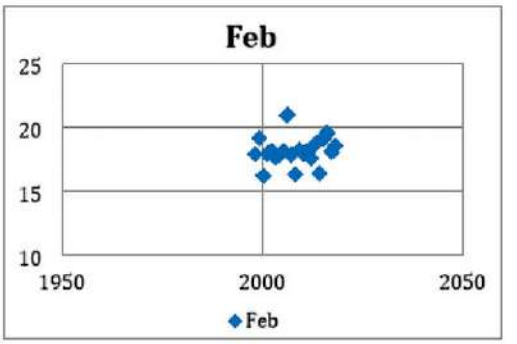
Fig2: Graph showing rainfall trend

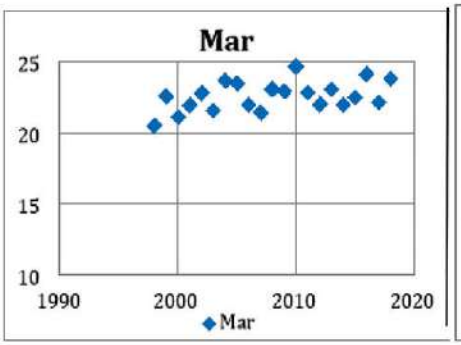
Overall pattern of rainfall (mm) during the 20 years period (1998-2018) shows a decreasing trend, i.e., the rainfall is decreasing each year for the station. The variation in the yearly rainfall pattern seems drier than the earlier years. When fitted linearly, the straight trend line is also oriented towards the decrement; however, the value of R2 is only 0.348 which means the fitted decreasing trend line covers only the 35% of variance in the data. Thus, for the given data observation, the change in rainfall pattern cannot be established.

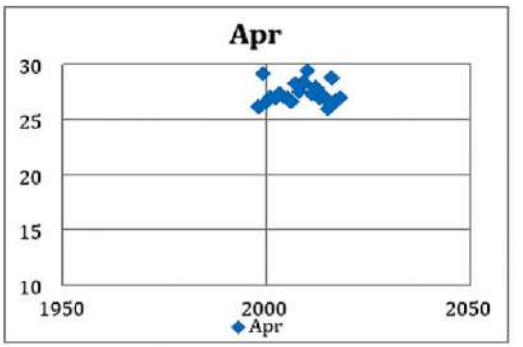
Table2: Temperature pattern (Data Source: Simara Station, Bara)











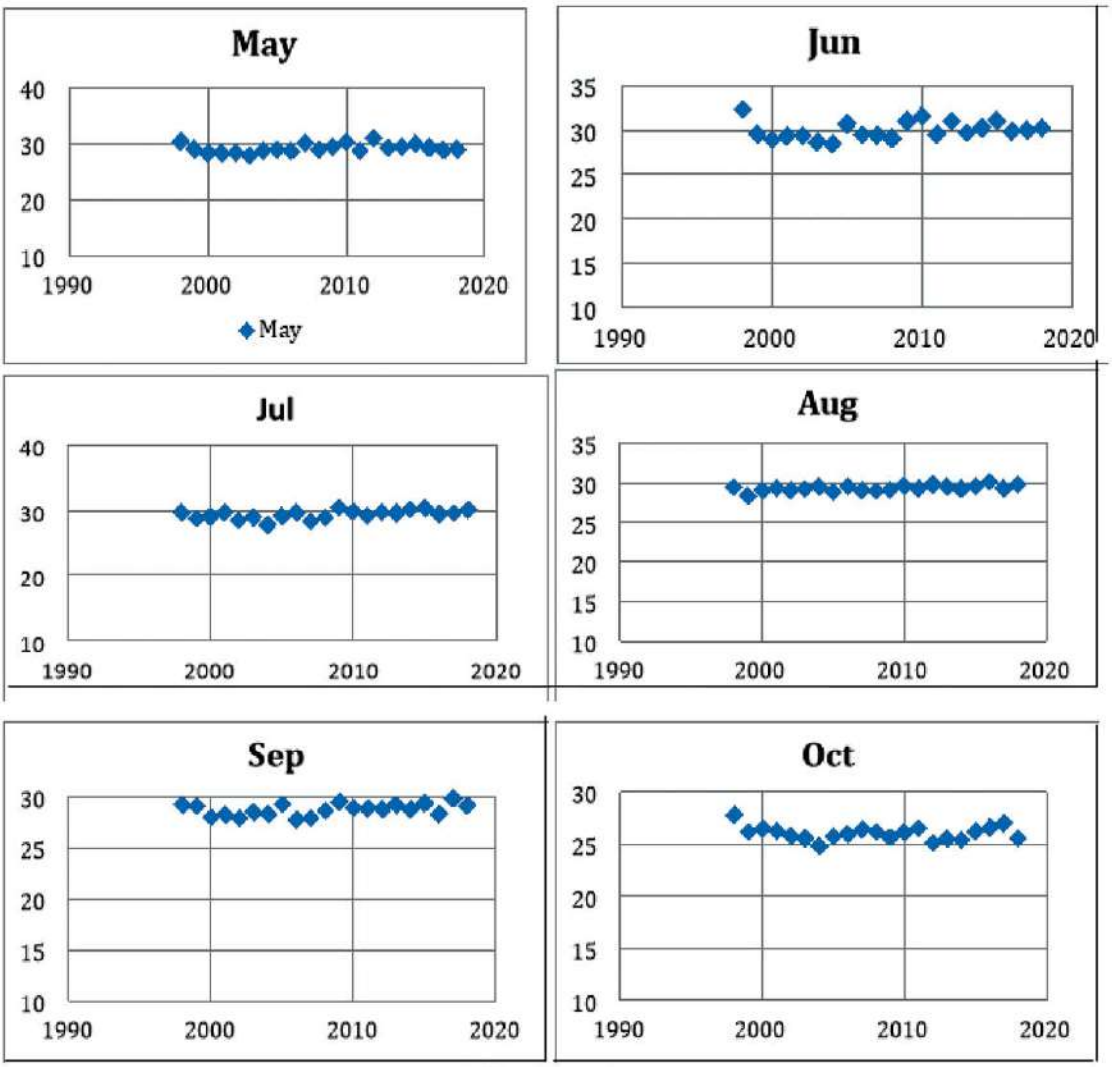


Fig3: Monthly plot of temperature

There is no observable change in temperature pattern for the given data for the period. The minor variations observed in the scatter-plots for each month do exists but no trend line with significant R2 can be obtained with the given data range for the temperature.

The analyzed 20 years data of rainfall (annual) and temperature (Yearly averages for the months) has not been able to establish climate change. Reasons could be many. The data was not qualitatively checked and analysis was done with the data as was availed. The data is based on a single station that might be insufficient to see yearly trends. Also, the land-use change at the station location could be intact enough to maintain the less varying climate phenomenon.

Impacts of climate change in Indigenous Tharu people of Paterwa-Sugauli Rural Municipality according to the perception of people are described below:

Agriculture and Food Security

Tharu call themselves as 'son of soil' (Bhumi putra) and 'people of land' because their life is attached with soil. It was found that 97% in average of respondent households of both the wards depends on agriculture. They produce baskets of grain viz. Paddy, wheat, maize, mustard, pulse, vegetables. Their perception towards climate change is that there is change in monsoon pattern, shifting of seasons; rise in temperature greatly has enhanced the degradation process of land in both the wards. The other drivers of land degradation during two decades in the study area are identified to be conversion of forests land into other land use types and use of synthetic fertilizers and pesticides. According to Agriculture Inputs Company Limited Birgunj, 18,880metric tons of synthetic fertilizers have been consumed in fiscal year 2018/19. Though the agricultural production has been improved comparatively in the region, participants expressed there is shifting of growing time of vegetables and crops along with shifting of harvesting time. The breed of paddy that was cultivated earlier is not cultivated at present. Hattijhulan, Khera, Kartika, Basmati, Bholani, Thulo mansuli, etc. are some of paddy species which were cultivated previously. 1442, Sona mansuli, hybrids of mansuli, US 312, Ganga kaveri, etc. are some of the new paddy species that have replaced the older paddy species. Farmers stated that from the last few years, the productivity per bighas of land is increased up to five times because of modern machineries, improved crop breeds, sufficient irrigation facility from artesian wells, use of synthetic fertilizers and pesticides. But they stated that it is hard to cultivate crops like grams and peas without using pesticides and insecticides as insects and pests attack on them. The size of fruits, potatoes, leafy vegetables and crops remain small in size unless insecticides are not applied. The condition becomes pathetic when insects, caterpillar, flies, white pests attack on vegetables and crops which were unknown to the farmers previously. Agriculture has become comparatively expensive due to unwanted pests, shifting of season and drought.

Forest: Ancestors of Tharu settled in the periphery of forests and on riverbank. Parsa National Park is nearest forest to the study area which is rich in Sal (Shorea robusta), Asana (Terminalia tomentosa), Tuni (Toona ciliate), Barro (Terminalia bellerica), Harro, Karma (Adina cardifolia), Bot dhangero (Lagerstromi aparviflora), Bhudkul, Shirish (Delonix regia), Kyamuna, Jamun, Kadam, Khair-Sisoo, etc., climbers like Bhorla (Bauhinia vahlii), Debre lahare (Millettia auriculata). Tharu people used forests products like food, fodders, water, leaves, woods, medicinal herbs, etc. for their livelihood. They worship Sal trees as Ban shaktimai (Goddess of Forest Power) before they enter into the jungle. The community is witness for disappearance of giant Sal trees during past two/ three decades. They express their sorrow on vanishing of such trees and drying out of

Gaadi khola flowing in the forest. They say that they have to walk a long distance inside the jungle in search of climbers and leaves that were easily available near the entrance of forest in previous days. Leaves of these climbers are used in wedding and religious ceremony. Human induced activities like deforestation and unmanaged settlement in the area are equally responsible for disappearance of those trees and biodiversity. Resettlement of 100 households near Gaadi forests from Bhattha village has accelerated the rate of forest destruction in the area. Most of the people of this rural municipality depend on firewood for cooking. Total number of house-holds dependency on usual source of cooking fuel found in the field survey is presented below-

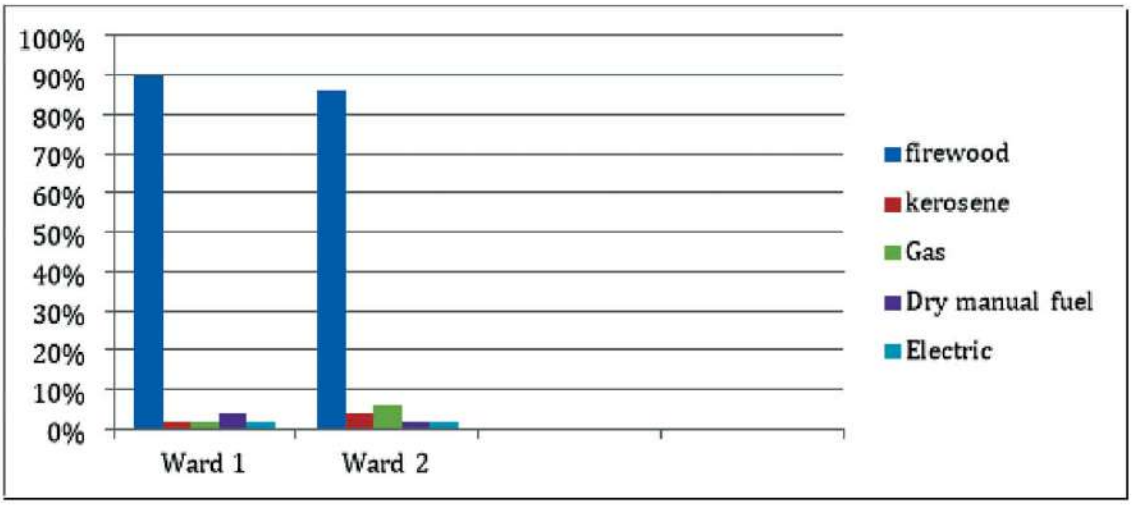


Fig4: Households dependency on fuels

Water Supply and Irrigation: Water bodies like river, pond and wells play a crucial role in livelihood of Tharu. In the study area, Gaadi khola was the main source of freshwater in earlier years. Deforestation has been accelerated in Churia area from few decades that have induced change in the pattern of local weather, droughts in the area, decrease in ground water table, dry out of river and ponds, etc. Tharu farmers stated that the two Churia originated rivers Gaadi and Bhaluwahi were perennial rivers in previous days but now converted into seasonal rivers. Bhaluwahi khola was almost 2m deep in previous days but siltation has turned the riverbed into plain surface. This causes flood in the region in short period of time after rainfall. Previously, the requirement of irrigation in study area was fulfilled by Gaadi Khola. It was observed that Gaadi khola was shrunk out leaving remains of sand and pebbles. As a result, dependency of people upon artesian well has increased. There are more than 50 artesian wells together in both wards from where water is extracted continuously to meet the needs of water in the villages. Over extraction of water has led other environmental problems like submergence of land in the villages.

Culture: Indigenous culture is one of the important factors in the development of tourism. Indigenousness is taken as new subjects to influence tourists in such a country like Nepal. The way of living of Indigenous Tharu community is environment friendly with sustainable use of available natural resources. The dependency of this community on resources is higher but their carbon footprint is comparatively lower. The raw materials for making indigenous cottage, household utensils and handicraft accessories were found on the bank of rivers, ponds and forests. In the present time, those raw materials are found rarely because of shrinking of rivers. Over extraction of stones, pebbles and sands from those rivers cause depletion of such materials, biodiversity loss with change in river morphology. People lack awareness towards environment while policy maker is lacking long-term vision in the level of decision making. Government lacks sensitization towards full reorganization and promotion of indigenous culture. Similarly, restriction for the entry of people in national parks is another cause of declination in Indigenous traditional skills. Maghi (Makkar Sankranti), Soharaiya (Dipawali), Ghato, Chhat are the main festivals celebrated by Indigenous Tharu. They celebrate the festivals in their own way. Preservation of Tharu culture may not be possible without conserving the components of environment. Dish of fish, prawn, eel and crabs is compulsory for Tharu people to celebrate their festivals but these species are found rarely because of drying out of rivers and ponds.

A significant change has been seen in pattern of agriculture practice. Tharu farmers are witness of seasonal change, change in weather pattern and movement of wind. The destructive cyclone occurred in Parsa and Bara districts in 2019 can be taken as fresh proof of sudden change in weather pattern. Farmers have experience of unwanted weeds, excess growth of pests in crops due to which they have to use massive number of inorganic fertilizers and pesticides. Shrinking of water bodies had added irrigation problem. Excessive extraction of ground water through artesian wells and deep boring for irrigation has combated the risk of drought in agriculture. However, excessive amount of ground water extraction has caused some other environmental problems. Improved breed of crops is the other reason for higher production in agricultural sector. Destruction of Churia forest and other anthropological activities such as over extraction of river materials are the reasons for disappearance of local traditional trees, forest fruits, fodders and herbal medicines. Destruction of Churia can impose more risk to its southern plain causing prone to desertification. Hence, Chure and its associated forests need more attention for its conservation.

Conclusion

The perception of indigenous tharu people of the study area towards climate change is clear enough. Changing climate pattern has caused stress on forests, ground water table, land, water bodies, on agriculture, culture and their surrounding natural resources. We can say that the impact on forest resources and culture of indigenous tharu people

seems more human-induced as compared to water resources and agriculture which is highly affected due to climate change. According to local farmers, climate change has imposed unnecessary burden in agriculture. However, the interpreted meteorological data shows that the study area lies in mid-vulnerable index with moderately susceptible to climate change. Rainfall is decreasing each year for the station. The variation in the yearly rainfall pattern seems drier than the earlier years. However, there is no observable change in temperature pattern for the given data for 20 years of time period. There can be some other reasons. Analysis was done with the available data and is based on a single station that might be insufficient to see yearly trends.

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Sound Pollution in Kathmandu Metropolitan City

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Abstract

The rapid urbanization in Kathmandu has resulted in the increment of noise pollution. This study focuses more on noise pollution in different wards of the Kathmandu Metropolitan City (KMC). Noise level was measured by using the sound level meter (SLM) at the day time from 10:00 A.M. to 4:00 P.M. in the month of November and December, 2019. It was found that the average equivalent noise level (Leq) in KMC was 82.58 dBA (decibel arithmetic average), maximum Leq 85.23 dBA and minimum Leq 77.81 dBA in ward no. 24 and ward no. 12, respectively. This result showed that the equivalent noise level is above the prescribed noise level standard given by the Government of Nepal (GoN) and the World Health Organization (WHO). Therefore, government should prioritize the public awareness as well as noise barrier to minimize the effect of noise pollution.

Keywords: *Decibel, Equivalent Noise, Kathmandu Metropolitan City, Noise Pollution, Sound Level Meter*

Introduction

Noise pollution, in recent times, has been considered as one of the significant problems that impact the quality of life worldwide (Ozer et al., 2009). With the rapid increase in urbanization, industrialization and transportations systems, noise is emerging as a significant problem that has reached a disturbing level over the years (Hunashal & Patil, 2012) affecting the quality of life. Urbanization in the past few decades in developing economies has triggered several environmental problems including noise pollution (Halonen et al., 2016).

Persistent noise is one of the most common pollutants in the urban area very harmful to human health (Gidlof-Gunnarsson & Ohrstrom, 2007). For instance, exposure to noise pollution entails adverse, accumulative, and direct effects on human health such as detrimental to hearing disturbance on the cardiovascular system, nervous system and the endocrine system (Münzel et al., 2018) sleep disturbances, and impaired wound

healing (Krachman et al., 1995). Psycho-social effects of excessive noise include miscommunication, and increased annoyance (Goines & Hagler, 2007). Various countries have taken several initiatives to check the noise level. For example, the USA has taken the initiative to create sites where human-caused noise pollution will not be tolerated (Geary, 1996).

In Nepal, limited studies on noise pollution being carried out. Even such a survey revealed that sound levels in urban areas are generally much higher than recommended International Standards (Joshi & Subedi, 2003). Some of the studies related to the noise pollution of Kathmandu were previously done by Shrestha and Shrestha (1985); Manandhar et al. (1987); Sapkota et al. (1999); Murty et al. (2007); Joshi et al. (2003); Shrestha et al. (2009); Pant and Neupane (2017). All of those findings show that 70-100 dBA range of noise level was typically observed in urban Kathmandu valley. A study carried out by Shrestha et al. (2011) investigated 110 traffic police working in different places of Kathmandu valley showed a noise-induced hearing loss prevalence of 66.4 %.

In Kathmandu valley, rapidly growing urbanization and industrialization also increase number of vehicles; which are the immense source of noise pollution. This has led to overcrowded roads and noise pollution in Kathmandu city. Therefore, this study has conducted to know the status of noise pollution in Kathmandu Metropolitan City, which is a major issue and needs proper legislation and study to tackle the problem.

Materials and Methods

Study Area

The study on status of noise pollution was carried out in 32 wards of Kathmandu Metropolitan city (KMC). Kathmandu is the capital and eldest metropolitan city of Nepal. The city is bowl-shaped, stands at an elevation of approximately 1400 meters above sea level in central Nepal. Geographically, Kathmandu ranges in the geometry of 27°46'N 85°16'E / 27.767°N 85.267°E. The total area of the metropolitan city is 51 Km2. The city is administratively, divided into thirty-two wards. The city has an annual growth rate of 6.5% combined with one of the highest urban densities on earth and 2.5 million people living in the valley (CBS, 2011). Kathmandu's urban cosmopolitan character has made it the most populous city in Nepal, recording a population of 671846 in 2017 according to United Nations (UN) (2018). Figure 1 represents the study area: KMC.

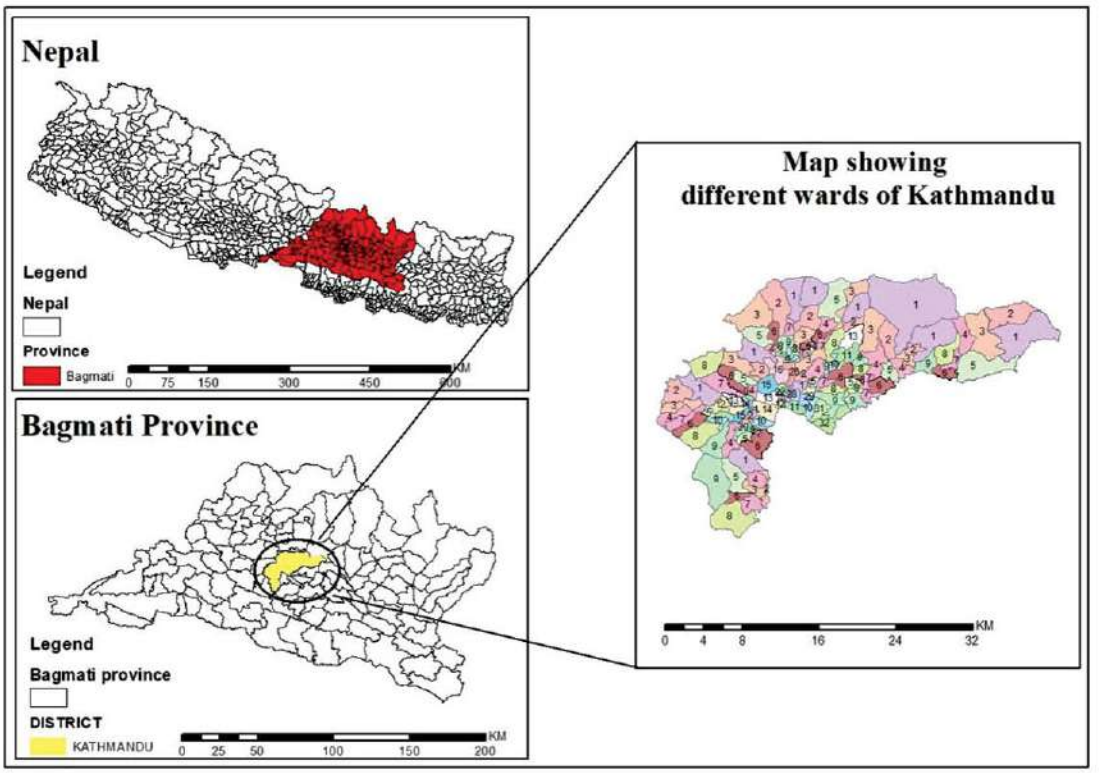

Figure 1. Study area showing different wards in Kathmandu Metropolitan City

Methodology

The noise levels were measured with the help of a portable precision digital sound level meter (Model IEC61672-1). This instrument is primarily designed for community noise surveys. A large digital display gives a single value indication of the maximum (A) weighted root mean square (RMS) sound pressure level measured during the previous second. It is equipped with high sensitivity Bruel and Kjaer Prepolarized condenser microphone. The instrument was adjusted at dB (A) and measurement was carried out at the range of 30-130 dBA. The sound level was measured in the day time from 10:00 AM to 4:00 PM in the month of November and December 2019. The sound levels were measured at the interval of every minute and about 30 reading at each sampling site. The sound level meter was taken in hand height of 1 m and a distance of 15m from the center in the roadside, premises of hospital and campus, and along the streets in residential areas. The measurements were carried out under the normal atmospheric condition.

All the sound pressure level readings have been taken under A-weighted network, as scientific researchers have proven that the A-weighted network weights the contribution of sounds of different frequencies as simulated by the response of an average human ear.

The sound pressure level was analyzed based on L_{eq}, the equivalent sound level measure in dBA.

The decibel is a ratio of one pressure in another. In terms of environmental noise, the sound pressure level in decibel is calculated from the following equation:

$$Lp = 10log_{10}\left[\frac{P}{P_0}\right]^2$$

Where P is the sound pressure being measured, P_0 is the reference sound pressure; $2\times10^{-5}\ N/m^2$ and L_p is sound pressure level.

The reference sound pressure corresponds to the lowest sound pressure a healthy human ear can detect at $1000H_z$. Thus, the decibel is a logarithm of a ratio of one sound against the lowest sound a healthy human ear can hear. So, sound pressure level is the level of sound, expressed in decibel relative to the hearing threshold (Enda & Eoin, 2014).

Results and Discussion

The average equivalent sound level measured at different places of the 32 wards of KMC is shown below in the (Table 1).

Table 1. Average equivalent sound level of different wards of Kathmandu Metropolitan City

S.N	Ward number	No. of spots of measurement	Equivalent sound level dB(A) [Average]
1	1	8	82.2
2	2	6	83.07
3	3	8	84.85
4	4	4	82.76
5	5	8	78.21
6	6	8	81.45
7	7	8	84.41
8	8	3	77.88
9	9	8	79.95
10	10	8	84.54
11	11	7	82.92
12	12	3	77.81

S.N	Ward number	No. of spots of measurement	Equivalent sound level dB(A) [Average]
13	13	8	83.29
14	14	8	84.81
15	15	8	79.87
16	16	8	84.98
17	17	8	84.02
18	18	6	80.15
19	19	8	83.99
20	20	5	83.76
21	21	8	83.40
22	22	4	83.35
23	23	6	83.58
24	24	4	85.23
25	25	5	83.23
26	26	8	83.11
27	27	8	84.65
28	28	8	80.69
29	29	7	80.07
30	30	6	78.23
31	31	7	80.48
32	32	8	82.91

The maximum equivalent sound level was observed in ward no.24, which is 85.23 dBA, and the minimum was observed to be 77.81 dBA at ward no.12. The equivalent sound level is the continuous steady sound level with the same total acoustic energy as the fluctuating noise measured over the same time. The results show that the average equivalent sound levels are above the noise level standard prescribed by Government of Nepal (GoN) and the World Health Organization (WHO). The equivalent sound pressure level in the different wards lies in the range of 77.88-84.98 dBA.

The noise level at a particular location depends upon the distance of the source and surrounding conditions. Along the roadside, it relies on the density of vehicular flow, vehicle type, conditions of vehicle and roads. There is less noise in the smooth and wide road compared to rough, damaged and congested road. The noise pollution problem is severe in the cities of developing countries and is mainly caused by traffic. Data collected alongside densely travelled roads were found to have equivalent sound pressure levels

for 24 hours of 75-80 dBA (Mage & Walsh, 1998). Study conducted at 14 different sites in Karachi showed that in 11 of the sites, the average noise level ranged between 79-80 dBA (Bosan & Zaidi, 1995). The noise level survey carried out by (Sapkota et al., 1999) shows that the noise level varied from 65.1 dB to 74.5 dB in heavy traffic area and 63.2 dB to 72.1 dB in low traffic area of Kathmandu. According to (Kandel & Regmi, 2003), the average traffic noise in Kathmandu city was found to be 79 dBA and the trend of noise level is increasing in Kathmandu. (Table 2) shows a brief summary of various sound pressure levels with examples of recognized noise sources.

Table 2. SPL and recognized sources of noise (Agarwal, 2009)

SPL dBA	Example
0	Threshold of hearing
20	Studio from sound pictures
30	Studio for speech broadcasting
40	Quite room
50	Residence
60	Conventional speech
70	Street traffic at 100ft
74	Passing automobiles at 20ft
80	Light trucks at 20ft
90	Subway at 20ft
100	Looms in textile mill
110	Loud motorcycle at 20ft
120	Peak level from rock and roll band
140	Jet plane on the ground at 20ft

The results can also be shown in the graphs where sound pressure level is plotted against the different wards of the KMC.

The difference in noise level at these locations is due to various reasons. The maximum noise level at ward no. 24 it might be due to the heavy traffic flow, crowded environment and congested road. The noise level in this area is also added by using pressure horns due to the congested road. The low level of noise at ward no. 5, 8, 9, 11, 12 and 15 might be due to their location being away from the main highway. However, in the (Figure 2), it shows that those areas that have greatly affected by outdoor sources of noise, particularly traffic activity resulted higher equivalent noise level than prescribed by GoN and WHO. Noise level standards formulated by GoN are shown in (Table 3).

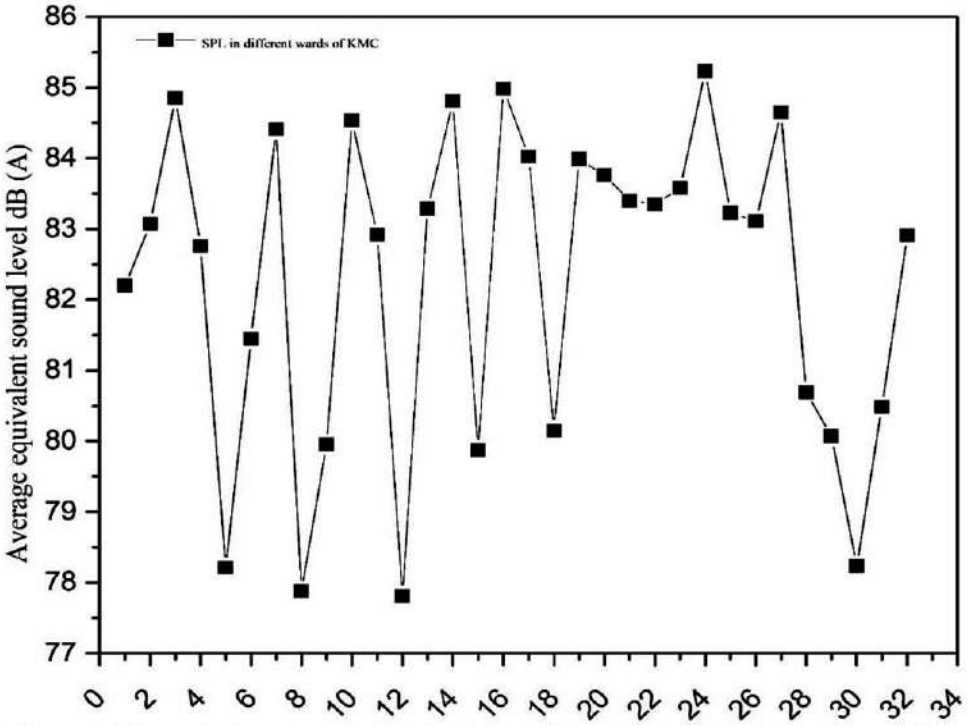

Figure 2. Graph showing equivalent sound level in different wards of KMC

This finding is in accordance with several studies in different cases. For example, (Sapkota, 1997) has reported hazardous sites in Kathmandu valley where the noise level was found above 80 dB (A). Similarly, the day-time urban noise quality assessment was done in Kolhapur, for five critical zones. The result indicated that the highest equivalent sound pressure level of 72.25 dB (A) was observed in the industrial area, followed by 64.47 dB in the commercial zone, 63.71 dB in the educational zone and 42.84 dB in the silence zone (Hunashal & Patil, 2012).

Table 3. Noise Level Standard of Nepal (2069)

		Noise level (dB)	
S.N	**Area**	**Day time**	**Night time**
1	Silent zone	50	40
2	Industrial area	75	70
3	Rural residential area	45	55
4	Urban residential area	55	40
5	Business area	65	55
6	Mixed residential area	63	40

Source: Nepal Rajpatra, Kartik 13, 2069

The mean level of noise in KMC was found to be 82.58 dB (A). Similar phenomenon was found in other study as well. For instance, according to (Kandel et al., 2003), the average traffic noise in Kathmandu city was found to be 79 dBA and the trend of noise level is increasing in Kathmandu. The study of noise level around Tribhuvan International Airport carried out by (Bhattarai, 2009), shows highest noise level to be 101.5 dBA at Gothatar and least 63.5 dB (A) at Datidol. In a study of (Murty et al., 2007), the overall minimum and maximum noise level for the main road are 60.1 dBA and 110.2 dBA and at residential site, a minimum of 59.11 dBA was observed in Banepa, semi urban town in Nepal. Moreover, 101 dBA, 100.4 dBA, 99.9 dBA, 91.6 dBA was found in Mangala Devi Secondary School, Pashupati Multiple Campus, Tri-chandra Campus, Amrit Campus, respectively (Chauhan, 2019). This results,the occupants of the sites may be badly affected due to their long-term exposure to the high levels of environmental noise. Environmental noise can produce adverse effects on people's health since it interferes with basic activities such as sleeping, resting, studying and communicating. In addition, chronic noise exposure may cause longer-term activation of several predictable physiological responses such as increased heart rate, blood pressure and endocrine outputs. Thus, it is crucial to study noise pollution from a quantitative perspective of the annoyance produced in the population (EHC, 2004).

Conclusion and Recommendations

Conclusion

This study focused on the evaluation of the noise level in the selected sites of the different wards of the KMC, the highest noise level was found in ward no. 24 and ward no. 12 was least noisy. Almost all the wards have noise level above the recommended value. The main sources of noise in the metropolitan city are the vehicles like buses, trucks, motorcycles, taxi, vans, microbuses, etc. on the roads. Similarly, the bad conditions of the vehicles and their vibration produce more noise. Moreover, the damaged roads and the drivers' behavior of using high pressure horns add more noise. Although the use of pressure horns is banned in the Kathmandu Valley, it is not appropriately implemented.

The mean equivalent sound level of the KMC was found to be 82.58 dBA which means this is the continuous noise level over the time period. According to the guideline value for community noise by WHO (1999), equivalent noise level of 70 dBA for 24 hours of time limit can cause hearing impairments, annoyance, disturbances in sleeping, communication, etc. Therefore, strong rules and regulation towards the pressure horn and maintaining damaged roads will help to reduce the noise pollution. In this aspect, public and government should be aware about the increasing level of noise pollution otherwise, it enhances worse condition of human hearing as well as other adverse impact.

Recommendations

Noise does not directly affect human health, but it is considered as a source of environmental pollutants. Hence, indirectly the human health and several other environmental components are influenced by the sound we perceive daily. So, before it becomes hazardous, we need to control the harmful aspects of noise pollution. Some of the recommendations are listed below:

- The noise level should be assessed regularly, and a noise level map should be prepared in the Metropolitan area.
- The noise level standards formulated by the GoN should be strictly implemented by the concerned authority.

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