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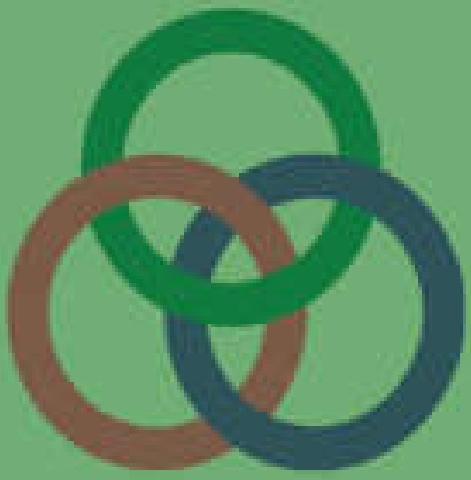

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Editorial

It is our great 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 6, 2020 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 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 and human resource 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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Impact of Covid-19 Lockdown on Agriculture and Developing Strategies Against It for Sustained Food Production and Supply: Special Focus to Nepal

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Abstract
The schedule of food production, collection and distribution has been affected leading to hassling, product wastage and price fluctuations by the impact of Covid-19 lockdown in 2020. The import has been limited and food demand has been increased because of returnee population with higher rate of unemployment. Personal observations were made and the relevant literatures reviewed to find the impact on agriculture and developing strategies for sustained food production and supply with special focus to Nepal, in the year 2020. Immediate action is needed to link agriculture to national Covid-19 mitigating program for the safety of the farmers and agri-workers, continuation of food production and supply. An action plan for impact mitigation on agriculture shall be prepared and implemented. Free movement of vehicles for transportation and farm operations, markets linked with improved delivery of agro-products, input management, agro advisory services and food education need to be facilitated. Intermediately, small scale family farming and the urban agriculture shall be massively promoted for enhancing local level food self sufficiency. Resumption of full-fledged farming operations and revival of agri-based enterprises is needed for the livelihood recovery and economic resilience in post lockdown period. It is needed to reform the policy on land use, food security and priority settings on establishing new commercial agriculture farms, expansion of crop area/heard sizes and making agriculture the most attractive business. Local governments shall emphasize on local food self sufficiency and the provincial governments on the commercial food production and economic resilience. Buffer stocking of non-perishables for emergencies, and maintenance of cold chains and cold storage for perishables are recommended. A huge public and private investment may be needed for sustainable food supply and mitigating Covid-19 lockdown.

Keywords: *production, supply, enterprise, livelihood, policy.*

Introduction
The plague of Justinian struck of 6th century, black death of 14th century, smallpox of 20th century, influenza/flu and HIV pandemic of 19-21th centuries were the devastating pandemic disaster in human history. The novel corona virus, known as Covid-19 is highly infectious disease noticed first time in October 2019, from Wuhan, China. It became pandemic, infecting and killing millions of people within few months (Bryan, 2020). Communicable or infectious diseases are also natural or man-made disasters (Thomas et.al., 2012). Such disasters pose huge economic challenges to nations, communities, and corporations worldwide (Reddy et. al., 2016). The global health impact of influenza pandemic is affecting food production and supply. Such disaster quickly creates food shortage because of restrictions on transportation and disruptions in the markets (Patho. Org., 2019). Therefore, the establishment and management of an emergency supply chain during the containment effort are of paramount importance (Thomas et.al., 2012). The resilience of the food supply chain to disruptions is the issue for extended, globalised, and complex network of modern

food chain (Reddy et. al., 2016). Agriculture is one of the sectors most affected by natural disasters, fluctuating in food production, food trade and food supply chains (Reddy et. al., 2016). There is a need to develop a plan for communication, establish buffer stock of food, safe transportation, supply and distribution during the period (FIA, 2020). It is necessary to educate the public for home production, canning, and food preservation. Needs to encourage household and community food production by distributing seeds, tools, and fertilizers for small rural farms and urban gardens, provide local technical services for the production and local use of foods (Patho. Org., 2019). There is starting to be a supply shock because of less production, lower freight rates, lower capacity use and disrupted supply chain during Covid-19 pandemic in 2020. Reduction in labor force, reduced access to animal feed and production inputs, transport restrictions, quarantine measures, curbing productive capacities and denying a point of sale for produce raise food shortages. High value supply chain is more vulnerable than upstream staple. Example can be taken from the increased demand in both staple food and ready-to-eat food resulted in Italy during Covid-19 period in 2020. The demand for flour was increased by 80%, canned meat by 60%, canned beans by 55%, and tomato sauce by 22% (Cullen, 2020). These trends lead to difficulties to sell produce, loss of perishable produce and income. Closure of farmers' markets, preventing smallholder famers to direct sell to consumers, leading to loss of income, loss of perishable product and accumulation of non-perishable product.. The main purpose of this, study is to access the impact of Covid-19 lockdown on agriculture and develop strategies against the disease pandemics and disasters for sustained food production and supply with special focus to Nepal.

Materials and method

Available reports, scientific papers, journal articles related to human disease pandemics and the possible impact on agriculture, food and nutrition supply and availability were reviewed. Present situation of Nepal on food production, distribution and service delivery in relation to Covid-19 lockdown were closely observed. Web pages of Food and Agriculture Organization (FAO), World Health Organization (WHO), European Union (EU), World Bank, Food Industry Association (FIA), Research Gate, Food Tank, Ministry of Agriculture, Nepal Food Security Monitoring System (NeKSAP), Organization for Economic Co-operation and Development (OECD) and news papers were visited. The agriculture statistics like, crop area, livestock population, food productions, import and export were taken from the secondary sources mainly from Statistical Information on Nepalese Agriculture, Ministry of Agriculture Development. Available literatures related to food policies, disease pandemics/disasters preparedness and food supply, agriculture extension, food self-sufficiency, trend of food production and supply, land use, urban agriculture and agriculture technology were reviewed. Finally, the future strategy needed for the sustainable food production and supply for mitigation against the impact of Covid-19 lockdown is recommended.

Results and discussion

Overall agriculture situation during Covid-19 lockdown

Every segment of the economy including food production, processing and distribution is affected by the Covid-19 Lockdown. The schedule of food production, collection and distribution especially, livestock management, crop harvesting, procurement, transportation and marketing has been disturbed. Labor shortage and distorted supply system has lead to hassling, and product wastage with price fluctuations. Food system/availability especially in urban areas distorted severely. Agriculture extension support from public sector institutions is ruined/broken because of the lockdown. Import of food stuffs from rural areas to cities and in country from aboard has been completely stopped. The returnee population in home country from other countries has been abruptly increased, raised the food demands. Delayed on next

season planting and livestock stocking, manuring/fertilizer, irrigation, and other farm operations and agro harvesting, most likely will lead to food deficit and price hike in the days ahead. Daily wage labors, poor and peasants are affecting most severely.

Need of linking agriculture to Covid-19 national mitigating program

There is an immense need of preparing the safety guideline and follow by every country for awareness creation and breaking the chain of infection among farmers, agri-workers and the agro-entrepreneurs. The safety guideline shall support to minimizing the movement and social gathering and continue the farm operation. The safety guideline shall be annexed with the route map that shows the infected areas, quarantine areas, isolation centers, health centers/hospitals, settlements, and agriculture areas. So that, the concern persons shall follow the map escaping from the Covid-19. Distribution of safety materials/equipments to farmers, agri-workers and agro-entrepreneurs such as masks, sanitizers and personal protection equipment is necessary. Every food production and distribution activities shall be linked with overall Covid-19 lockdown impact mitigating program. The program especially shall be tie up with the quarantine and isolation procedure, healthcare scheme, door steps medicines supply at village level and linked to referral hospitals. In addition the program can be linked with loans distribution for rescue and farm operation, job creation focus to rural areas and free provision of food grains, pulses, sugar and essential commodities to all needy households including resource poor agriculture labors and the poor farmers.

Immediate agriculture extension support to mitigate impact of covid-19 lockdown

It is needed to permit movement of vehicles and harvesters for farm-related operations by observing adequate social distancing during the disease pandemic. For an example harvesting of winter crops like wheat, lentil, rajma, winter maize (green) and their marketing during the Covid-19 lockdown was the immediate need. Spring planting/transplanting of summer crops like early rice, spring maize and stocking were delaying. It was the time for stocking poultry chicks and fish fingerlings and harvesting honey. It is immensely necessary to solve those kinds of problems during the disease pandemics and disasters. Extensive arrangements to harvest and procure the perishables like: milk, meat, egg, fish, vegetables, honey, green maize cobs and fruits from village level to existing cluster markets is necessary. It needs several number of operational cluster markets across the country. In addition, it is necessary to linked agro-products (both perishable and non-perishables) to online home delivery to customers in cities and suburban centers. Delivery can be arranged by the distributing agencies and volunteers. Facilitate transportation of agro-products to major outlets in any other provinces, cities and municipalities are equally important. Seed management is one of the challenges during the lockdown period. Seed harvesting of winter plantings, wheat, lentil, rajma etc in time is an issue because of restriction on transportation, vehicle and harvester movement and the unavailability of labor. There are hurdles on seed harvesting, threshing, collection, transportation, processing and storage. Distribution of seeds for next seasons planting/transplanting of spring and summer crops like early rice, spring maize and others is also need to facilitate. The seed production initiatives already stepping ahead should not be geared back. Lower seed replacement rate should be accelerated through the continued seed support services, supporting quality inputs and source seeds, improved seed regulation and linking farmers/entrepreneurs to seed markets and ensuring seed self-sufficiency for the time of limited seed import in the country.

Cereals are the staple foods in many of the countries. Rice is the staple food in South Asia and maize the second most grain used for both food and feed. Governments should facilitate for the upcoming spring and summer planting of these crops. The self sufficiency ratio (SSR) of cereals in Nepal is 97.4% (MoAD, 2017/018) and there may not be importing cereals at

present. South Asia especially Nepal deficit on vegetable consumption based on ICMR (1985) and WHO (1986) recommendations where, the SSR of vegetables is about 65.9%. If not continued the import the consumption will further decreased, leading the nutrition problem. So, government shall take an immediate action for facilitating the farmers for the spring and summer planting of major cereals and vegetables. Nepal is almost self sufficient on poultry eggs and poultry is one of the most promising enterprises in Nepal (MoAD, 2017/018). The SSR of meat is 61% and the milk 79%. Where, the SSR of fish is only 17.2%. However, the per capita consumption of meat fish and milk in Nepal are also below than the ICMR (1985) and WHO (1986) recommendations. If the import will be limited the per capita consumption of these foods may also decreased leading to under nutrition. Thus, immediate action is needed for stocking the poultry chicks and fishery fingerlings is utmost for not to defecate the animal source foods in the days ahead. In addition, government should facilitate on the harvesting, transportation and distribution of animal source foods not to waste in the source of production and not to be short supply. Spring is one of the most favorable times for the beekeepers. Blossoming spring flora invited beekeepers to migrate their honeybee colonies and increase harvesting of hive products like honey. The SSR of honey is estimated 24.6% if taken 0.5kg honey/year/person (MoAD, 2017/018). Government should support beekeepers in this season for colony migration and collection of honey and consumption that enhance immunity against Covid-19.

Establishment of nationwide helpline network with a number of helpline numbers to answer queries and provide agriculture advisories on crop cultivation and livestock, fishery and apiary management practices is necessary. The federal, provincial and the local governments shall prepare covid-19 lockdown agriculture impact mitigation action plan that covers immediate, intermediate and post Covid-19 lockdown period and follow to improve the food supply situation in the country. Governments should allocate sufficient resources or make budget transformation from any budget headings for the priority of basic food availability.

Intermediate agriculture extension support to mitigate impact of covid-19 lockdown

Intermediately, urban agriculture and massive small scale farming shall be prioritized. Small scale farming covers small and family farms, home gardening, nutrition gardening, kitchen gardening and urban agriculture that led to home or local scale food availability and nutrition. Small scale farming and urban agriculture are the ways of better utilizing agriculture land, vertical farming, roof top farming, use of high tech high density intensive farming that covers hydroponics, aquaponics, etc. to enhance local foods supply. It can substitute the food imports (FAO, 2020). The city demand of entire vegetable could be produced through urban agriculture. Close proximity to the customers allows for same-day harvest and delivery of fresh vegetables through adopting rooftop poly-culture farms with larger/commercial greenhouses with hydroponics technique. It requires low water use, capturing rain water and recirculate, minimum inputs and is giving maximum yields round the year, in a business model (Smart city, 2019). In Berlin, there are aquaponic farm on the roof of the building and producing both fish and vegetables (Fuzzmag, et. al. 2012). However, establishing a professionalized workforce with greater labor efficiency may be an issue (Robert, et. al., 2020). Waste can be effectively recycled to fertilize in these urban farms that can add on food availability (News.fr.msn, 2012). There are commercial larger Aero Farms (vertical farms) growing leafy greens, tomatoes and cucumbers around the year with 390 times higher yields/sq.ft. Milan (country?) is pioneer city for commercial urban agriculture in larger green houses and vertical farming (Smart city, 2019). It is most necessary to create awareness of small-scale farming, urban agriculture and small scale family farming among a large population, through the extension materials. It needs to distribute millions of vegetable seed

packets, breed chickens, honeybee colonies, and small scale fishery for nutrition gardening to massive households. The agriculture workers and the community volunteers can be mobilize for it.

Post lockdown agriculture extension support to mitigate impact of covid-19 lockdown

Resumption of full-fledged farming operations and revival of agri-based enterprises shall be the priority for the livelihood recovery and agriculture resilience. Agriculture is only a means for rural employment and food security too. It covers the following steps:

Policy support and priority setting

Policy amendment is needed for land use and improved food production, food self sufficiency, commercialization and strengthening agro-business. Nepal committed for food and nutrition security, right to food, food sovereignty, and zero hunger initiative. Department of Food Technology and Quality Control is placed for food quality control and Ministry of Supply is in place for food supply. However, the live coordination between the food production, processing, quality regulation and supply system need to strengthen. It is most important to have a food policy reform in Nepal for strengthening food production system for domestic consumption, import substitution or for export promotion or to support the food industries from supplying the raw materials. The illegal export of paddy and other cereals from Terai boarder just after their harvesting is frequently reported from Nepal. So it needs to stop and maintain at least 50% food deficit as buffer stocks and stop cane/sugar import to restore national food sufficiency in Nepal (Pokhrel, 2020). Government shall fixed the priority and the production target of major agriculture commodities based on the demand, import dependency and production potentiality. Local governments shall emphasize on the production of the commodities for local food self sufficiency and the provincial and federal governments for the commercial production and economic resilience, tying up the agriculture research, education, extension and infrastructure development activities. China introduced a series of "vegetable basket" policies even in Covid-19 lockdown to stabilize production and supply, combining conventional channels and emergency channels, combining traditional circulation and new business formats, and working to reduce the impact of the epidemic on the purchase and sale of agricultural products to small farmers (Cullen, 2020).

Establishment of new agriculture farms and area/heard expansion

The federal, provincial and local governments should emphasize on the activities to establishment of new commercial agriculture farms or to expand the cultivated area and farm sizes for the prioritized commodities. It support to increase the production and productivity of the foods targeting the commodities with higher Import Dependency Ratio (IDR) like fruits, pulses, fish, sugar, oilseed and other daily needs. However, expansion of area for a particular commodity can reduced the production of others. Countries like US, China and Brazil either have larger land masses or they are part of bigger economic unions have scope for the expansion of the cultivated areas and herd/farm sizes for the commercial production (Sushma, 2018). In Japan, municipalities prepare the land-use plans in accordance with national and prefectural laws and regulations and pass auxiliary regulations guiding land use in their jurisdictions (OECD, 2017). Where, the land use policies are supported for the expansion and commercial production of livestock and pasture use in Hokkaido and for paddy, soybean, onion, wheat, barley, sugar beet and starch potato on rest of the uplands. The priority has been given based on their competitive price, domestic demand, soil health and industrial use (OECD, 2009). The expansion of the cultivated areas/herd size is not feasible for all the commodities in Nepal too. Thus, it needs to prioritize the commodities to allocate the cultivated land areas for crop farming, fish ponds, apiary or the livestock farm or pasture.

Moreover, establishment of large size, high tech farms like buffalo fattening farms, goat farms, piggery, poultry farms, apiary, fish farms, high density fruit orchards and commercial organic vegetable farms to continue national food sufficiency. It can also generate employment and income for the economic resilience.

Program for raising the food productivity

An increased productivity increases the farm incomes and fueling the linkages between farm and non-farm poverty reduction programs, which are the consequences of agricultural growth (Dhital, 2017). The average cereal productivity in the world is 4.0t/ha (The World Bank Group, 2019), vegetables 13.9t/ha and fruits 12.04t/ha (FAO, 2010). The crop and animal productivity in several other countries are very high. The productivity of corn alone in USA is 10.07t/ha (Wikipedia, 2020).Where, the vegetables yield was 31.3t/ha (Knoema, 2018) and the cereals yield 5.5t/ha (Martin, 2018) in Denmark in the year 2018. In addition, the average dairy farm has 160 cows and the average milk yield per cow was 10,300kg/yr in Denmark in the year 2015 (Henrik, 2015). The food productivity is comparatively very low in Nepal (MoAD, 2017/018). In this connection, Nepal should invest for improved farming for raising the food productivity. However, the food productivity cannot increase beyond a limit. The productivity can only increase with a strong research and technical back up, technology, infrastructure, funding support and an enabling environment. So, for restoring the food self sufficiency it needs a combined effort with the scope of area/heard expansion with predominantly an increase in food productivity.

Infrastructures support

Infrastructures are basic things for modernizing the agriculture. Community refrigerators have helped reduce food wastage in the UAE, Germany and France (Sushma, 2018). Many other countries having higher animal and crop yield like USA and India have developed, popularized and scaled up the high tech initiative for higher and quality yields (World Bank Group, 2020). Similarly, Nepal needs to develop sufficient farm structures, irrigation structures, custom hiring centre, community seed banks, community storage, cold storage and cold chains, high tech nurseries, green houses, collection/processing/packaging units, agro-industries and the market structures to restore the food self sufficiency in the country. Cold chain has been promoted for the supply of perishables in many of the countries (Cullen, 2020) but still lacking in some countries like Nepal.

Farmer's welfare scheme and financial support

Agriculture must make an attractive business. Farmer's welfare scheme that covers output/production based subsidy distribution, crop/livestock insurance, soft loan and interest subsidy programs are necessary to make the agriculture competitive and profitable. Input subsidy should be provided on voucher system, land banking is necessary for land pulling and the long run subsidy including pension scheme for the farmers welfare are equally important. Recent commitments of the African countries like Ghana, Ethiopia and Rwanda devoted larger shares of government budgets and attracted new private investment on agricultural Input Subsidy Programs (ISPs) in the last decade. The ISPs have raised the rate of purchasing agriculture inputs including fertilizer in prior seasons and has improved national food production and farmer's income (Food Tank, 2018). There are public subsidies on agriculture production inputs like improve seeds, fertilizers and machineries in Nepal too. However, the accesses of local farmers on these inputs are frequently questioned. The short term farm subsidies on production inputs shall be continued by the municipalities for improving the agriculture productivity. However, the long term agriculture subsidy that covers overall support framework, better infrastructure, research, knowledge dissemination,

capacity building, market support, institutional strengthening, farmer's welfare scheme, insurance and agriculture risk reduction are important to be addressed to hold food self sufficiency and national food security (Pokhrel, 2020).

Food buffer stocking

Food security and crisis management needs to maintain at least 25% of needs as the buffer stock in case of non perishable like cereals, pulses, oil seeds, and the seeds in Nepal. The community food banks shall be established in provinces and municipalities. Illegal export of rice and cereals from Tarai shall be collected in time, buffer stocked and supply in crisis. Maintenance of cold chains and cold storage for perishables are also important.

Food education

Moreover, the food education is needed to improve the food consumption and nutrition pattern and balancing diet in Nepal (NeKSAP, 2011/012). India has its own per capita diet/food recommendation (ICMR, 1985). However, Nepal lacks such food/diet recommendation. The per capita consumption of energy in Nepal is very high with lower uptake of protein and edible oil/fat. It seems the source of our food is mostly from plant sources dominated by cereals (NeKSAP, 2011/012). It needs to decrease the cereals mostly rice and increase the consumption of pulses, fruits, vegetables, milk, meat, fish, oil and fats (ICMR, 1985 and MoAD, 2017/018). At recent the staple food and the food habit are changing in the globe. Rice is the staple food in South Asia. There is a need of changing food habit to minimize the rice consumption and balancing the calories uptake in Nepal (Pokhrel, 2020). Increased calories uptake can be reduced by the increased consumption of the neglected foods, non cereals and the animal products. Rice consumption also can be minimizing from the consumption of potato, wheat and other cereals. Reducing the food waste at all stages especially in cities may also help on restoring food security. Food diversification from nutritious local foods also can be the alternatives substitute of rice in Nepal (Pokhrel, 2020).

Research and technology support

Nepal should focus on agriculture research for developing high yielding breed and varieties can enhance food sufficiency (EU, 2015). Different countries are adopting modern and advanced technologies for to secure food security. The seed improvement, breed improvement and hybridization program helped to commercial agriculture in USA (Wilde, 2018). Farmers in India also are benefitting from the advanced technologies to increase their yields from farming and livestock rearing (Sharma and Mungrawal, 2019). However, use of high tech agriculture is still not advanced in Nepal that could led the country toward self sufficient in many of the agriculture commodities.

Reform and strengthen agriculture extension

The ruined/broken extension support of the public sector institutions during the lockdown of Covid-19 needs reorientation. Establishment of a tele-counseling service center and application of mobile app on farming practices on crops and livestock for extensive use by the farmers is also important. The advisory shall be freed available jointly from agriculture extension, research and education sectors. Mobilization of agriculture extension workers, public sector organizations, privet sectors, and cooperatives network and community volunteers are needed. It shall emphasize on social mobilization, strengthening farmers groups, cooperatives and farmers organizations. The agriculture extension materials especially on high tech agriculture, urban agriculture and vertical farming and small scale family farming and shall be produced and massively distributed. There is a need to replace

the domination of supply driven agriculture extension approaches by the demand driven services (Birner & Anderson, 2007). The extension services based on more and more donor's interest and less concerned on the demand of farmers should be improved (Dhital, 2017). A good demand driven extension service is possible when there is commercialization and privatization of the extension services (Birner and Anderson, 2007). Recent political transformation has brought changes on service delivery system in agriculture development in Nepal. Human resource development (technical) and training is a challenge for the R/Municipalities. There are a number of emphasis based production projects like Prime minister Agriculture Modernization Project (PMAMP), Food and Nutrition Security Enhancement Project (FANSEP), implementing for the commercialization of agriculture in Nepal. These projects must play role to restore food self sufficiency in the country.

Improve the supply chain

Strengthening agriculture markets are necessary. However, the post harvests operations: collection, processing, packaging, transportation, storage and distribution/supply system shall be on priority. Cullen (2020) pointed on the need of establishing the interconnection mechanism of farmers and merchants for improving the agricultural supply chain system. It included grains, oils, vegetables, meat, eggs, milk, and aquatic products in the scope of daily necessities during the epidemic prevention and control and continue afterward. E marketing and home delivery system shall be continuing after the lock down.

Budget management

Tax exemptions and food add has been given to the job less in Italy, Australia and USA (Cullen, 2020). The local, provincial and federal governments should immediately manage the budget transferring from any of the budget against possible food crisis due to Covid-19. Restoring food self sufficiency on crisis may need a huge investment/budget on agriculture as indicated by Birner & Anderson (2007). Funding on agriculture sector is in declining trend in Nepal (Dhital, 2017). There lacks integrated approaches on public-public partnership, majority private funds are mobilizing separately against public-private partnership and private-private partnership is also not materialized enough as projected by ADS. Thus, it is recommended to have improved agriculture funding through increasing public investment and attraction of the private fund for restoring food security in Nepal (Pokhrel, 2019).

Conclusion

The schedule of food production, collection and distribution has been affected leading to hassling, product wastage and price fluctuations by the impact of Covid-19 lockdown in 2020. The import has been limited and food demands increased because of returnee population with unemployment problem. There lacks to link agriculture to national Covid-19 mitigating program to continue the farm operations, food distribution system and safety of the farmers and agri-workers. Government and public institutions should have been pre-prepared for food security during the period of disease pandemics and disasters but it was not happened in many countries including Nepal. Immediate action to facilitate crop harvesting, transportation, crop planting/livestock stoking and farm operations, product marketing, seeds and other input distribution needed. Intermediately, the local food supply chain should be strengthened through small scale family farming and urban agriculture through mobilizing the agriculture workers and the community volunteers. Moreover, the full flagged agriculture activities in post pandemics/disasters shall be enhanced through expansion of crop area/heard size of the selected commodities or predominantly from increasing food productivity to restore the food security. In addition, food buffer stoking with strong supply systems and

food education are necessary. It also needs to reform the food policy and priority settings for the period of disease pandemics and other disasters.

Recommendations

A. Immediate actions

- Governments must allocate sufficient resources, from transforming the budget from any budget lines for the basic food production and supply
- The impact mitigation action plan for agriculture against Covid-19 lockdown shall be prepared and implemented.
- Immediate action shall be taken to facilitate the farm operations like crop planting, harvesting, livestock, poultry chicks, fingerlings and honeybee colony stocking and transportation of the agri products and inputs.
- Establishment of cluster markets linked with online home delivery of agro-products (both perishable and non-perishables) to cities and suburban customers.
- Input management the fertilizers, manure, seed etc and their distribution
- Establishment of nationwide helpline network and online/mobile advisories.
- Food education shall be started to improve the production and minimize the food waste and for its best utilization.

B. Intermediate actions

- Massive promotion of small scale family farming and the urban agriculture (vertical farming, aero farms, rooftop agriculture..) and use of larger green houses, high tech, high density, poly-culture, intensive farming. Needs to enhance waste recycling and use to promote local food supply.
- Massive distributions of extension materials, vegetable seed packets, breed chickens, honeybee colonies, and small scale fishery through mobilizing the agriculture workers and the community volunteers.

C. Resumption of full-fledged farming operations in post lockdown period

- Policy reform and priority settings on government food policies, subsidy on food production, food trade, food marketing, food buffer stocks, food use and food habits.
- Local governments shall emphasize on local food self sufficiency and the provincial and federal governments for the commercial production and economic resilience.
- Establishment of new commercial agriculture farms, expansion of crop area/heard sizes for the selected commodities, high tech buffalo fattening farms, goat farms, piggery, poultry farms, apiary, fish farms, high density fruit orchards and commercial organic vegetable farms.
- Program for raising the food productivity with a strong research back up, technology support, infrastructure, funding support and an enabling environment. However, a combined effort with the scope of area/heard expansion with predominantly an increase in food productivity are recommended.
- Farmer's welfare scheme covering output/production based farm subsidies on production inputs, including soft loan and interest subsidy, risk reduction through crop/livestock insurance coupled with the long run subsidies on infrastructure, research, knowledge dissemination, capacity building, market support, institutional strengthening are recommended for making agriculture an attractive, competitive and profitable business. The voucher system for subsidy distribution and land banking for land pulling are also necessary.
- Food buffer stocking at least 25-50% of non perishable and maintenance of cold chains and cold storage for perishables are also important.

- Moreover, the food education is needed to improve the food consumption and nutrition pattern, balancing diet and minimizing the waste. Rice consumption shall minimize with potato, wheat and other cereals. Food diversification from nutritious local foods also can be the alternatives.
- Agriculture extension reform from establishment of tele-counseling services, application of mobile app, farmer's advisory services and integrated extension service delivery through commercialization and privatization is needed.
- Restoring food self sufficiency after the Covid-19 lockdown needs a huge investment/budget that must manage by increasing the public sector funding and through the attraction of the private funds.

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Impact of COVID-19 Lockdown on Fine Particulate Matter ($PM_{2.5}$) in Kathmandu, Nepal

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Abstract
Government of Nepal has imposed lockdown over the whole country, including Kathmandu Valley, to restrain the impact of pandemic COVID-19. This paper presents the analysis and interpretation of ambient particulate matter concentrations of $PM_{2.5}$ in Ratnapark air quality monitoring station in Kathmandu valley from January to mid-May in general and during the month of April of the years 2019 and 2020 more specifically . The Main finding demonstrated the change in concentration of $PM_{2.5}$ between April 2019 and 2020. The mean monthly concentration of $PM_{2.5}$ of April 2020 was found significantly lower than April 2019 in Kathmandu. Improvement in the air quality in terms of fine particulate matter was observed following the lockdown. The number of days exceeding national ambient air quality standard of 2019 for $PM_{2.5}$ was found higher than April 2020. Overall the study showed anthropogenic source control can improve the air quality.

Keywords: *Daily Average $PM_{2.5}$, Diurnal Variation, Monthly Average $PM_{2.5}$, National Ambient Air Quality Standards (NAAQS), $PM_{2.5}$*

Introduction
The COVID-19 disease caused by corona virus was first identified in Wuhan, China and spreaded worldwide affecting every aspect of human life. To restrain the corona virus (COVID-19) pandemic, Nepal government has imposed nationwide lockdown from March 24 to June 15. Till June 15, 2020, the coronavirus (COVID-19) has infected over 7.7 million people and caused 4,30,241 deaths worldwide and infected 6211 people and caused 19 deaths in Nepal (https://covid19.mohp.gov.np/#/). By this nationwide lockdown almost all industrial activities and mass transportation have been prohibited and economic activities have been shrinked.

Although lockdown has severe impacts on people's social life, mobility and economy, recent researches have revealed that lockdown has temporarily improved air quality. For example, the lockdown improved the air quality of the 103 cities in India- the most polluted country in the world which has 21 out of the 30 world's most polluted cities (Singh and Chakraborty, 2020). The analysis of local data from different regions in India, to assess effects of the lockdown on air quality, observed the 43% reduction in $PM_{2.5}$, during the lockdown compared to the same time period of the past four years (Sharma et al., 2020). The $PM_{2.5}$ and $PM_{2.5}$ concentrations of New Delhi during lockdown reduced by about half in comparison to pre lockdown period (Mahato et al., 2020). A study on air quality index in Bengaluru, India during lockdown period has shown that improvement of air quality from hazardous to better (Yogendra Kambalagere, 2020). Also the analysis of air quality data from Sao Paulo, Brazil showed the reduction in concentration of CO, NO and NO_2 during the lockdown as compared to the same time period of the past five years (Nakada & Urban, 2020).

There are media reports, primarily based on satellite images, about reduction of air pollution due to the lockdown globally, and some recent scientific studies conducted in a small number of countries (He et al., 2020) and cities (Cadotte, 2020) indicated such reductions.

Air pollution is the single largest environmental health risk in the world and seven million people die prematurely every year globally and thirty eight thousand people every year in Nepal due to air pollution. Also known as fine particulate matter, $PM_{2.5}$ includes the particulate matter with an aerodynamic diameter less than 2.5μ in size. While particles with a diameter of 10 microns or less, ($\leq PM_{10}$) can penetrate and lodge deep inside the lungs, the even more health-damaging particles are those with a diameter of 2.5 microns or less, ($\leq PM_{2.5}$). $PM_{2.5}$ can penetrate the lung barrier and enter the blood system. Chronic exposure to particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as of lung cancer (WHO, 2018). It has been found that, with high level of air pollution exposure, Nepal, especially Kathmandu, is suffering from a potentially serious human health burden from air pollution (Gurung et. al., 2017).

Nepal Government has set and enforced National ambient air quality standard (NAAQS) and has a legal obligation to maintain this standard (NAAQS, 2012). Department of Environment under the Ministry of Forests and Environment has started to establish and operate air quality monitoring station since 2016. By the end of April 2020, 22 monitoring stations came into operation whole over the country with seven monitoring stations within Kathmandu Valley. This paper is an outcome of assessment of air quality data from Ratnapark Station to know the impact of lockdown on air quality in comparison to non lockdown period of previous year. Understanding this temporary improvement in air quality provides a unique opportunity to study processes and implications of policy changes to reduce air pollution in future. The main purpose of this study includes analyzing the monthly, daily and hourly average $PM_{2.5}$ before and after lockdown.

Methodology

Study Area

Ratnapark air quality monitoring station is located in Ratnapark area of Kathmandu Metropolitan City, Kathmandu district. It came in operation since 2016 and represents the core urban area of Kathmandu valley. Kathmandu valley comprises of three districts namely Kathmandu, Lalipur and Bhaktapur covering total area of 902.61 sq. km (https://en.wikipedia.org/wiki/Kathmandu_Valley). Some basic descriptions of Kathmandu valley are shown in the following table 1.

Table 1: Basic descriptions of Kathmandu Valley

Descriptions	Remarks
Population Size(Kathmandu, Lalitpur, Bhaktapur)	24,72,071 (Central Bureau of Statistics, 2011)
Climate	88% subtropical and 12 % temperate (https://en.wikipedia.org/wiki/Kathmandu_Valley)
No. of Vechiles Registered	10,42856 in Bagmati Zone and 90 % of which run in Kathmandu valley (Department of Transport Management, 2017)
No. of Industry	4,607 (Department of Industry, 2019)
No. of Brick Kiln Industry	110 (Department of Industry, 2019)

Fig 1: Location map and Image of Air Quality Monitoring Station in Ratnapark, Kathmandu.

Data Collection and Analysis

This monitoring station has Grimm Electronic Dust Monitor (EDM) 180 to measure particulate matter of different sizes. It uses the use light-scattering technology of particle count. A semiconductor-laser serves as the light-source. The particle size analyzer/dust monitor determines the dust-concentration (counts/liter) through the optical-light-scattering method directly; however, the mass concentration is determined by extrapolation.

The instrument collects data in every minute. The data collected from the instrument is transmitted to data management software located at National information Technology (NITC), Kathmandu. The measurement from the monitoring stations is communicated to the public through the website www.pollution.gov.np.

The hourly average $PM_{2.5}$ data was collected from January to May in 2019 and January to mid May 2020 for the purpose of study. The data of April 2019 and April 2020 was taken into account more specifically for the comparison purpose. Although National Ambient Air Quality Standard (NAAQS) of Nepal has defined nine parameters to describe air quality of a region, only $PM_{2.5}$ data was collected and analyzed. This is the most common parameter used by scientific community to assess the status of air quality. The 24 hour average national standard value prescribed by Nepal Government for $PM_{2.5}$ is 40µg/m3 (NAAQS, 2012).

For the analysis of the data, hourly average $PM_{2.5}$ data of study periods were downloaded from the server. From those hourly averages, daily average $PM_{2.5}$ and monthly average $PM_{2.5}$ were calculated. Only the days that have complete data is chosen for data analysis. The number of days with valid data and the number of days that exceeds national standard were calculated. Pivot table from excel program is used to calculate the daily, monthly and diurnal $PM_{2.5}$ levels. Depending on the nature of data, the results have been displayed in Column chart and chronological chart. Two samples T test has been run to compare the significance of difference between monthly averages of two consecutive years at 95% level of significance.

Results and Discussion

Monthly average PM $_{2.5}$

The monthly average $PM_{2.5}$ concentration for the April 2019 and April 2020 were found to be 52.38µg/m^3 and 33.49µg/m^3 respectively (Fig 2). It is reduced by 36.06% in April 2020 in comparison to April 2019 which is quite low but comparable to the Sharma et al., 2020

findings of the 43% reduction in $PM_{2.5}$, during the lockdown compared to the same time period of the past four years in various cities of India.

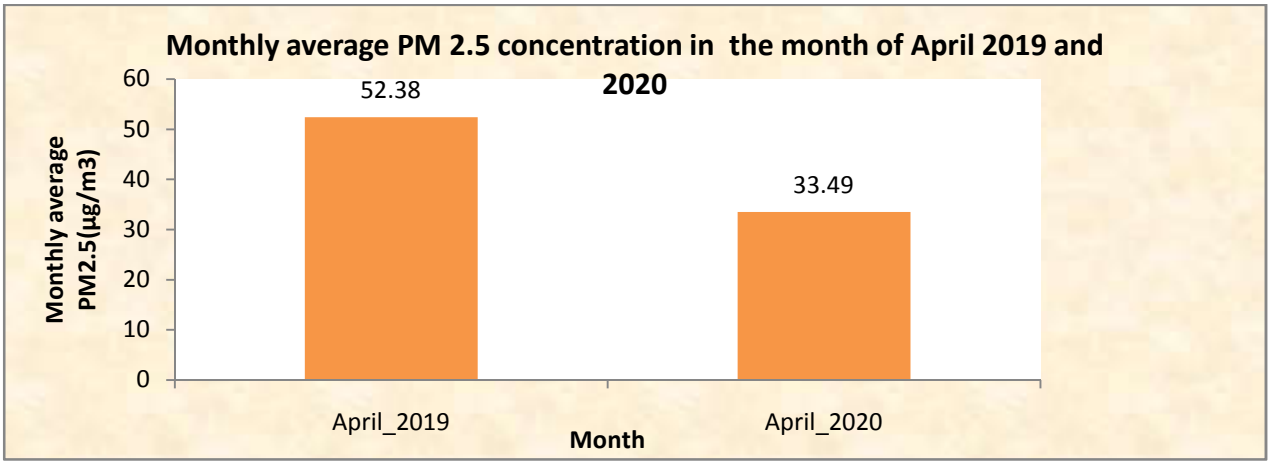

Fig 2: Monthly average $PM_{2.5}$ of April 2019 and April 2020

The P value of T test for the comparison of two means from two samples was calculated as 0.000849* which is less than 0.05 at 95% level of significance. It indicates the average $PM_{2.5}$ of April 2019 is significantly higher than average $PM_{2.5}$ of April 2020. It shows the lockdown has significant contribution in lowering the $PM_{2.5}$ level in April 2020 in comparison to same time period of previous year.

Daily average

The daily average $PM_{2.5}$ value in April 2019 ranges in between 1.71 - 74.57µg/m^3 and, in April 2020, it ranges in between 9.81 - 75.57 µg/m^3 (Fig 3). The trend was found increasing in April 2019 where as it was found decreasing in April 2020.

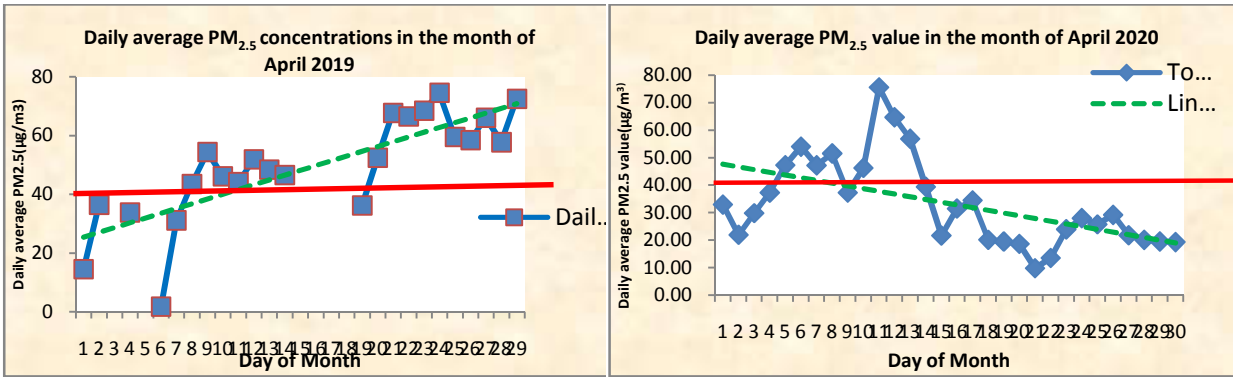

Fig 3: Variation of Daily average $PM_{2.5}$ during April 2019 and April 2020

As most of the $PM_{2.5}$ values in April 2019 were found above the NAAQS standard value of 40 µg/m^3, most of the values were below it in April 2020. Although lockdown was imposed from March 24 2020, the $PM_{2.5}$ level was found increasing until mid-April and the level was found declining then after. This might be due to the continuation of sources like forest fire, waste burning (solid waste and agricultural waste) and brick kiln during lockdown period.

The following chronological chart shows the plot of daily average $PM_{2.5}$ value from January to May in 2019 and January to mid May in 2020.

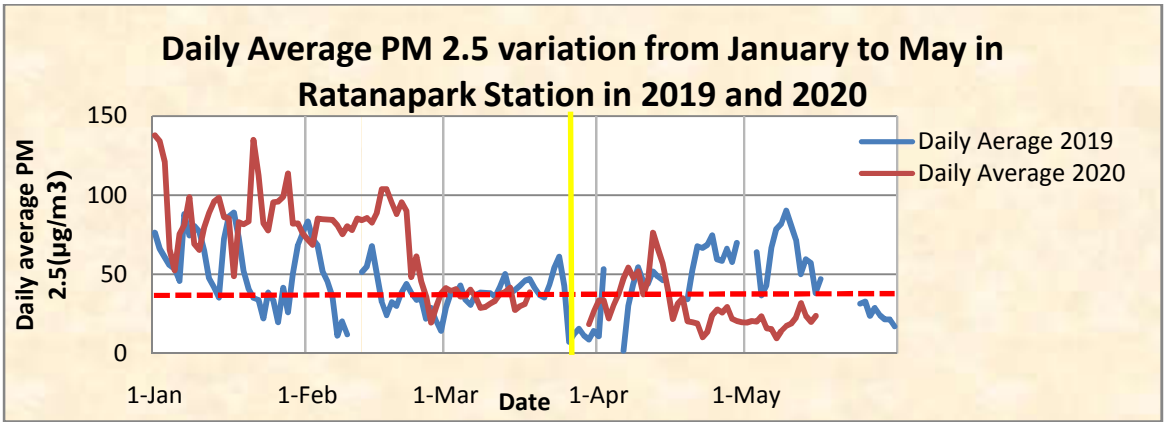

Fig 4: Variation of Daily average $PM_{2.5}$ before and during April 2020 in comparison to April 2019

The yellow line in above figure 4 indicates the beginning of lockdown time in Nepal. The $PM_{2.5}$ level in 2020 was relatively higher than $PM_{2.5}$ level in 2019 before lockdown. Both years $PM_{2.5}$ level was running parallel until mid April and then values of 2020 went down below the values of 2019. The impact of lockdown on $PM_{2.5}$ level was found after mid April 2020.

The number of days exceeding national $PM_{2.5}$ standard was found 8 out of 30 in April 2020 in comparison to 16 out of 23 in April 2019 as shown in the following fig 5.

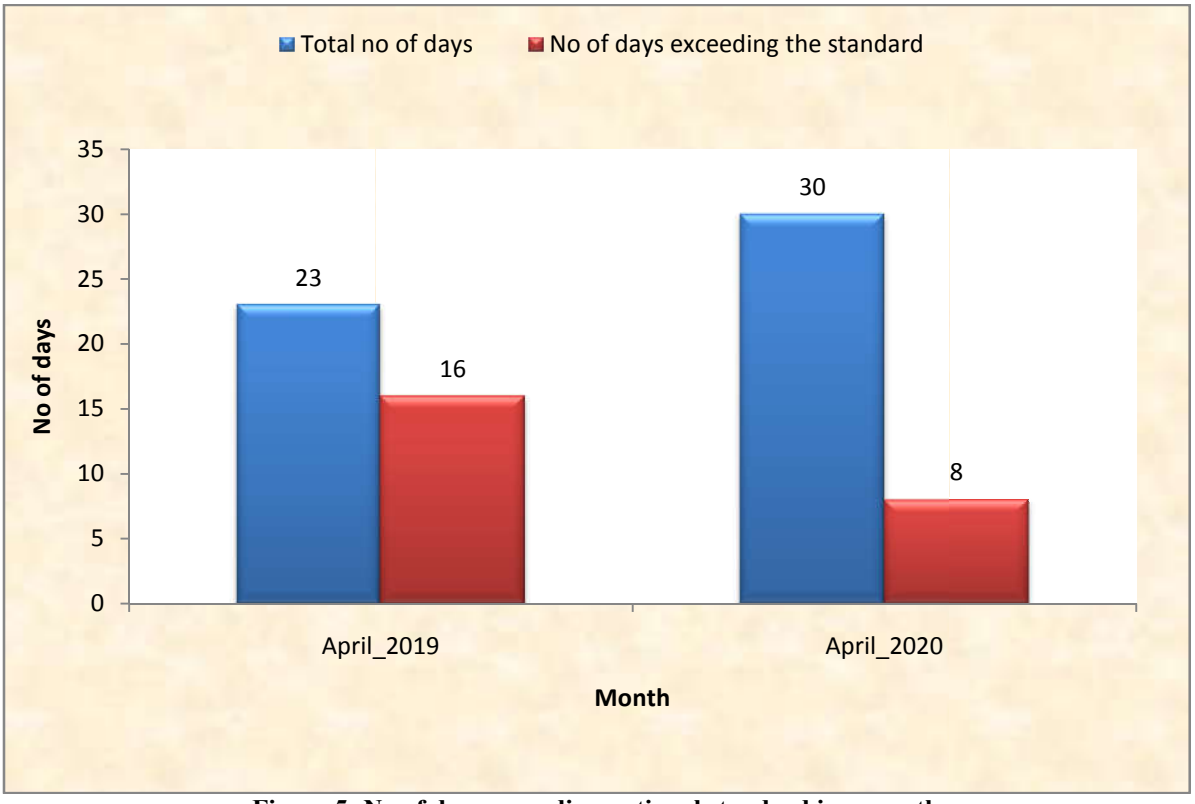

Figure 5: No of days exceeding national standard in a month

Diurnal variation of $PM_{2.5}$

The variation of hourly average $PM_{2.5}$ within 24 hour duration time in April 2019 and April 2020 is shown in the following figure 6. The pattern of increasing and decreasing was found more or less similar in both April 2019 and April 2020.

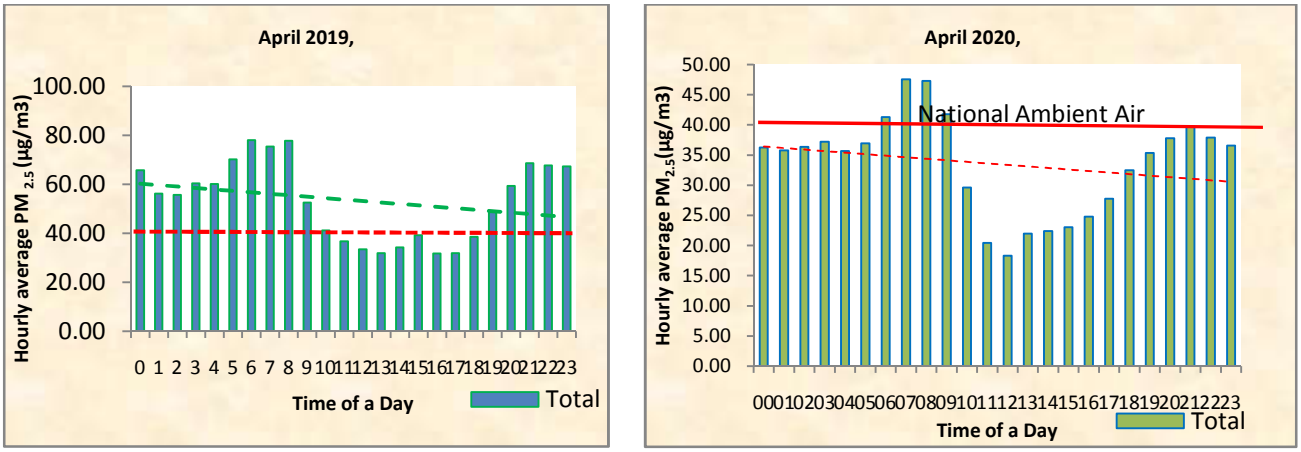

Fig 6: Diurnal variation of hourly average PM2.5 values in April 2019 and April 2020

It was found, in years, increasing in morning time with peak around 9 am and slowly decreasing during day time. It was again found increasing after 5 pm onwards till 10 pm and then showing decreasing until early morning time. The lower hourly average $PM_{2.5}$ levels were found in April 2020 in comparison to April 2019. Lockdown has resulted to lower down it in April 2020 in comparison to April 2019.

Conclusion

The monthly average $PM_{2.5}$ value of April 2020 was found significantly lower than April 2019. The trend of daily average $PM_{2.5}$ value was found increasing in April 2019 where as it was found decreasing in 2020. The drop down of $PM_{2.5}$ was found only after mid of April 2020. The number of days exceeding national standards was found lesser in lockdown period. The trend of diurnal variation of hourly average $PM_{2.5}$ level was found more or less similar in both study periods. It was found maximum in morning around 9 am and found gradually decreasing during day time in both cases. Lockdown has significant contribution in lowering the $PM_{2.5}$ level in Kathmandu. It indicates the anthropogenic sources are major contributors for fine particulate matter pollution in Kathmandu. This study shows that improvement in air quality can be achieved by controlling anthropogenic sources of air pollution.

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Diversity and Species Selection in Urban Forestry: Reflection from Maitighar to Tinkune Road of Kathmandu Valley, Nepal

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Abstract
This study aimed to identify the diversity of tree species planted along the roadside and to access the appropriateness of species choice objectively. Total census along Maitighar to Tinkune road section of Kathmandu Valley was performed. Saplings of woody species were planted along the 4 rows (two on borders and two at middle dividers, cumulatively 3.2 km X 4 lines = 12.8 km) of the road. Total saplings were enumerated and documented individually. A total of 61 woody species belonging to 28 families of 2531 individual were accounted. The floral diversity shows that relatively higher diversity (Biodiversity Index: 0.024, Samson Index: 18, Shannon Index: 3.36) within the limited extends. The choice of species for roadside plantation in this area seemed unprofessional and haphazard species selection. Critical analysis indicates the cruelty and likely accidents in the road would increase far high due to plantation than currently occurring because of inappropriate species choice for plantation. Otherwise, not only increase the maintenance cost, time, pollution and risks associated with but also reduce the aesthetic beauty, faith and ownership as socio-cultural and environmental benefits of urban settings. Therefore, species choice and maintaining diversity in urban areas is a serious concern for decision-maker to be conscious before plantation. The findings would be a reference for plantation focusing on diversity and species selection in urban forestry in and outside the country.

Keywords: *floral diversity; Kathmandu valley; species choice; urban forestry*

Introduction
The mind and management of tree plantations in urban areas to make the ambient environment clean and green is urban forestry. The urban forestry is generally practiced by municipal and commercial arborists, environmental policymakers, city planners, researcher, educators and community activists. The major benefits of urban forestry include- minimize the heat through evapotranspiration, provides shading to streets and buildings, improve human comfort, reduces the risk of heatstroke, improve air quality by absorbing pollutants, carbons sequestration, water absorption, noise control, traffic control (Pearlmutter et al., 2017; Konijnendijk et al., 2005;Kielbaso, 2008; Negi,1998) as well as promote social harmony inclusiveness (Peters et al., 2010; Lamichhane and Thapa, 2012).Roadside greenery also improves the appearance of the highway by adding a variety of amenities and enhances the aesthetic appeal of surroundings due to their foliage, flowers and shape. Though the benefits of urban forestry for urban dwellers are incalculable for long and healthy life, very little attention has been given on it in Nepal (Gautam et al., 2006). Some of the governmental organizations have been taken an initiative on urban forestry through research and studies from their annual program in recent years like Department of Forests, Department of Forests Research and Training Center, and Department of Plant Resources as well as some University student to pursue their thesis (Lamichhane and Thapa, 2012).

The concept of maintaining greenery along the roadsides of Kathmandu Valley has seemed to begin before the 14th century. Importance of roadside greenery at ancient time of Kathmandu

valley reflect from an announcement made by Mr Jayasthithi Malla, (Nepali King,1380 -1395 A.D.) with a huge amount of money for punishment (NRs. 5 at that time) and send to prison those who cut trees along the *Sadaks* (roadsides). But, his focus plantation was remaining along with his settlement territory. However, just outside of King Territory, people had a long-standing tradition of planting Pipal trees (*Ficus religiosa*) in strategic places affording pedestrians a convenient resting spot (*Chautara, paty and pauwas*).

At the time of Rana Prime Minister Chandra Shamsher (1901-1929 A.D.), many paths were expanded and trees were planted on both sides of the way. Chandra Shamsher imported new species like monkey puzzle (*Araucaria araucana*) an evergreen tree from Europe and introduced in Kathmandu valley. Today, most of the old remaining roadside trees in Kathmandu Valley are proof of then Chandra Shamsher's vision. At the time of Rana regime periods, mostly pine (Pinus species), monkey puzzle (*Araucaria araucana*) and other locally available species including fast-growing Populus, Eucalyptus were planted in Lainchaur, Maharajgunj, Patan, Balaju, Lainchaur and Babarmahal area within Kathmandu valley (http://ecs.com.np)**.**

After the introduction of modern urban environmental planning in the 1960s and 1970s, the Government of Nepal renovated roads and trails throughout the city. In the process, many of Kathmandu's older streets were expanded to protect fully developed trees and planting new one where no trees existed even in a single line. After the 1980s, urban environmental planners shifted their focus on three lines green belt along the road. Soon after the construction of Ring Road in Kathmandu Valley, more than one hundred thousand fast-growing trees were planted along that road to beautify the Valley (Personal communication with environmental experts).

Figure 1: A section view of Maitighar-Tinkune road, near Babarmahal Forestry Complex area.

The systematic research-based species selection in an urban plantation in Kathmandu has not yet been reported. However, properties like evergreen and fast-growing species were seemed to be planted. The major planted species were *Populus species*, *Eucalyptus species*, birch (*Betula alnoides*), mimosa or silk tree (*Albizzia indica*), willow (*Salix babylonica*) and *Jacaranda mimosifolia* in and around the Kathmandu. In recent decades, Kathmandu has been facing tremendous pressure from a mushrooming population and pollution, promoting green value is an ultimate need but a serious challenge. Several attempts have been made to planting several thousands of tree species along the roadside with various institutions like Kathmandu Metropolitan and other Municipalities of Kathmandu Valley, Ministry of Forests and Environment, Department of Forests and Soil Conservation, Department of Environment, and several International Non-Governmental Organizations and Non-Governmental Organizations. However, plantation looks haphazard without considering the principles of species choice for and proper plantation techniques in urban forestry. Most of the plantations show emergency plantation, means ad-hoc, without any systematic planning and implementation system. Therefore, we attempted to analyze the species choice and diversity of plant species on the plantation site through a case study from Maitighar to

Tinkune areas of the Kathmandu Valley of Nepal (Figure 1).

Objective

The main objective of this study was to assess (diversity and species choice) the urban plantation from Maitighar to Tinkune road of Kathmandu Valley.

The specific objectives are:-

- To assess the floral diversity of the roadside plantation.
- To examine the choice of species in the roadside avenue.

Materials and Methods

Study Area

The present study area was a roadside plantation that covers on in between and both sides of the main road from Maitighar to Tinkune section of Kathmandu Valley, Nepal. The total distance of the study site was about 3.2 Km with 3-4 rows of plantations collectively (12.8 km) (Figure 2).

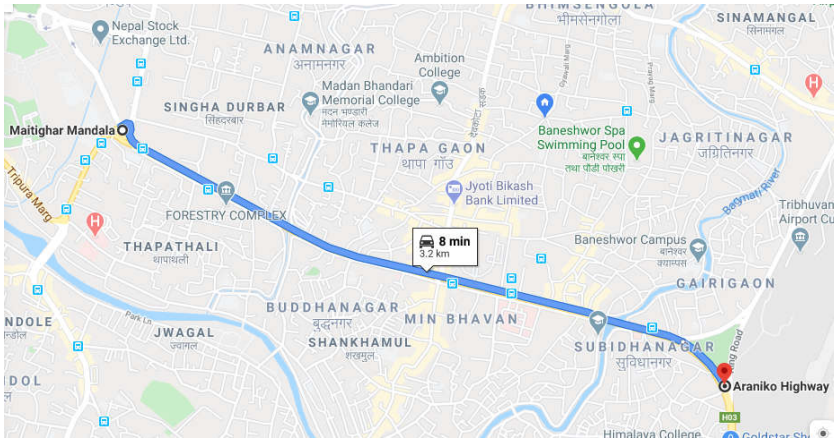

Figure 2: Google map screenshot showing the study area in Kathmandu Valley

Data Collection: The data collection process includes the following methods;

- **Primary Data Collection**

The primary data were collected in autumn 2015. The numbers of individual planted tree in the field were accounted through direct visits to every planted seedlings/saplings along the road from Maitighar to Tinkune section. Total Species, the spacing between every successive plant, as well as any damage due to human activities including dead tree were recorded (Figure 3 and 4). The total enumerated tree species were recorded with their phonological characteristics like structures of leaves, flowers, stem, and branching system. The photographs of each tree species were taken to verify the identification. Most of the species were identified in the field by the research team. Some unidentified species were identified with the help of botanist (Taxonomists) from the Department of Plant Resources. The taxonomist helps to identify the species with references to the photographs of individual species.

Figure 3: A photograph showing a glimpse of Maitighar-Tinkune road, Kathmandu Valley during data collection period

To document the management practices of the plantation, a discussion was made with workers who were working on maintenance for roadside plantation. The few information was gathered on the origin of planted species, management system, irrigation, weeding, and manuring and pest management.

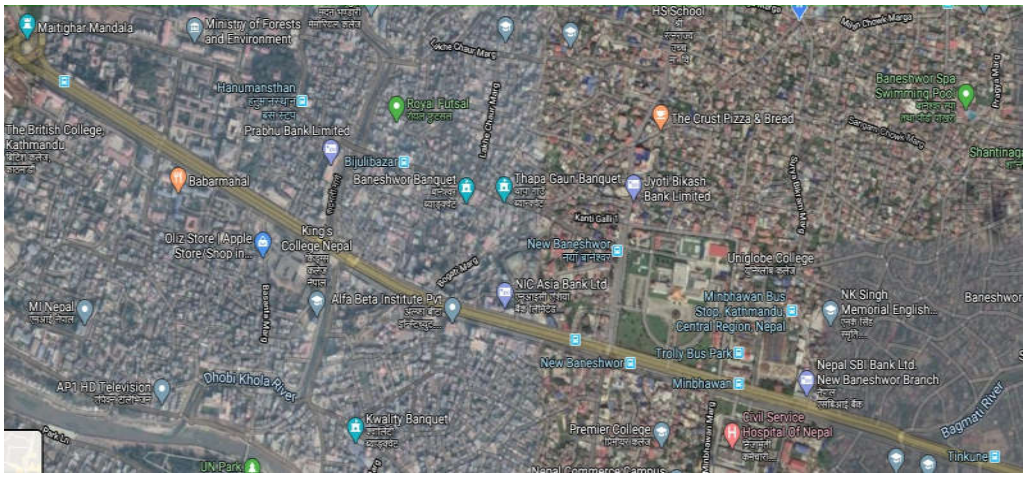

Figure 4: Bird-eye view of study area and surroundings

Data Analysis

The data were analyzed by using MS excel sheet. Floral diversity was analyzed by using Shannon index and Simpson index. The diversity indices were estimated using the following equations.

- **Shannon Index (H)**

$$\text{Shannon Index (H)} = -\sum_{i=1}^{s} p_i \ln p_i$$

Where,

p = proportion (n/N) of individuals of one particular species found (n) divided by total no. of individuals found (N)

ln = natural log

$\sum$ = the sum of the calculation

s = no. of species

- **Simpson's Index**

Since evenness and dominance are simply two sides of the same coin, their measures are complimentary. Simpson's index is based on the probability of two individuals drawn at random from an infinitely large community belonging to the same species;

$$\text{Simpson Index (D)} = \frac{1}{\sum_{i=1}^{s} p_i^2}$$

Similarly, *Pi* is the proportion of individuals found in species i. for a finite community, this is

$$Simpson\ Index(D) for\ finite\ population = N(N-1)/(\sum n(n-1))$$

Where,

p = proportion (n/N) of individuals of one particular species found (n) divided by total no. of individuals found (N)

$\sum$ = the sum of the calculation

s = no. of species

Source: Prof. Kerkhoff, 2010

Choice of species is subjectively judged in the view of researchers 'expertise. Results are presented in graphs, charts and tabular forms.

- **The biodiversity index**

The biodiversity index was calculated by following Magurran (2004).

$$Biodiversity\ index = \frac{(the\ no.\ of species\ in\ the\ area)}{the\ total\ no.\ of individuals\ in\ the\ area}$$

Result and Discussion

Floral Diversity

The study found 61 plant species belonging to 28families with 2531 total tree count from Maitighar to Tinkune road. There are parallel three layers from beginning to the end of the road. A continuous plantation was found along all sections of road in regular spacing except along bridges and roundabout. The family-wise species richness indicated that Leguminosae with 11 different species is planted along this roadside followed by Apocynaceae and Cyaceae with 6 and 4 species respectively (Figure 5).

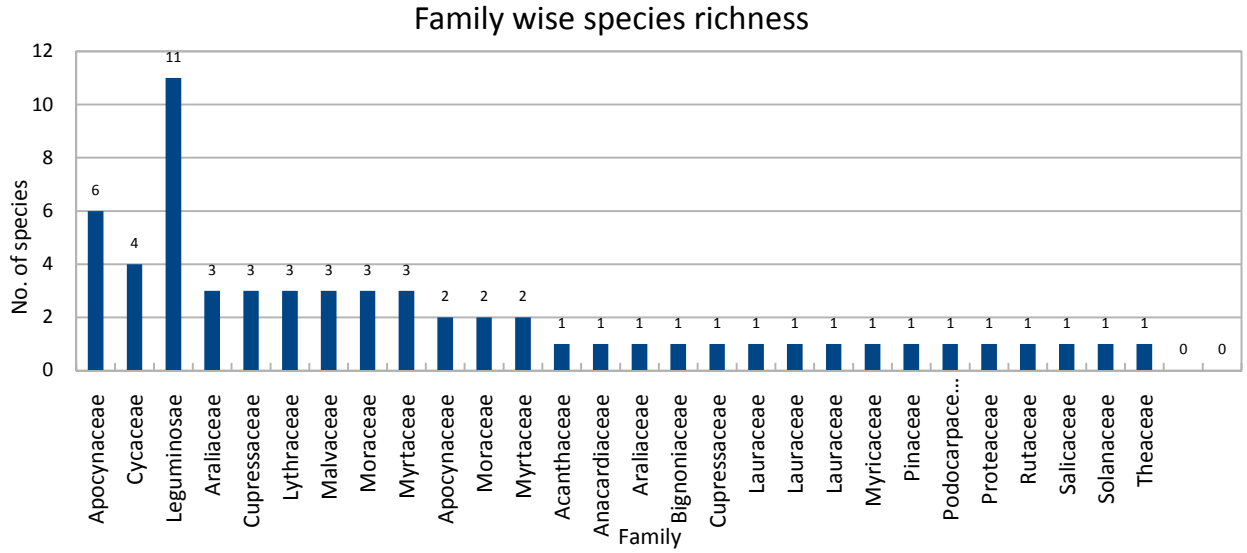

Figure 5: Species richness on planted tree species from Maitighar to Tinkune road

Diversity Indices

Diversity components that were considered in the study were Biodiversity index, Sampson index, the distance between the species (density), numbers of family, total numbers of species, and height of planted tree species (Table 2). Results showed that the diversity indices

are relatively good in this plantation section. Quantitatively, Biodiversity index found 0.024, Sampson indices are just above 18, and Shannon index is 3.36 (Table 2). Remarkably, consisting of 28 families within a 3.2 km (cumulatively 3.2 x 4 = 12.8 km) alongside is great diverse maintenance of floral diversity perspective.

The highest range of spacing was found to be 34 meters in front of Everest Hospital, near Baneshwor, along the pavement (path) way that allowed the multiple entrances and exit as a public avenue and the nearest species found on a meter in many instances. In the study area, the species survival rate also found to be excellent (97.5%), the figure tells that only 65 plants individuals were found to be dead, where 2531 individuals are vigorously growing.

Table 1: Overall summary of the diversity indices and diversity components

SN	Diversity components	Results
1	Biodiversity index	0.024
2	Sampson Index(fin.)	18.16
3	Sampson Index (Inf.)	18.04
4	Shannon Index	3.36
5	Total distance (km)	12.8
6	Total number of plants	2531 (excluding dead ones)
7	Total number of species	61
8	Total family	28
9	Range of space between plants(m)	1-34
10	Range of height(m)	0.2-2.5

Within 3.2 km (cumulatively 3.2 x 4 =12.8 km) distance, 81 different plant species from 28 different plant families showed very good species richness and diversity.

Species choice

In this plantation section of Kathmandu Valley, no systematic selections of species were found. Several planted species were climatically unsuitable in Kathmandu valleys like *Cupressus species* and *Cedrus deodara.* Out of 2531 total planted tree counted, 404 trees (16%) is covered by *Ficus Benjamina* and *Callistemon citrinus, Michelia kisopa, Cupressus tolurosa* with 210,129 and 125 counts respectively (Table 2).

Table 2 Total number of dominant species on Maitighar to Tinkune road

SN	Vernacular name	Scientific names	Family	Individual trees
1	Swami	*Ficus benjamina*	Moraceae	404
2	Bottlebrush	*Callistemon citrinus*	Myrtaceae	210
3	Champ	*Michelia kisopa*	Magnoliaceae	129
4	Raj Sallo	*Cupressus torulosa*	Cupressaceae	125
5	Kapoor	*Cinnamomum camphora*	Lauraceae	117
6	Laurel spp	*Persia* species	Lauraceae	117
7	Kyamuna	*Cleistocalyx* species	Myrtaceae	116
8	Kalkatte plant	*Camelia japonica*	Theaceae	102
9	Kaiyophul	*Gravelia robusta*	Proteaceae	95
10	NA	*Callindra* species	Leguminosae	92

The maintenance of very good spacing between plants in this section demonstrates the real expectation in urban forestry (McKinney, 2008).The major purpose of this urban plantation seems for ornamentation as well as to maintain the urban ecosystem intact. Besides, road site

trees ultimately fulfilled the amenity, shelter, wind firm, evergreen and urban park. However, Swami (*Ficus benjamina*) is the most common tree found in this study may not be a right choice for this roadside plantation because the size of the tree, their location if not carefully planned at planting, raise and crack the pavement with their roots. The same case is for *Ficus religiosa* in some section of the road.

The expected benefits from the urban forestry are that prevents or at least reduce wind erosion, reduce evaporation from the soil, moderate extreme temperatures. The physical characteristics of planted trees species must be fast-growing, having straight stems, can be prune as desire, evergreen, wind firmness, deep root system, relatively long-lived, not subject to wind throw or breakage of large branches, and comparatively resistance to drought and must be suitable in the local climate (http://www.fao.org). In Kathmandu Valley specific deciduous trees also suitable for plantation because these trees have an important advantage is their ability to provide shelter in summer but allow sunlight to penetrate in winter however the leaves need to be gathered during and after leaf fall. The form and height of the species must be suitable for the width of the street in which they are to be planted (http://www.fao.org/). Besides, the roadside plantation must consider such trees which produce edible fruits, pods, provide food and shelter for birds and when bloom must be pleasant fragrant and valuable for beekeeping too. Recently, in the inauguration of plantation years in Nepal, a practice has been started in Koteshwor-Ekantakuna-Kalanki Ring Road section (Personal Communication with the Department of Forests and Soil Conservation, 2019).

There are several advantages of Maitighar to Tiknune plantation of Kathmandu by increasing scenic beauty, ameliorate to the main road with a very good diversity of plant species but this study identified some following shortcoming.

- *Ficus bengamina* and *Ficus religiosa* are two religious trees with a very dominant habit that may not ideal because they are buttress forming, prop-rooted, branchy, spread horizontal branching, deciduous, zoophile species. Thus may not consider as an excellent choice of species for Roadsides Avenue. We found this is the most abundant in the study area (Table 2)
- *Gravelia robusta* and *Magnolia species* are wind threw, surface feeder, deciduous, branchy species. This may cause an accident in the road and its sides, regarded as a decorative plant but not for roadside growing. Also, these species found commonly in the study site (Table 2)
- *Cupressus species* and *Cedrus deodara* are upper temperate trees. These are climatically unsuitable in Kathmandu Valley since this belongs to the ecological zones of sub-tropical regions (average elevation of the valley is 1400 m above sea level) (Wikipedia, 2020).

Conclusion

Only in 3.2 km (cumulatively 3.2x4=12.8 km) long main road of Kathmandu Valley, the floral diversity (both richness and evenness) is very good with 61 different species within 28 plant families. The choice of species for this plantation showed unsystematic and unplanned. Though species composition showed a wide range of varieties appropriate choice remained haphazard and without considering the general principles of urban forestry. Therefore, species choice is a serious concern for decision-maker to be conscious before plantation in an urban environment. Proper and scientific species selection not only reduce the cost of species

management, disaster risk, many types of pollutions and time for maintenance in term of economic advantages but also facilitate to increase the aesthetic beauty, faith and ownership as socio-cultural and environmental benefits of a heavily populated area in urban settings like Kathmandu Valley.

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Urban Solid Waste as a Renewable Source of Energy: A Case of Dhulikhel Municipality

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Abstract
Municipal solid waste (MSW) management has become a pressing issue in many developing countries of the world including Nepal. At the same time, energy access is another major problem in context of Nepal. In such a scenario, developing a solution that addresses these problems and weans off the non-renewable energy sources will directly not only weave way for better urban waste management but also offers several environmental benefits. This paper assesses one such solution in biogas generation from organic fraction of MSW collected by Dhulikhel Municipality; located 25km North East of Kathmandu, and perform the cost benefit analysis of the project. The result indicates that 5 tons/day biogas system can be installed in the municipality, which would give 120 kg/day of upgraded bio Compressed Natural Gas (CNG) with more than 96% methane content and 1040 kg/day of organic fertilizer. In addition, it can negate production of 907.8 tons of CO_2 annually. The payback period for the project with subsidy is 6.17 years and without subsidy is 10.29 years. Moreover, the financial analysis indicates that the payoff period for the biogas project maybe unattractive for project developers and investors; the primary cause being small scale of the project. Hence, the project should scale up in size by collaborating with adjacent municipality to collect larger amount of waste or seek options for Co-digestion of MSW with other kinds of organic waste to make the biogas venture economically profitable.

Keywords: *Organic Waste, MSW Biogas Plant, Clean cooking fuel, Organic fertilizer, Greenhouse gas (GHG) emissions savings*

Introduction
Waste generation rate around the globe is rising including Nepal. As of 2016, the waste generated by the world's cities was 2.01 billion tonnes with per capita generation of 0.74 kg/day and is expected to increase to 3.40 billion tonnes in 2050 (WorldBank, 2019). Solid waste management is a major challenge for urban and semi-urban region of the developing and low-income countries (Thenabadu, 2014). Efficient management of solid waste is capital intensive, requiring about 20% -50% of municipal budgets. As a result, more than 90% of waste generated in low-income countries is haphazardly dumped creating wide array of environment and health hazards (WorldBank, 2019). On the other hand, Nepal mainly imports cooking and transport fuel from India (WECS, 2010) and chemical fertilizers from several producing countries like China, India, Turkey and Egypt (Panta, 2018). As per the fiscal year 2017/18, Nepal imports 370560 MT (2,609,577 cylinders) of LPG (NOC, 2018) and 3, 24,977 MT chemical fertilizer as of year 2016/17 (Panta, 2018).

In 2015, Nepal faced acute shortage of fuel and cooking gas due to an unofficial blockade by India(Pathak, 2015). The major takeaway from the blockade would be to find the alternative solutions to meet the domestic fuel demand. Further to that, methane is released in the atmosphere during the decomposition of the organic waste at the landfill site. Of the Global GHG emissions in 2004, the total CH_4 emissions accounted for 14.3 % of which 2.8% was from waste management (IPCC, 2007). In this regard, Municipal biogas plant could be an

effective solution for managing large amount of waste going to the dumping/landfill site and to partially fulfill the energy demand locally, as more than 50% of MSW in Nepal comprises of organic waste (ADB, 2013).Realizing the need and growing market of alternative energy source, each municipality should look waste management as business opportunities and act accordingly.

Organic fraction of MSW can be viable source of energy (Cheng & Hu, 2010). 1 kg of MSW can generate about 0.56 m^3 of biogas with up to 75% of methane content (AEPC, 2014). Methane released from the decomposition of organic waste can be captured and used as a cooking fuel(IRENA, 2017). This not only fulfills the energy demand but also helps in climate change mitigation. Besides, the bio slurry can be used as organic fertilizer.

This paper presents the overview on biogas generation potential of organic fraction of MSW from Dhulikhel municipality. In addition, it estimates the GHG emissions savings from the installation of biogas plant.

Objectives

- Quantification and characterization of MSW collected by Dhulikhel municipality and assess the potential of biogas energy from the organic waste fractions collected
- Estimate the volume for biogas digester and perform the cost benefit analysis of the MSW biogas project
- Evaluate the Greenhouse gas emission savings from the designed biogas project

Materials and Method

Study Area

The study was carried out in Dhulikhel Municipality in October 2018. Dhulikhel Municipality is located 30 km to the east of Kathmandu valley, Province No. 3. In the year 2043/11/05, it was established as a municipality with nine wards. At present, Dhulikhel Municipality covers an area 54.62 sq. km and consists of 12 wards. It has mixed population of ethnic communities and is dominated by Newar – 29%, Brahmin – 19%, Tamang 20%, Chhetri – 15% among others. About 52% of the total population is engaged in agriculture as their primary occupation (Dhulikhel Municipality Profile, 2016).

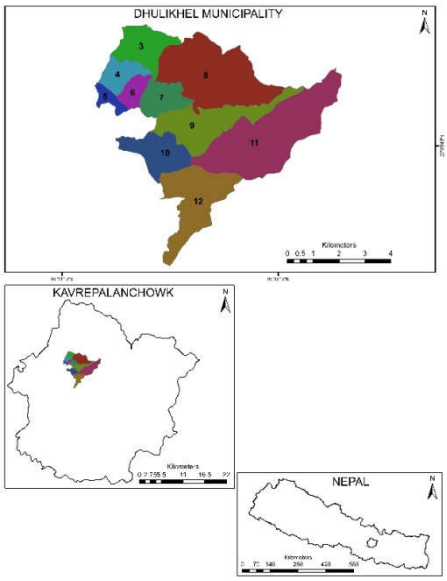

Figure 1: Study area

Sampling design

Firstly, a reconnaciance survey was carried out to identify the potential sites of MSW collection coverage from the Dhulikhel municipality. Out of 12 Wards in the municipality, Ward 1 and 2 were not included in the survey as these wards lies in rural setting of Dhulikhel municipality; it does not provide any waste collection service therein and they manage almost all of the organic waste by themselves. The total targeted households from rest of the wards were 6929. The sample size was determined by using Arkin and Colton (1963) formula (Paudel & Thapa, 2004);

$$n = \frac{z^2 \times \mathrm{N} \times \mathrm{p}(1-\mathrm{p})}{\mathrm{N}d^2 + z^2 \times \mathrm{p}(1-\mathrm{p})}$$

Where,

Z at 95% confidence level = 1.96
N = Total no. of population/ household
p = Estimated population proportion
d = Margin of error limit
n = Sample size

$$\text{Sample interval} = \frac{\text{Total targeted households}}{\text{Sample size}}$$

The sample size was calculated to be 277 with 6% margin of error, 95% confidence level and 50% estimated population proportion. The sampling interval was found to be 27. Using proportionate to size sampling process, sample size was divided (Table 1) with 3.7% households from each ward. Subsequently, a systematic random sampling was performed, where first house in each ward was selected randomly and after an interval of 27 houses (approximate observed distance was 300m to 500m) next house was surveyed following a route.

Table 1: Estimation of sample size from each ward

Ward no.	Total Household	Sample size
3	563	21
4	1066	40
5	412	15
6	470	17
7	931	34
8	831	31
9	743	27
10	330	12
11	932	47
12	651	33

Waste quantification and characterization

The field study was performed during the month of October 2018. The waste quantification and characterization was performed for a period of week. The amount and composition of household waste was determined using collection at generation site and direct hand sorting method. Each household was provided with two polythene bags for waste segregation (organic and inorganic). The segregated waste was then sorted and weighed at the field.

Similarly, to quantify the amount of the waste collected by Dhulikhel Municipality, the waste collecting vehicles were weighed for a period of seven days. The weight of the empty vehicles was deducted to get the net amount of the waste collected by the municipality. To find out the municipal waste composition; waste segregation and quantification in the dumping site was carried out for seven days following Quartile method.

Biogas generation potential and digester sizing

Biogas digester size design and gas generation Potential from the municipal solid waste was performed using the Alternative Energy promotion Centre (AEPC) guideline (AEPC, 2014)

GHG emission savings

In this study, a basic estimation of potential GHG emission savings was carried out while converting organic MSW to biogas. The biogas that can be generated from the given amount of organic waste using anaerobic digester was calculated. The GHG emission savings was estimated assuming 60% of methane content in the biogas and subtracting the CO_2 released while using methane as a cooking fuel. Consequently, this study does not represent the detailed GHG emissions savings. It only accounts for the amount of methane captured and has not directly released into the atmosphere.

Results and Discussion

Quantification and characterization of MSW

a. Household Waste Generation and Composition

The per capita waste generation of each household was found to be 226 gm/day. It was calculated by dividing the total waste produced by the number of people living in that household on that day. The survey conducted in 250 households of the Dhulikhel municipality showed highest fraction of organic waste (76%) followed by plastic (19%) and paper (5%) (Figure 2).

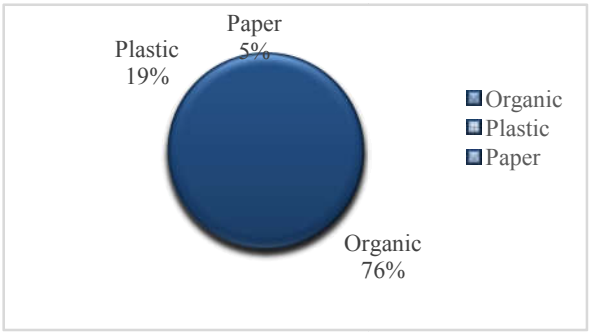

Figure 2: Household waste composition

b. Dumping zone waste composition

The waste at the landfill site was categorized to understand the municipal waste composition. The waste composition of dumping site showed high fraction of organic waste (58%) followed by paper (9%), plastic (8%), glass (7%), textile (7%), metal (7%), and others (4%) (Figure 3). The result was similar to the study conducted by ADB in 2013, which shows that 56% of MSW in Nepal comprises of organic waste.

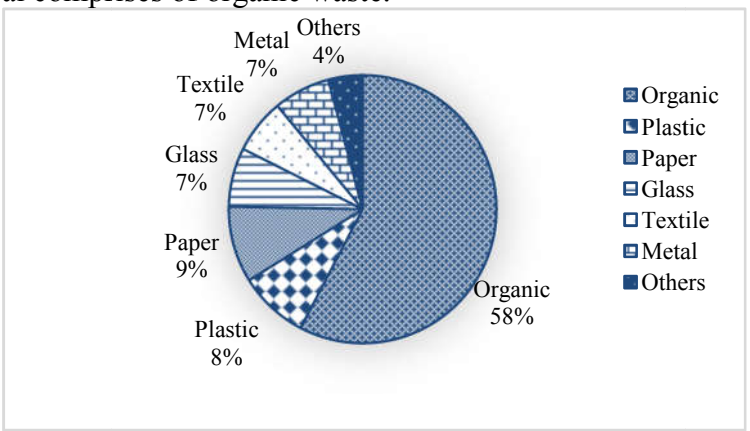

Figure 3: Dumping zone waste characteristic

Out of the 12 wards, Dhulikhel Municipality collects waste from ward no. 4,5,6,7 and partially from ward no. 8 and 3. The seven days waste quantification survey showed 8694 Kg of waste is collected by Dhulikhel Municipality. As 58 % of waste collected by the

municipality is organic in nature (Figure 2), 5042 Kg of waste will be available for biogas production. The detail of the waste collected by the municipality is shown in Table 2.

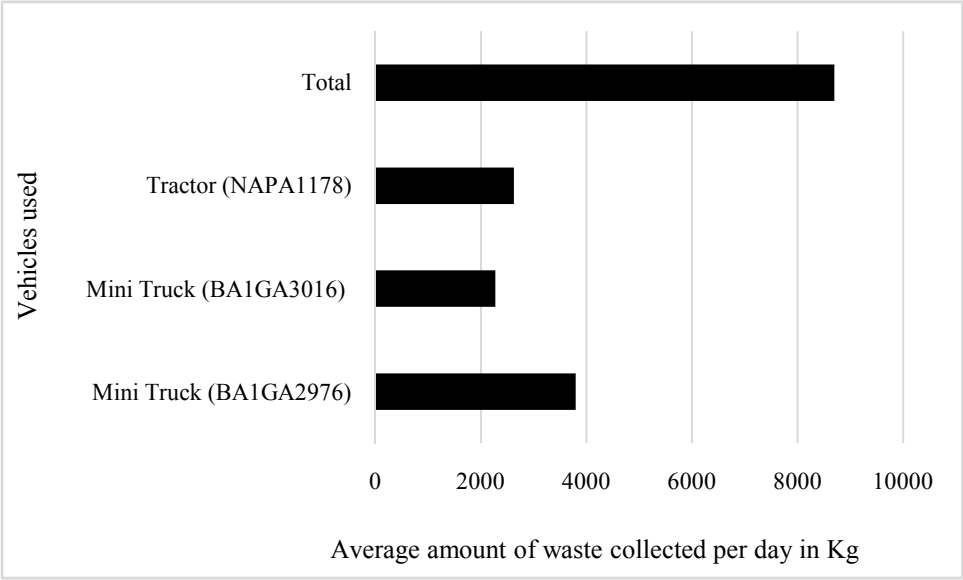

Figure 4: Municipal Waste Quantification

c. Biogas generation from the Organic fraction of collected Municipal Solid waste

Biogas generation from the available organic waste (5042 kg) was calculated using the AEPC standard value. Biogas generation potential of different feedstock is provided in Table 2. These values are recommended by AEPC and is approved by Ministry of Renewable Energy India.

Table 2: Waste characterization and Biogas generation Potential (AEPC, 2014)

Substrate	Biogas yield (m^3/kg VS)
Cow dung	0.25
Water buff dung	0.25
Pig manure	0.38
Poultry litter	0.31
Kitchen/MSW	0.35
Night soil	0.13

The above estimation can be used to quantify the biogas generation from municipal solid waste in context of Nepal. Utilizing data for MSW from Table 2, the biogas generation from organic fraction of MSW in Dhulikhel Municipality would be 280 m^3/day. Considering 60 % of methane in the biogas generated, 120 kg/day of purified bio Compressed Natural Gas (CNG), which has more than 94% of methane content can be obtained.

Digester design and cost benefit analysis

a. Design of anaerobic digestion system for Organic Fraction of MSW collected in Dhulikhel Municipality

In this study, continuously stirred tank reactor is considered for anaerobic digestion of MSW, where the substrate inside the digester is completely mixed by agitators. To maintain the constant temperature throughout the year, a mesophilic digestion system operating at the temperature of 37±1 is used in the system. The Hydraulic Retention Time (HRT) for the system is considered 30 days, with 9% total solid content of the feed. To use biogas as CNG,

biogas must be upgraded for which a biogas purification unit and a compressor must be installed. The design of the anaerobic digestion system for the waste available is prepared following the Biogas design and construction manual for large size biogas plant (AEPC, 2019).

Water required for dilution =Mass $_{(Final)}$ - Mass $_{(Substrate)}$

Mass $_{(Final)} = \frac{20\% \times 5000}{9\%}$

$= 11{,}111.11$ kg

Mass $_{(Water)}$ = Mass $_{(Final)}$ - Mass $_{(Substrate)}$

$= (11{,}111.11\text{-}5000)$ Kg

$= 6{,}111$ kg

Due to the high water content in the feed, density of the feed is considered equal to the density of the water (1000kg/m^3).

Then, Volume of the substrate/day = $\frac{11{,}111}{1000} m^3$

$= 11.11\ m^3$

For HRT of 30 days,

$= 11.11\ m^3 \times 30$

$= 333.33\ m^3$

The final volume of the digester should be 20-30% more than the hydraulic volume. Thus, taking average i.e. 25 %, final volume of the digester is 416.66 m^3.

b. Cost Benefit Analysis

There are several methods such as payback period, net present value (NPV), internal rate of return (IRR) used to examine the profitability of a project (Ong & Thum, 2013). In this analysis, only payback period will be used to determine the economic feasibility of the project.

In Nepal, Large-scale biogas project is partially subsidized by World Bank through AEPC under scaling Up Renewable Energy Program (SREP)(World Bank, 2014). The Cost benefit analysis is performed based on the following assumptions under two different scenarios; with and without subsidy for the biogas project.

Assumptions:

Total investment (NRs.) [a]	47,600,000 (US $ 417,360.80)[d]
Annual operating cost	4,760,000 (US $ 41572.05)(10% of total project investment)
Biogas	280 m^3
Bio CNG (Considering 60% methane in raw biogas)	120 kg
Organic fertilizer [b]	1040
Cost of bio CNG (NRs./kg) [c]	100
Cost of Organic Fertilizer (NRs./kg)	15
Operating Period	20 yrs
Working days/year	340

**a; Own analysis after reviewing quotations from different technology provider*

**b; Calculation using AEPC biogas calculation tool*
**c; Nepalese market price of bio CNG*
**d; (US $ 1= NRs.114.5) US dollar exchange rate as of 31 December, 2019*

Revenue
Utilizing the price value of bio CNG and organic fertilizer in Nepalese scenario, the total revenue generation from the project would amount to NRs 9,384,000.

Revenue from bio CNG	NRs. 4,080,000 (US $35633.18)
Revenue from Organic fertilizer	NRs. 5,304,000 (US $46323.14)
Total	NRs. 9,384,000 (US $ 81956.33)

Thus, Net annual income from the project would be NRs. 4,624,000(US $ 40384.27).

Payback period = Investment/net profit
=10.29 yrs.

When subsidized,
Equity Investment = 47,600,000 – 40% of 47,600,000

= NRs. 28,560,000(US $ 249432.31)

Equity Payback period = 6.17 yrs.

The project when not subsided has much longer payback period i.e. 10.29 years as compared to the payback period under subsidy scheme i.e. 6.17 yrs. The subsidy scheme may not always be possible; hence, more amount of organic waste is required to make it more economically feasible. Dhulikhel Municipality may collaborate with adjacent municipality to collect more raw materials and seek options for co-digestion of organic fraction of MSW with other waste to make the waste to energy business economically profitable.

Greenhouse gas emissions saving
Methane is released in the atmosphere during the decomposition of organic fraction of MSW. When this organic waste is treated and used as a feedstock for biogas plant, methane can be captured, upgraded and used as a cooking or transport fuel or can be used to generate electricity. The processing of the given waste (5 tons/day) using biogas plant in Dhulikhel Municipality can generate 280 m^3/day of raw biogas. Assuming the average methane of 60% in organic fraction of MSW, the methane production will be 168 m^3/day. Considering the density of methane is 0.717 kg/m^3 (Engineering Toolbox, 2003), methane production would be 40800 kg/year or 40.8 tons/year. As methane is 25 times more potent GHG than CO_2 over a 100-year time, methane production is equivalent to 1020 tons CO_2 per year.

The total CO_2 emission from the combustion of 40.8 tons/year of methane would be 112.2 tons/year. Therefore, deducting 112.2 tons CO_2 from the aforementioned value of CO_2 savings i.e. 1020 tons/year, the estimated CO_2 emissions saving from the biogas project would be 907.8 tons/year.

Total methane emissions from 5 tons/day of MSW = 40.8 tons/year i.e. equivalent to 1020 tons CO_2 /year

Emissions from combustion of captured methane = 112.2 tons CO_2/year

Total savings with biogas project= 907.8 tons CO_2/year

Conclusion

The production of bio-CNG from organic fraction of MSW could be a sustainable option for organic waste management as well as energy generation. However, not all municipalities generate huge amount of organic waste daily and for a small size project, the capital investment seems to be very high waning the financial viability of the project. Hence, a collaborative approach among different adjacent municipalities is essential to synergize the efforts and resources, thus making the biogas plant feasible.

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Comparative Study on Solid Waste Management Practices (A Case of Shree Naya Kiran Secondary School and Narayani English Model Secondary School, Bharatpur-11, Chitwan)

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Abstract
In the present study effectiveness of EFLGP was compared between EFLGP implemented Shree Naya Kiran Secondary School (SNKSS) and EFLGP non-implemented Narayani Model Secondary School (NMSS), Chitwan on the basis of indicator prescribed by EFLGP framework 2013. The study was carried out in September- November 2018 with objective of effectiveness of EFLG implemented program. The objective was to compare effectiveness of EFLGP implementation through daily waste generation, waste management practices of school & student and change in behavior of students. Results show that implementation of EFLGP brought significant change at settlement (tole) and ward level. Change in knowledge and behavior of student was questionable as it was not studied previously. Student change in behavior before and after EFLGP implementation was recorded using self-administered questionnaire. Obtained data were processed using Microsoft Office Excel 2008 and other tables and graphs.

It was further observed that average per-capita waste generation was high in SNKSS 0.013Kg/person/day as compared with NMSS which is only 0.009Kg/person/day. Different indicators such as drinking water, sanitation, energy consumption, etc. showed that knowledge of students from SNKSS have been enhanced but are still lagging when compared with that from NMSS.

Keywords: *Behavior, Comparison, EFLGP, Effectiveness*

Introduction

The Environment Friendly Local Governance Program (EFLGP) framework 2013 has been issued to add value to the environment friendly local development concept with the vision of establishing environmental governance and create a sustainable environment friendly society at household, village, municipality and district levels. Government has been declaring different wards, municipalities and districts as eco-friendly local governance. While making such declaration it is essential that they meet criteria after declaration too. EFLG has been implemented in different schools but its effectiveness still remains researchable. Students were assumed to be representative of community and their study represents community so for this reason two school, SNKSS and NMSS having similar background were selected and compared against indicators prescribed by EFLG Framework 2013, through self-administered questionnaire survey and field observation. Eagles & Muffit (1990) in a study of Canadian students in 6^{th}, 7^{th} and 8^{th} grade found that no differences between the sexes in waste management. A study by Ayodeji Ifegbesan (2015) found the need for behavioral and attitudinal change was essential for effective participation in waste reduction, reuse and recycling. A study carried out by ADB (2013) revealed school and colleges composed of 45% paper and paper products, 22% organic waste, 21% plastic. Same report has found average daily waste generation of school was 4.00 Kg.

Materials and Methods

Study Area

Bharatpur is the fastest growing city in the central southern part of Nepal; with a population of 280,502 people (CBS, 2015). It was declared metropolitan in Dec 2016. Shree Naya Kiran Secondary School (SNKSS) 27°41'9.89''N and 84°27'6.53'' E occupies an area of approximately 2,775 square meters providing quality education with 528 students in academic year 2075 is located in Bhojad, Bharatpur-11. This school has been awarded with environment friendly title after launch of EFLG program.

Narayani Model Secondary School (NMSS) 27°40'56.39''N and 84°26'2.70'' E with an area of approximately 19,790 square meters is located in Hospital Road, Bharatpur-11. It had 1,471 students from grade nursery to X excluding XI and XII in academic year 2018/019.

Research Time and Duration

Research was carried from 3rd September to 28th November, 2018. Total of 35 samples were taken on different dates during the period.

Sampling

Waste generated throughout the day was collected in a sack and measured at the end of the day by using digital spring balance. It was further classified into several group on the basis of its nature and weighed separately. Total number of students present on each day was also recorded to calculate per capita waste per day.

Qualitative information was taken through field observation, questionnaire-survey and focused group discussion.

Thus, obtained data were processed using Microsoft Spreadsheet 2007, where descriptive analyses through the use of numbers, tables and graphs were used to describe and present data.

Result and Discussion

Shree Naya Kiran Secondary School has an average of 436 students coming regularly at school. Whereas Narayani Model Secondary School had an average of 1,194 students coming regularly at school. As a result, Narayani Model Secondary School produced higher amount of waste every day as provided in the figure 1.

Average waste produced by NMSS was 10.012 Kg with standard deviation of 1.4 Kg. Average daily waste produced by SNKSS was 5.5 Kg with standard deviation of 1.1 Kg. The result from this study contradicted with ADB, 2013 report. Report by ADB (Figure 2) had found that average waste generated by educational institute was 4.0 Kg per day but this study found average waste produced by two schools was 7.74 Kg per day which shows increase in educational waste from 4 Kg per day. Despite of the fact that higher waste is generated in NMSS than SNKSS, average per capita waste per person per day is higher in SNKSS which could be due to higher number of students in NMSS.

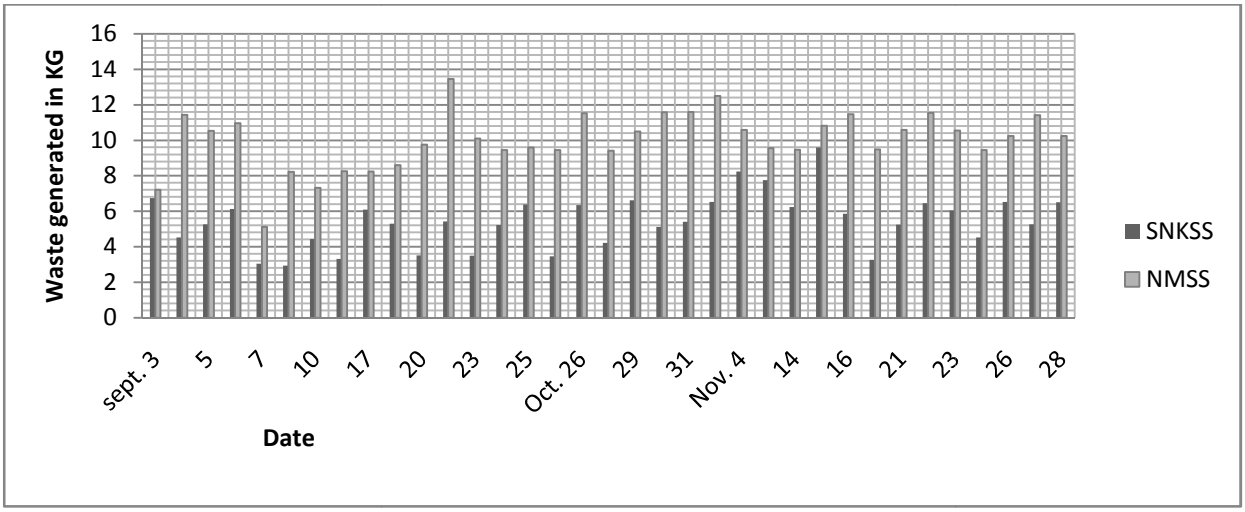

Figure 1: Daily Waste Generation

The composition of waste was found to be proportional throughout the samples. This study has found change in waste composition when comparing with report by ADB in 2013. Volume of plastic waste has increased from 21% to 33%, whereas volume of paper has decreased from 48% to 37%. Plastic waste today mainly comprises of plastic wrappings, pen, refill and polyethene bags. Increase in volume of plastic waste could be mainly due to increasing use of plastic based products. They are being widely used from food wrapping to instruments for students. Organic waste was found to occupy 9% of total volume as very little food was thrown away and rare presence of fruit remaining. The detail of the findings is provided in the figure 3.

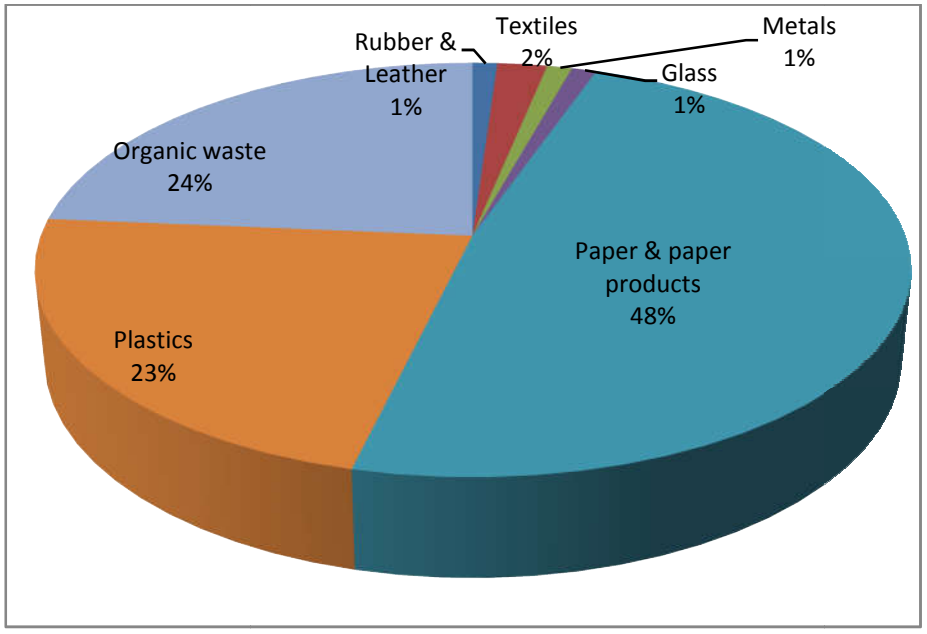

Figure 2: Institutional Waste Composition by ADB, 2013

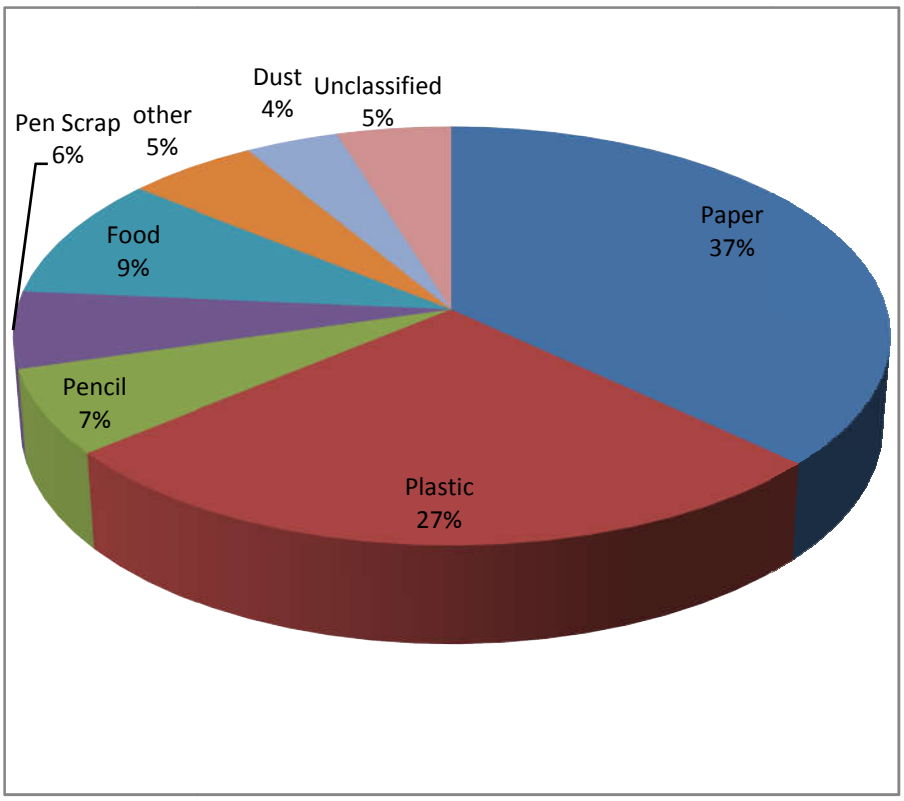

Figure 3: Waste Composition in Study Area

Waste segregation was carried out in SNKSS but due to poor management and disposal of segregated waste it was abandoned afterward. Several dustbins marked with degradable & non-degradable were observed which contained mixed type of waste. NMSS still practiced waste disposal by burning. Waste was collected and dumped in a nearby pit where it was burned occasionally whereas in case of SNKSS waste is disposed by handing it over to municipal waste collecting van.

Students living in close proximity to town area mainly from NMSS had advanced latrine as compared to those living away from core area. The number of students using dug well latrine have reduced after EFLGP implementation. Few students from SNKSS who previously used burning as a means of waste disposal have also switched to municipal waste collection center after EFLGP implementation. It could be also due to the fact that open burning of solid waste was banned by community development committee.

Almost all responded students from both school NMSS 100% and SNKSS 91.3% used to wash their hand after toilet and before meal but at present100% of the responded students wash their hand after toilet and before meal. Larger number of students from SNKSS goes for weekly sanitation than students from NMSS; this could be due to influence of EFLG about environment sanitation. The number of students using LED bulb have been increased after EFLGP implementation. This could be due to knowing the benefits of using LED bulbs and subsidy given by government in buying CFL & LED bulbs. It was found that only 13% of students were depending on kerosene as cooking fuel which was previously 21.74% in case of SNKSS, whereas in case of NMSS only 4.35% responded students depend on kerosene as fuel for cooking.

Although the number of students from SNKSS depending on bio-mass have decreased from 41.3% to 26.09% but it is still higher than that of NMSS by 4.35%. This could be due to close proximity of students from forest area where bio-mass is available easily and at a cheaper rate though they might have knowledge on forest conservation. The decline in bio-mass user could be due to awareness program launched during EFLG implementation about impact of human activities on environment and ways to overcome them. Only 1 student out of 92 responded students was found to still rely on using dung cake, this was due to his agriculture-based background.

Student living within or close to core area have access to drinking water from government supply. Majority of students from NMSS 93.48% relied on government supply water system whereas only 39.13% student from SNKSS depends on government supply as it is not reliable outside core area. Large number of students (74%) from SNKSS depends on well for drinking and domestic purpose. No student was recorded to rely on river/spring water for drinking purpose as most of the springs and river have dried or are drying and are already polluted or being polluted within and near city area.

SNKSS had green force which worked to promote environmental consciousness among school children. Programs could not work effectively as programs were conducted without proper planning and information. They were also ineffective due to unavailability of resources. According to present chairman of the club it was known that inadequate supervision from concerned authority and less interaction was also responsible for poor performance of the club. This also caused by number of programs conducted by club to be less ineffective and few in number as well.

Conclusion

Average daily waste generated by a school depends on average number of student present. Assuming ADB 2013 report as baseline waste generation per day by an educational institution has increased almost by twofold. Average waste generated per day by SNKSS is lower than that of NMSS but when it comes to average per capita waste per day per person NMSS have lower waste generation rate than that of SNKS. Average per capita waste per person per day of SNKSS is 0.013Kg/person/day whereas NMSS have 0.009Kg/person/day. Although SNKSS previously practiced waste-segregation now it is not doing so. NMSS practice burning of waste which is an issue that have adverse impact on human and environment. EFLGP implementation has brought change in student's behavior but environmental consciousness is higher in NMSS students than SNKSS students.

Recommendation

Programs to enhance environmental consciousness should be launched in both schools. Supervision, resources and instructions should be given to students to promote environment-friendly activities from student level. Similar club like Green force should be established and made functional in NMSS too. Further studies can be carried out for overall effectiveness of EFLG implementation in community, ward and municipality level.

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Increasing the Value of Community Managed Forests with Deer Farming

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Abstract
Community Forestry in Nepal has been progressing at a steady rate since its introduction in the 1970s. The early focus on afforestation and subsequent move towards conservation as the main concern of community forestry has brought immense benefit to the environment, biodiversity and local communities. This has been achieved not only through forest restoration and protection but through local communities being given permission to conserve and manage the forest. These communities have also benefitted from access to forest products and land. However, the increasing demands of the economy as a result of changing socio-economic dynamics in Nepal have prompted a review of the current forestry and wildlife policy. The effects of modernisation, globalisation and outward migration have led to a need to modernise forestry policy. This is because rural communities are becoming remittance dependant, agricultural land is being abandoned and youths are not as engaged as their elders in community forestry. In view of this, the government has introduced a policy which allows for privatised farming of wildlife on community forest and fallow agricultural land. In this paper, the feasibility of deer farming in Nepal is considered for integration with community forest and agricultural land. A high level of knowledge and skill regarding deer species is required relating to issues such as capturing, reproduction, nutrition, medicine and handling, all of which FAO has provided details on. In addition, the policy must ensure that animals are not exploited for financial gain and that conservation and preservation progress should not be undermined. Local communities should not be excluded from benefits due to the entrance of private corporations and should also be included in the consultation process. Whether in situ conservation in community forest land or ex situ farming in private land by making suitable habitat, for both regular support from veterinary services are essential as well as appropriate guidelines for maintaining the ecological integrity of the enterprise. This must be supported by monitoring and certification so that adverse impacts are not shifted to wildlife in the forest. Nepal being a natural habitat for deer species, it has the scope for promoting business in the form of recreational parks and farming while creating employment for youths.

Keywords: *Community Forestry, Wildlife Farming, Deforestation, Out-migration*

Introduction on Community Forests of Nepal
Policies relating to the development of Community Forestry in Nepal have been hugely successful for over 50 years and forest area in Nepal has nearly doubled in the 40 years leading up to 2019 and 'The 2015 Forest Resource Assessment' highlighted that Nepal's canopy cover was 29% in 1990 but had increased to 45% in 2015 (Awale, 2019). The first community forest in Nepal was declared in 1973 in a village named Thokarpa in the Sindhupalchowk district (Poudel, 2018). When it was first introduced, the Community Forestry practices in Nepal related mainly to afforestation in order to reverse deforestation, meet needs for fuel, and as a tool for farmers to stabilise the farming system. The focus on the forestry sector has led to more than 23% of Nepal's total area being declared as protected, and within this area are included 12 national parks, one wildlife reserve and six conservation areas (Poudel, 2018). Nepal's forests had been nationalised in 1957, which caused

dissatisfaction amongst the people who were reliant on forests and had been using them for free. Following this the government allowed for the creation of Community Forestry User Groups so that the subsistence needs of the locals could be met and the deterioration of the forest could be controlled (Bhattarai, 2016). Since the inception of community forestry policies, 850'000 hectares of forests have been handed over to 11'000 forest user groups who use the forests to generate income for activities such as irrigation, canal improvement, school and community buildings, temples and drinking water systems (Joshi, 2017). As the forestry sector in Nepal progressed into the 1980s, it was realised that forestry practices in Nepal needed to move towards a more conservation and development focus, rather than just concentrating on afforestation. This was in response to the realisation that the non-timber forest products that local communities gain from community forests are highly valuable and can be used as a reason to effectively discourage the conversion of forest land for agricultural and livestock purposes (Arnold, 1987).

Out migration and forest cover nexus

A further stimulus which prompted a greater focus on a conservation based forestry policy in Nepal was the 'Theory of Himalayan Degradation' which came to light in the years leading up to the 1980s. This theory put forward by Erik Eckholm stated that there would be no forests left in Nepal by 2000 if deforestation and degradation, which Eckholm linked to population growth, continued at the then prevalent rates. While this theory has been heavily critiqued in the years since 1980, the theory held prominence at the time and was a contributor to the heavy focus on conservation and supporting livelihoods, which are reliant on a subsistence lifestyle, in forestry policy and practices in Nepal in recent decades (Guthman, 1997). These incentives promoted community forestry in Nepal, and it is generally agreed that community forestry practices have worked well in Nepal, with some citing the country as having experienced a 'forest resurgence', as shown by the increase in forest cover from 26% in 1992 to 45% in 2016, an increase which makes Nepal an exception to the global trend which is of deforestation in developing nations (Gill, 2019). The reliance on forests for livelihood purposes was high in Nepal as community forests are a source of income for rural communities, and have an important role to play in ensuring food security, fodder for livestock and as a source of timber and non-timber forest products (Acharya, 2002).

However, in recent years Nepal has experienced drastic changes due to the effects of globalisation which has led to large scale out-migration from Nepal, which in turn has led to the inflow of remittance money into rural areas. This increased income has led to increasing consumerism in rural households, which when coupled with increasing rural electrification and development of road networks, has manifested into significant lifestyle changes in Nepal. There is increased use of petroleum gas and less use of wood, houses are built from brick rather than stone and wood and there has been a move from fodder dependent cattle and goats which engage in free ranging in the forest, towards chickens which rely on imported feed, and there is a positive correlation between these factors and forest regeneration. While it is agreed that Community Forestry User Groups have played the largest role in increasing forest area, outward migration has also been an important factor in decreasing pressure on forests (Awale, 2019). It has been reported that in the years since 2008, more than 3.5 million labour permits have been issued for Nepalese to work abroad and that Nepal's economy is one of the most remittance dependant in the world, relying on remittance money for roughly one third of its annual GDP. This migration was made desirable by easier access to passports, the push factor of the civil war and the poor state of the domestic economy. These factors have been so influential that in some areas, such as in the Harpan watershed in the Kaski District, 75% of

households have at least one member of their family working abroad, sending back on average USD 206 every month (Jaquet et al., 2016). Large scale outward migration has been linked convincingly to forest recovery, as remittance money has alleviated economic pressures and agriculture is less depended upon to sustain livelihoods. Families of migrants have increased household income due to remittances and are thus less reliant on forest products and also may abandon farmland. In addition to not needing the farm land due to increased income, families have allowed land to remain fallow due to lack of manpower as the young members of the household are predominantly the ones who migrate, or they may have resettled in more urban areas. The abandonment of agricultural land can lead to trees growing on fallow fields and can ease the pressure on the land. These factors have led to the creation of a 'remittance landscape' whereby reforestation can take place. Indeed this has been seen already as the areas with the highest level of outward migration are also the areas with the most forest recovery. This is an example of forest transition theory which states that industrialisation contributes to widespread reforestation by pulling people away from agriculture to employment in urban areas (Gill, 2019). According to 'Mountain Research and Development' the favourable ecosystem conditions in Nepal have meant that abandoned land turns to shrub-land after just two or three years, and that overall forest cover increased 12.5% between 1978 and 2014 in part due to the large-scale abandonment of private land (Jaquet et al., 2016). It is clear therefore, that out-migration from rural Nepal has led to an increase in forest cover mainly in the hills. Environmentalists would hail this as a significant achievement and that nature should be protected for the sake of the environment, without consideration of economic benefit, and where economic benefit must be sought, the contribution of new forest growth to water supply, tourism and creation of carbon sinks should be considered (Awale, 2019). However, it can be said that the primarily conservation focused view of community forestry in Nepal is now too limiting when considered in light of the many changes, mainly outward migration, which have taken place. As community forest started with the purpose of conservation, it resulted in increased forest coverage but without contributing to the economy (Awale, 2019). An example of this can be seen in the timber industry in Nepal. Timber imports into Nepal are increasing, even though there are timber resources in the country. This is because forestry has had a conservation focus and policies are very restrictive, meaning that the forestry sector is not conducive to business interests, and it is easier to import timber rather than procure it locally, as is shown by the fact that 80% of the country's timber is imported (TMT, 2016). Leaders and policy makers have not allowed trees to be harvested, and the wastage of these resources is not beneficial to any involved actors. The arguably narrow focus on conservation to the detriment of the economy can be seen in the wastage of 37'654'295 cubic feet (1'066'250 cubic meters) of decayed forest matter that may have been used for economic benefit had it not been for the strictly environmental policies in place (Khatri, 2016). This highlights the issue that while forest cover has increased and is continuing to do so, the forest is not creating new jobs and is not able to attract youths to the forestry sector (Poudel, 2018). The agricultural land which has reverted to forest and existing forest land can be used more effectively to meet the needs of the country and communities today. After five decades of successful conservation of forests by communities, the combination of out-migration, changes in lifestyle and the aspiration of the youths could lead to the loss of the very ethos of community interest in forests in the future. This calls for re-evaluating other options to increase the value of standing forests and attract the youth to forest management. Amongst others, one green economic model for the sustainable and economically profitable use of forest resources and also to encourage the youths is to integrate deer farming in community forests and in agriculture lands. As this is a type of farming which has not yet been implemented in Nepal, the method adopted by this

paper has been to review the the existing literature available online regarding wildlife farming and consider the possibility for the same in Nepal.

New policy on wildlife farming

In order to address the aforementioned changes, the government has created a provision which allows for the farming of wildlife species. Deer farming has been popular across large swathes of Australia, New Zealand and the United States. There are numerous products which can be gained from deer while they are alive, such as velvet, musk and milk, and when they are slaughtered, such as venison, skin and organs. There was previously an animal farming policy proposed by the government in 2003. In 2003, the government of Nepal launched a policy on wildlife farming, breeding, and research under the fifth amendment of the National Parks and Wildlife Conservation Act 1973. The main aim of the policy was to promote biodiversity conservation and also to improve the livelihood standards of poor and marginalised communities. However during the approval process, there was no consultation with the concerned stakeholders and institutions. Due to which the policy suffered as wildlife conservationists and animal activists opposed the implementation of the approved policy. Additionally, there was a lack of clear indication of how poor and marginalised communities will benefit from wildlife farming. While the policy claimed to promote biodiversity conservation and improve livelihoods for the poor, it did not adequately address the externalities and thus was largely criticised.

Subsequently, the Government of Nepal Forest Act 2019, clearly directed that a person, cooperatives, enterprises or communities can engage in wildlife farming in both private forestry and leasehold forestry for forest conservation and protection. Similarly, the Government of Nepal is in the process of amending the National Parks and Wildlife Conservation policy (niyamawali) 1973 where individuals, cooperatives, private sectors and businesses can farm and breed selected wildlife species for meat, wildlife commodities and is in line with International Trade Policy 2019. This new policy is aimed at leveraging green investment from the public, private sectors, and co-operative sectors. According to this policy, the meat and body parts of farmed wild animals can be consumed and used as marketable commodities legally. The bill is yet to be endorsed by the Department of National Parks and Wildlife Conservation and they have formed a working committee to study the intricacies of the policy. The committee has proposed that Spotted Deer, Samber Deer, Hog Deer, Barking Deer, Wild Boar, Snake, Crocodile, Frogs, and Birds may all be farmed (Shrestha, 2019). The Himalayan Times reported that ‘any person or entity willing to keep [deer] shall submit an application, accompanied by a detailed work plan, to the Department of National Park and Wildlife Conservation.’ In turn the DNPWC will be the deciding entity on who is granted a license to farm wildlife, and the licensees themselves will bear all costs associated with keeping the animals. The seed animals for farming will be provided by the DNPWC upon clearing all the required procedures and the owners can only use the second generation wildlife born from the seed animals for meat, and other commercial purposes and must submit their progress reports to the DNPWC on a monthly basis (TMT, 2019). Unlike other forest products which the local user groups could not sell products or fix prices without the permission of the government (Awale, 2019), the deer farms would be private enterprises, able to determine their own prices.

Table 1: Wildlife Species proposed for farming in Nepal and their Red List status

Species	IUCN Red List
Spotted Deer	Least Concern*
Sambar Deer	Vulnerable**
Hog Deer	Endangered***
Barking Deer	Data Deficient****
Wild Boar	Least Concern*
Snake (species yet to be mentioned)	Species level information required
Crocodile (species yet to be mentioned)	Species level information required
Frogs (species yet to be mentioned)	Species level information required
Birds (species yet to be mentioned)	Species level information required

Extinct in the Wild. A taxon is considered Extinct in the Wild when it is only known in captivity, in cultivation, or in a naturalized population well outside the past range. Examples: South China tiger, Alagoas curassow

Critically Endangered. A taxon is considered Critically Endangered when it faces an extremely high risk of extinction in the immediate future. it needs to meet any of the five criteria for Critical Endangered. Examples: Arakan forest turtle, Javan rhino, Brazilian merganser

*** Endangered. A taxon is considered Endangered when it faces a very high risk of extinction in the near future. It must meet any of the five criteria for Endangered. Examples: blue whale, snow leopard, African wild dog, tiger, albatross, crowned solitary eagle

** Vulnerable. A taxon is considered Vulnerable when it faces a high risk of extinction in the medium-term. It needs to meet any of the five criteria for Vulnerable. Examples: cheetah, gaur, lion, wolverine

Near Threatened. A taxon is considered Near Threatened when it may be considered threatened in the near future. It does not qualify according to the five criteria for Critically Endangered, Endangered, or Vulnerable at the present time, but is close to qualifying or likely to qualify in the near future. Examples: blue-billed duck, solitary eagle, small-clawed otter, maned wolf

* Least Concern. A taxon is considered Least Concern when there is no immediate threat to the survival of the species. It is evaluated against the criteria and does not qualify for any of the above categories. Examples: brown rat, Nootka cypress, wood pigeon

**** Data Deficient. A taxon is considered Data Deficient when there is inadequate information to make a direct or indirect assessment of the risk of extinction base on distribution or population status.

Not Evaluated. A taxon is considered Not Evaluated if has not yet been evaluated against the criteria.

All the above-listed animals which are proposed for commercial farming or breeding do not come under the Convention on International Trade in Endangered Species of Wilde Fauna and Flora (CITES) Appendix 1, which means commercial trading of these animals is allowed. CITES bans the trade and use of Appendix 1 flora and fauna for international trade and commercial use, they can only be used for scientific research once both parties have provided clear legal documents.

Deer can now be legally integrated and reared in community forests by making fenced enclosures in their natural habitat (in situ conservation) and also reared in private farmlands by fencing and establishing suitable habitat (ex situ conservation). Such prospect for wildlife farming will create a green investment opportunity for community forestry institution, private sector, resorts, and farmers which can create a new employment opportunity for the youth thereby contributing to the rural economy.

Opportunities and Challenges

There are many factors relating to deer farming which are encouraging and positive. This does not mean that there are no hurdles and challenges which must be considered. It is therefore of importance to create a conducive and cooperative environment between government agencies (i.e. DNPWC) and the deer farmers. The introduction of deer farming can create business opportunities which relate to the forest and which can be conducted in rural areas, which may act as incentives for young people to remain in their communities as they have the opportunity to earn larger incomes. The fact that the youth can be engaged in forestry related issues, albeit on a small scale, has been seen in the Community Based Anti-Poaching Units and also in Community Managed Zoos and recreational community forest in various locations across the country. These indicate that there is the possibility for youth engagement in deer farming as young people have already shown an interest in forestry related activities.

In recent years, deforestation and encroachment in Terai have increased, similarly electro fishing has wiped out aquatic biodiversity and poaching of deer and birds is continuing unabated (Awale, 2019). With the introduction of private deer farming, it is anticipated that illegal poaching will decrease as the farmed deer meat and other products will be legally available for domestic consumption and export. Furthermore, if community forest and agricultural land is used by private enterprises, it is likely that the fencing installed for deer farms can reduce encroachment on forest land as the area requires constant monitoring by the licensees. The focus on local communities in the deer farming endeavour in theory looks like a win-win situation for forest, biodiversity and local communities. However, in practice this is yet to be proved.

A study conducted by Gill (2019), showed that in countries such as Guatemala and Nicaragua, where outward migration and foreign remittances have also led to increased animal farming, cattle ranching has actually harmed forests. In New Zealand it has also been seen that intensive deer farming has had negative effects on soil and water quality and that deer farming went from contributing 1.5% to total greenhouse gas emissions in New Zealand in 1990 to 7% in 2010. Soil damage occurs due to compaction, erosion and water damage through eutrophication, sediment loss and fecal contamination. Though deer farming contributes less to greenhouse gas emissions than sheep and dairy farming, it still has an impact in overall methane and nitrous oxide emissions (De Klein et al., 2003). Therefore when considering the possibility of deer farming in Nepal it must be taken into account how this may harm the forests and perhaps even undermine regeneration and restoration achievements that have been made thus far. Some recommendations have been made in the

New Zealand context which can be heeded in Nepal as well. By regularly changing fence placement, the effects of erosion can be reduced. Water movement can be slowed by using gravel, creating buffer zones near waterways and not allowing heavy grazing in wet areas. Wooden planks can also be installed as walkways for the deer in order to prevent fecal matter from falling into water bodies and to protect the soil. Dietary modifications and additives in food, which have been used in the dairy industry, may also be used on deer in order to reduce methane and nitrous oxide emissions (De Klein et al., 2003). There must also be a consideration of the social changes which this may bring about. Until now deer meat has been an illegally traded commodity and is not widely accessible. However the embedding of deer farming in policy may lead to the conception that commercial exploitation of wildlife for human use is acceptable, and furthermore may even lead to changing public tastes over time as new sources of meat become more accessible on the market (Shrestha, 2019). Similarly, there is also the general public concern that legalizing wildlife farming is also an implicit attempt to legalise wildlife trade market and perhaps benefit a certain population, clearly indicating that for some wildlife farming is not a viable solution for conservation. This sentiment was echoed by a campaigner for Animal Nepal who suggested that wildlife farming may lead to fur farms, bile farms, circuses, zoos and experiments conducted on animals. However it must be considered that conservation efforts in Nepal have been successful for decades now and that the new policy is limited to meat and animal products being traded. In addition to the concern for the animals, the impact on local rural communities must also be considered as a potential challenge or potential negative impact of deer farming. Community Forestry has been, until now, a program which aims to meet the needs of the community and to improve their livelihoods. However, it has already been shown that community forest operations are more resource draining for poorer households. These households put in more than they gain from it. This creates issues regarding equity when it comes to volunteering of labor for the community forest's needs which also disproportionately affect the poorest households (Joshi, 2017). The most vulnerable households also rely on the forests to meet their daily needs, with 90% of rural household income coming from non-wood forest products (Bhattarai, 2016). Therefore, it must be noted that households may be negatively impacted in their ability to use the forest for this if parts of forest land are converted for farming purposes. While it may be argued that the local people themselves may form a co-operative and begin deer farming themselves, questions arise about their ability to remain competitive with farms run by private investors and large corporations who will likely make large investments. Therefore, while the deer farming enterprises may bring economic prosperity to the farm owners and local economy at large, there may be additional challenges to community forest user groups to be able to meet initial investment requirements so that they can also benefit of this proposed wildlife farming policy. They must ensure that the forest resources are continuously made available to their members and that wildlife farming must not make any household worse off. The decisions need group consensus and implementation must be done through collective action, making the transaction cost high. The government must therefore take precautions to ensure that going forward, the local communities are engaged in the process of implementing the policy and that benefits to one social group (farm owners) does not cause increasing disadvantage to another (community forest user groups). Therefore the aim of introducing wildlife farming at this stage should be about creating a large enough pie for everyone, creating economic benefit for locals, farmers and investors and moving beyond the solely conservation oriented forest and wildlife policy that has been seen until now, while still ensuring that forests and wildlife are preserved and can offer diverse use and benefit.

FAO guideline on deer farming and how to take it forward in Nepal

There is much information which suggests that deer farming can be a successful sector in the Nepali context. Deer can be raised and domesticated in a wide variety of terrains and can be kept even on small tracts of land. Deer farming can also be more profitable than cattle and more traditional livestock farming as deer consume less fodder and are less damaging on the land. Deer have also been seen to mature more quickly than traditional livestock and can continue to be bred for up to 20 years (Schmitt, 2014). These indicators suggest a positive outlook on deer farming, which can further be achieved through consideration of the deer farming guidelines and information set out by the Food and Agriculture Organisation of the United Nations (FAO). It is essential to be trained to follow guidelines and for licensees to have knowledge on deer behaviour, nutrition, calving, herd composition and slaughtering and for the government to monitor these factors.

Unlike traditional animal husbandry compromising of cows, buffalos, goats, sheep, yaks and poultry, deer handling requires a new set of skills as they are more sensitive than traditional livestock. For example, when capturing deer the upmost care should be taken as stress caused by capture can even cause death amongst deer.

Human interaction with deer should be carefully planned and researched as well. Though deer can adapt to human presence quickly when presented with palatable food, they can be dangerous to those who handle them. Additionally, if the daily routines of the deer are interrupted by people too frequently, the animals can become stressed and therefore reduce productivity. Depending on the species of deer, it can be easier to handle the animals when they are in a darkened environment, such as when there is roofing over the fields in which they are kept. It is also recommended to give the animals an area that is covered in the winter, especially in case of snowfall. While kept in fields the deer should not be overcrowded as this will prevent handlers from moving freely amongst the deer to carry out work like ear tagging and vaccination. When considering outdoor areas for the deer, areas with swamps or ponds should be avoided as young deer can become trapped. This may also occur in the fencing and so fences should be monitored daily.

In terms of calving and reproduction care must be taken and knowledge of the reproductive characteristics of particular deer species must be gained. Male and female deer reach sexual fertility at two years of age, and proper nutrition is essential to ensure a positive influence on fertility, especially in the stags that are expected to produce the most calves. While males and females associate in different groups for most of the year, when male deer are ready for reproduction they can fight amongst themselves for the possession of a harem of female deer and in New Zealand it has been observed that 6 male deer held over 200 female deer in harems. There must be numerous stags in a mating group, as an infertile stag could have long lasting negative impacts on calving. Also in New Zealand, it has been noted that females at later stages of pregnancy should not be moved as this can increase calf mortality and that twinning and adoption of calves is also common. Females should also be left undisturbed right after mating but following the third month of pregnancy, exercise and exposure to sunshine should be encouraged as this builds up health. Once the calf is born, it should not be touched by humans as deer may easily abandon their calves.

Once calves are born, they should be weaned and vaccinated at the appropriate time so that they do not interfere with future mating. When calves move on to being fed, the apparatus used must be kept hygienic. When feeding deer, it is essential to consider growth patterns, efficiency of food utilization and the need for maximum velvet production and reproduction. Therefore, nutrition should be a particular focus in the spring time so as to keep metabolic

disease away and ensure high reproductive performance. Similarly, supplementary food such as hay, acorns, oats, maize, potatoes, sesame and sunflower seeds, and root crops should be considered in the winter to keep body weight up. Feeding and veterinary inspection are both ways of acclimatizing deer to human interaction. Veterinary care should be given to each deer individually and they can be physically restrained if this is necessary (De Vos, 1982).

Conclusion and recommendations

In order to increase the value of community managed forest, the government needs to establish a clear guideline for integrating deer farms with forest and private lands with stocking rate, percentage of area under grassland, floral diversity and canopy cover threshold. These guidelines must mimic the natural habitat of the enclosed species. Similarly, guidelines must also be made for the private sector that wants to conduct deer farming on privately owned land. Whether in situ conservation in community forest land or ex situ farming in private land by making suitable habitat, regular support from veterinary services are essential. As this is a new enterprise, veterinary service must also have adequate knowledge.

Despite the presence of challenges in deer farming in Nepal, it also has a promising future. There is reason to believe in the success of deer farming given its success in other countries, though the practices adopted abroad will have to be adapted to fit the economic, geographic and ecological particularities in Nepal. It must be kept in mind that policies should create economic benefit and prosperity while still upholding, and certainly not undermining, regeneration and conservation efforts made so far. Maintaining a balance between animal welfare and production will be a major challenge. Particularly if the profits are too large, there will be an incentive to overcrowd farms and degrade animal health and also the land. Therefore all concerned stakeholders should be consulted, along with experts in deer farming, veterinarians to develop a code of conduct for deer farming enterprise. Additionally, without thorough and consistent monitoring and evaluation, deer farming may not be maintained as a sustainable ‘green’ economic business. Finally, there is a requirement for deer produced in community or private farms to be certified so that they are differentiated from wild deer populations and the deer farming policy can be implemented effectively.

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Occupancy of Mammalian Carnivore in Triyuga Forest of Eastern Lowland, Nepal

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Abstract
*Nepal, despite being rich in mammalian carnivore species, the studies on ecological aspects are limited in scope and number in areas outside protected area system, particularly Chure region vastly under explored. Thus, this study was conducted to estimate the occupancy of carnivores in the Triyuga Forest in eastern part of Nepal. For the study purpose, the area was divided into the girds of 3*3 sq. km selecting 30 grids randomly excluding the grids with less than 50% coverage inside the study area boundary. In each grid, a Six km transect was surveyed for carnivore signs and potential factors influencing their presence and detection, considering each segment of one km as a spatial replicate. The data was analyzed using Presence software and unmarked package in R using standard occupancy framework. Carnivore occupancy was found to be governed by the canopy cover viz. higher occupancy in the high canopy cover areas with and low in the low cover areas. The influence of cover can be interpreted as influence on prey species. In the study area, as forest cover is gradually decreasing, forest enhancement interventions are recommended.*

Keywords: *Canidae, Disturbance, Forest cover, Leopard, Sloth Bear.*

Introduction
Mammalian carnivores are group of flesh-eating mammals and are important to regulate ecosystem dynamics. Being the member of top predator community, they require large portion of landscape to meet their dietary requirements (Fauvelle et al. 2017) and are notably sensitive to habitat fragmentation, disturbance, and exploitation by humans (Ginsberg 2001; Woodroffe 2001).Many species are threatened to extinction due to cumulative effects of aforementioned threats. The extirpation of carnivores may result in cascading effects in the ecosystems (Miller et al. 2001).Degradation of habitat can further aggravate the threats raising question on survival of carnivores, particularly the species of Felidae, Canidae and Ursidae families (Karanth and Chellam 2009). Chure region of Nepal, in terms of representation in protected area network, is also considered as forgotten landscape (Thapa and Kelly 2017). Biodiversity conservation is challenging in these areas (Singh 2017). Understanding the species-habitat relationship has important conservation implication particularly for areas where human-caused changes to ecosystems threaten viability of carnivore species (Mitchell and Hebblewhite 2013). This study was designed to understand the conservation status of carnivore species in Triyuga Forest of eastern Nepal.

Materials and Methods
Study Area
The study was conducted in Triyuga Forest of Udayapur and Saptari districts of Province 1 and Province 2 respectively. The forest lies in Chure region and are distributed under Triyuga Municipality and Chaudandigadhi municipality of Udayapur district and Surunga, Khadak,

Shambunath, Kanchanrup and Saptakoshi Municipality and Krishna SawabaranRuapni Rural Municipality of Saptari district (Figure 1). The area was the easternmost and one of the four hunting reserves proposed by Per Wegge in 1976 for Tarai region of the country which was never materialized (Heinen and Kattel 1992). Sub-tropical climate influenced by monsoon is predominant the area. Average annual temperature is 24.3 °C which reaches up to 38 °C in peak summer. And mean annual precipitation was found to be 1493.1 mm of which nearly 1231 mm occurred during the monsoon season (CBS 2014; Subedi et al. 1991). Tropical Sal mixed forest, Deciduous Mixed Forest and Riverine Forests are found in the area. *Shorea robusta* (Sal) forest dominate the northern belt of study area. Riverine and mixed hardwood species are also reported from the area. The southern belt of study area is dominated by mixed hardwood forest. Along most of the stream banks, there is presence of *Dendrocalamus* sps in both the districts. *Terminalia tementosa* (Saaj), *Dalbergia latifolia* (Satisal), *Acacia catechu* (Khair), *Semicarpous anacardium* (Bhalayo) are common species in mixed forest. Khair and Satisal dominant the riverine forest. Most of the area is dominated by *Phoenix humilis*. The study areaforest is regarded as the second most important habitat of Sloth bear (*Melursus ursinus*) after Chitwan, with an estimated population of about 50 individuals (Jnawali et al., 2011). Common leopard (*Panthera pardus*), Golden Jackal (*Canis aureus*) Jungle Cat (*Felis chaus*), Small Indian Civet (*Viverricula indica*), Muntjak (*Muntiacus muntjak*), Wild Boar (*Susscurfa*), Striped Hyenas (*Hyena hyena*), Rhesus monkey (*Macaca mulatta*), Terai Grey Langur (*Semnopithecus hector*) and Ghoral (*Naemorhedus goral*) are other major mammalian species of the forest. Peafowl (*Pavo cristatus*), Kalij (*Lophura leucomelanos*), Jungle fowl (*Gallus gallus*) are the major avifauna. The migratory wild elephants (*Elephas maximus*), that travel all the way from West Bengal are found to use the forest as their migration route.

Triyuga Forest lies within the Chure hills, with domination of sandstone and mudstone rocks, are the youngest and most dynamic mountain systems of the world. These mountains are being degraded due to accelerated human interferences. According to the recent National population census (CBS 2014), total population of Udayapur district was 317,532 in 2011. Ofthe total population, 149,712 were male and 167,820 were female belonging to 66,557 households. In Saptari district, 639,557 individuals were reported from 121,098 households. Many of these households depend on the forest in the study area as the forests are limited within the northern boundary of the Saptari district. Triyuga Forest is one of the larger forest habitats outside the protected area system in eastern

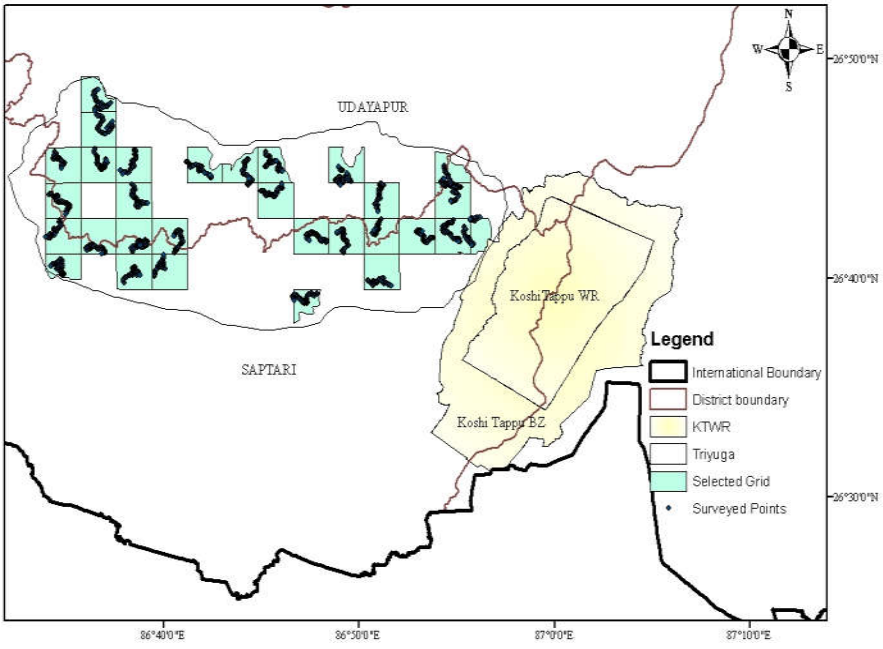

Figure 1: Map of Study area with selected grids and surveyed points (which lies at the west of KoshiTappu Wildlife Reserve

lowlands of Nepal and is considered as one of the most important corridor linking the Koshitappu Wildlife reserve with the other protected areas of Nepal (Ministry of Forests and Soil Conservation 2016).

Sample design

This study was designed to model occupancy of carnivore species in the selected area (Figure 1). Simple random sampling was used to select sampling units. At first, grids of 3*3 sq. km. were laid down over the map of study area. The grids with less than 50% area inside study area were neglected. From the remaining grids, thirty grids were randomly selected using Arc GIS (ESRI, 2011) software to carry outfield survey.

Field methods

Field study was carried out between January 28, 2016 and February 29, 2016. It was not practically possible to measure the distance in field, thus foot step was calibrated in the project area using replicated counting. After calibration 115 steps were scaled as 100 m and data were collected in those section. Altogether 6 KM were surveyed in each grid (30*6 = 180 KM total transect walk). Informal discussions with local people were also carried out whenever possible. The animal signs noted were verified with local people and by using field guide (Baral and Shah 2008; Menon 2014).

Data Analysis

Carnivore species are mostly elusive in nature and many of them are nocturnal, which implies that there remains possibility of non-detection of the species when the species are actually present within the habitat. Occupancy modeling relates the species presence with the environmental factors (Gaston and He, 2011; Spencer et al., 2011). Occupancy modeling helps to address the issues of pseudo absence and when species cannot be detected with perfection (MacKenzie et al., 2002; MacKenzie et al., 2005).

Covariates selection and occupancy modeling

Based on the field experience, presence of *Phoenix humilis* (Thakal) and elevation (coded as elv in the model) of sampling locations were expected to be the determining factors for detection of carnivore signs thus, they were modeled as sampling covariates. While the forest canopy coverage % (coded as cover for modeling), distance (m) from water (coded as water in model) and human interference (fodder collection, firewood collection and timber extraction coded as '**vi**' in model) were used as habitat level covariates.

Only the confirmed signs of Common Leopard, Asiatic Golden Jackal and Sloth Bear were used in the analysis. Though the response of the different carnivore species varies greatly to the disturbance and other factors, Common Leopard and Asiatic Golden Jackal are generally tolerant to the human disturbance. Sloth bears, in case of disturbed habitat, were reported from the areas close to human settlements (Akhtar et al. 2004). Thus, signs of all these three species are pooled together for occupancy modeling. Carnivore populations are governed largely by prey availability (Karanth et al., 2004) and water and cover provides the proxy measure to the prey availability and thus, are selected as covariates.

Occupancy modeling was carried out using unmarked package(Fiske and Chandler, 2011) in R Software Environment (R Core Team, 2016). As the fires were found to be used by poachers in the forest during hunting to trap the target animals, fire was used as an indicator of poaching. In occupancy modeling grazing, fodder collection, fuelwood collection, logging, elevation, slope and distance from the water holes were used as covariates. The model

selection was done according to the AIC value with delta AIC <2 (Burnham and Anderson, 2004). The degree of fit of the best model was assessed by using AICcmodavg package by bootstrapping the model for 1000 iterations and the over dispersion were assessed (Burnham and Anderson, 2004; Mazerolle, 2016) to check the fit of the models (MacKenzie et al., 2004). Average beta coefficients were calculated in using AICcmodavg package in R (Mazerolle, 2016).

Results and Discussion

The elevation ranged from 101.1 m to 342.3 m within the study area. Signs of fuelwood collection, fodder collection, grazing and logging activities were high in 16 of the 30 grids studied. Distance from water source ranged from 56.5 m to 924.55.m.

Evaluation of Null model of both the standard occupancy model (MacKenzie et al. 2002) and spatially correlated detection(Hines et al. 2010) is shown in table: which shows that the model favored towards standard occupancy framework.

Table 1: Comparison of null model of standard framework occupancy and spatially correlated framework

Model	AIC	deltaic	AIC wgt	Model Likelihood	Number of Parameters
psi(.)p(.)	28.43	0	0.9453	1	2
psi,th0(),th1(),p(),th0pi()	34.13	5.7	0.0547	0.0578	5

Detection Model

Of the total 180 replicates in which the survey was accomplished, carnivore signs were detected from 23 of those plots. This implies that the detection probability of signs of carnivore species in the area was found to be 0.184 ±0.036 per kilometer of transect surveyed. On modeling the data, using standard occupancy framework, null model was found to be the most suitable model (Table 2). Both, site level and observation level covariates collected failed to explain the detection probability of the carnivore species.

Table 2: Model summary of detection probability

	nPars	AIC	delta	AICwt	cumltvWt
p(1)psi(1)	2	138.19	0	0.248	0.25
p(water)psi(1)	3	139.16	0.96	0.153	0.4
p(thakal)psi(1)	3	139.4	1.2	0.136	0.54
p(cover)psi(1)	3	139.5	1.31	0.129	0.67
p(elv)psi(1)	3	140.08	1.89	0.097	0.76
p(thakal+water)psi(1)	4	140.38	2.18	0.083	0.85
p(thakal+cover)psi(1)	4	140.61	2.41	0.074	0.92
p(elv+thakal)psi(1)	4	141.36	3.16	0.051	0.97
p(thakal+elv+cover)psi(1)	5	142.56	4.37	0.028	1

Occupancy

Canopy coverage, human disturbance and water were found to be important factors for the presence-absence of species in the area (Table 3). Based on the MacKenzie and Bailey goodness-of-fit for single-season occupancy model, it was found that model fitted well with the data makingthe model suitable for drawing inference (p-value>0.05) and problem of

overdispersion or underdispersion was not observed (c-hat = 0.72)(Burnham et al., 2004; MacKenzie et al., 2004; Welsh et al., 2013).

Table 3: Top model selected for model averaging of covariates

Model	nPars	AIC	delta	AICwt	cumltvWt
p(1)psi(cover+I(cover^2))	4	134.8	0	0.3511	0.35
p(1)psi(cover+I(cover^2)+vi)	5	136	1.2	0.1926	0.54
p(1)psi(cover+I(cover^2)+water)	5	136.78	1.99	0.1299	0.67

Occupancy of the carnivores was found to range from 0.07 to 1.0 (Annex 2) and affected by cover, fire, disturbance and water availability (Table 4). Though insignificant negative relation was observed with cover (odds ratio=0.0001), quadratic relationship exists between canopy cover and occupancy, with occupancy of carnivore higher in medium canopy cover while low occupancy in high and low canopy cover (Figure 2). The probability of habitat use by carnivore species is directly proportional to the prey status (Karanth et al. 2004).The results obtained are similar with the findings of researches carried out in other parts of globe. Ground level protection, natural forest extent and connectivity were of profound impact for conservation of leopards in Srilanka (Kittle et al. 2018). Based on the findings of previous study in the area, where site level occupancy of the species was governed by the cover, occupancy of carnivore species can be considered to be affected by the prey distribution (Aryal 2016). Prey size were found to have profound impact on tigers in Nepal. Considering cover as proxy for prey species, we can state that prey population have profound impact on the distribution of the carnivore species in the area (Aryal 2016; Barber-Meyer et al. 2013).

Table 4: Model averaged estimates of coefficient from top models

SN	Covariates	Estiamtes	Low	High	SE	Odds ratio
1	Intercept	-1.62	-4.99	1.61	1.74	0.1979
2	Cover	-9.09	-19.32	1.14	5.12	0.0001
3	Water	0.12	-2.05	2.28	1.1	1.1275
4	VI	1.87	-2.78	6.51	2.37	6.4883

Beside forest canopy cover, presence of water source, fire and impact of vegetation were found to be significant predictors of carnivore occupancy (Table 3, 4) in the study area. Low occupancy of the species in the areas with low canopy cover might be explained by the fact that most of the forest in the area were with moderate to high level of disturbances. Among the variables explaining the variation of the species, cover in linear form has insignificant effects on the presence of the carnivore species (Table 4), while presence of water and human impacts on vegetation (fuelwood collection, fodder collection and grazing) also significantly explain the occupancy of carnivore species. Presence of the carnivore species such as Common leopard, Asiatic Golden Jackal and Civets that are more adaptive to the human dominated environments might potentially explain the influences of the positive relationship of carnivore occupancy with the human impacts on vegetation (Jacobson et al. 2016). As the sampling was carried during late winter in the year 2016 which was affected by El Nino, with low precipitation in the winter season, might provide plausible explanation for correlation of occupancy of carnivore with distance from water holes.

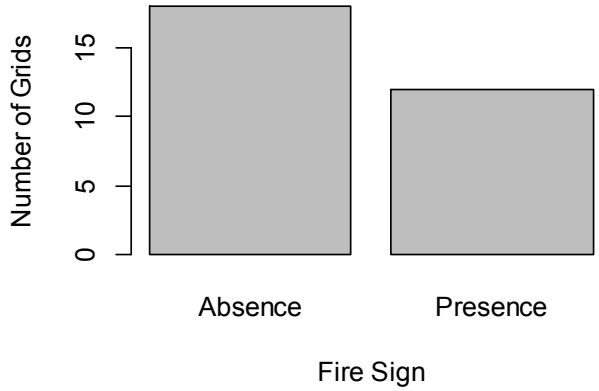

Figure 2: Summary of fire sign in the study area

Human disturbance in the area are not limited to fuel wood, timber and fodder collection. During field visit poachers, people with fire arms for hunting, were encountered especially in the core areas of forest. They were observed to use fire for poaching. The signs of fire including both fresh and old signs were reported from 12 grids out of 30 grids surveyed (Figure 3) indicating the poaching pressure in the area. During informal conversations, local people acknowledged prevalence of poaching pressure in the region. This might result in vanishing of carnivore species from the area which might threaten the ecosystem of Triyuga region leading to local extinction (Miller et al. 2001).

Implications for Conservation

Law enforcement and conservation initiation outside protected area network are very poor in Nepal challenging the conservation of biodiversity (Ghimire et al. 2014). High degree of disturbances is reported from the study area threatening the biodiversity. Investment on conservation of carnivore species in the area could prove insurance policy for conservation of other entities of biodiversity. And as the occupancy of the carnivore species were high in the moderate level of canopy coverage, their management is vital. Besides, carnivore activities were found to be regulated by the water sources but due to lack of perennial rivers in the region, Chure region faces the scarcity of the water resources in the dry season. Water resources management through water holes might be essential.

Conclusion

Detection probability of carnivore species was found to be 0.18 per KM of transect surveyed and were found to be independent of the covariates of the data collected. Occupancy of mammalian carnivore fauna was found to range from 0.08 to 1. Forest cover was found to be a significant factor in determining the occupancy probability of carnivore species. As cover was used as proxy to the prey availability, we can conclude that prey presence was the major contributing factor in regulation of carnivore occupancy. Forest cover in the study area was reported to decline in the recent period. Thus, to conserve the forest species human interferences should be regulated.

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Bengal Fox: Distribution and Den Site Characteristics in Western Jhapa, Nepal

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Abstract
Bengal fox, an endemic medium-sized mammal of Indian subcontinent, is among neglected species for research and conservation. Observed decline in populations and predicted serious future habitat loss reveal pressing needs to collect baseline information. This study was undertaken to locate distribution pattern of den sites of Bengal fox and also collect data on characteristics of the dens in the western part of Jhapa district of Nepal. Randomly selected 16 grids of size 3x3Km^2 were used for the field survey. Total of 21 den sites were identified and density based den abundance estimated was 0.0049/ha. Most were complex cavernous den types, followed by simple ones and some in transition phase. Dens were located in open, 'tall vegetation'-less areas and mostly seem to be avoiding human disturbances. Major threats faced by the species were killing for meat and retaliatory actions along with encroachment of habitat due to increased human populations and settlement sprawl.

Keywords**:** *Bengal Fox, Lowlands, Canids, status, threats*

Introduction
Bengal fox (*Vulpes bengalensis*, Shaw 1800) is an endemic medium-sized mammal species to Indian subcontinent (Menon 2003). It is among the three fox species i.e. Red fox (*Vulpes vulpes*), Tibetan fox (*Vulpes ferrilata*), and the Bengal fox (*Vulpes bengalensis*) itself, found in Nepal (Jnawali et al. 2011). Though the Bengal fox is enlisted as Least Concern (LC) globally in the IUCN Red List (Johnsingh and Jhala 2008), it is listed as Vulnerable (VU) in the National Red List Series of Nepal due to observed dwindling populations and posed high threats (Jnawali et al. 2011). Literature on Bengal fox reveal only limited information on external morphological measurements and presence records from Nepal (Pocock 1936; Mitchell 1977). Stated presence in Annapurna Conservation Area, Bardia National Park, Chitwan National Park (CNP), Dhorpatan Hunting Reserve, Koshi Tappu Wildlife Reserve, Parsa National Park, Shuklaphata National Park are mostly based on observations and perceptions of people rather intentional studies (Jnawali et al. 2011). Information consists mostly of not very reliable old records from Lamtang National Park and Shey Phoksundo National Park (Shrestha 1997, Johnsingh and Jhala 2008). The most recent and reliable information of the Bengal fox comes from trapping during a tiger census in CNP (Karki 2011). Given that habitat loss will further threaten the species (Minin et al. 2016) and that it is data deficient, there is an urgent need on basic information on the ecology of the fox (Jnawali et al. 2011). Therefore, to contribute to the conservation of the Bengal fox, this study aims to determine the current distribution and characteristics of den sites.

Materials and Methods
Study Area
The study area is on the western part of a lowland district called 'Jhapa' and covered 434.8Km^2 (Figure1). The area experiences moderate climate complexion, i.e. Cwa type, as lies in the Indo-gangetic plain. Rainfall received per year is 250 to 300 cm and most of that occurs during the monsoon season in the summer. Being a part of the lowland district, the

settlement and household density are comparatively higher with much part of land used for agricultural purpose. There are no protected areas in the region and only has a few remnants of native vegetation as well as plantations.

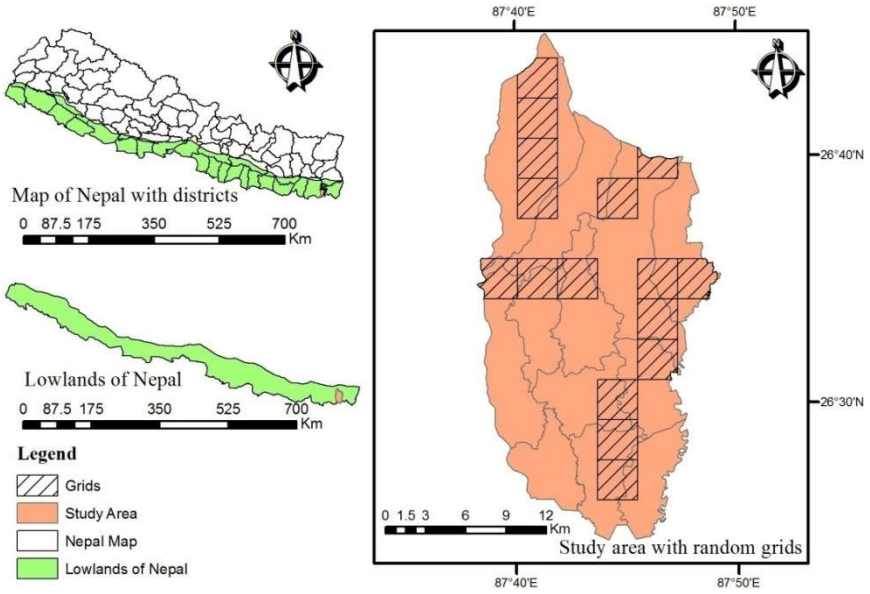

Figure 1: Map of Study Area

Methods

To locate Bengal foxes, 16 grids of 3x3Km^2 were randomly set up in the study area. Three 750m straight-line transects from north to south were laid in each of the grids. Surveys were performed between January 26 and March 20, 2016, for 55 days. Line transects were surveyed by walking at about 2 to 2.5Km/hr. Opportunistically met local inhabitants were consulted to ask for their help in tracing the locations and all the probable sites for Bengal fox were searched in detail. Observed den sites were confirmed either after direct sighting of species or measurements of available scat or pugmarks or the use of camera traps (Bushnell 8MP Trophy Cam Trail Camera). Among the opportunistically met and consulted inhabitants, eight responses from each of the grids were noted for perception analysis. Land-cover pattern, vegetation structure and types, canopy and cover provided by hide available were collected in 20x20m^2 quadrates laid around the den sites. Measurement of numbers of den openings, diameters of openings, distance to settlements, nearby trees, water bodies, trails and roads from den sites, and location coordinates of den sites were taken. Height difference from den openings to nearest water logging areas was also measured. Furthermore, human population and household data were taken from National Census-Nepal 2011 (CBS 2012). Spearman's correlations between presence of Bengal fox per grids and field variables were estimated for drawing inferences. Statistical computations were performed in Excel 2013 and R (version 3.3.0, 2016-5-3).

Results

Altogether 21 den sites of Bengal fox were identified in 9 grids (Figure3). Density based den site abundance for the study area was estimated 0.0049/ha. Among the den sites, four were confirmed with direct sighting of the species (Figure2), seven with the help of camera traps, four with measurements of scats and rest six with measurements of scats and pugmarks.

Figure 2: Image of Bengal fox Seen during the Field Survey

Altitude of dens ranged from 73 to 139m above sea level. The openings and diameter in each den site varied. Out of total, 130 were the complete den openings and remaining were being built. Complete openings ranged from 1 to 22 per dens whereas incomplete were up to 8 in number. Six den sites were simple, 12 belonged to complex cavernous type and the rest three were in the phase of transition from simple to complex i.e. had incomplete burrows being built. The mean diameter (±SD) of complete den openings was 23.5±5.197cm and ranged from 11.25 to 43.50cm. Diameters of incomplete openings ranged from 4.75 to 15.25cm. Based on the measurements of distinguishable and traceable (using a tracing paper) pugmarks (n=10) resulted in to average length of 4.17±0.83cm, width of 3.59±0.58cm and pad width of 1.88±0.4825cm. Scats collected (n=31) from 10 den sites yielded an average diameter of 13.24±2.0mm and ranged from 10.04 to 16.55mm.

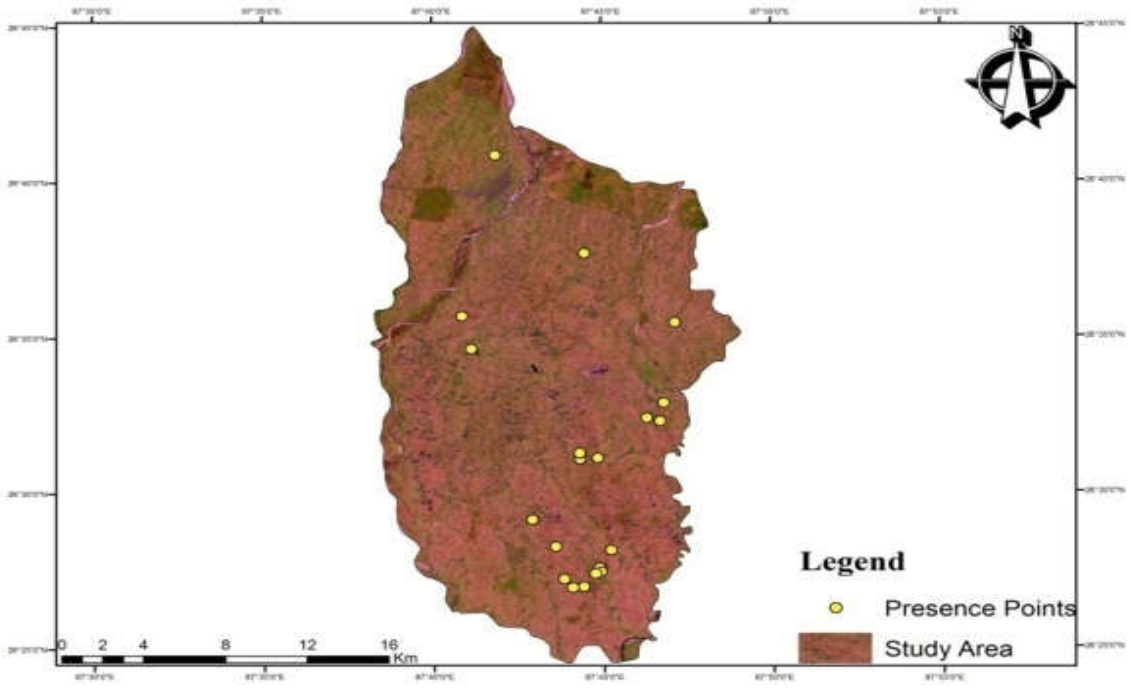

Figure 3: Presence Locations of Den Sites

Four den sites were located in abandoned agricultural land, five in agricultural land, four along the river banks, five in marginal area of agricultural land with mostly temporary or permanent water bodies in the proximity, and rest of the three locations were in the tree plantation area. Except for four den sites there was no tree coverage above others. The average canopy coverage in percentage per den site was 4.38±17.39 and ranged from 0 to 80 percent. Leaving eight locations, rest had available hide of grasses ranging from 0 to 85% and average of 9.57±19.88. The vegetation structure was dominated by herbs and the average percentage was 83.05±30.51 ranging from 5 to 100%. Shrubs, trees and saplings were available in varying percentages ranging from 0 to 15%, 0 to 85% and 0 to 8.3% respectively. The average value in percentage for shrubs, trees and saplings were 3.31±4.77, 12.33±27.61 and 1.51±3.04 respectively. The dens were situated 0.4±0.41m above the nearest water logging sites. The height differences ranged from 0 to 1.33m. Distance from den sites to water bodies ranged from 3.5 to 1,598m with the average of 365.31±483.04m, to human trails/roads ranged from 16 to 725m with the average of 179.43±197.3m, to settlements ranged from 47 to 676m with the average of 241.19±229.28m and to nearest trees ranged from 0.45 to 88m with the average of 34.62±27.19m.

The vernacular names for the Bengal fox in study area were known to be *Khirkhire*, *Khek Syal*, *Khekri* and *Ram Syal*. The respondents (n=128) belonged to tribal communities of Brahmin, Chhetri, Indigenous groups and Ethnic minorities. Among the respondents, 81% believed on dwindling population of Bengal fox whereas 5% and 14% stated of having 'no idea' and 'constant population' respectively. Of the total respondents, 5% were involved in killing the species somehow. Santhal indigenous group was known to be hunting for flesh where the rest were retaliatory killings. Eighteen individuals including 9 adults and 9 pups were killed in the past year by those hunters among the respondents consulted. Of the foxes killed, 55% were for meat and 45% were retaliatory killings. Various methods applied for killing were; using smoke in the dens, digging dens, chasing individuals with dogs (*Canis familiaris*), and opportunistic killings during monsoon seasons when the dens get water logged and species leave the dens. Other probable threats were observed to be increasing encroachment of suitable habitats with increasing urban sprawl, use of agrochemicals in the agricultural lands to control insects and keeping dogs as pet by people. Majority of the people (81%) took the species simply as a pest due to existing conflict with their poultry.

The correlations of the field variables and presence of Bengal fox showed very weak to very strong association (Table1). Altitudinal variation of den sites was found very weakly influencing the presence. And, distance to trail/road very strongly positively influenced the presence whereas canopy coverage very strongly negatively.

Table 1: Spearman's correlation between presence of Bengal fox dens and variables measured

Variables measured	Correlation coefficient
Human population density	-0.27
Household density	-0.41
Canopy coverage	-0.87
Hide available	0.19
Distances to trails/roads	0.91
Distances to settlement	0.75
Distances to water bodies	-0.0087
Distances to nearest tree	0.66

Discussion

The average den opening diameters of 23.5±5.197cm can be taken as a reference for the future study purposes for similar kind of landscape feature. Because other sympatric wild carnivores are absent, the dens were confirmed to belong the Bengal fox. Due to the same reason of no other sympatric carnivores, the complying results of pugmarks and scat measurements with Gompper and Vanak (2006) bear much entrust.

Dens of Bengal fox observed in Jhapa district were primarily of the complex cavernous types as observed by Johnsingh (1978) and Vanak (2003). These higher occurrences of complex cavernous dens with a few in transition phase might be due to study period falling into the pup bearing period of Bengal fox. It is because Johnsingh (1978) had observed that they use simple dens only for resting and for short periods during hotter climatic conditions. Study also revealed the occurrences of Bengal fox in the study area but was not evenly distributed throughout. The altitudinal variation was not affecting distribution of the fox strongly since the variation was not much larger due to the study area falling completely in lowlands. The den sites were situated above a certain height from the nearest water logging sites and the reason for the fact could be keeping water from entering during the monsoonal surface flow. Very low negative association of fox's presence with distance to water bodies also might have the same reason as height difference of den openings i.e. to avoid water from entering during monsoon or flood periods.

The den sites were dominated by vegetation structure of herbs followed by trees, shrubs and saplings. Canopy cover was absent in majority of the den sites and was very strongly negatively associated with presence of dens. Also, the land-cover types for den sites were mostly agricultural and bare lands with a few in vegetated areas. These facts revealed the habitat preference of Bengal foxes to be open areas with short grasses rather forests or others. Similar results were observed by Kumara and Singh (2012), and Johnsingh and Jhala (2004). Strong positive affinity of 'presence of den sites' with 'distance to nearest tree from den' also supported the avoidance of canopy by the Bengal fox for denning. The case of preferring open habitat for den sites might have caused the very low positive relation with hide availability as well. Weak negative relation of fox's presence with human population density, moderately negative with household density, strongly positive with distance to settlement and very strongly with distance to trails/roads explain avoidance of human disturbance and modified landscapes by the species though can tolerate much of it as concluded by Vanak and Gompper (2010). This also indicates the presence of a few den sites in tree plantation area to be likely due to compulsion caused by declining suitable habitats.

Density based den abundance for the study area was lesser than observed by Kumara and Singh (2012) in Jayamangali Blackbuck Block and private areas in India. This might be due to different biophysical settings and level of existing threats in the study site. Existing conflict scenarios resulting into retaliatory killings and hunting trend for meat have appeared as serious threats. It is because the hunters of tribe Santhal were mostly landless and most of the free time they preferred hunting and killing different availablse species in the area for consumption. The perception of local inhabitants mostly taking the fox as a nuisance can further worsen the case. Unlike as stated by Jnawali et al. (2011) the threats of trade for fur or any other purposeful usage were not found in the area. Furthermore, activities seen like encroachment of bare grasslands, urbanization sprawl, and presence of dogs were seen frequently and these might aid to threaten the Bengal fox for their survival.

Conclusion

The occurrence pattern of Bengal fox was found to be mostly in canopy-free grasslands having short grasses and agricultural lands. The abundance of den sites was observed to be comparatively the highest for bare lands followed by agricultural. Human modified lands were rather seemed being used due to compulsion of lacking good habitats. Population of the species was found to be decreasing and was exposed to threats like habitat encroachment and conversion, conflict-induced hunting and killings, decrease in food due to use of agrochemicals, and presence of dogs in the vicinity. Perception of local residents was also not in the favor of the species. Having all the threats in the forefront, the species requires much attention than has ever received with the conservational efforts from all the concerned bodies.

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Ecological Assessment of Mai Pokhari: A Ramsar Site of Eastern Nepal

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Abstract
Benthic macroinvertebrates play an important role in the food chain of aquatic ecosystems and act as bioindicators for the evaluation of environmental stress resulting from various human activities. Seasonal survey were conducted during winter (January 2018) and spring (April 2018) seasons in Mai Pokhari Wetland, with the purpose of assessing ecological status and identifying stressors deteriorating the wetland. Habitat-specific sampling approach was followed for sampling benthic macroinvertebrates from the littoral zone. The site information was collected using the standard Lentic Ecosystem Field Protocol. Land cover change was determined using satellite images. Various metrics such as Shannon-Wiener diversity index, species richness, total abundance and Nepal Lake Biotic Index (NLBI) were determined. The taxa richness was 10 and 13, Shannon diversity was 1.48 and 1.34, and NLBI was 4.01 and 4.44 for winter and spring seasons respectively. The pollution tolerant taxa belonging to Diptera and Oligochaeta orders were highly abundant in all sampling sites and in both sampling seasons. This study identified Mai Pokhari as moderately polluted. pH was measured acidic in both sampling seasons and concentration of nutrients were measured higher in spring season. Shannon diversity and ETO taxa were negatively correlated with nutrients. The number of pollution tolerant taxa increased with increasing nutrient concentration. Organic waste deposition and change in land cover was found to be major stressors responsible for the low dissolved oxygen and fluctuation in the concentration of nutrients. Thus, it is necessary to manage the major stressors in order to ensure sustainable management and conservation of wetland ecosystem. We expect the research results will help concerned authority to avoid further degradation and enhance the ecological integrity of the wetland.

***Keywords**: Macroinvertebrates, Ecological status, Bioindicators, NLBI*

Introduction
Wetlands being a most productive ecosystem (Gautam, Maskey, Sapkota, & Dangol, 2014; Thompson & Hollis, 1995) provide provisioning, regulating, supporting and cultural services to sustain human kind. It also supports ecological functioning through hydrologic transfer and storage of water, biogeochemical transformation, primary productivity and decomposition (Richardson, 1994; Stevenson & Hauer, 2002). However, excessive extraction of wetland resources, disposal of solid waste and release of agricultural, municipal and industrial effluents and land encroachment are major stressors to the wetland ecosystems in the present days (Kafle, Balla, & Paudyal, 2008). These identified impacts results in eutrophication of wetland causing poor aquatic diversity and water quality.

Nepal is rich in wetlands and consists of almost 5358 lakes distributed in different ecological belts and altitude (Bhuju *et al.* 2009); 51% lakes are recorded in lowland (<500m), 42% lakes above 3000m and 7% lakes in between 500m to 2999m (Bhuju, Khadka, Neupane, & Adhikari, 2009).Among these wetlands, 10 wetlands are designated as Ramsar sites of international importance (MoFE, 2018). These wetlands are rich in biodiversity and equally known for spectacular environment (Gautam et al., 2014).

Ecological assessment quantifies the effects of stressors on the distribution of aquatic flora and fauna. This is an important tool to assess the relative impacts and responses of aquatic community to anthropogenic stressors (Morse et al., 2007; Tachamo Shah et al., 2011). Benthic macroinvertebrates are commonly used for the assessment as it provides deeper understanding of ecosystem dynamics and ecological change (Tachamo Shah et al., 2011). In Nepal, Nepal Lake Biotic Index (NLBI) based on tolerance score of taxa is used to determine the ecological quality of lakes and reservoirs (Tachamo Shah et al., 2011).

Mai Pokhari wetland is a natural carter wetland formed at the top of hill (Rai, 2013). It is the ninth Ramsar listed (2008) wetland of Nepal and first Ramsar site from midhills of Nepal. This site gains its popularity because of diverse assemblages of floral and faunal species. More than 300 native and seasonal birds are recorded along with mountain lizard (Thukthuke), white-rumped vulture, leopard cat, Eurasian otter and gold fish. 296 floral species including 30 medicinal plants are also recorded in and around Mai Pokhari wetland. Wetland is surrounded by moderately dense forest of *Schima castanopsis*, laurel oak, variety of rhododendron and orchids, cone trees and medicinal plants. Mai Pokhari is equally known for its cultural importance.

Mai Pokhari is facing the problems of dropping water level, deposition of organic material, and eutrophication. The land use change in its surrounding is also significant. In this context, it is important to understand the present status of the wetland and the drivers that deteriorate it. The study employed integrated approach for the ecological assessment and identifying the stressors. The results of this study will help concerned authority to develop the strategic plans to avoid further degradation and enhance the ecological functions of the wetland.

Materials and Methods

Study Area and Sites

Mai Pokhari wetland is located 15 km north from Ilam Bazar ($27^0 00' 27.5'' N$-$87^0 55' 55.3'' E$). It is situated at the altitude of 2105masl to 2120masl covering an area of 90 hectares with 1.8 hectares of land covered with water (Fig. 1). It is irregular shaped lake with nine corners. The area of Mai Pokhari wetland consist botanical garden, religious and community forests. Mai Pokhari is natural, rainfall feeding lake but in present days, it is fed by Puha River. The lake is surrounded by *Schima castanopsis* and cone shaped trees. Fallen plants parts are the major bed materials of the lake.

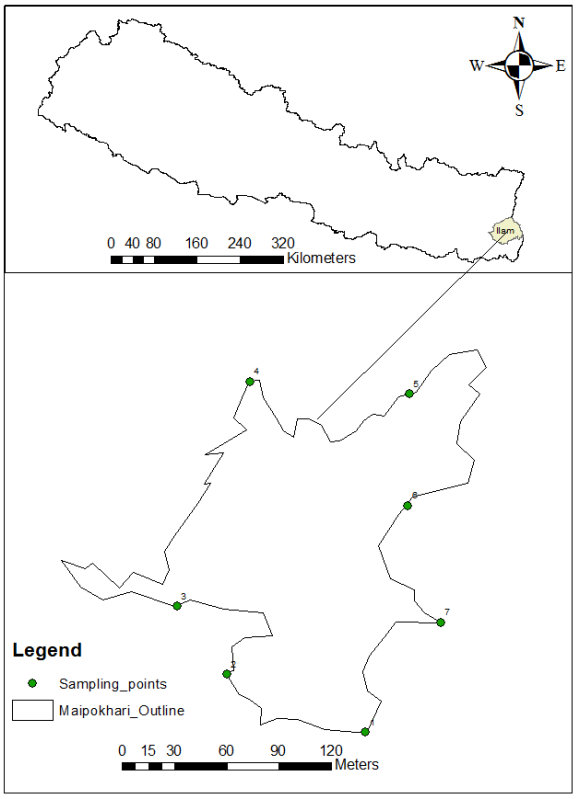

Figure 1: Study area Mai Pokhari and the distribution of study sites in the littoral zone.

Sampling was carried out in the month of January (winter) and April (spring) of 2018. A method of data generation was based on the types of the data required. Primary data were collected from the field survey and laboratory processing whereas secondary data were obtained from the literature. The land cover data was downloaded from ICIMOD website.

Satellite image of two different periods *i.e.* 2000AD and 2010AD were compared and analyzed. An area around Mai Pokhari was selected keeping the radius of 1km from the edge of Mai Pokhari. An area around the wetland was selected with the aim of assessing the impact of land cover change on wetland water level.

Methods

Water quality

Water samples were collected from nine different sampling sites. Parameters like pH, water temperature and dissolved oxygen were measured in-situ between 11AM and 3PM. For the analysis of total hardness, total alkalinity, nitrate, ammonia and total phosphate, water sample were collected in 1L plastic bottle, and transported to the laboratory maintaining cool environment in icebox. The analysis of water samples were done applying the standard methods and equipment (Federation & Association, 2005).

Macroinvertebrates sampling and laboratory processing

Macroinvertebrate sampling was carried out based on habitat-specific sampling approach. Samples were collected from seven sampling sites located in the littoral zone. Round shaped hand net of mesh size 250 μm was used for the collection of sample. GPS recoding, hydro-morphological characteristics, biotic and mineral habitat and sign of pollution at sampling sites were noted in the standard Lentic Ecosystem Field Protocol (Shah et al., 2011). Samples were washed rigorously, removed leaves, twigs and rock materials and preserved in 95% ethanol. The well-preserved samples were transported to the laboratory for taxonomic identification. Samples were identified up to family and order level with the help of identification keys (Shah et al., 2015).

Data analysis

Richness measures (Taxa richness, Shannon-wiener diversity, ETO taxa, Diptera and Oligocheata), composition measures (% of ETO taxa, % of Diptera and Oligocheata) and tolerance measures (% of tolerant, facultative and intolerant taxa) were calculated from the macroinvertebrates collected during winter and spring seasons (Shah et al., 2011, 2015). After calculating biological metrics, NLBI was calculated using tolerance score of each recorded taxa. Kendall rank correlation metrics was used for analyzing seasonal water sample data. Wilcox signed rank ($p<0.05$) was used to determine significant differences among measured parameters in winter and spring seasons. Pearson correlation was performed between nutrient parameters and Shannon diversity and ETO taxa richness. All the statistical analysis were done using MS Excel 2010 and R 3.2.5. Satellite images were used for comparing land use and land cover change between 2000 A.D. and 2010 A.D. ArcGIS 10.2.1 was used for selection of area outside the lake and separation of different types of landforms.

Results and Discussion

Land use and land cover change

Three land cover types i.e. Forest, agricultural land and grassland were identified within the area around the Mai Pokhari (Table 1).

Table 1: Area covered by different land use type in 2000A.D. and 2010A.D. expressed in percentage.

Land cover type	Area of land cover in respective years (%)		Change in area (in %)	Remarks
	2000 A.D.	2010 A.D.		
Grassland	14.69	14.47	0.22	Decreased
Forest	74.53	71.31	3.22	Decreased
Agriculture	10.79	14.22	3.44	Increased

Agricultural land was observed significantly increased whereas forest and grassland were found decreased. The reduction in forest cover along with rapid infrastructure development could impact on ground water table causing lower ground water level (Alam, 2011). The change in land use pattern such as agriculture and urban development might have affected the water quality and biological assemblages of Mai Pokhari (Shrestha & Adhikari, 2016). Construction of roads and building around the wetlands, moving of heavy vehicles are causing additional impact on Mai Pokhari. The conversion of land cover has negative impact on wetland resources, function (Alam, 2011) and ecosystem services (Zhanget al., 2015).

Water Quality Parameters

Among the measured physio-chemical parameters, nutrient concentrations were only significantly different ($P<0.05$) during winter and spring seasons (Table 2). pH was measured acidic in both seasons. This might be because of the fallen parts of *Pinus roxburghii,* which is responsible for maintaining acidic condition. Formation of carbonic acid by the release of carbon dioxide from decomposition of organic matter might also be responsible for acidic environment. Measured pH was below the national water quality guidelines for the protection of aquatic life (6.5-9), however, aquatic species can survive at pH 5 to 9 (Mesner & Geiger, 2010).

Table 2: Physio-chemical parameters measured at different sampling sites in winter and spring season.

Parameters	Unit	Winter	Spring	P-value (P<0.05)
		Mean±SE	Mean±SE	
pH	pH Scale	5.69±0.11	5.82±0.12	0.56
DO	mg/L	2.13	2.39	
Temperature	^{o}C	16.55	18.78±0.32	
Total Hardness	mg/L	11.56±1.27	11.67±1.24	0.86
Total Alkalinity	mg/L	39.22±2.39	32.22±1.36	0.08
Nitrate	mg/L	0.37±0.07	2.41±0.17	<0.001
Ammonia	mg/L	0.42±0.06	1.56±0.09	<0.001
Total Phosphate	mg/L	1.22±0.27	2.54±0.28	<0.001

Wilcox signed rank ($p<0.05$) is used to measure the significant difference between winter and spring season.

Presence of limestone as bed and bank material is responsible for hardness of water. Total alkalinity is associated with hardness of water as both are influenced by carbonates. Major source of nutrients (Nitrate, total phosphate) and ammonia in Mai Pokhari are organic matter, dissolution of bed and bank materials and river water carrying agricultural residues, plant debris and animal feces to the lake.

The nutrients were measured higher in spring season. Nature itself is a source of nutrients however runoff from the adjacent agricultural land and domestic sewage enhances its concentration (Kazi et al., 2009). Higher concentration of nutrient enhances density, composition and richness of aquatic vegetation in lakes (Dar, Pandit, & Ganai, 2014; Rosset, Lehmann, & Oertli, 2010).

pH was negatively correlated with EC, total hardness, total alkalinity and total phosphate (Table 3), however, positively correlated with nitrate and ammonia. There was strong positive correlation between EC and total hardness, total alkalinity and total phosphate. Total hardness was positively correlated with total alkalinity, ammonia, nitrate and total phosphate.

Total alkalinity was negatively correlated with ammonia and nitrate and no relation with total phosphate. Strong positive correlation was measured between ammonia, nitrate and total phosphate.

Table 3: Kendall rank Correlation matrix (r) among different physio-chemical parameters of water sample (p<0.05)

Parameters	pH	Total Hardness	Total Alkalinity	Ammonia	Nitrate	Total Phosphate
pH	1.00					
Total Hardness	-0.22	1.00				
Total Alkalinity	-0.22	0.33	1.00			
Ammonia	0.13	0.02	-0.43	1.00		
Nitrate	0.18	0.14	-0.42	0.87	1.00	
Total Phosphate	-0.01	0.39	0.00	0.56	0.66	1.00

Macroinvertebrate Assemblages

In total, 618 individuals of macroinvertebrates belonging to 14 families of 10 orders were recorded from littoral zone of Mai Pokhari (Fig. 2). 10 families belonging to 8 orders during winter and 13 families belonging to 8 orders during summer season were recorded. Diptera and Oligochaeta were recorded in highest number in all sampling sites in both seasons.

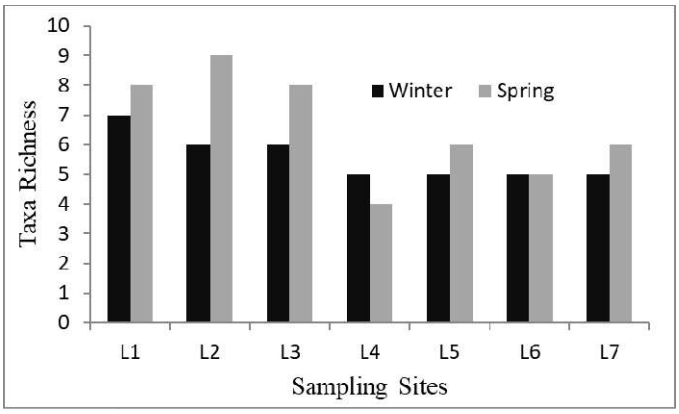

Figure 2: Recording of taxa in different sampling sites measured during winter and spring season.

ETO taxa were present in least number in both seasons (Fig. 3). Richness of Coleoptera, Megaloptera and Hirudinea were low but present in both seasons. Heplotaxida was recorded only in winter and Hemiptera was recorded only in spring season. Diptera comprised 45.94% and 55.92% in winter and spring seasons respectively whereas Oigocheata was recorded 35.36% and 33.75% in winter and spring seasons respectively. ETO taxa comprised less than 10% in both seasons.35% of pollution tolerant taxa and 20% of pollution intolerant taxa were recorded at family level. ETO taxa are sensitive taxa to the pollution. The lower number of ETO taxa might be due to low dissolved oxygen and higher concentration of nutrients. Decrease in water level might also have influenced the presence of ETO taxa as it creates unsuitable habitat. Low abundance of ETO taxa represents the poor ecological quality of wetland.

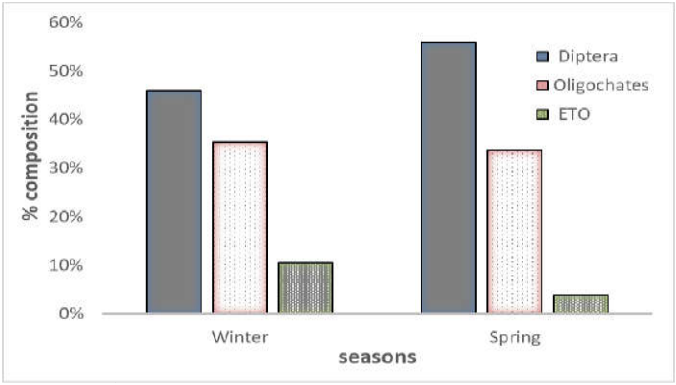

Figure 3: Composition percentage of Diptera, Oligocheata and ETO taxa measured in winter and spring season

Shannon-Weiner diversity index (H) was calculated at family level. Diversity ranged from 0.34 to 0.59 in winter and 0.35 to 0.51 in spring season with average 0.45 and 0.44 respectively (Fig. 4). Shannon diversity was measured almost similar and low in both seasons. The external stressor influencing the wetland ecosystem is one of the major reason for low diversity (Odum, 1959). Similar kind of substrate type during both seasons, deposition of organic matter, and dominance of single taxa could be the reason for low diversity.

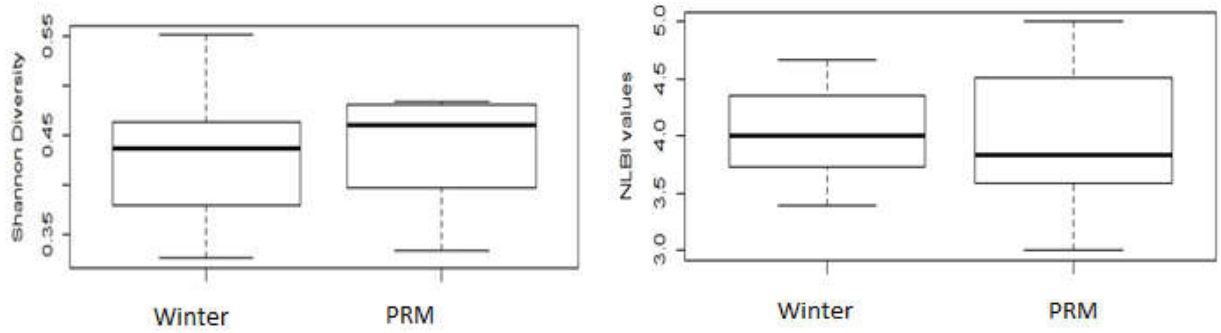

Figure 4: Box and Whisker plot for Shannon-Weiner Diversity index (H) and NLBI for winter and PRM (spring) seasons

NLBI values for two seasons (winter- 4.44, spring- 4.01) were found almost similar. NLBI value ranges from 0 to 10 where towards 10 provides indication of higher ecological quality of lake having none to minimal level of pollution whereas value towards 1 indicates poor to bad ecological quality of lake water having extreme level of pollution (Tachamo Shah et al., 2011). Measured NLBI value revealed that Mai Pokhari is moderately degraded with fair water quality (Tachamo Shah et al., 2011).

The relationship between Shannon-Weiner diversity index (H) and nutrients were examined. The parameters such as Ammonia, Nitrate and Total Phosphate were analyzed. Negative correlation was observed between Diversity and Ammonia (R^2= 0.0685, r=-0.26) and between Diversity and Total Phosphate (R^2=0.0685, r=-0.262) (Fig. 5). There was no strong correlation observed between diversity and Nitrate (R^2=0.0006). Shannon diversity was found decreasing with increasing concentration of measured nutrients. ETO taxa richness had responded differently with the nutrients. ETO taxa richness showed strong negative correlation with Ammonia (R^2=0.367, r=-0.605) and with Nitrate (R^2=0.322, r=-0.567). ETO taxa richness had weak negative correlation with Total Phosphate (R^2=0.122, r=-0.349). ETO taxa richness decreased with increased concentration of nutrients.

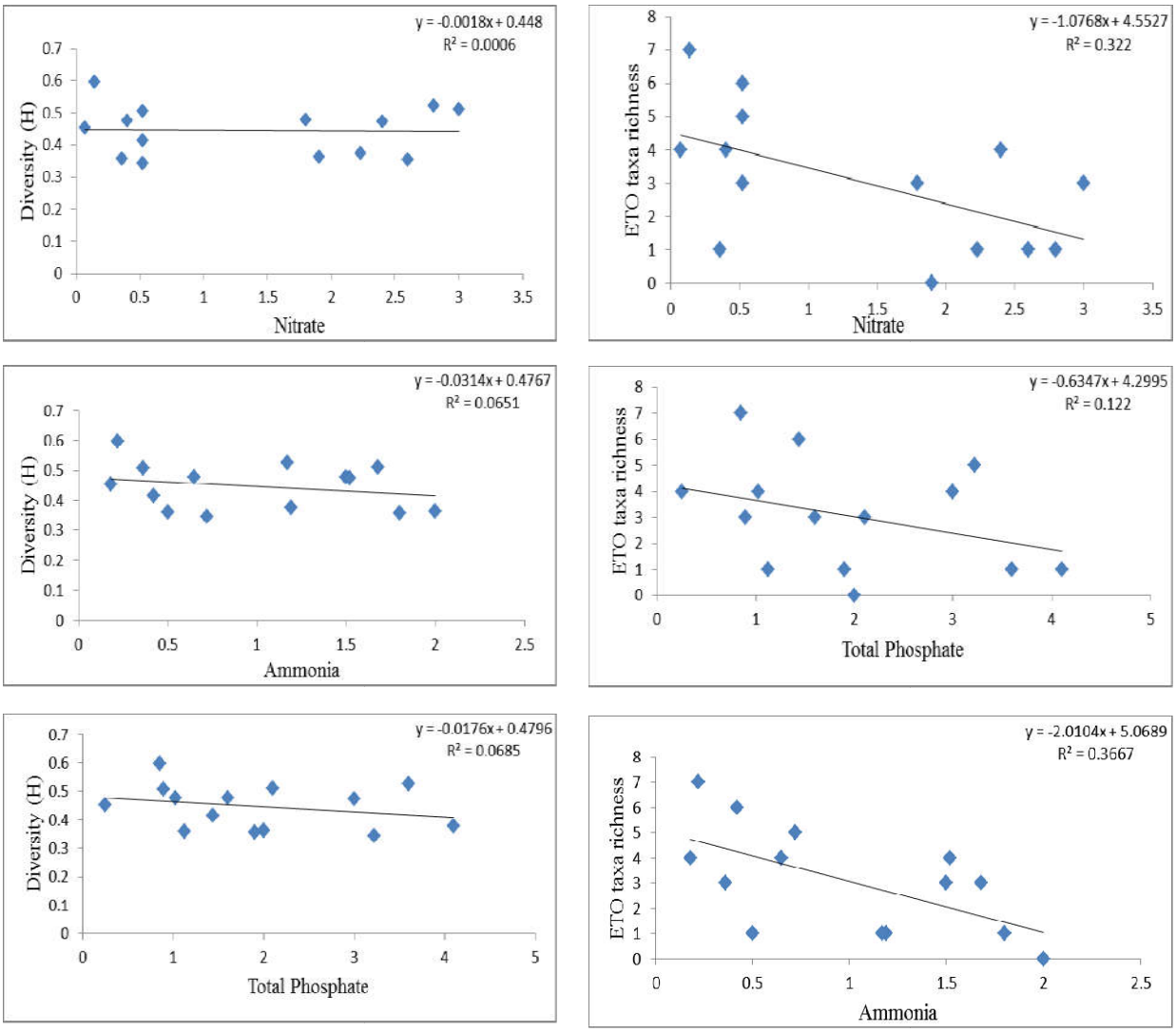

Figure 5: Correlation measure between Nutrient parameters, Shannon diversity and ETO taxa richness.

Conclusion

The Mai Pokhari wetland had high abundance of Diptera and Oligocheata, low abundance of ETO taxa, and low Shannon diversity index. The NLBI value reflected that the wetland was moderately degraded. Change in land use type, high deposition of organic matter, acidic nature of wetland, and increasing concentration of nutrients are responsible for the current degradation.

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Hydro-geochemistry and Water Quality Assessment of Groundwater and Surface Water along Lal Bakaiya River

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Abstract
Lowlands of Terai are generally considered as huge potential of groundwater. Groundwater is the major source for domestic and agricultural activity in this area which are extracted through dug well sand pumps. This study assesses the hydro geochemistry for water quality assessment in the region of Lal Bakaiya river. Estimation of groundwater quality was done to recognize the appropriateness use for drinking and agricultural use of groundwater and surface water. Altogether 28 samples were collected from surface water and groundwater along the region. Onsite measurement of various parameters such as pH, electrical conductivity and temperature were taken in field whereas major cations (Ca^{2+},Mg^{2+}, K^{+}, and Na^{+}), anions (Cl^{-}, NO_3^{-}, HCO_3^{-} and SO_4^{2-}) were analyzed in laboratory. On the basis of NDWQS, all samples are within the permissible range for drinking whereas, WHO standard indicates slight hardness in few samples but within permissible limit. On the basis of different water quality indices: SAR, Sodium percentage, RSC, Kelly's Ratio, MH, groundwater and surface water of the study region is fit for agricultural usage. Water quality was classified as medium salty and low sodium (C2-S1) category according to US salinity diagram indicating excellent to good quality. The pattern of cationic dominance are $Ca^{2+}>Mg^{2+}>Na^{+}>K^{+}$ whereas the pattern of anionic dominance are $HCO_3^{-}>SO_4^{2-}>Cl^{-}>NO_3^{-}$. Piper's diagram classification shows that majority of the samples belong to $CaMgHCO_3$ hydro chemical facies. Gibbs plot and scattered plot revealed all samples fall on rock dominance and chemical weathering as controlling factor of chemical composition.

***Keywords**: Groundwater-surface water, Water quality, Lal Bakaiya, Hydrochemistry.*

Introduction
Groundwater serves as an important and economical natural source of water in Nepal; it provides a reliable source of water for majority of population for domestic and irrigation purpose. Thus, it is the most valuable resource for Nepal with huge pressure on groundwater as more than 50% of water demand is fulfilled solely by groundwater. In fact, the rate of extraction of groundwater, has been far above the rate of its recharge (Awale, 2017; Saha, 2018). Nepal is divided into 8 physiographic region with Siwalik range having low water table (Dahal, 2006). The Terai region consists of vast amount of groundwater with parts of Chure range containing shallow and deep aquifers (Kansakar et al., 2004). The shallow aquifers are unconfined and well developed in most areas whereas the deep aquifers are confined. Bhabar zone is the main recharge zone for groundwater in the Terai region. It consists of sedimentary rocks along with boulders, cobbles and pebbles because of which it is highly permeable and immensely contributes to groundwater recharge (Pathak, 2016). Natural factors like climate, slope, drainage conditions, water–rock interaction and anthropogenic activities (extraction, pollution, mining etc.) contributes to the groundwater quality and chemistry (Rao, 2006). Change in hydrochemical characteristics reveals suitability for irrigation, agriculture, drinking and industrial purposes (Sadashivaiah et al., 2008). Many studies have found degradation in Chure hills responsible for reducing its water-holding capacity and, thereby, causing the off-season flows in the streams (Singh, 2016).

Despite the importance of groundwater signs of depletion of the water table, more groundwater is being extracted without proper implication impacting water balance (Villholth, 2006). The depletion of water table leads to change in chemistry and quality of water resource according to its geology and anthropogenic activities. Thus, this study aims to assess the groundwater's quality, chemical composition and usage along the periphery of Lal Bakaiya River.

Study area

The study area is Lal Bakaiya river basin (27˚15'00" N to 85˚20'00" E) located in Province 2, central southern part of Nepal which flows from Bara to Rautahat covering a total basin area of 868 km^2 (Figure1). The elevation of the study areas is from 245 m to 70 m Geologically, the study area can be divided into 3 regions: Terai and Bhabar in the south; Chure including Dun Valley in the middle; and the Mahabharat range in the north. The mean annual precipitation is 2,040 mm at Nijgad (Bhabar region). The study area experiences high intensity rainfall and flash floods (Dhakal, 2014; PCTMCDB, 2074; Pokhrel et al., 2013). The initial point of the study area lies in middle siwalik and lower siwalik and maximum area lies in recent geology. The landuse is dominated by agricultural field of sugarcane, banana and crops production. The urban areas are clustered in Nijgadh, Katahariya.

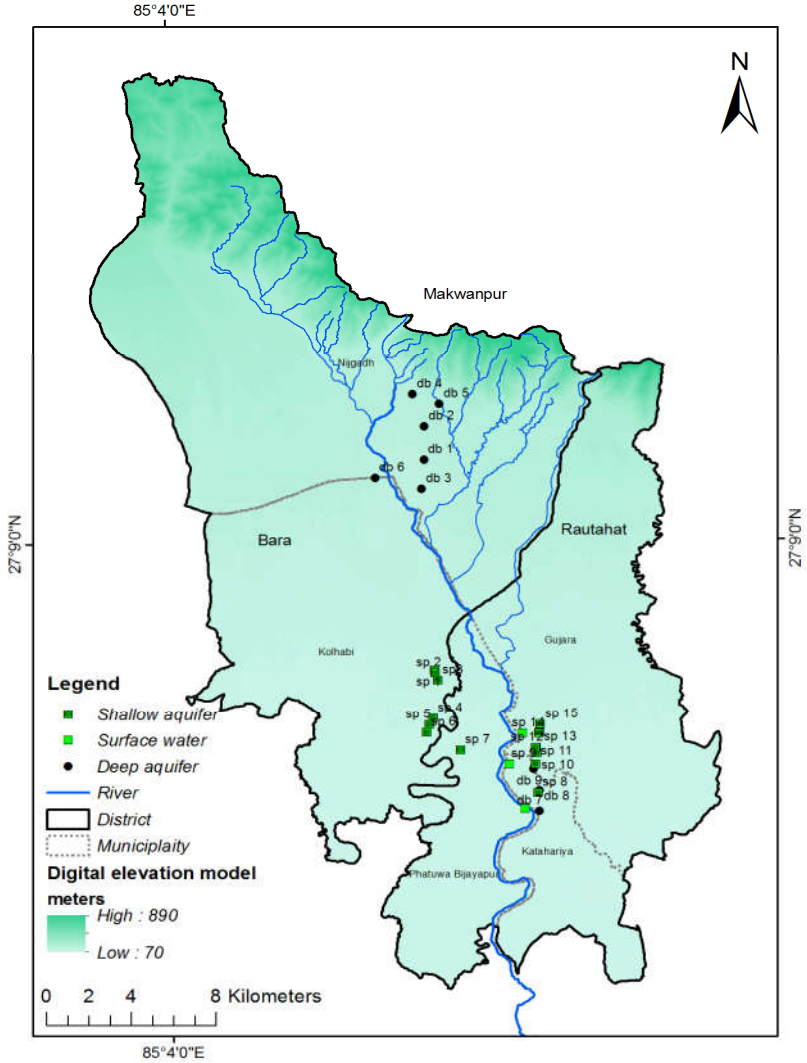

Figure 1 Map of the study area showing sampling sites with boundary of Bara and Rautahat district

Materials and methods

Sample collection

Twenty eight samples were collected from three sources; shallow aquifer (n=15), deep aquifer (n=10) and surface river water (n=3) based on convenient sampling within the buffer of 4 km from the river. Sampling was done from Feb 25 - Feb27, 2019 covering a stretch of 25 km. The water samples was collected in 1 liter PET bottle for ion analysis by rinsing with sample water initially. The samples were initially measured for physical parameters-hydrogen ion concentration (pH), temperature, electrical conductivity (EC), total dissolved solids (TDS), oxygen reduction potential (ORP), dissolved oxygen percentage (%DO), dissolved oxygen (mg/l) (DO), salinity and turbidity in laboratory. These parameters were measured by Hannamultiparameter kit HI-9829-13042 initially calibrated for all the parameters.

The cations and anions- Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Bicarbonate (HCO_3^-), and Chloride (Cl^-) was measured in Goldengate International College laboratory. The rest of the ions- Sulphate (SO_4^{2-}), Nitrate (NO_3^-), Sodium (Na^+) and potassium (K^+) was measured in Central Department of Environmental Science (CDES), Tribhuvan University. The summary of the method used and the instrument used for analysis of physio-chemical parameters are given in the table 1. For analysis of all the ions standard procedures, Trivedi & Goel (1986) and APHA (2005) was followed.

Table 1 Physio chemical parameters analysis

Parameters	Analytical method	Instruments
pH	Instrumental	pH meter, Hanna HI 96107
	Instrumental	Hanna multiparameter kit HI-9829-13042
Temperature	Instrumental	Thermometer
	Instrumental	Hanna multiparameter kit HI-9829-13042
EC	Instrumental	Conductivity meter, Hanna HI 8633
	Instrumental	Hanna multiparameter kit HI-9829-13042
ORP		
% DO		
DO(mg/l)		
TDS		
Salinity		
Turbidity		
Ca^{2+}	Volumetric Titration method	EDTA titration with murexide
Mg^{2+}	Volumetric Titration method	EDTA titration with Eriochrome Black T (EBT)
Na^+	Flame Photometric method	ESICO- 1382/1385
K^+	Flame Photometric method	ESICO- 1382/1386
Cl^-	Volumetric Titration method	Silver nitrate $AgNO_3$ (0.02 N) titration with potassium chromate (5%)
HCO_3^-	Volumetric Titration method	HCl (0.01 N) titration with methyl orange
NO_3^-	Spectrophotometric method	SSI 2101
SO_4^{2-}	Spectrophotometric method	SSI 2102

Analytical techniques

Classification and characterization of hydrochemical facies

Golden software (Grappher version 14) was used for preparing graphical analysis of Piper trilinear plot which is a combination of anions and cations triangles that lie in a common baseline. This diagram reveals similarities and differences among water samples because those with similar qualities will tend to plot together as groups. Samples points plotted in diamond shape of piper diagram was further classified into seven fields (designated with alphabets from A to G) using Langguth (1966) classification for Piper diagram of the analysis.

Gibbs diagram was used to interpret the effect of hydrogeochemical processes such as precipitation, rock-water interaction mechanism and evaporation on groundwater geochemistry. The reaction between groundwater and aquifer minerals has a significant role in groundwater quality which is useful to assume the genesis of water (Hwang et al., 2017). Gibbs ratio is calculated using the following equation (Gibbs, 1970).

Gibbs ratio I for anion = $Cl^{-}/(Cl^{-} + HCO^{3-})$
Gibbs ratio II for cation = $(Na^{+} + K^{+})$ $(Na^{+} + K^{+} + Ca^{2+})$

Groundwater quality analysis for drinking purpose

The resulted physio-chemical parameters was compared with Nepal Drinking water Quality standard NDWQS (2005) and WHO(1997)for permissible analysis of samples for drinking.

Groundwater quality analysis for agricultural usage

The amounts and combinations of soluble salts, proportion of sodium to relative cations, bicarbonate concentration to calcium and magnesium defines the suitability water for irrigation and the potential for plant toxicity. Parameters such as Sodium Adsorption Rate (SAR), Sodium Percentage (Na (%)), Residual Sodium Carbonate (RSC), Magnesium Hazard (MH), Kelly's Ratio and Potential Soil Salinity (PS) were used for estimating the suitability for irrigation purpose.

Table 2 Classification for agriculture usage

Items	Equation	Classification	References
SAR	$Na^{+}/\sqrt{[(Ca^{2+} + Mg^{2+})\ 2]}$	Excellent, Good, Permissible, Doubtful	Richards (1954)
Na (%)	$[(Na^{+}+K^{+})/(Ca^{2+}+Mg^{2+}+K^{+}+Na^{+})]*100$	Excellent, Good, Permissible, Doubtful	Wilcox(1955)
RSC	$(HCO_3^{-}+ CO_3^{-})-(Ca^{2+}+Mg^{2+})$	Good, Medium, Bad	Richards(1954)
MH	$[(Mg^{2+})/(Ca^{2+}+Mg^{2+})]*100$	Suitable, Unsuitable	Paliwal(1972)
Kelly's Ratio	$[(Na^{+})/(Ca^{2+}+Mg^{2+})]*100$	Suitable, Unsuitable	Kelly(1940)
PS	$Cl^{-}+ \sqrt{SO_4^{2-}}$	Excellent to good, Good to Injurious, Injurious to Unsatisfactory	Doneen (1954)

Principal Component Analysis

Principal Component Analysis (PCA) was used to determine data reduction, to assess the continuity/overlap of clusters or clustering/similarities in the data, and was used to determine the sources of variation between parameters.

Result and discussion

General hydrochemistry

The order of abundance of the cations concentration is $Ca^{2+} > Mg^{2+} > K^{+} > Na^{+}$ while those of the anions are $HCO^{3-} > Cl^{-} > SO_4^{2-} > NO^{3-}$. The representation of the major anions and cations of all the groundwater and surface water samples are shown in Scholler figure (Figure 2). The figure shows the variability and range of each anions and cations. Ca^{2+} and Cl^{-}shows major variability whereas, Na^{+} depicts the least variability. The major cations and anions of deep aquifer groundwater contributes 54.35% and 45.64% of TDS, respectively. However, the major cations and anions of shallow aquifer contribute 55.04% and 44.95% of TDS, respectively. The major cations and anions of surface water also showed similar contribution 55.98% and 44.01% of TDS, respectively. The concentrations of Ca^{2+} and Mg^{2+} in shallow aquifer were larger than deep aquifer and surface water, however, the concentrations of K^{+} was higher in surface water which might be because of presence of $CaCO_3$ and $CaSO_4$ minerals present in the soil due to evaporation of soil water and ion exchange minerals (Ramesh & Elango, 2012). The groundwater and surface water of the study region was neutral to slightly alkaline in nature which might be because of the HCO_3^{-}, the dominant anion in the groundwater ranged from 20.7 mg/l to 78.08 mg/l, which is produced by the reaction of the CO_2 present in soil space and rainwater (Madhav et al., 2018).

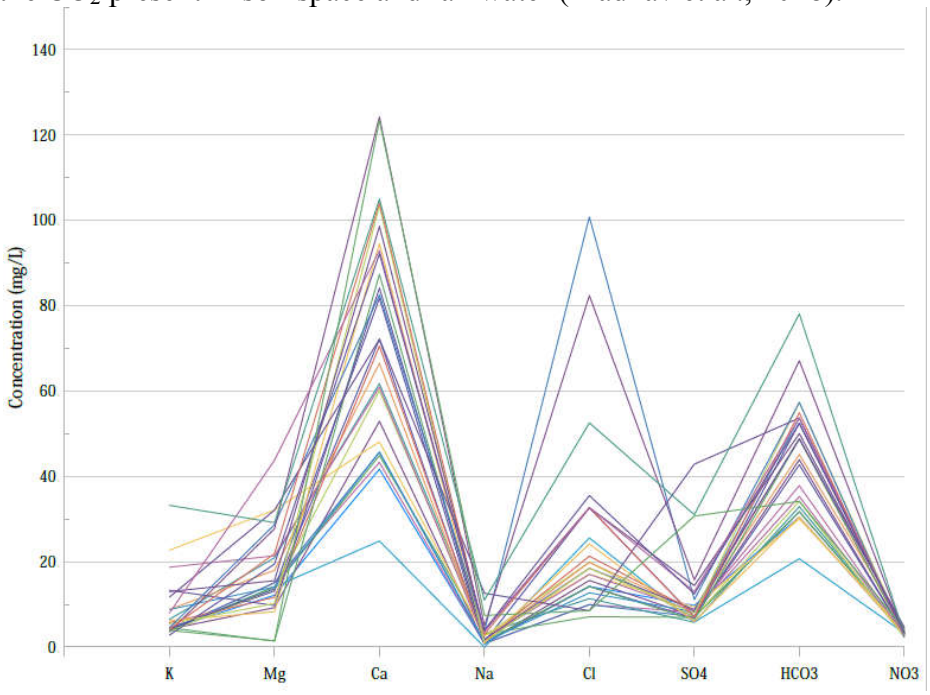

Figure 2 Scholler diagram showing all the cations and anions of 28 samples

Drinking water quality

The parameters such as pH, EC, TDS, Na^{+}, NO^{3-}, Ca^{2+}, Mg^{2+}, Cl^{-} were estimated to assess the suitability of groundwater for drinking in accordance to NDWQS and WHO. The WHO standard is stern than NDWQS so, all the samples are within desirable limit as NDWQS has broad range for rural groundwater drinking criteria. Of these parameters, sodium, nitrate and chloride concentration satisfied the WHO drinking-water quality recommendations. Two samples exceeded EC, TDS, high Mg^{2+} value and high Ca^{2+} concentration deeming unfit for drinking. In shallow aquifers, the EC is higher because of ionic substances (metallic ions, organic matters containing ionic charges, ammonium ions) in the groundwater table. The maximum concentration of Ca^{2+} is 124.24 mg/l of shallow aquifer and none of the shallow aquifers are used for drinking purpose, only for household activities. Hardness of water is due

to presence of soluble metal salts, particularly the calcium and magnesium carbonates which seemed high in shallow aquifers (Pant, 2011). Minimum amount of chloride estimated in groundwater suggest that the chloride rich minerals are not present in the groundwater table of the lowland.

Table 3 Comparing samples with WHO and NDWQS standards

Parameters	WHO (1997)	NDWQS (2015)	Comparing with WHO desirable limit	Comparing with NDWQS desirable limit
pH	6.5-8.5	6.5-8.5	0	0
EC	750	1500	2	0
NO_3^-	45	50	0	0
Ca^{2+}	75	200	13	0
Mg^{2+}	30	300	3	0
Cl^-	250	250	0	0
Na^{+*}	50	*	0	*
TDS*	500	*	0	*

*: NDWQS standard not available

Agricultural water quality

The study area was dominated as an agricultural land with the major use of water being used for irrigation purpose. Suitability of the water samples for irrigation are SAR (Excellent (100 %)), Na% (Excellent (100 %)), RSC (Good (100%), Kelly's ratio (Suitable (100 %)), MH (Suitable (96.5%), Unsuitable (3.5%)), PS (Excellent to Good (100 %)).

Table 4 Categorization of samples for irrigation purpose

Parameters	Water class	Range	Samples	Percentage
SAR	Excellent	<10	28	100
	Good	10-18	-	-
	Permissible	18-26	-	-
	Doubtful	>26	-	-
Na (%)	Excellent	<20	28	100
	Good	20-40	-	-
	Permissible	40-60	-	-
	Doubtful	60-80	-	-
	Unsuitable	>80	-	-
RSC	Good	<1.25	28	100
	Medium	1.25-2.5	-	-
	Bad	>2.5	-	-
MH	Suitable	>0	27	96.5
	Unsuitable	<50	1	3.5
Kellys ratio	Suitable	<1	28	100
	Unsuitable	>1	-	-
PS	Excellent to Good	<5	28	100
	Good to Injurious	5-10	-	-
	Injurious to Unsatisfactory	>10	-	-

All the values are negative and lie between -1.91 to -6.88 meaning samples are within the safe quality categories for irrigation. Negative RSC indicates that sum of carbonates is in excess of Ca^{2+} and Mg^{2+}, and can be precipitated as CO_3^{2-}(Hwang et al., 2017; Ranjan et al., 2013). But, Mahida (1981) reported that RSC is not a suitable index for determining the quality of irrigation water (Ramesh & Elango, 2012). The Ca^{2+} and Mg^{2+} ions maintain a state of equilibrium in most groundwater. In equilibrium, Mg^{2+} in water affects the soil by making it alkaline and results in decrease of crop yield. The result of this study shows that majority of samples were suitable for irrigation purpose and one deep aquifer sample was unsuitable for irrigation purpose and exert magnesium hazard. And, water with Kelly ratio of less than 1 is suitable for irrigation, while those with a ratio more than 3 are unsuitable for irrigation (Kelly, 1940). All the samples are within permissible level with respect to PS.

Electrical conductivity and sodium percentage

Sodium reacts with soil to reduce its permeability via osmotic pressure (Wilcox, 1955). High salt content in water leads to formation of saline soil affecting crop germination and yields (Hwang et al., 2016). As per the Indian standards (BIS, 2003), a maximum Na content of 60% is recommended for irrigation water. Classifying groundwater based on Na% and EC following Wilcox (1955) (Figure 3) shows that 92.8% of the groundwater samples fall in the fields of excellent to good region while 7.2% of the samples fall under good to permissible region for irrigation. The agricultural yields are observed to be high in the study area which is due to good circulation of air and water (Ramesh & Elango, 2012)

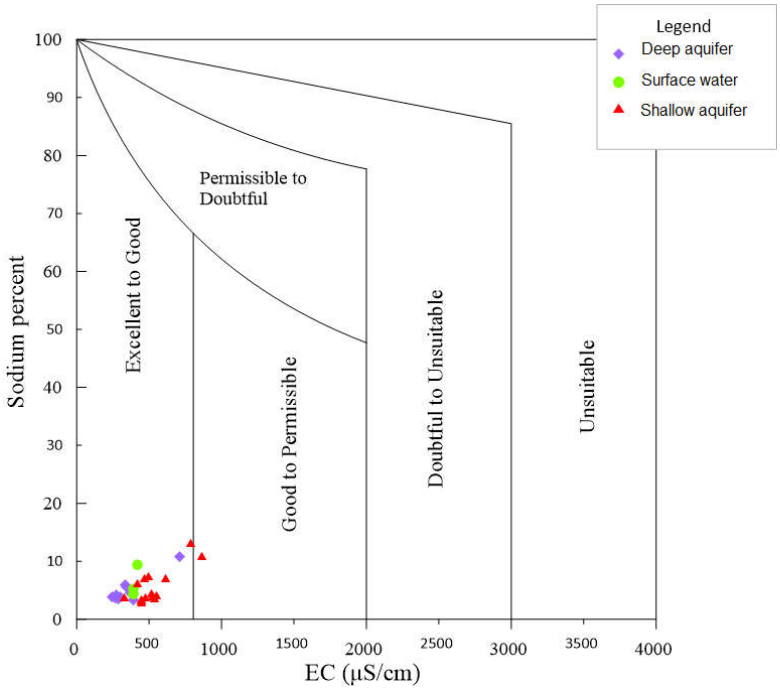

Figure 3 Wilcox diagram showing EC vs. TDS

Salinity Hazard

The sodium adsorption ration (SAR) indicates the effect of relative cation concentration on sodium accumulation in the soil; thus, sodium adsorption ration (SAR) is a more reliable method for determining this effect than sodium percentage (Deshpande & Aher, 2012). The plot of data on the US salinity diagram (Richards, 1954), in which the EC is taken as salinity hazard and SAR as alkalinity hazard, shows SAR content variation from 0.02 to 0.24 with an average value of 0.07 shows that most samples (89.2%) were classified as C2S1 which represents medium salty and low sodium which is a good range. This is due to enrichment of

EC and Na^+ concentrations (Figure 4). The elevated EC and Na^+ concentrations could be attributed to bedrock formation, saline soil, and agricultural activities, storage of animal waste and local contamination of domestic sewage. The moderate waters can be used to irrigate salt-tolerant and semi tolerant crops under favorable drainage conditions. The bad waters are generally undesirable for irrigation and should not be used on clay soils of low permeability.

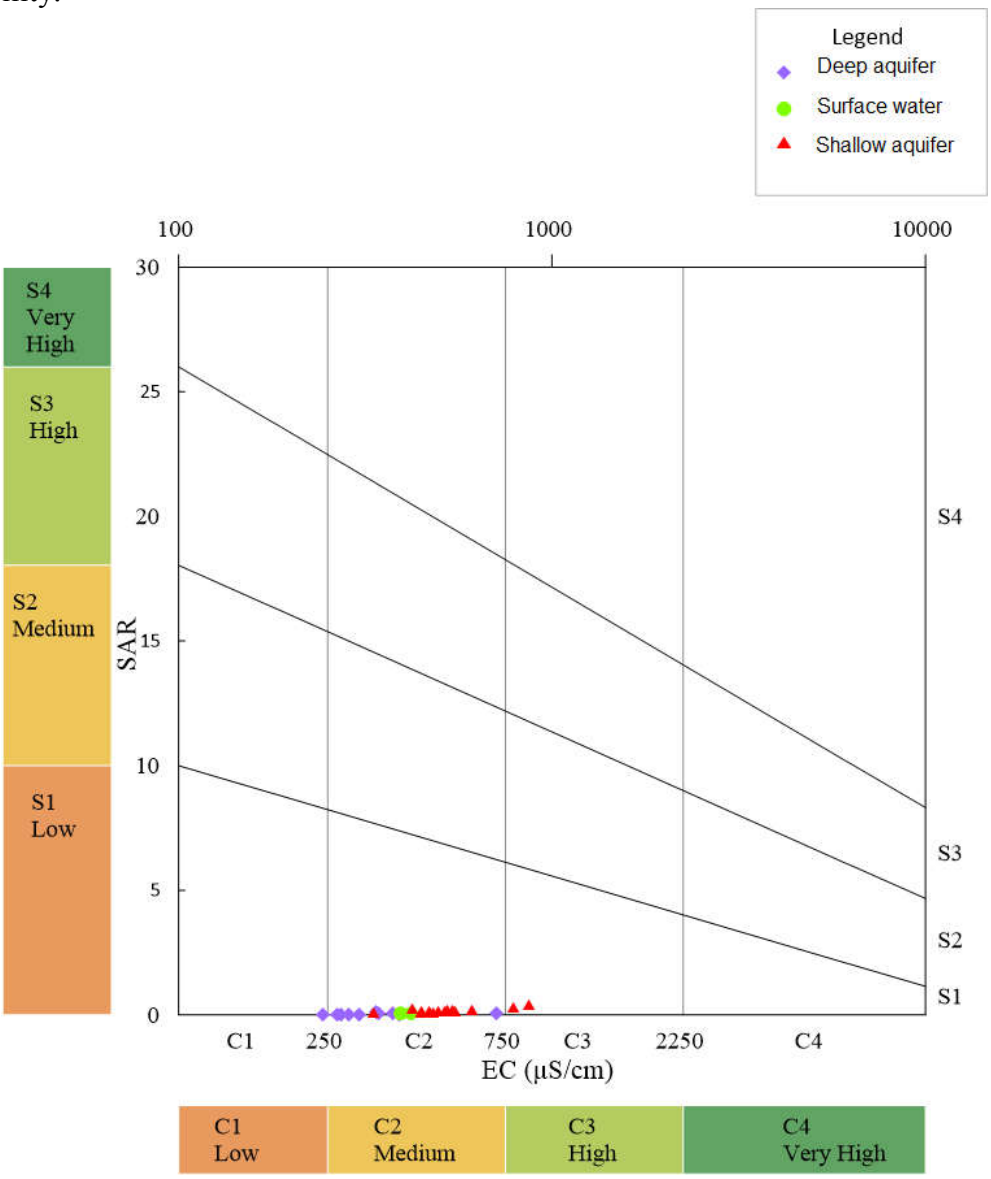

Figure 4 USSL plot showing EC vs. SAR

Hydro geochemistry facies

From analysis of the Piper trilinear diagram (Figure 4), it is apparent that majority of the samples (64.28%; 10 Shallow aquifer, 5 deep aquifer and 3 river samples) belong to Ca^{2+}-Mg^{2+}-Cl^--SO_4^{2-} (field I) demonstrating the dominance of alkaline earths over alkali (viz., Ca+Mg>Na+K) and strong acidic anions over weak acidic anions (i.e., $Cl+SO_4 > HCO_3$). Rest of the samples (35.71%; 5 Shallow and deep aquifer samples respectively) plotted under field (IV) belong to $Ca^{2+}Mg^{2+}HCO_3^-$ signifying the dominance of alkaline earths over alkali and weak acidic anions over strong acidic anions. None of the samples represented fields (II) and (III) and hence $Na^+K^+Cl^-SO_4^{2-}$ and $Na^+K^+HCO_3^-$hydrochemicalfacies are absent. The hydrogeochemical results shown in this study are confined only into two types as representing the carbonate dominant lithology in all the samples. Thus, and major water type

of study area is the $CaMgHCO_3$ type (Madhav et al., 2018). Here calcium accounts for 72.49% of total cations and bicarbonate accounts for 52.82% of total anions which indicates the carbonate dominated features. The major source of Ca^{2+} in the groundwater maybe due to ion exchange of minerals from carbonate rocks of this area (Ramesh & Elango, 2012) and the dominance of bicarbonate can be rationalized by the presence of carbonate rocks (Vystavna et al., 2015).

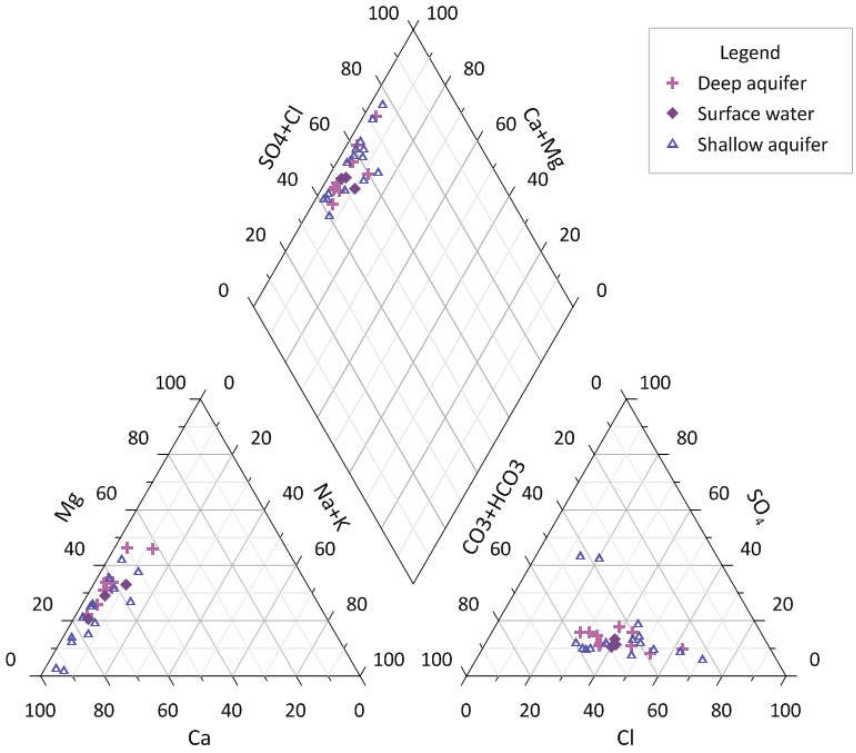

Figure 5 Trilinear piper plot of the samples

From Langguth table below (Table 5), the water samples from the study area were distinguished into three categories designated by A, B and C, the first category is characterized by normal earth alkaline water with prevailing bicarbonate (3.57%), The second is characterized by normal earth alkaline water with prevailing bicarbonate and sulfate or chloride (64.28 %); the third characterized by normal earth alkaline water with prevailing sulfate or chloride (32.14%).

Table 5 The Langguth category of trilinear piper plot

S.N	Water type	No. of sample	%
A	Normal earth alkaline water with prevailing bicarbonate	1 (Shallow aquifer)	3.57
B	Normal earth alkaline water with prevailing bicarbonate and sulfate or chloride	18 (7 Shallow aquifer, 8 Deep aquifer, 3 River)	64.28
C	Normal earth alkaline water with prevailing sulfate or chloride	9 (2 Deep aquifer, 7 Shallow aquifer)	32.14
D	Earth alkaline water with increased portions of alkalis with prevailing bicarbonate	-	-
E	Earth alkaline water with increased portions of alkalis with prevailing sulfate and chloride	-	-
F	Alkaline water with prevailing bicarbonate	-	-
G	Alkaline water with prevailing sulfate or chloride	-	-

Gibbs (1970) diagram enlightens about the hydrogeochemical procedures that influences of water-rock interaction, evaporation and precipitation in water chemistry. Gibbs diagrams, representing the ratios of Na^+: (Na^++Ca^{2+}) ranging from 0.05 to 0.34 and Cl^-:(Cl^-+HCO^{3-}) ranging from 0.13 to 0.63 as a function of TDS are used to assess the functional sources of dissolved chemical constituents, such as precipitation-dominance, rock-dominance and evaporation dominance. Gibbs plot specifies that all the sample of the study region is from rock dominance (Figure 6 and 7). Since the groundwater and surface water samples do not fall under evaporation end member, the constituent of Na^+ and Cl^- is also low supported by Piper plot thus, carbonate weathering is the main source of calcium and bicarbonate ions in the water (Gupta et al., 2008).

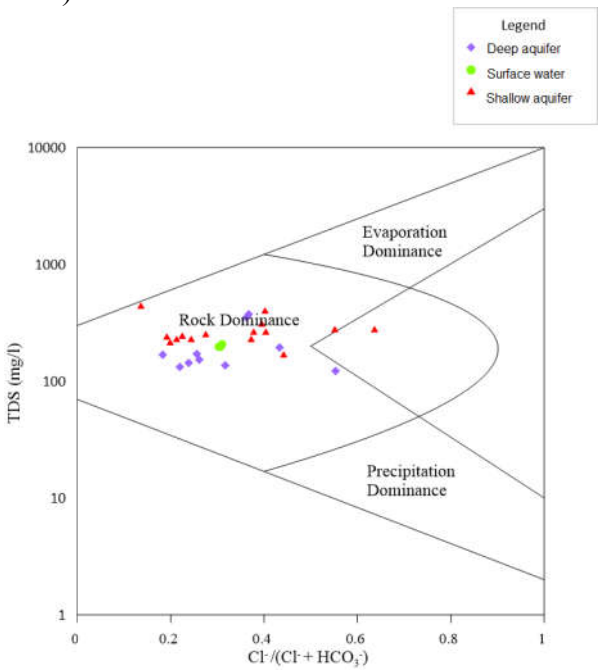

Figure 6 Gibbs plot showing TDS vs. anions

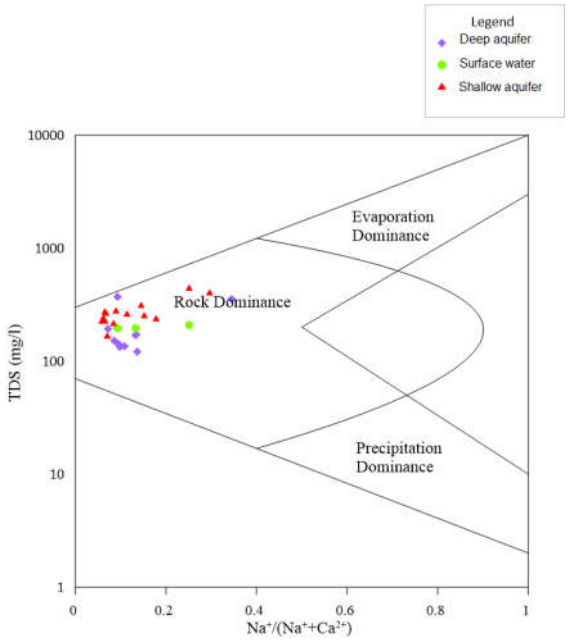

Figure 7 Gibbs plot showing TDS vs. cations

Correlation matrix

The correlation matrix exhibits the correlation among the different physiochemical parameters at 0.05 significant level. The highlighted values are considered for the relationship study consisting of moderate and strong correlation. There is strong positive correlation between EC and TDS (r = 1). NO_3 and Na^+ (r = 0.94), Na^+ and EC (r = 0.78), Na^+ and TDS (r = 0.73), NO_3 and TDS (r = 0.71) shows positive correlation. There is negative correlation between Cl^- and SO_4^{2-} (r = -0.28), Ca^{2+} and pH (r = -0.22), SO_4^{2-} and Mg^{2+} (r=-0.19) and Na^+ and pH (r = -0.18). The strong correlation between TDS, EC, Na^+, and NO_3^- indicates that these ions could be derived from the same source. Moreover, there was a significant correlation (r = 0.737; P< 0.05) between Na^+ with EC, TDS and NO_3^-, which might have originated from rock source. From the analysis of the major ions, it was observed that Ca^{2+} and Mg^{2+} were the dominant cations but are not strongly correlated.

Table 6 Correlation matrix of 28 samples

	pH	EC	TDS	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HCO_3^-	SO_4^{2-}	NO_3^-
pH	**1.00**										
EC	-0.10	**1.00**									
TDS	-0.10	**1.00**	**1.00**								
Ca^{2+}	**-0.22**	0.44	0.37	**1.00**							
Mg^{2+}	0.21	0.57	0.51	0.07	**1.00**						
Na^+	**-0.18**	**0.78**	**0.73**	0.45	0.46	**1.00**					
K^+	0.10	0.65	0.56	0.08	0.42	0.46	**1.00**				
Cl^-	0.26	0.32	0.28	0.44	0.44	0.22	0.07	**1.00**			
HCO_3^-	0.13	0.64	0.28	0.65	0.37	0.49	0.32	0.56	**1.00**		
SO_4^{2-}	-0.09	0.14	0.28	0.12	**-0.19**	0.01	0.16	**-0.28**	-0.03	**1.00**	
NO_3^-	-0.15	**0.71**	0.28	0.40	0.32	**0.94**	0.40	0.10	0.40	0.13	**1.00**

PCA

PCA of the pH, TDS, EC and major ions of the 28 samples with variance is shown in Table 7 and figure 8. Three components were extracted from principal component analysis method. The cumulative variance explained by the three components was 79%. The component PC1 explains 45.87% has strong loading on TDS, Na^+, EC and K^+; PC2 explains 15.18% with strong loading on Ca^{2+}, HCO_3^- and Cl^-; PC3 explains 12.24% of the total variance and has strong loading on pH, Mg^{2+} and NO_3^-,respectively.

Table 7 Principal component analysis of the physiochemical parameters of 28 samples

	Component matrix			Rotated Component matrix		
	PC1	PC2	PC3	PC1	PC2	PC3
Ca^{2+}	.579	.001	-.715	.181	.877	-.211
Mg^{2+}	.618	.405	.396	.636	.084	.540
Na^+	.873	-.219	-.001	.802	.371	-.169
K^+	.626	-.115	.533	.808	-.165	.095
Cl^-	.451	.715	-.306	.113	.667	.592
HCO_3^-	.741	.318	-.318	.438	.713	.226
NO_3^-	.068	-.596	.026	.189	-.148	-.550
SO_4^{2-}	.789	-.340	.008	.758	.289	-.284

	Component matrix			Rotated Component matrix		
	PC1	PC2	PC3	PC1	PC2	PC3
EC	.947	-.109	.116	.898	.339	-.023
TDS	.947	-.110	.117	.899	.338	-.024
pH	-.046	.639	.414	.020	-.194	.737
Eigen value	5.046	1.740	1.346	4.160	2.260	1.700
Variance (%)	45.874	15.819	12.240	37.840	20.600	15.480
Cumulative (%)	45.874	61.694	73.934	37.840	58.440	73.930

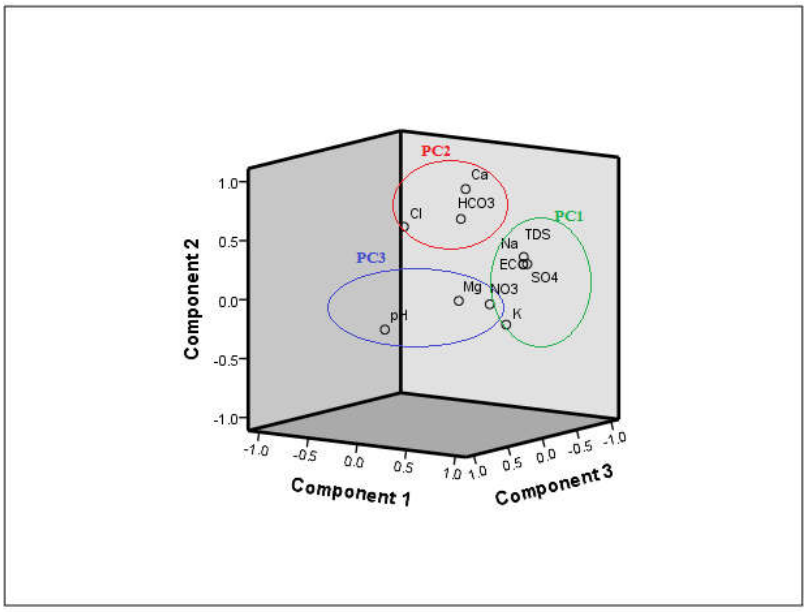

Figure 8 Factor loading plot of the principal component analysis

Conclusion

Hydro geochemistry methods was applied to study groundwater–surface water interaction, suitability for drinking purpose and irrigation uses and dominant hydro geochemical facies respectively. The overall result showed that the surface and groundwater in the study area is alkaline in nature. NDWQS and WHO standards, SAR, RSC, Kelly ratio, Magnesium ratio, Percentage sodium and Permeability index were the indices employed in this study. The results indicate that groundwater quality status is good for human consumption based on NDWQS and (46.4 % samples) slightly hard according to WHO standards. Moreover, the groundwater quality is also suitable for agricultural usage according to Kelly ratio, magnesium hazard. Based on the USSL diagram, most of the groundwater samples (89.2 %) fall under medium salty low sodium (C2-S1), which indicates suitability for irrigation purpose with no salinity problem. Surface water samples are good for irrigation in almost all type. Moreover, PS values indicate that surface and groundwater samples are suitable for irrigation. The conclusions derived indicate that the water is relatively free from pollution and anthropogenic influences except in few locations for salt water intrusion. The chemical composition of groundwater exhibited distinct spatial patterns with distance to river. The order of abundance of cations concentration is $Ca^{2+} > Mg^{2+} > K^{+} > Na^{+}$ while those of the anions is $HCO^{3-} > Cl^{-} > SO_4^{2-} > NO^{3-}$ in groundwater and similar in surface water. The type of water that predominates in the study area is Ca-Mg-HCO_3 type based on hydrochemical

facies. In Piper plot majority of surface water showed mixed Ca^{2+}-Mg^{2+}-Cl^{-}-SO_4^{2-} and Ca^{2+}-Mg^{2+}-HCO_3^{-}facies. Water rock interaction, including dissolution of carbonate mineral and silicate weathering (chemical weathering), was the dominant hydrogeochemical processes that affect the groundwater hardness (Ca^{2+} and HCO_3^{-}) in the study area as shown by Gibbs plot.

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Assessment of Mainstreaming Disaster Risk Reduction and Climate Change Adaptation in Local Disaster Management Plan (A Case Study of Manahari Rural Municipality, Makwanpur)

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Abstract
Mainstreaming of Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) activities in local disaster management plan is urgent for improving the sustainability of development. This study was carried out in Manahari Rural Municipality primarily to analyze the risk reduction and adaptation of climate induced disaster along with perception of stakeholders. For the study, primary data were collected using participatory tools viz. Key informant interview (KII), household survey (HH), focus group discussions (FGDs), etc. The finding from the study showed various DRR/CCA activities are being carried out in Manahari RM to cope with disasters.

A wholesum budget of NRs. 2,08,45,000.00 (US$185,519.76) was allocated in fiscal year 074/075 and this specific investment of budget and current planning process was a key factor that contributed to effective work. The local authorities have satisfaction and willingness to continue the activities in the future, whereas the community people were somewhat skeptical of it, at the same time they were willing to collaborate. In addition, study indicates the need of concrete adaptation plan that will respond to the local needs effectively.

Keywords: *Disaster, Climate Change, Budget, Community, Manahari Rural Municipality.*

Introduction
Nepal is among disaster hotspot and most climate vulnerable countries in the world (GoN, 2015). Nepal ranks 4th, 11th and 30th in terms of climate change, earthquake and flood risk respectively (MoHA, 2016). Fragile geophysical structure with greater climatic variability and poor economic condition have made Nepal vulnerable to natural disasters. 2017 floods caused a loss of USD 584.7 million and over 1.7 million people in 35 districts were affected (GoN, 2017). Earthquake of April and May 2015 killed nearly 8,857 people and injured more than 2,20,000 (GoN, 2015).

Makwanpur district due to its weak geographical structure is at high risk of disasters, especially its its Manahari Rural Municipality. Thus, the study was conducted with objectives to identify and review DRR/CCA activities, assess mainstreaming situation of DRR/CCA along with practices and perception of local authority and people and then recommend local authority to improve the DRR system through mainstreaming process.

Materials and Methods
Study area
This study was carried out in the Manahari Rural Municipality (MRM) of Makawanpur District, which lies in one of the disaster vulnerable districts (Pradhan, 2007) of the Bagmati province of Nepal. It is located in South Western part of Narayani Zone. The geographical position of the MRM lies between latitude 84042’35” to 85057’36” N and longitude 27023’34” to 27036’37” S.

This Rural Municipality (RM) is surrounded by Hetauda submetropolitan city and Raksirang RM in the North, Chitwan National Park in the West, RaksirangRMin East and Parsa National Park in the South covering an area of 199.52 km^2.It lies in a subtropical zone with an elevation ranging from 390-760 m above sea level. Administratively, it comprises of total 9 wards by merging the earlier Manahari and Hadhikhola VDC. Around 38,399 people from 7,891 households inhabit this area (CBS, 2018) comprising different caste/ ethnic groups of people. The majority of the ethnic groups were Tamang, Chepang, Brahmin/Chhetri, Rai, Dalit and Bankariya.

Patches of sissoo (*Dalbergia sissoo*), Khair (*Acacia catechu*) and simal (*Bombax ceiba*) forests were found along the banks of the Manahari River. Sustainable Action for Resilence and Food Security (SABAL), Birat Nepal Medical Trust (BNMT), Center for Community Development Nepal(CCDN) andNepal Red Cross Societyare the major organizations working in this sector. Based on vulnerability and risk towards disasters, 4 wards (6,7,8,9) of MRM were chosen for detailed analysis.

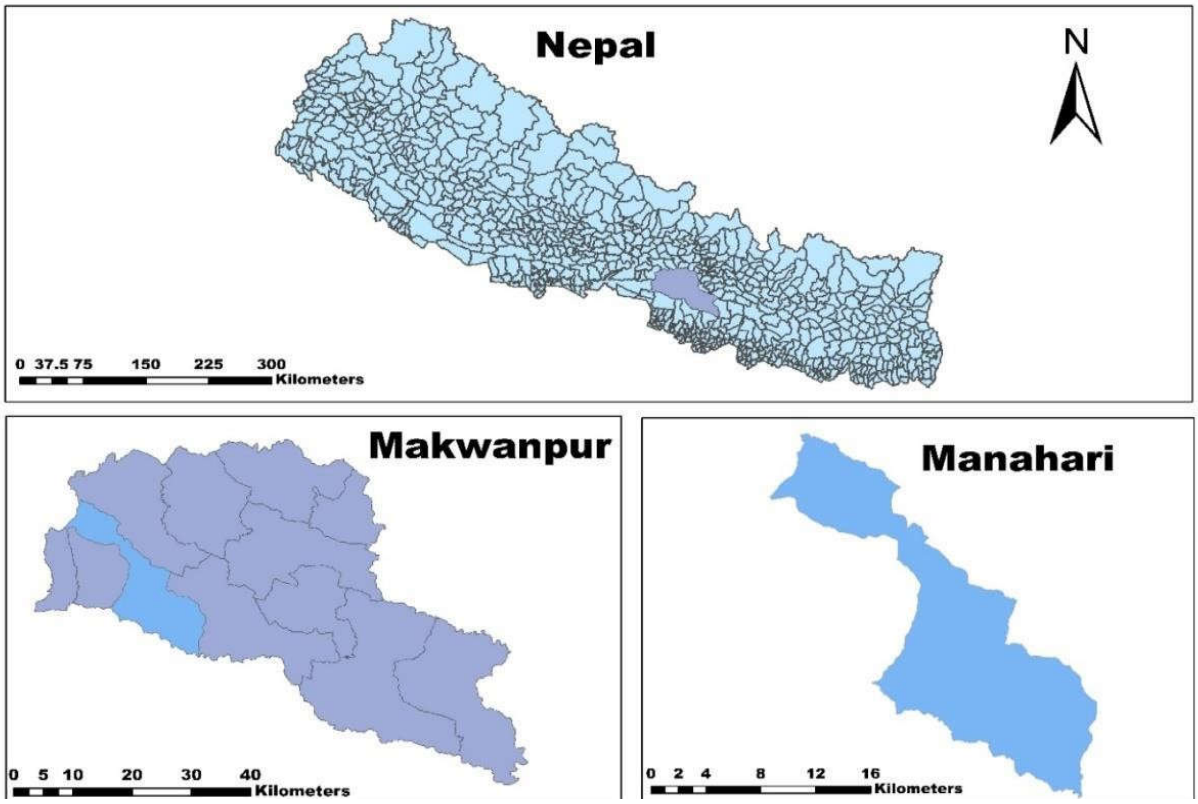

Figure 1. Location map of the study area

Sampling methods

This research is based on explorative research design. Field sampling was conducted in 2019 to find the objectives of the study. Data were collected using Participatory tools and methods i.e. Key Informant Interview (KII), Household Survey (HH), Focus Group Discussions (FGDs) and Direct Observation through Semi Structured questionnaires after the confirmation of respondent by pre-testing. Purposive sampling techniques was applied for selection of the respondents. A total of 87 households, 13 KII and 2 FGD surveys were conducted. Secondary data were collected from the sources likegovernment reports, journals, published and unpublished reports, articles and websites. All the gathered data from the field were categorized and fed in the computer and analyzed using MS Excel. Quantitative data were analyzed with the help of different statistical tools like percentage, mean, frequency, table,

figures. Similarly, the qualitative data were analyzed using a Likert scale with scale 1 representing strongly disagree and 5 to strongly agree.

Results

Respondents understanding of DRR/CCA

Out of the total 87 respondents, only 16 percent stated that they know about what the term DRR/CCA meant to some extent, whereas, 84 percent were unknown with the term 'DRR/CCA'.

There seems to be a great variation in male and female understanding of DRR/CCA. Male had greater understanding on DRR/CCA compared to female. Furthermore, the majority of respondents stated that they knew about DRR/CCA through CF meetings, training, NGOs and INGOs (CCDN, SABAL, Red Cross) and Media (Radio, Newspaper).

Ward overview: Disaster and climate change impact at household level

More specifically, 6,7,8,9 wards of Manahari RM were chosen based on the risks towards disaster/climate change.

Table 1: Risks faced by ward

Ward	Risks
Ward-6	Flood, Flash flood
Ward-7	Flash flood
Ward-8	River cutting
Ward-9	River cutting, Landslide

Disaster and climate change impact at household level

Fig 2. Shows that Ward-6 has faced the highest level of impact and ward-9 has faced the lowest level of impact. The majority of the community faced impact in agriculture production and physical assets.

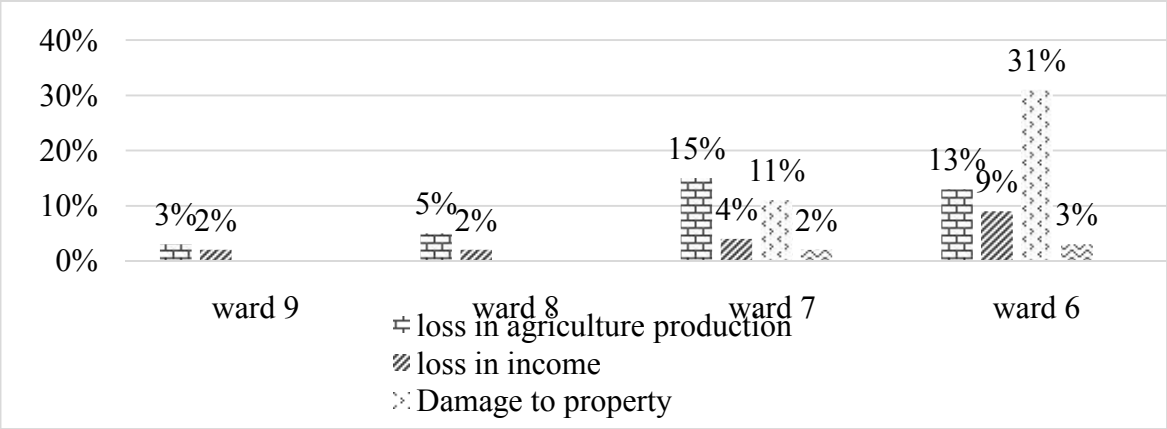

Fig 2. Disaster and climate change impact at household level

Activities related to DRR/CCA of fiscal year 2074/075 based on annual development work plan

Different activities related to DRR/CCA are carried out each year in Manahari RM to reduce the extreme of disaster/climate change. The activities related to DRR/CCA of fiscal year 074/075 on the basis of the annual development work plan in MRM are kept under the specific sectors or, through topics of Forest and Soil conservation, Watershed conservation,

Environment protection /Climate Change, Waste management/ Drainage management, Water induced disaster control and Agriculture.

For mainstreaming of DRR/CCA, separate budget for DRR/CCA activities has been allocated in the annual development work plan. A total amount of NRs. 2,08,45,000.00 (US$ 185,519.76) was included in the annual development work plan of Manahari RM for DRR/CCA related activities in the fiscal year 074/075.

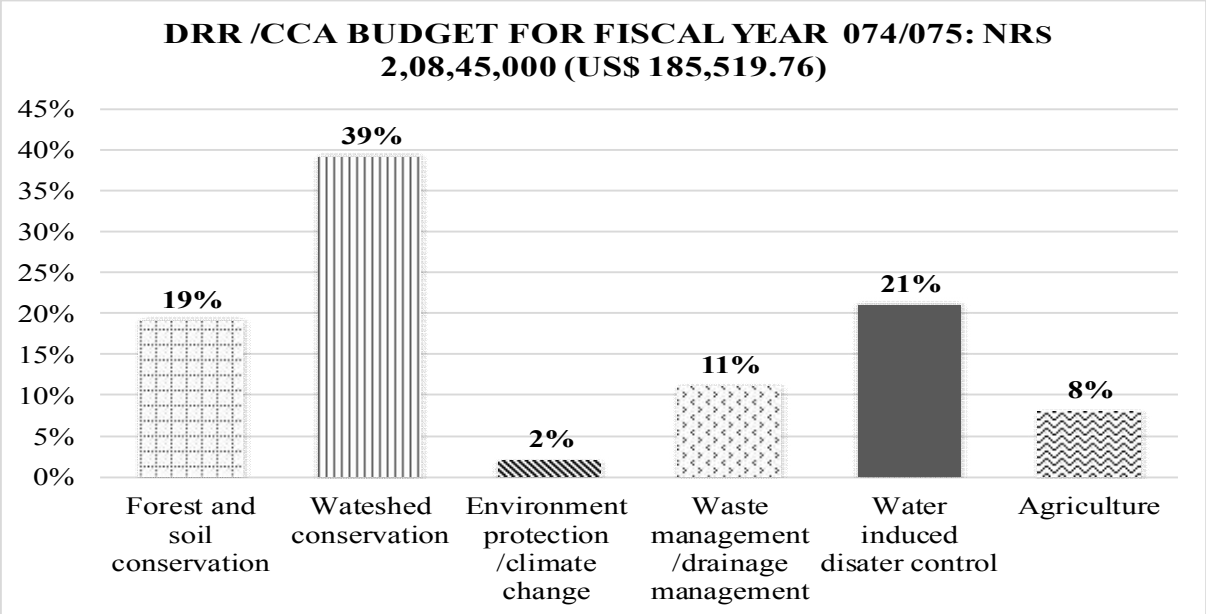

Figure 3. Distribution of budget 074/075 for DRR/CCA mainstreaming

Activities in the sector of forest and soil conservation

Table 2. DRR /CCA budget 074/075 for forest and soil conservation

Sector	Activity Type	DRR /CCA budget for Fiscal year 074/075: NRs 39,10,000.00 (US$ 34,798.86)	Budget (%)
Forest and soil conservation	Embankment construction	US$ 23,315.24	67%
	Slope stabilization	US$ 6,263.79	13%
	Community saving program	US$ 4,523.85	18%
	Earthing system	US$ 695.98	2%

Activities in the sector of watershed conservation

Table 3. DRR /CCA budget 074/075 for watershed conservation

Sector	Activity Type	DRR /CCA budget for fiscal year 074/075: NRs 82,20,000.00 (US$ 73,157.71)	Budget (%)
Watershed conservation	Purchase of chain link wire, gabion box &community conservation	US$ 20,484.16	28%
	Embankment construction	US$ 28,531.51	39%
	Community saving program & capacity building	US$ 8,778.92	12%
	Flash flood control	US$ 8,047.35	11%
	Culvert construction	US$ 7,315.77	10%

Activities in the sector of environment protection /climate change

Of the total budget distribution, 2% or NRs 5,00,000.00 (US$4,449.98) was included in the plan for the plantation at the site of non-registered government land. To carry out the overall work effectively '1 village, 1 nursery' was introduced in the year 2075.

Activities in the sector of waste management/ drainage management

Table 4. DRR /CCA budget 074/075 for waste management/drainage management

Sector	Activity Type	DRR /CCA budget for Fiscal year 074/075: NRs 22,50,000.00 (US$ 20,024.92)	Budget (%)
Waste management /drainage management	Public toilet construction and maintenance	US$ 13,416.70	60%
	Sanitation program	US$ 5,406.73	27%
	Drainage disposal & sewage management	US$ 2,603.24	13%

Activities in the sector of water induced disaster control

Table 5. DRR /CCA budget 074/075 for water induced disaster control

Sector	Activity Type	DRR /CCA budget for Fiscal year 074/075: NRs 43,65,000.00 (US$ 38,848.34)	Budget (%)
Water induced disaster control	Ravine, Gully & stream control	US$ 23,697.49	61%
	Wooden bridge construction	US$ 8,158.15	7%
	Embankment construction, maintenance	US$ 2,719.38	25%
	River diversion and control	US$ 2,719.38	7%

Activities in the sector of Agriculture

Table 6. DRR /CCA budget 074/075 for agriculture

Sector	Activity Type	DRR /CCA budget for Fiscal year 074/075: NRs 16,00,000 (US$ 14,239.94)	Budget (%)
Agriculture	Tunnel support	US$ 2,705.59	19%
	Construction of agriculture product collection center	US$ 8,828.76	62%
	Village level agriculture committee formation	US$ 2,705.59	19%

Practices and perception of Local authority and people for mainstreaming DRR/CCA

Local authority Perception on level of effectiveness of mainstreamed DRR/CCA activities along the Manahari area

Out of 13 KII respondents, 31% were positive about the mainstreaming work and thinks that the implemented DRR/CCA activities holds a high level of effectiveness.Whereas 54% find out the activities that are being implemented are moderately effective and the more activities need to be mainstreamed in the annual plan for high effectiveness and remaining 15 % neither think it needs more importance nor less.

People perception towards government work for mainstreaming DRR/CCA

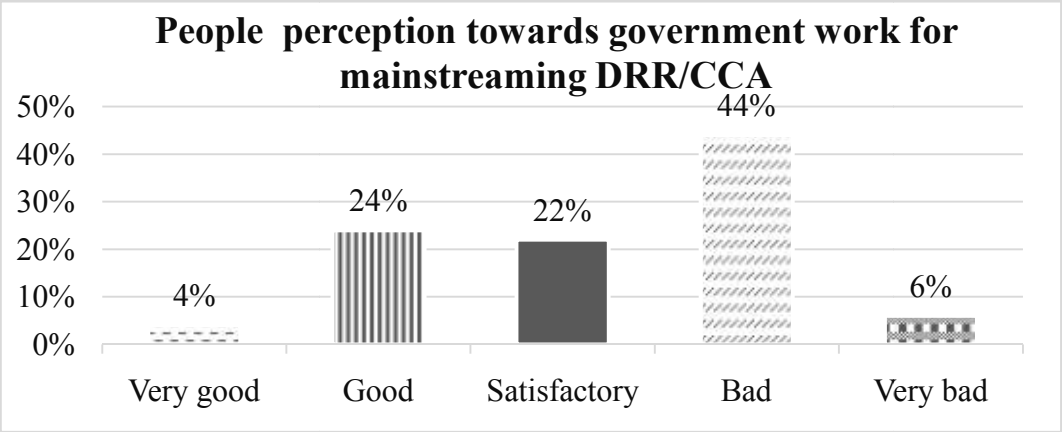

Figure 4. People perception towards government work for mainstreaming DRR/CCA

Figure 4. Shows, higher number of negative responses of people compared to positive responses. The study indicates that the activities and practices carried out by RM executives were not yet sufficient to address the voice of vulnerable communities.

Practices of Local authority on budget allocation

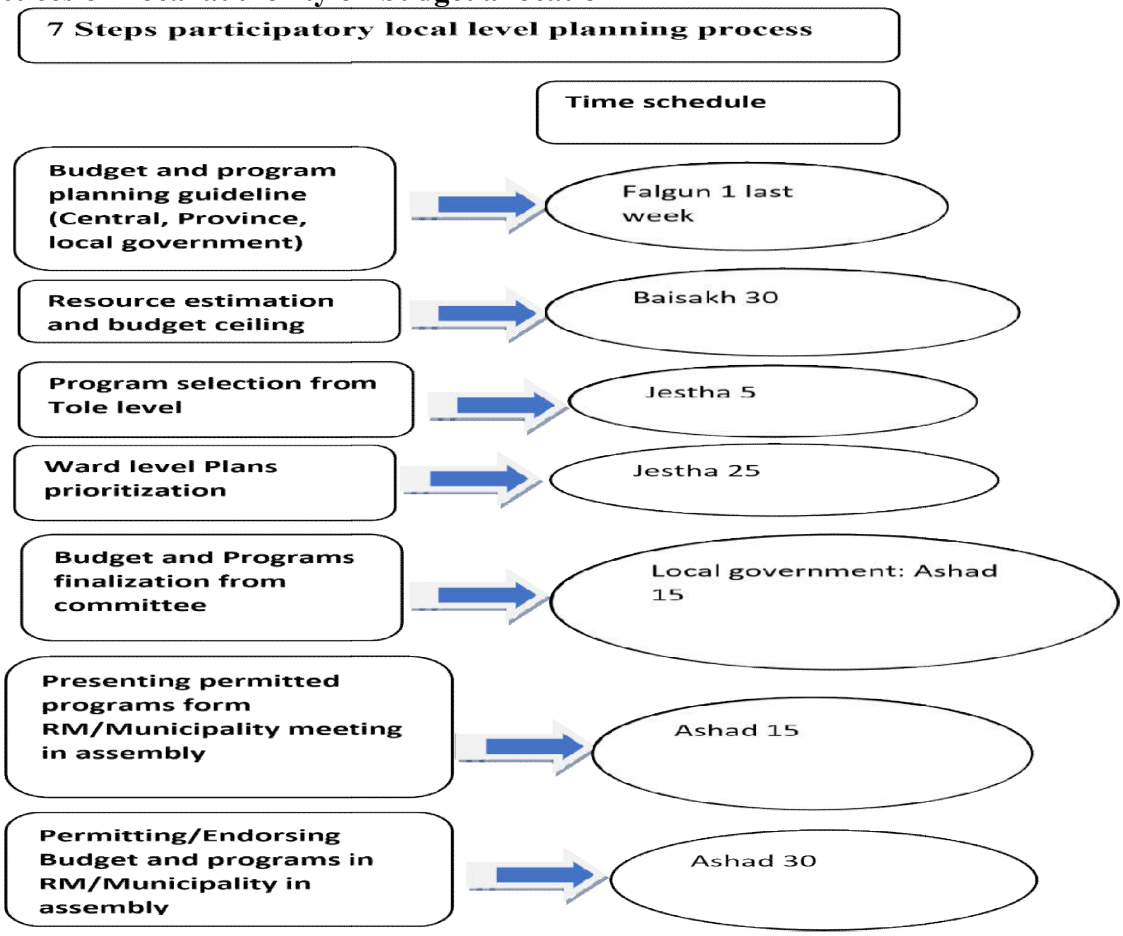

Figure 5. Seven steps of participatory local level planning process on a new structure

Due to change in an old structure to a new structure, it consists of seven steps of the local level planning process and with this change, the activities were being carried out precisely and the voice of poor and vulnerable communities was heard even more.

Discussion

Disaster risk reduction is most effective at the community level where specific local needs can be met. When used alone governmental and institutional interventions often prove to be insufficient (DGCD, 2011). This research shows that the newly formulated structural changes have somehow provided a better facilitative environment, making people engaged in the planning and implementation of DRR/CCA more than ever. However,DRR/CCA mainstreaming was much more successful in Kailali district (Joshi, 2018). The LAPA framework was adopted as a National Framework in 2011 by the Government of Nepal. In response to this framework, NCCSP facilitated the preparation of 70 LAPAs in 14 program districts of the Mid and Far West regions of Nepal (NCCSP, 2016) which includes 14 districts of province 5 ,6 and 7.

According to the Previous study, the total amount of budget distribution of Kailali RM in DRR/CCA in 073/074 was NRs 1,23,00,000.00 (US$100,768.02) (Joshi, 2018). Through the overall analysis of 074/075 budget investment in DRR/CCA activities; preference was given to the budget investment than the proper formulation of policy. Though, Makawanpur is listed as one of the disaster vulnerable district few concrete plans have been prepared, especially in its Manahari RM compared to other districts like Kailali. Beside this, A few satisfactory results were observed through KII like local disaster management committee formation in most of the wards, various trainings and awareness programs on preparedness, rescue and relief implementation of technology for early warning system. All of these mentioned programs can be a great pathway to address the voice of poor and vulnerable communities, but needs to be implemented in every ward of Manahari.

Communities are the first responders in case of any disasters (CBDRM, 2018). Regarding this, their perception on DRR/CCA is also an important consideration to bring out the positive change. Our study showed, negative responses to be greater than positive responses. This increase in negative perceptions was because of the lack of concrete DRR/CCA plan and less peoples' participation to address the current prevailing environmental issues. Communities who participated more in the planning, implementation of Disaster /Climate change activities expressed more positive responses and were able to respond to the crisis more effectively.

Conclusion

From the study, it is concluded that the overall performance of mainstreaming work is satisfactory in case of Manahari RM. The implemented DRR/CCA activities by RM and NGOs/INGOs (CCDN, SABAL, Red Cross) seem to be popular among the community. Introduction of various practices such as provision of early warning system, embankment as well as check dam construction and plantation activities carried along the bank of Manahari river were well known among the community members as well as the introduction of off-season vegetable farming, tunnel farming, river bank farming, improved seed distribution and agricultural techniques seem to have visible positive impacts on community people.

Through the implementation of these DRR/CCA related activities, it has somehow built up the capacity of households and communities to mitigate, adapt to, and recover from shocks and stresses and have contributed to achieve a better quality of life by creating opportunities for better livelihood outcomes. However, all of these measures were inadequate considering people’s needs. Despite the ongoing efforts, frequent floods and flash floods in Manahari River and landslides over the hills during monsoon season have caused environmental stress on their livelihood. So, the major gap identified in this RM was a lack of concrete adaptation plan and lack of people’s participation in implementing DRR/CCA activities.

Therefore, much effective implementation of LAPA and LDRMP would have provided a route for adaptation and would have ensured the participation of vulnerable local people in selecting, prioritizing, planning and implementing climate change adaptation activities to adapt to the adverse impacts of climate change/disaster.

Recommendation

To strengthen the DRR/CCA mainstreaming and ensure the sustainability of DRR/CCA in developmental work and effectiveness of the plan, a set of recommendations are made based on an analysis of the overall implemented activities, findings of this study and existing literature.

- LAPA, LDRMP should be integrated into the planning process to address the disaster/ climate change impacts with people's participation. There should be an engagement of local people in every step from selection, prioritization, planning to implementation.
- The DRR/CCA committees like LDMC should be inclusive and it should ensure participation of vulnerable group and people with disabilities to provide barrier free access support and attention in necessary. In addition, Indigenous knowledge and practices should be promoted to enable communities to increase their resilience against the impacts of climate change and disaster.
- DRR/CCA should be mainstreamed into the education system in order to help raise awareness and DRR /CCA focal persons, local leaders, local facilitators should be well trained for its effective mainstreaming.

Acknowledgement

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Baseline Study for Ecotourism Development in Nepal: Reflection from Chitwan and Ghorepani

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Abstract
In this paper two research sites were selected for study- Chitwan National Park (CNP) in Terai region and Ghorepani Hill of Annapurna Conservation Area (ACA). Both sites were selected for baseline study of ecotourism from environmental lenses. Smokeless practice in tourism is known as ecotourism, no harm to natural, cultural and geographical setting which ultimately renders sustainability concept in tourism. Promotion of ecotourism in this region depends upon utilization and mobilization of locally available natural resources with existing traditional community culture. The success of ecotourism in CNP reflects the need for conservation, communities and demands to go hand in hand. Ghorepani lies in Annapurna Conservation Area Project (ACAP) which is largest undertaking of National Trust of Nature Conservation (NTNC). From the findings of this paper we can conclude that ecotourism is outcome of active participation of local people in resources conservation. Tourism and related campaigns are vital in ecotourism but implementations of those campaigns are major concern.

***Keywords**: Indigenous peoples, Biodiversity, Ecosystem, Wildlife, Natural Resource Management*

Introduction
Ecotourism gives priority to ecological resource integrity, environmental conservation, community development and economic development by maintaining low-impact and non-consumptive use of local resources. There are different forms of ecotourism developed worldwide as community based ecotourism, ecosystem ecotourism, cultural ecotourism, nature based ecosystem, protected area ecotourism and rural ecotourism (K.C, 2017). Ecotourism also called environmental friendly tourism is one of the best mechanisms to explore local products to all over the world via protection, preservation and participation of local or indigenous people. Local people are experts in endogenous development. CNP and Ghorepani are two well established ecotourism destinations lying in two different geographical parts of Nepal. Both have unique and separate baselines for the development of ecotourism. The objective of this study is to identify those baselines of these two destinations that can be implemented while set up of new ecotourism destinations in other part of the country.

Materials and Methods
Chitwan National Park is situated in south central Nepal in inner terai of Chitwan, Makwanpur, Parsa and Nawalparasi districts. It lies between $27^0$16'56"N to $27^0$42'14"N latitude and $83^0$50'23"E to $84^0$46'25"E longitude. The altitude ranges from 110 m to 850 m above sea level (masl). Ghorepani is a village in Myagdi district at an elevation of 2874 masl and between 28° 23′ 55″ N latitudes and 83° 41′ 57″ E longitudes. The village lies within Annapurna Conservation Area (ACA).

This study is based on field visit, questionnaire and interaction with stakeholders. Field visit was conducted during first week of Kartik, 2073 in Chitwan National Park and again during second week of Baisakh, 2074 in Ghorepani village of Myagdi district. Wide range of stakeholders viz. Government officials, park authorities, hoteliers, CFUGs, local people and other concerned agencies were interacted. Questionnaire was used during interaction. Primary and secondary data were used in this article. Different secondary papers, journals, books, research papers and articles were reviewed.

Results and Discussion

I) Chitwan National Park

The Chitwaniya Tharus' neighboring forest was declared a hunting reserve in 1963. In 1973 His Majesty Late King Mahendra approved it as the first National Park because of its potential of environment for Rhinoceros and Tiger preservation (Kunwar, 2000). The park is bounded by the Rapti and Narayani River in the north, Parsa Wildlife Reserve in the east and Madi settlements and India border in the south. Triveni ghat is on the Narayani River which is a holy site for bathing. It attracts most of the nepali and Indian pilgrims especially on Maghe Sankranti. Valmiki Ashram, Kamal-nainacharya Ashram, Gajragaha near Triveni Ghat and Siddha Baba temple in Nawalparsi district are other sites for seasonal tourist flow. Chitwan National Park is a world heritage property which was enlisted as a World Heritage Site in 1983. One very important part of the CNP so far, is Nepal Army. NA acts as frontline conservation heroes in this park. CCTV is installed in the park region and by East-West highway to control the vehicle speed, minimize poaching and other criminal activities. CNP has been able to mark two consecutive years of zero poaching due to such vigilance. On the other hand, Biodiversity Conservation Center (BCC) regularly monitors birds, rhino, tiger and their base prey. BCC has undertaken various conservation initiatives from single species conservation to landscape level biodiversity conservation. Also, it has established Vulture breeding center recently to revive the shrinking population of species of vultures. The joint effort of different organizations like NTNC, BBC and WWF has placed a significant role in management and conservation of Park.

Some major highlights of Chitawan National Park are; a) Second largest population of the Greater One-horned Rhinoceros in the world. b) Home to more than 120 Royal Bengal Tigers, Gaur Bison, Gharial Crocodile, Elephant, bird species. c) Elephant breeding center at Khorsor and Gharial Crocodile breeding center at Kasara. d) Elephant safari and Canoe riding, Bird watching, Village tour, Tharu culture and Churia hills and Madi valley and the last e) Community forests.

II) Brief introduction to Ghorepani

The Ghorepani lies within Annapurna Conservation Area (ACA). This area surrounds the entire range and foothills. This place lies in Mygdi district and 17 kilometers far from district headquarter Beni. The village area has a diversity of ecosystems, including terraced landscape, pristine natural scenery of Rhododendron forests and incredible Himalayan views. Major attractions of this area are: a) Natural Hot Spring in Tatopani, b) Typical Magar and Gurung villages. c) Stunning sunrise and breathe taking Himalayan panorama, and d) Asia's Biggest Rhododendron Forest alpine trees.

There is a subcommittee that conducts forest management and wildlife management activities, soil and water conservation, training for local nursery workers, forest guards and leaders, promotion of alternative energy and fuel-efficient technologies, etc. Rhododendron forest is dominating flora in the area. The local people are not allowed to cut Rhododendron

trees. Permission of committee is compulsory needed to collect even the dried wood products of the forest. The enforcement mechanism for forest and wildlife conservation is community-based with the forest guards being hired by community.

Baselines of ecotourism identified in CNP and Ghorepani

i) Wildlife

Wildlife is the main base of tourism destination in Chitwan National Park. The park was introduced by Government of Nepal for Wildlife and biodiversity conservation. With the time being, it was converted as tourism destination along with biodiversity conservation. The park is home to more than 68 species of mammals, 55 species of amphibians and reptiles, 546 species of birds and 120 species of fish (DNPWC). The endangered fauna found in the park include the One-horned Rhinoceros, Gaur Bison, Royal Bengal Tiger, Wild Elephant, Four-horned Antelope, Pangolin, Golden Monitor Lizard, Python, Bengal Florican, Lesser Florican, Giant Hornbill, Black Stork and White Strock (DNPWC). Besides, CNP is one of the best places in the world to watch rare bird species. In the winter, migratory birds from as far as Siberia as well as other places reach CNP; join local birds providing birds watching opportunity.

Ghorepani village is one of the most popular villages for trekking in Nepal which provides excellent views of Himalayan panorama of Nepal. The tantalizing glimpse of high mountains that is Dhaulagiri, Annapurna, Nilgiri, peak of Macchapuchhre (Fish-tail peak), Baraha Sikhar, Manaslu, Tukche peak, Thakpa peak, Butterfly peak consists most spectacular mountain escape. This trek in Annapurna foothills to the view point on Pun Hill offers all the best of trekking in Nepal. Ghorepani lies on a major trail linking several other villages as well as Annapurna Base Camp. The trek route from Tatopani to ghorepani passes through villages of Dana, Shikha and Chitre.

ii) Physical attributes

CNP is considered as third most popular destination for tourism in Nepal. Bharat Airport is the nearest airport to this park. It is connected by Mahendra East-West national highway and is easily accessible from Kathmandu. The physiography of the park consists of the Terai and Siwaliks. The area comprises Tikauli forest from Rapti River to the foothills of the Mahabharat. Hence, research is highly possible in this area because of being rich in biodiversity and ecosystems. CNP shares the eastern boundary with the Parsa Wildlife Reserve and southern boundary with the Balmiki Tiger Reserve in India. Beeshazaari and associated lakes is in buffer zone of the park, were declared wetlands of international importance under the Ramsar Convention in 2003. In 1963, the area to the south of the Rapti was declared a rhino sanctuary. At Present days, Rhino is taken as the hallmark icon of this park.

Ghorepani lies in Annapurna Conservation Area Project (ACAP) which is largest undertaking of National Trust of Nature Conservation (NTNC). There is an ACAP subcommittee in Ghorepani which performs the different conservation activities. The subcommittee conducts forest management and wildlife management activities, soil and water conservation, training for local nursery workers, forest guards and leaders, promotion of alternative energy and fuel-efficient technologies, etc. Permission of committee is compulsory needed to collect even the dried wood products of the forest. The enforcement mechanism for forest and wildlife conservation is community-based with the forest guards being hired by community.

CNP has become tourism destination because of its natural beauties. It consists of tropical and subtropical forests with mostly Sal *(Shorea robusta)* forests covering about 62% of the

areas. Grasslands cover about 12 per cent of the park (DNPWC). An area of 750 km^2 surrounding the park comprises a buffer zone, which consists of forests and private lands including cultivated lands. The park authority and the local people have jointly initiated community development activities and sustainable management of natural resources in the buffer zone. National Park and Wildlife Conservation (NPWC) Act 1973 has made provision to retain 30-50% generated revenue by the respective park for buffer zone community development and conservation purposes (HMG/N, 1996). Therefore, half of the revenue collected by the CNP is invested in its buffer zone.

iii) Environmental concern

The authority of Chitawan National Park conducts trainings and campaigns for the park employees time to time such as Wildlife training and waste management. The responsibility of collection of waste, home-stay waste collection, river garbage has been provided to Municipality. Environment day is annually celebrated with campaigns of sanitation and cleanliness in the park. Plastic is strictly prohibited throughout the park area by Government of Nepal. Alternative energy are promoted by Community forest users' group by distribution of solar and biogas. Wooden bridge constructed near Beeshazaar lakes adds beauty to the lake. CNP Air quality Observatory has been established by ICIMOD in collaboration with NTNC to monitor air pollution at the periphery of National Park. There is a tourist management subcommittee in Ghorepani. The subcommittee conducts clean-up campaigns regularly in order to maintain sanitation in the villages and trekking routes. Waste produced by trekkers is collected and is managed by reusing, burning, dumping and selling to the waste collectors. Workers are appointed in each ward. The committee provides remuneration to sweepers to keep the area clean. The committee collects revenue from internal as well as external tourists and uses it in health post maintenance support, drinking water supply, etc.

The Annapurna region contains Asia's largest rhododendron forest in Ghorepani. This region has wide spectrum of endemic, rare and medicinal types of vegetations. Plant species distributions in this region are Laligurans *(Rhododendron arborum)*, *R. barbatum, R. lepidotum, R. campanulatum,* Chilaune *(Schima wallichii),* Pine *(Pinus roxburgii),* Kharsu oak (Quercus lamelossa), *Q. semecarpifolia*, Himalayan fir *(Abies spectabilis),* Himalayan yew *(Taxus baccata),* Orchid, etc. Some of the rare animal species found within this region are barking deer *(Muntiacus muntjak)*, Ghoral *(Nemorhaedus ghoral)*, Himalayan bear *(Selenarctos thibetanus)*, Musk deer *(Moschus chrysogaster)*, Snow leopard *(Panthera uncia)*, Red panda *(Ailurus fulgens)*. This region also has habitats of various types of springs and autumn birds migrating from India and China as well as from other places.

iv) Socioeconomic aspects

Many indigenous groups of Chitwan and other ethnic communities live around CNP buffer zone. The indigenous groups include Tharu, Kumal, Chepangs, Musahar, Bhotes,etc. Among these, Tharu community is the largest indigenous group to live there. After the CNP establishment, these communities have felt drastic influence in their socioeconomic status. CNP provides great opportunity in uplifting their livelihood and lifestyle. At least one the family member from each household is engaged in some type of job related to CNP and tourism like elephant's caretaker, mahouts, nature guides, jungle drive, elephant safari, machan observation, birds watching, canoe rowers, hoteliers, hand crafters, etc. Women User's Group in Sauraha is organized to empower women, offers variety of handicrafts. Tharu culture is a unique and exclusive culture in Nepal. Tourists enjoy visiting Tharu village in the name of "Tharu Village Tour" in ox-cart ride to see their traditional culture, lifestyle, art, crafts and practices. Tharu home-stay and Chepang village home-stay trekking provides

opportunity to explore and observe lifestyle of these communities. Tharu cultural museum aims to preserve the endangered Tharu culture. Half of the revenue collected by the park is spent in community development activities along with buffer zone upgrading. Similarly, Community Forest Users' Groups also spent few of the collected revenue on community development works together with forest conservation.

- **Tourism Management: The subcommittee focuses on** programs like formation of local lodge management committees with hotel and lodge management training for lodge operators, brochure and publicity materials, information posts, visitor centers, helicopter evacuation for visitors for search and rescue during emergency, training for trekking guides and eco-camp site development, etc.

- **Conservation, Education and Extension:** Programs like conservation education classes in schools with conservation awareness camps, indoor and outdoor conservation education centers, education materials development, village clean-up campaigns, visitor information services, study tours and training for villagers, etc.

Conclusion

The origins of the term “ecotourism” are not entirely clear, yet it can be said that ecotourism is the outcome of environmental movement of 1970s and 1980s (Blamery, Encylo. Eco p. 5, cited from Bhatt, 2015).

The term 'Ecotourism' is derived from the concept of sustainable development. It involves a focus on nature as the primary motivation for travel and regarding further natural knowledge and awareness . However, it also involves the notion that the activity of ecotourism must positively contribute to conservation in the destination area or host community. This sector generates local employment, both in the tourism sector and in various support and resource management sectors. Ecotourism is a road to protect the natural environment and create social and economic benefits for local communities. Its aim is to conserve resources, especially biological diversity, and maintain sustainable use of resources which can bring ecological experience to travelers, conserve the ecological environment. Ecotourism encompasses a spectrum of nature-based activities that foster visitor appreciation and understanding of natural and cultural heritage and are managed to be ecologically, economically and socially sustainable. Therefore, ecotourism is accepted as an alternative way of sustainable development.

Nepal is nature lover’s paradise. It is very small Country but has a diversity due to its topographical variation. Nepal has a varied and rich species of fauna. Nepal has tropical, sub-tropical and alpine climates with natural differences in its flora and fauna within its small compass (Satyal, 2000). Ecotourism accepts tourism activities in an environment as it is, without any alter in it. CNP is situated in Terai Region of Nepal. Terai region lacks hills and mountains sceneries but has sufficient spectacular beauties and natural resources like rivers, wildlife and greeneries. Therefore, involvement of local communities, their local knowledge and cultural identity in ecotourism is a good step for ecotourism sustainability. Tourists are found enjoying typical tribal hut and bamboo tents rather thanstar hotels and cozy rooms. So the sense of modernization should be introduced as modernization-from-within means the revalorization and adaptation of existing social and cultural capital. Community Forests Users' Group has been proved as a good model to assist the local communities, environment and the park.

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Environmental Problems of Squatter Settlements in Bagmati Riverside: A Case Study of Kathmandu Metropolitan City-31

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Abstract
Squatter Settlement is a residential area which has been developed illegally or semi-legally. Usually, these areas are found in neglected part of cities, and even though infrastructure and services in these areas are inadequate, the desire to exploit the financial opportunities attracts the migrants from rural areas to settle down in these areas. Our study focuses on identifying environmental challenges in the areas around squatter settlements, and how socio-economic characteristics of residents reflect on these environmental challenges. The research was carried out at Ward 31 of Kathmandu Metropolitan City, where primary field work was carried out in October 2018 consisting of focus group discussion, interview and household sampling. Out of 365 squatter households in the research area, 51 were randomly selected for questionnaire survey. Our research revealed flood, sanitation and open burning (incineration) of waste as major environmental challenges faced by the families and also found a strong correlation between the socio-economic status of families and their reaction to the environmental challenges. The study recommends that it is about time the concerned authorities focused on the major environmental challenges in Ward 31, mainly flooding of settlements and open (burning) incineration of solid waste.

Keywords: *Environmental Challenges, Squatter Settlement, Sustainability*

Introduction
The growth of metropolitan cities in Nepal has been largely unplanned and haphazard and this can be inferred from the fact that visible portion of the total urban population lives in slums and squatter settlements and the trend is only getting popular. Squatter settlements are rising in fast-growing cities such as Kathmandu and Pokhara, as well as in urban areas such as Dharan, Birgunj, Bharatpur and Mechinagar (MoUD, 2015) The increasing population of squatter settlements is determined by general population growth, rural to urban migration and sky-high prices of lands in urban areas. The main reason for the migration is the easily available financial opportunities in cities compared to rural areas where most of the migrants come from. Since the migrants cannot afford to buy or rent a place in the cities, they look for alternatives in existing squatter settlements or create their own. And as population increases, the informal settlements grow and eventually contribute to ruining of environment.

Kathmandu, like other big cities in South Asia, is also facing squatter settlement problems. History of squatter settlements or slums on the bank of Bagmati River shows few of these were established more than 50 years ago. The MoUD (2015: p. 28) estimates that about 10percent of the total urban population in Nepal comprises of squatters. In 2012, Kathmandu city had 29 riverside squatter settlements with 2031 households, and 17 settlements in other locations with 467 households (MoUD, 2015: p. 28).

Objectives

This study was carried out to understand the complexities of environmental vulnerabilities in the research area (Ward No.31, Kathmandu) and to formulate a justifiable goal of any future programs.

- To identify problems of squatter settlements on environmental management.
- To know the effects of socio-economic status of families in their role in environmental management.

Materials and Methods

Study Area

Kathmandu ward 31 is in, Kathmandu district, Province 3, Central Region, Nepal. The study area covers squatter settlements from Bhimsengola Bridge to Shankhamul Bridge along the Bagmati riverside. It consists one of the old squatters' settlements in Kathmandu Metropolitan city. It is a prime location in Kathmandu and can be regarded as heart of the city. In this densely populated region lies many social, economic, educational and political institutions including colleges, business hubs etc. The riverside of Bagmati region in this area is now increasing its mobility towards economic activities through small businesses after the Bagmati corridor plan. However, due to rampant poverty, people from different region of the country have captured the municipal land as an unlawful tenant. This location is selected as the study area because no any research under this topic is already conducted here and it bears more potential for our topic in every aspect of environmental management.

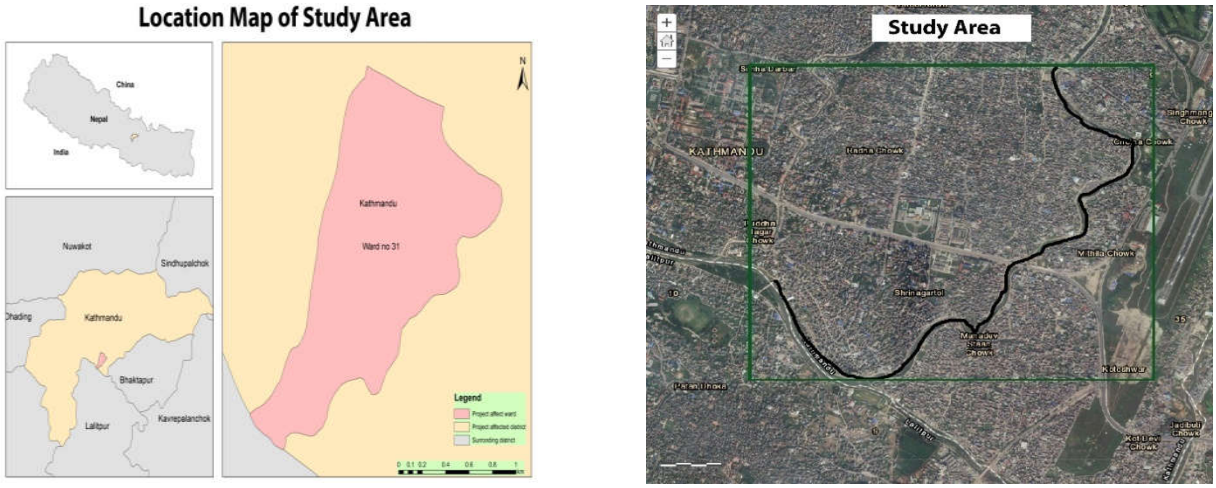

Figure 1&2: Study area

Study Population

The study involved the population of 51 households from which individuals of 18 years old and above, both sex (male and female) were systematically selected. In addition, the study consulted governmental and other officials such as social activists as well as a ward executive officer as key informants. Similarly, focused group discussion was done with the local people of the study area.

Sample Size

In this research simple random sampling is used. This is because each household from the study area had an equal chance of being selected as a sample. There are 365 households in the study area. Among these, 51 households were selected for collecting data by using simple random method. The chosen samples were 14% out of the total research population.

Data Collection Methods
Data collection methods used in this study was to collect primary and secondary data; methods used were interviews, observations and questionnaires.

Observation
Semi participant observation was used in the field throughout the field visit, along with taking photographs using the camera. This method provides the information which will not be provided by any other data collection methods; moreover, it validates the information gathered by other data collection methods in the field. Various qualitative data were collected, such as peoples' settlement pattern, habits related to health and hygiene, common consciousness on environment management, waste management techniques etc. in the squatter settlements.

Interview
Structured interview was used to gather information from key informants. This method involves obtaining information through face to face conversation with the respondents. The interview was taken with Mr. Narayan Prasad Bhandari; Chairman of Ward31.

Focused Group Discussion
The focused group discussion was carried out with the local people consisting of 14 among which 9 were females and 5 were males. Group discussion was focused specially to house-wives, money earnings males, elderly people and youths. The reason ortargeting these groups is, as house-wives spend most of the time in household works, they are directly linked to waste-water management, health and sanitation. In case of money earning males, they provide the data of actual income that reveals the socio-economic status. Finally, youth were taken, as they are the key persons in educational field and in environmental management activism.

Questionnaire Survey
Closed structured questionnaires were prepared in English language and translated in Nepali language to collect information from household respondents without any language barrier.

Secondary Data Collection
Secondary data were collected from different sources like as publication of CBS, official publications, related journal articles, books, newspapers and thesis work.

Results and Discussion
The major problems in Bagmati squatters are health hazards, lack of basic amenities like safe drinking water, proper housing, drainage and excreta disposal services, making squatter population vulnerable to infections. During the research in the particular squatter area of Ward 31, safe drinking water and drainage system was found to be quite impressive as there was proper drainage system in almost all of the houses and they had access to proper drinking water supply. This information can be inferred from the following table 1.

Table 1: Source of Water of the Respondents in Study Area

Variables	Number	Percentage (%)
Well/Tube-well	36	70.6
Stone Tap/Spring	0	0
River	0	0
Jar Water	27	52.9
Public Tap	31	60.8
Private Tap	0	0

83.7 % of the respondents used to treat the water which are obtained from the above sources while remaining of them do no used to treat it. Filtration is the widely used water treatment system followed by boiling, use of Piyush and Chlorination. Deshar, (2013) has reported that major water sources were from underground.

Similarly, out of 51 respondents 100 % of them have toilet in their houses, 92 % of them have General Pan for excretion while 6 % have Commode and only 2 % of them have pit for the excretion. Also, among 51 respondents of the survey, 96.1 % of them dispose waste water produced from household in drainage while remaining of them dispose into the river. Study by Gcrard (2010) also explained that dumping waste in river and streams was very high.

Unsurprisingly, the rate of illiteracy is 33.3 % among the respondents and this states that there is lack of environmental education among the people of the study area as provided in the figure 3. This also indicates that most people in the study area had only basic education which restricted most of them to employment in informal sectors which rewarded them the bare minimum earnings. This low-income opportunity compels people to have low economic status which forced them to continue living in informal settlements, thus, increasing the tendency of informality in the ward and made them to avoid the cost of managing the environment.

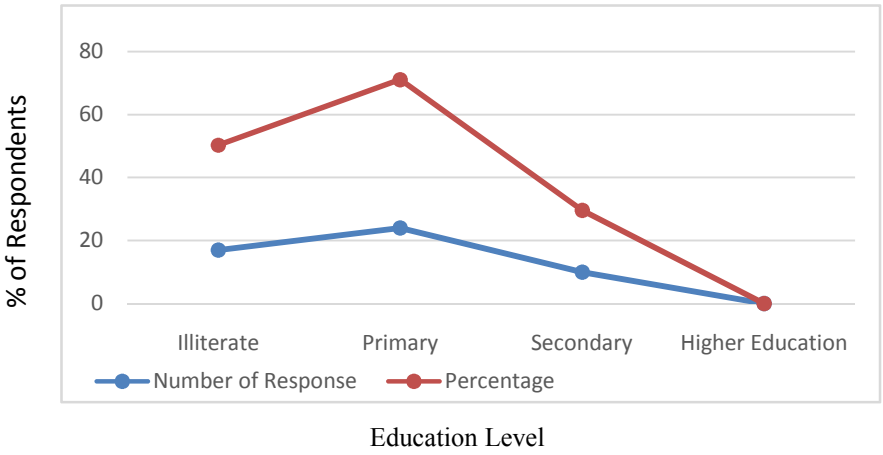

Figure 3: Education Level of the Respondents

It was found that households with better educational background had financial comfort because of good employment/business due to their qualification. They also had better sanitary condition in their houses compared to poor and illiterate family. Recalling back on the role of the people of the squatter settlement, this research identified that their roles were very minimal due to the negative attitude of the people on environmental management because of ignorance and lack of environmental education. The concerned stakeholders should design several techniques that will help the environmental education reach the people within the squatter settlement for better environmental management.

Table 2: Occupation of the Respondents of Study Area

Variables	Number of Respondent	Percentage (%)
Only Student	5	9.8
Employed	10	19.6
Own Business	8	15.7
Unemployed	28	54.9
Total	**51**	**100**

The findings from the table 2 above showed that most respondents (54.9%) were unemployed, 19.6% were employed, 15.7% run their own business and only 9.8% were only students.

As Table 3 shows most of the respondents have monthly income of NRs. 10000-20000 occupying 56.9 % and followed by monthly income of NRs. 5000-10000, NRs. 20000-30000, above NRs. 30000 and below NRs. 5000.

Table 3: Monthly Income of the Respondents of the Study Area

Variables	Number	Percentage (%)
Below Rs. 5000	1	2
Rs. 5000-10000	11	21.6
Rs. 10000-20000	29	56.9
Rs. 20000-30000	7	13.7
Above Rs. 30000	3	5.9
Total		

People were unemployed in the area due to which majority of respondents were involved in socioeconomic activities which are operating in informal settlements as a means of their survival. These people are surviving below the poverty line, and thus are capable of directly exploiting the river environment to their benefit.

Air pollution in the squatter settlements has been observed through solid waste burning practices whereas land pollution has been observed through dumping of solid wastes such as plastics, sands, packets of edible objects etc. on the open land around their settlements. Solid waste dumping along the banks of the river by squatter settlements is one of the major causes of river environment degradation. Throughout the stretch solid waste disposal is observed. At some places the disposal is intense and elsewhere scattered. Plastic are the fast eye catchers among those dumped heap as well as in the scattered wastes. Solid waste disposal is not limited to the banks but into the river and the piers of the bridge as well. Ultimately, the disposal has resulted in breaking flow of river and diversion to some extent.

Maximum number of households with illiteracy are engaged in open burning whereas the increment in educational level shows decrement in open burning involvement. It is shown in Table 4.

Table 4: Response on Open Burning Based on their Education

	Illiterate	Primary	Secondary	Higher Education
Yes	11	4	2	0
No	6	20	8	0
Total	**17**	**24**	**10**	**0**

MoUD, (2015) states that water pollution, air pollution, land pollution and aesthetic problems triggered health problems in slum areas.

Among total respondents of the survey 31.4 % of them used to segregate the different solid waste while 68.6 % do not used to segregate. And those who segregate the solid waste, 100 % of them do not quantify the segregated solid waste. 74.5 % of them sent solid waste to municipal collector while very few of them used it for pit composting and 33.3 % of them use it in animal farm.

As Table 5 shows, among total respondents of the survey, 96 % of them sent non-degradable solid waste to municipal collector while 36 % of them destroy it by open burning followed by scarp and collection centre.

Table 5: Non-biodegradable Solid Waste Management by the Respondents in Study Area

Variables	Number	Percentages
Municipal Collector	48	96
Collection Centre	1	2
Open Burning	18	36
Scarab	9	18
Private Collector	0	0
Any Other	0	0

88 % of the total respondent pay to the municipal collector as per house while 12 % of them pay as per family. Most of them pay below NRs. 300 while only 28 % of them pay NRs. 300 – Rs. 500.

The sanitation system of the squatter settlements of the study area and other aspects have played a major role in degrading the river and surrounding environment. The establishment of the squatter settlement along the Bagmati River is one of the major contributors of the river deterioration. Construction debris thrown haphazardly along the corridor is also another source of pollution. The river banks are also used by the municipalities to dump the solid waste in some parts for certain time.According to the survey taken with 51 households, 96.1 % said that flood, 82.4 % said earthquake, 23.5 % said fire that they are facing as a disaster. It is shown in Table 6.

Table 6: Disaster Faced by the Respondents of Study Area

Variables	Number	Percentage (%)
Flood	49	96.1
Earthquake	42	82.4
Fire	12	23.5
Any Other	0	0

As per the survey, 74 % said that they are facing such disasters once a year, 14 % said once in 5 years while 12 % said several times a year. Different respondents give different reasons for such hazards. 58.8 % said settlement in the bank of the river is the reason for the problems. Similarly, 88.2 % said lack of proper regulation of municipality, 25.5 % said public ignorance as a reason for the occurrence of such problems after disasters. Disasters are common in slum areas with different intensity in different season United Nations (2015).

Table 7: Response on Role of Community of Study Area

Variables	Number	Percentage (%)
No role of the community	30	58.8
Moderate managing roles of the community	18	35.3
Active role of the community	2	3.9
Don't know	1	2

The findings of the study revealed that community plays no role or very minimal role in managing environment. It was apparent that 58.8% of the total respondents revealed that

community have no role. This implies that community did not show much interest on environmental management as their priority regardless the environmental problems caused by their various socioeconomic activities. It is clearly stated that the community remains the main agent and victim of environmental problems, but they play a minimal role to reduce the negative effects and maximize the positive effect on the environment which in turn contributed to poor environmental management in their settlements.

Conclusion

The study concentrated on squatter settlement, focused on the problems regarding environmental variables and environmental challenges based on the socio-economic status of squatter households. From the data analysis, the major problem related to the squatter settlements were poor sanitation, air pollution, hygiene and disasters like flood. Research shows that open burning due to ignorance and lack of education was one of the problems causing air pollution. Likewise, out of major disaster such as flood, earthquake, fire and others, flood seems to be major issues since past 3 to 4 years as it has been destroying/disturbing most of the human settlements. The reason behind flooding was settlements very near to the river. However, study finds out some positive aspects as drinking water and drainage system was quite impressive in most of the households. For drinking water most of the people used various treatment methods and waste water was managed by directly connecting to the drainage system. This shows some positive aspects regarding environmental management. As in the society majority of individuals are very poor, people are involved in the work such as labor and other informal jobs. This has caused pathetic situation in their living standards which has caused ignorance in environmental concerns. Due to their range of income, the lifestyle is also quite different from each other. Poor educational status and awareness is also the major problem for poor sanitation and other environmental problems. Due to poor education and social awareness most of the people are facing the social problem such as violence and conflicts. These people have developed negative attitude towards environmental management. In addition, due to lack of knowledge, willingness and plans regarding the solution of various problems such as flood, poor sanitation and open burning, the squatter population themselves are victimized.

Recommendation

Based on the result of present study, the following recommendation have been suggested:

- Concerned authorities should focus on management of flood by various protection methods. Squatter settlements must be removed from the bank of the river resettled by the government in order protect and manage environmental resources.
- It is necessary to provide awareness regarding sanitation and hygiene through NGO related campaigns and governmental initiations.

Acknowledgement

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Seed Biology of Summer and Winter Generations of *Parthenium hysterophorus* L.

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Abstract

Parthenium hysterophorus L. is one of the successful invasive plant species in several countries of the world. Seed biology of two generations of Parthenium – summer and winter were studied. Mature seeds were subjected to seed germination experiment for 15 days. Germination Percentage (GP) and Germination Index (GI) were calculated. Seed size and seed mass were also measured. Seeds of summer and winter generations started to germinate on third and fifth day respectively. Higher germination (93%) was observed in seed lots of summer generation as compared to seed lots of winter generation (62%). Both GP and GI were found significantly higher in seeds of summer generation than winter generation. Extended flowering property of Parthenium along with high and continued germination potential in both summer and winter generation seeds could be some of the reasons for its rapid spread in Kathmandu valley.

Keywords: *Parthenium weed, seed germination, weed spread, weed biology, climate*

Introduction

Parthenium hysterophorus L. (Asteraceae) (hereafter *Parthenium*), one of the successful invaders in different parts of the world, was first recorded from Nepal in 1967 but spread significantly since 1990s (Shrestha et al., 2015; Bajwa et al. 2016). It is thought to have introduced unintentionally from India into Nepal via vehicles along the road connections (Shrestha et al., 2015, 2019; Bajwa et al., 2016). Relatively longer reproductive period with large number of seeds and its capacity to germinate and flower anytime when the condition is favorable have made *Parthenium* a successful invader in Nepal (Maharjan et al., 2014). In Kathmandu valley, there was the report of four cohorts of *Parthenium* seedling emergence every year at the same site i.e. in February, May, July and October (Pokhrel, 2013). Hence, the current study focused on its seed biology growing during two seasons i.e. summer and winter in the same site.

Materials and methods

Parthenium seeds from mature plants were collected from single population within 2 m × 2 m area in Kirtipur (27.67°N, 85.29°E, 1292m asl), Kathmandu in the month October 2017 and May 2018 (Figure 1a & b). Seeds collected in October (seedling emerged in July) were considered as 'summer seeds' and those collected in May (seedling emerged in February) as 'Winter seeds'. The seedlings during the month of July-September receive maximum rainfall whereas during the month of February-May receive less rainfall. So, these two months were selected for the seed collection. Seeds collected were placed in paper bag. They were air dried at room temperature under diffused light for 2-3 days and stored at room temperature.

Average monthly minimum temperature of the study area was 2.33°C during the month of January and average monthly maximum temperature was 28.7°C during month of June. The

study area received the total monthly maximum rainfall i.e. 285 mm during July and total monthly minimum rainfall i.e. 2 mm during November. The mean annual precipitation of the study area was 1221.4 mm. The maximum rainfall (884 mm) occur during the month June to September (Figure 2).

(a) (b)

Figure 1: (a) *Parthenium* infested area, (b) Flowering twig with mature flower

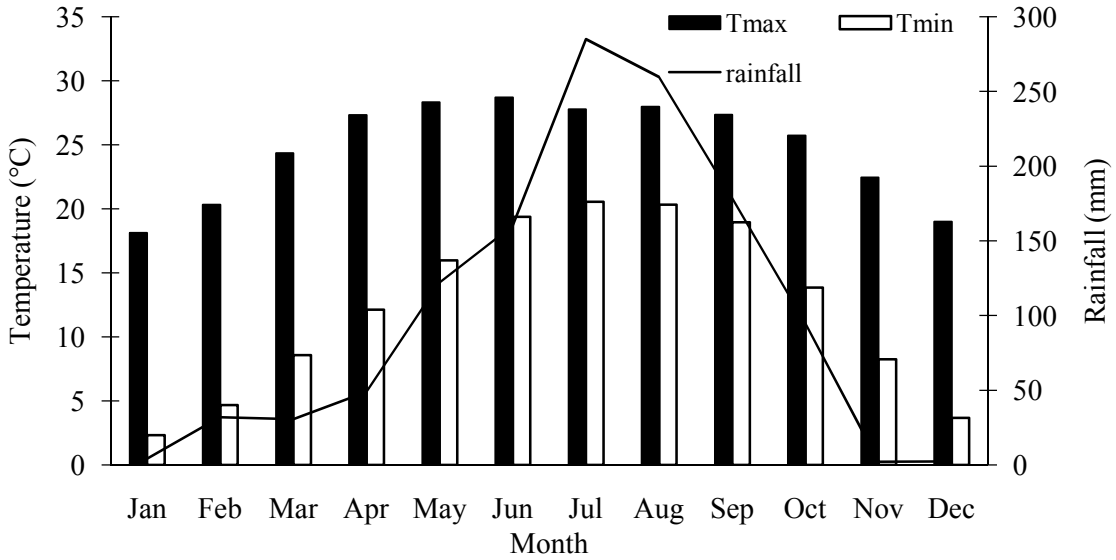

Figure 2: Average monthly minimum temperature (°C) and rainfall (mm) from 2007 to 2016 (ten years) recorded at Khumaltar Station (4 km north east from the study site), Lalitpur (27.67°N, 85.33°E, 1350m asl) (Source: DHM, 2016)

Seed germination experiment was carried out in the laboratory of Seed Science and Technology Division, Nepal Agricultural Research Council (NARC). Seeds were kept for

germination within a week of seed collection (during October for summer seeds and May for winter seeds) to avoid undergoing changes in their germination responses during dry storage at room temperature (Baskin and Baskin, 2014). The germination of seeds of both seasons was evaluated. Seeds of *Parthenium* were surface sterilized in 1% sodium hypochlorite solution for 5 minutes and washed with distilled water before transferred to the petri-plates. Twenty seeds were placed at equal distance in a petri plate containing double layered Whatman no. 1 filter paper moistened with 6 ml of distilled water. Replicates of thirty was maintained for both generations. All the petri plates were kept randomly in seed germinator (Accumax India AI-102) at constant temperature (25±2ºC). Appropriate moisture was maintained by adding distilled water as needed. Seeds were recorded as germinated when the radicle had broken through testa. The number of seeds germinated were counted and removed every day, to avoid any confusions while counting, till fifteenth day of the initiation of experiment. Seed germination percentage and modified Rozema index of germination index (GI) were calculated using following formula (Zheng et al., 2004).

$$\text{Germination percentage (GP)} = \frac{\text{Total number of seeds germinated}}{\text{Total number of seeds}} \times 100$$

$$\text{Germination index (GI) (\%)} = \Sigma(G_i/nt_i*100)$$

Where G_i is the number of seeds germinated at day t_i

t_i is the day 1, 2, 3, 4, 5, ……

n is the total number of seeds used

GP only reflects the final percentage of germination attained but do not provide the picture of speed or uniformity of germination whereas GI gives the most comprehensive measurement parameter combining both germination percentage and speed (Kader, 2005).

Seed size and seed mass

Air dried seeds that were collected for seed germination experiment were packed in airtight plastic bags before the measurement. Images of the 30 seeds per season were taken using a 10× objective lens fitted with camera (Excelis Unitron S/N 1505206) to the microscope (Biolam 2100-03) and the software CaptaVision version 3.6.9.1 (ACCU-SCOPE) was used to capture and measure the seed size (length and breadth) of the image (Fan et al., 2018). Before measurement the software was calibrated by using stage microscope for accuracy. Three batches of air-dried seeds, each containing 100, were weighed to determine mass using a digital balance with an accuracy of 0.0001g (KERN ALS220-4N).

Statistical analysis

All experiments were conducted in a randomized complete block design. All the analysis was performed by using R program 3.6.1 (R Core Team, 2019). Mann-Whitney-Wilcoxon test was performed to check statistical difference between germination percentage and germination index (GI) of two seasons as the data were not normally distributed. Seed size and seed mass data were normally distributed. t-test was performed to check the statistical difference between these data of two seasons.

Results and discussion

Germination percentage (GP) and germination index (GI) was found significantly higher in summer generation than in winter generation indicating increased speed of germination in summer seeds (w = 892.5, 856; p<0.001) (Kader, 2005) (Figure 3a and 3b). It has been reported that highly invasive biotype of *Parthenium* exhibited 100% germination in the laboratory without any physiological or physical dormancy mechanism (Bajwa et al., 2017; Adkins et al., 2019). The maximum germination ability of the seed without any seed dormancy is one of the important contributing factors in high invasiveness of *Parthenium*. Non dormancy in seeds of *Parthenium* is one of the major factors which help its extensive spread and establishment (Javaid et al., 2010).

First day of germination (FDG) in majority of the Petri plates (26) was the third day for the summer seeds while for the winter seeds the germination started only after fifth day. This indicates that the summer seeds have tendency to germinate faster in comparison to the winter seeds.

When we compared the day wise germination, maximum germination was recorded in fifth day for summer seeds (17%) and in sixth day for winter seeds (19%) (Figure 4). This indicates that the seeds of both generation of *Parthenium* have tendency to germinate earlier.

The average seed length and breadth for summer seeds was 2.43±0.2 mm and 1.35±0.1 mm and those for winter generation was 2.32±0.3 mm and 1.24±0.2 mm respectively. The seed size (length and breadth) of summer seeds were found significantly higher than those of winter seeds (t = 4.04, 5.14; p<0.001) (Figure 5). High rainfall during the summer season might be the reason behind the large seed size indicating favorable growth of the plant. The mass of *Parthenium* achene ranged from 43.8 to 54.4 mg per 100 achenes. Small seed size and mass is correlated with high seed output and seed dispersion by wind to the longer distance (Rejmánek and Richardson, 1996; Pysek and Richardson, 2007). The better and fast germination of larger achenes than small ones could be the result of greater food reserves as reported by Pandey and Dubey (1988).

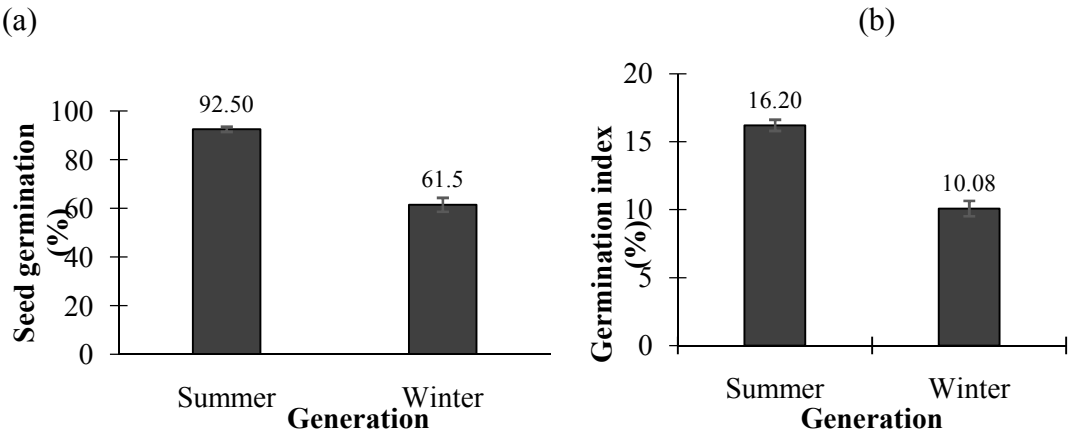

Figure 3: Seed germination percentage (a) and germination index percentage (GI) (b) of two different generations of *Parthenium*

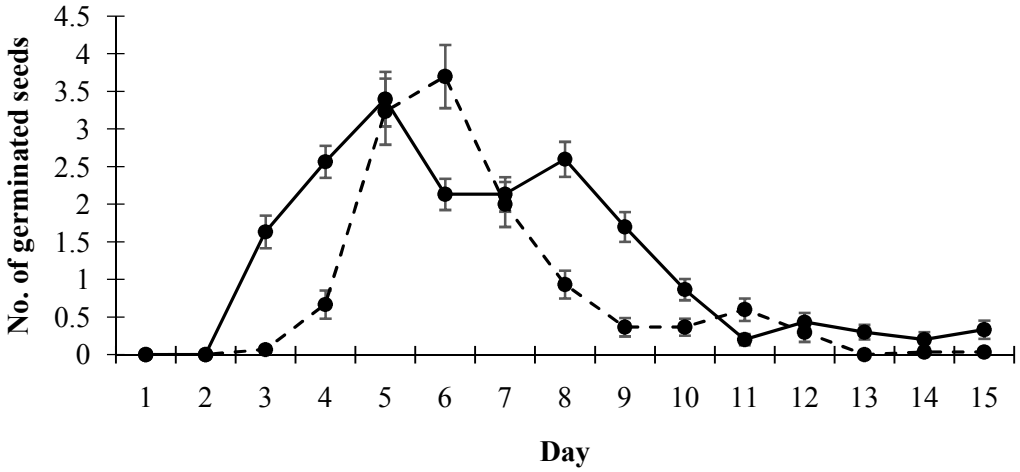

Figure 4: Average germination of summer generation (solid line) and winter generation (dashed line) *Parthenium* seeds. Bars indicate ±SE.

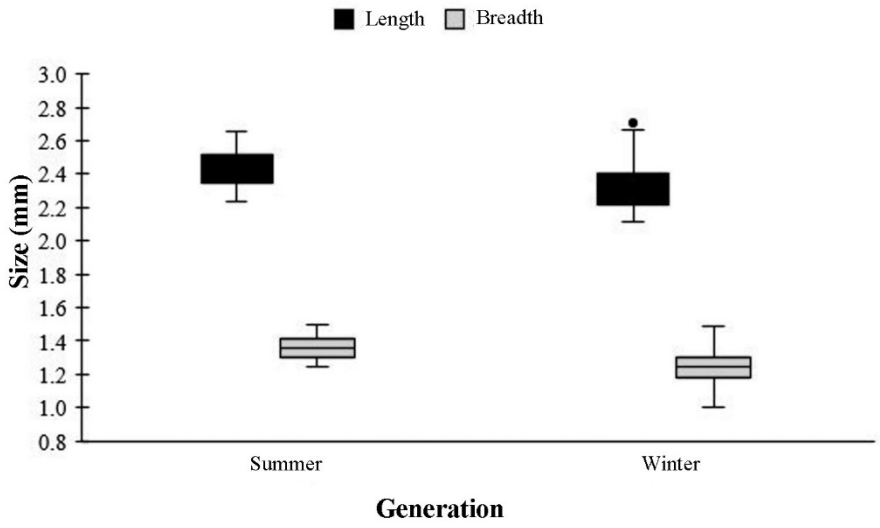

Figure 5: Seed size of two different generations of *Parthenium*

The rainfall reached to the maximum during the summer season (July-August) (Figure 2). Summer season is the most favorable season for the good growth of *Parthenium* in the study site (Pokhrel, 2013) which might be the reason for the development of larger seeds. Winter generation seeds are comparatively smaller in size which might be due to the colder temperature and less favorable environment as compared to the summer season (Figure 5). Studies of Roozrokh et al. (2005) showed that the large seeds have high germination percentage in compare with small seeds due to high protein production. There was the report of seed germination percentage with increase in seed size of *Parthenium* (Pandey and Dubey, 1988). Seed size is one of the most important characteristics of seeds that can affect the seed development duration (Rezapour et al., 2013). Hence, increased size of the seed could be the reason for the maximum germination of seeds with high germination speed in summer seeds compared to the winter seeds.

There is the report of the occurrence of *Parthenium* with the extended flowering period throughout the year producing large number of seeds from Ethiopia (Tamado et al., 2002), Nepal (Pokhrel, 2013), Pakistan (Fatimah and Ahmad, 2009). Extended flowering period is

considered as one of the important biological traits of invasive species that directly contributes to the fast spread in the new regions (Pyšek et al., 2009). This property of *Parthenium* along with more than 60% germination even in winter seeds and continued germination potential in both seasons could be some of the reasons for its rapid spread in Kathmandu in last 20-25 years.

Conclusion

Parthenium hysterophorus has ability to produce flower throughout the year with distinct generations in Nepal. Extended flowering property of *Parthenium* along with high, early and continued germination potential in both summer and winter generation seeds could be some of the contributing factors for its rapid spread in Kathmandu Valley.

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