Proceedings of International Conference on Forests, Soil and Rural Livelihoods in a Changing Climate

PROCEEDINGS OF
International Conference on Forests, Soil and Rural Livelihoods in a Changing Climate

Kathmandu University

Editors
Roshan M. Bajracharya, Bishal K. Sitaula, Subodh Sharma and Him Lal Shrestha

December, 2014

PROCEEDINGS OF

International Conference on

Forests, Soil and Rural Livelihoods in

a Changing Climate

Kathmandu University

Editors

Roshan M. Bajracharya, Bishal K. Sitaula,
Subodh Sharma and Him Lal Shrestha

December, 2014

Proceedings of International Conference on Forests, Soil and
Rural Livelihoods in a Changing Climate

27 - 30 September 2014

Held at the Himalayan Horizon and Arniko Hotel, Dhulikhel, Kavre, Nepal

Organizing institution: Kathmandu University in collaboration with the Norwegian University of Life Sciences, Nepal Agroforestry Foundation, Forest Action Nepal, and Department of Forest Research and Survey, MoFSC, GoN

Conference Organizing Committee

Technical Session Chair and co-chair:-- Prof. Bishal K. Sitaula/Prof. S. Sharma

Logistics and Public Relations Chair and co-chair– Dr. Bed Mani Dahal /S. Aryal
Financial Management Chair and co-chair– Dr. R.M. Bajracharya/S. Gurung
Hospitality and catering: Dr. B.R. Jha/K. Kafle
Conference Secretary/Assistant—Mr. Him Lal Shrestha/Ngamindra Dahal

Conference Secretariat ICFSRLSS

Him Lal Shrestha, Organizing Secretary
Aquatic Ecology Centre
P.O.Box 6250
Kathmandu, NEPAL
Phone: (977) 11-661399
Fax: (977) 11-661443
E-mail: hlshrestha@gmail.com

Review Committee
Prof. Roshan M. Bajracharya, Editor-in-Chief
Prof. Subodh Sharma
Dr. Bibhuti Ranjan Jha
Dr. Bed Mani Dahal
Dr. Ramji Prasad Neupane
Dr. Naya Sharma Poudel
Dr. Laxman Joshi

Citation for this publication:
Bajracharya, R. M.; Sitaula, B. K.; Sharma, S. and Shrestha, H. L. Editors (2015) Proceedings of the International Conference on Forests, Soils and Rural Livelihoods in a Changing Climate, Kathmandu, Nepal. pp 368

Printed in Nepal at
The Rising Sun Printers, Shaheed Shukra Vriksha Lane
Teku, Kathmandu. Phone : 4 243 557

Preface

The International Conference on Forests, Soil and Rural Livelihoods in a Changing Climate represents the culmination of the Norwegian Research Council funded collaborative project entitled, "Forest and Soil Restoration and Land Use Change Impacts on Carbon Pools and Fluxes in the Himalaya: Research and capacity building in Nepal". Project was a joint effort of the Norwegian University of Life Sciences, Kathmandu University, Nepal Agroforestry Foundation, Forest Action Nepal and the Department of Forest Research and Survey, Ministry of Forest and Soil Conservation of the Government of Nepal. The objectives of the research were to generate data on total carbon stocks under different forest and land management regimes, map and model the land use change over the past two decades, and determine livelihood implications of various land management practices in the context of a changing climate. The overall aim has been to apply geographical information system and remote sensing tools to map past and present land cover as well as current biomass and soil carbon stocks and predict future carbon fluxes due to land use changes. The international conference serves as a forum for dissemination of project-related research along with sharing of findings from other studies conducted on related themes within the region and beyond. The papers and posters presented herein have been organized in several sub-thematic focus areas, namely, forest/land degradation and restoration, governance and management of natural resources, remote sensing and geospatial approach to carbon quantification, ecosystem services and biodiversity, community/agro-forestry and livelihood security, watershed resources monitoring and conservation, atmospheric processes and climate change, and miscellaneous. It is anticipated that the ideas, data and findings of studies disseminated by publication in these proceedings will serve as a valuable literary resource to students and researchers working in the areas of forest and land management, carbon quantification, and the implications of land use change on local livelihoods and climate change mitigation as well as adaptation. Funding provided by the Research Council of Norway making the conference possible is hereby gratefully acknowledged.

Roshan M. Bajracharya, PhD, Professor, DESE, KU

Bishal K. Sitaula, PhD, Professor, Noragric, NMBU

December 2014

Contents

Theme 1

Forest/Land Degradation and Restoration

Forest and Land Degradation in Bangladesh

M. F. Hossain[*]

Abstract

Bangladesh, with an area of 147,570 sq. km, has a population 160 million, making it the highest population density in the world. The majority of the population depends on farming and natural resources for their food and income. Due to climate change, the frequency and intensity of disasters have increased. Natural calamities, such as drought, flood, cyclone, tornadoes and tidal waves occur almost every year. As a result, deforestation and land degradation are common problems in Bangladesh. Deforestation is the main cause of environmental imbalance in nature. Deposition of sandy soil on crop field during floods and over-exploitation of biomass from the cultivation fields for fuel and fodder are the important causes of land degradation in Bangladesh. Damage to the soil structure and reduced soil fertility in different parts of Bangladesh are caused by salinity, over cultivation, and continuous submersion of agricultural fields. River bank erosion, mainly during the rainy season, is also a serious cause of land loss in Bangladesh, while the northwestern part is prone to drought. All the above factors affect environment, agriculture and rural livelihoods of Bangladesh.

Key words : Floods, drought, soil erosion, climate change, natural disasters

Introduction

Bangladesh is an agricultural country where the majority of the population depends on farming and natural resources for their food and livelihood. Major agricultural products are rice, jute, wheat, potato, pulses, tobacco, tea, and sugarcane. The average temperature across the country usually ranges between 11ºC and 29ºC in winter months and between 21ºC and 34ºC during summer months. The annual rainfall varies from 1600 to 2000 mm in the west, 2000 to 4000 mm in the Southeast and 2500 to 4000 mm in the Northeast (Rashid, 1991). Environmental disasters like tropical cyclones, storm surges, floods, tornadoes and droughts ravage the country almost every year. Climate is an important determinant of the geographical distribution, species composition and productivity of forests and changes in the climatic regimes can modify the pattern and productivity irreversibly, affecting anthropogenic livelihoods, forest based industries, soil and water resources. It is the demand of time to check the further degradation and restore the degraded forest and land. Considering its impact on food security and environment, it is being important in many corners of the world. Degradation of land is a vital issue throughout the world with the particular references to Bangladesh as it a threat to agricultural productivity.It is also necessary to address political, social and economic constraints globally and regionally for the sustainable management of lands. This would provide alternative livelihood opportunities, food security and certainly help to develop a sound environmental system in the developing world (Divyalakshme et al. 2013). Climate change might further affect the chemical, physical and biological processes and thus contribute to degradation of lands.

Land degradation is one of the major ecological issues of the world. Land degradation means loss in the capacity of a given land to support growth of useful plants on a sustained basis (Singh, 1994). Land resource is the major asset contributing wealth and livelihood in rural areas, although land-man ratio is very low in the world, estimated to be 0.06 hectares (ha) per person (FAO, 2013). Land resources have been defined as soil resources other than minerals. In Bangladesh, soil resources mainly include yield crops, forest and pasture (Rahman et al. 1994). Land degradation is a global concern for agricultural productivity. About 70% of the total land of the world is under degradation (Dregne and Chou, 1994). Degradation of land is a vital issue throughout the world with the particular references to Bangladesh as it a threat to agricultural productivity. Major types of land degradation that occurs in Bangladesh are-water erosion, soil fertility depletion, salinization, waterlogging, pan formation, active flood plain etc. Among them, water erosion and fertility depletion are the main factors (Hasan et al. 2006). Land degradation is not merely a matter of physical loss of land or quality, but has inter-related impacts. Each year over one million people are affected by riverbank erosion (REIS, l985). However, it is clear that the quality of land has deteriorated, and its impacts are visible. Over the last decade, crop yield has declined due to deterioration of physical and chemical properties of land and soil. Besides its social and environmental aspects, the economic implications of land degradation are tremendous.There are two major constraints in preventing land degradation. The first one is the high population pressure on land, especially in the central, west and northwest parts of the country. In these regions, the exploitation of biomass due to a prevalent energy crisis appears to have exceeded the carrying capacity of the land, and led to encroachment on natural forests (MoEF, 2001).

* *School of Agriculture and Rural Development, Bangladesh Open University, Gazipur-1705, Bangladesh Corresponding author: Email: faridhossain04@yahoo.com*

Forest degradation is the reduction of standing biomass and in extreme cases, potential for regrowth of areas which still remain as forest or woodland. Forest degradation results from the cutting of woody formations in excess of their capacity for regrowth (Ahmed, 2008). The forest sector with its increasing trends towards deforestation will have significant impacts on agriculture, urban settlement, water level and coastal areas (Islam, 2005). Forest provides important ecosystem services in the region. Over one million people directly or indirectly depend on the forest for their livelihood and the forest contributes great amount of Gross Domestic Product (GDP) in Bangladesh (Giri et al. 2008). The rural population uses fuel wood and other minor forest products practically free of cost. Forest and tree resources also play an important role in protecting the coastal areas from natural calamities. The role of forest in protecting the environment from pollution and its contribution towards biodiversity is immense. Forest is a very important renewable resource in Bangladesh. It provides materials like timber, pulp, pole, fuel wood, food and medicine, habitat for wildlife and primary base for biodiversity. It also provides oxygen, controls or reduces the intensity of the cyclones and tidal surges in the coastal areas of Bangladesh. The 'Sundarban' mangrove forest is the largest remaining tract of mangrove forest in the world. It is an independent biome and very rich in biodiversity. Over 1186 numbers of known living species (flora and fauna) are found in the biome (Gilman et al. 2008). Mangrove forests are believed to be the shield of the coasts as all the natural storms originated from the Bay of Bengal first hit the mangrove forest. All the cyclones those have hit Khulna coast caused a devastating damage to the 'Sundarbans' mangrove forest. Recent cyclonic storms in1991 and SIDR in 2007 caused a great damage to flora and fauna of the 'Sundarbans' (Ahmed, 2008). Forest resources have a great contribution to the economic and ecological stability. Deforestation results from removal of trees without sufficient reforestation, and results in declines in habitat and biodiversity, wood for fuel and industrial use and quality of life. In light of the above factors, an effort was made to highlight the forest and land degradation situation in Bangladesh, based on a review of literature.

The key factors contributing to forest and land degradation are described below.

1. Soil Erosion

Soil erosion implies loss or removal of surface soil material through action of moving water and Wind.

1.1. Water Erosion: Water erosion is the most widespread form of degradation affecting 25% of agricultural land. Water erosion covers all forms of soil erosion by water including sheet and rill erosion and gullying. Human-induced

enhancements of landslides, caused by clearing of vegetation, earth removal, road construction etc., are also included. Accelerated soil erosion has been remarkably encountered in the hilly regions of the country which occupy about 1.7 million hectares (BARC, 1999). Though the loss of topsoil due to water erosion is evident in the vast floodplain areas, only a very limited research results are available for the quantification of soil loss. Faulty 'Jhum' cultivation in hilly area causes gully erosion and losses of soil ranges from 10 to 120 t/ha/ yr. (Farid et al. 1992).

1.2. Wind Erosion: Fertile top soil is lost due to wind erosion, drifting of sand, damage to crops. Wind erosion refers to the loss of soil by wind, occurring primarily in dry regions. In Bangladesh, some areas are affected by wind erosion mainly in the northern districts of 'Rajshahi' and 'Dinajpur' during the drier months of the year. Droughts frequently lead to wind erosion and have a negative impact on agricultural production (Karim et. al. 1990).

2. Waterlogging

Bangladesh is a land of rivers and heavy monsoon rains. It is subject to inundation by over bank spills due to drainage congestion, rainfall run-off and storm-tidal surges (Hossain et al. 1987; Milliman et al. 1989). Waterlogging is responsible for decreasing of land productivity through rise in groundwater close to the soil surface. Waterlogging is also linked with salinization, brought about by incorrect irrigation management. In Bangladesh, about 0.69 million hectare has been protected from tidal surges by constructing coastal embankments. About 8000 hectares of waterlogged land in 'Khulna' and'Jessore' district areas is the result of human induced degradation due to faulty construction of embankment (MoEF, 2005).

3. Drought

Drought is an abnormal condition where there is lack of sufficient water to meet various requirements and to support satisfactory plant growth without enough soil moisture (Rahman, 1994). The northwestern part is prone to drought mainly because of rainfall variability in the pre-monsoon and the post-monsoon periods. Inadequate pre-monsoon showers, a delay in the onset of the rainy season or an early departure of the monsoon may create drought conditions in Bangladesh, and adversely affect crop output. Since it puts severe strain on the land potential, it acts as a catalyst of land degradation through reduced soil moisture and water retention, increased soil erosion, decline in soil organic matter content and over-exploitation of sparse vegetation (MoEF, 2005).

4. Irrigation

Irrigation is one of the most essential inputs for agricultural production. Irrigation is being used to grow high yielding variety rice in deferent seasons on the same field. In such a case the land remains water-logged round the year. This practice, though yielding good harvest initially, degrades the soil by continuous submersion for a prolonged period. The causes of soil degradation due to continuous submersion are: Continued absence of oxygen in the subsoil, Chemical changes of soil materials by forming compounds toxic to plants, Constant loss of soil nutrients by percolation, and incidence of pests or diseases associated with water-logged environment (MoEF, 2005).

5. River Bank Erosion

River bank erosion is a serious cause of land loss in Bangladesh. Every year large areas along riverbanks erode mainly during the monsoons taking away good agricultural land, vegetation and human settlements creating acute socio-economic problems. In Bangladesh, bank erosion is caused mainly due to strong river current enhanced by mechanized river traffic and/or channel diversion during the rainy season. About 1.7 million hectares of floodplain areas are prone to river bank erosion. Siltation in the floodplains also contributes towards degradation of land due to flashflood and sediments accumulated from riverbank erosion. There are many factors that may be responsible for riverbank erosion. The unique, natural geographic setting, the behavior of an alluvial channel, together with characteristics of the tropical monsoon climate, is mainly responsible for these ravages. An enormous volume of water comes from the melting of ice in the Himalayan range (Islam, 1986). River bank erosion can lead to displacement of people losing stability in their lives and social status (CUS, 1988).

6. Sedimentation on Agricultural Land

Another form of land degradation is deposition of sandy materials on agricultural land particularly in pediment areas of northern district. Land degradation by deposition of infertile soil on agricultural land also occurs by breach of embankment during floods.The soils eroded from the hills are usually deposited in the downstream areas. Siltation in the floodplains also contributes towards degradation of land due to flashflood and sediments accumulated from riverbank erosion (MoEF, 2005). This phenomenon is a result of deforestation in the hills and faulty cultivation practice in the upper catchments areas.

7. Decline in Soil Fertility

Decline in soil fertility is manifested in deterioration of soil physical, chemical and biological properties. It occurs through a combination of lowering of soil organic matter and loss of nutrients. Whilst decline in fertility is indeed a major effect of erosion, the term is used here to cover effects of processes other than erosion. In Bangladesh, depletion of soil fertility is mainly due to exploitation of land without proper replenishment of plant nutrients in soils. The problem is enhanced by intensive land use without appropriate soil management. The situation is graver in areas where high yielding varieties are being cultivated using low and unbalanced doses of mineral fertilizers with little or no organic recycling. Degradation of soil quality in the floodplains is mainly attributed to improper use of chemical fertilizers and pesticides to boost agricultural production. The main processes of soil fertility decline in Bangladesh are:

7.1. Depletion of Soil Organic Matter (OM): A good soil should have an organic matter content of more than 3.5 per cent. But in Bangladesh, most soils have less than 1.7 percent and some soils have even less than 1 % organic matter. The declining productivity of Bangladesh soils is the result of depletion of organic matter caused by high cropping intensity. Degradation of physical and chemical properties of Soils with intensive cropping in the same land year after year without proper soil management practices, both physical and chemical properties of soils are liable to degradation. In Bangladesh, crop residues are widely used as fuel and fodder and usually not returned to the soil. Even cow dung is widely used as fuel in rural areas. This results in a decrease in soil organic matter content. The amount of organic matter in the soil is one of the best indicators representing soil quality. The concentration of soil organic materials in the country has been deteriorating over the last few decades. Now over 50 per cent of the agricultural land is below the critical level. In Bangladesh, active land degradation process is water erosion and loss of fertility due to physical, chemical or biological degradation of soils. Various kinds of soil erosion such as sheet, rill and gully erosion, landslide, bank erosion and in some cases wind erosion are occurring in Bangladesh (BARC, 1999). Decline of soil fertility occurs through and combination of lowering of soil organic matter and loss of nutrients. The average organic matter content of top soils (high land and medium high land situation) have gone under from about 2% to 1% over the last 20 years due to intensive cultivation which means and decline by 20-46% (Miah et al. 1993).

7.2. Reduction in the availability of macro- and micro-nutrients: The areas of low fertility comprise about 60% of the total cultivable land of the country. Nutrient uptake by modern crop varieties is usually greater than that by the local varieties. Hence, in areas with increased cropping intensity coupled with the use of modern varieties, the net removal of major nutrient (NPKS) are high and ranges between 180 and 250 kg/ha/yr. (Karim et al. 1994). Most of the soils under high land and medium high land situations are low in fertility level where especially N, P, K and S are deficient. Deficiencies of micro nutrients like Mg, Zn, B and Mo have also been detected in some areas. Mono-cropping patterns in the country are also responsible for the deterioration of soil quality and productivity of land due to intense use of chemical fertilizers and pesticides, and deteriorating soil quality (Karim et. al.1998). This is emerging as an important issue regarding sustainability of the cropping pattern and productivity.

8. Salinization

Salinization is used in its broad sense, to refer to all types of soil degradation brought about by the increase of salts in the soil. As human-induced processes, these occur mainly through incorrect planning and management of irrigation schemes. Also covered in the definition is salinity intrusion, the incursion of sea water into coastal soils arising from over-extraction of groundwater and tidal flooding. In Bangladesh, salinization is one of the major natural hazards contributing towards land degradation. About thirty percent of the net cultivable area is in the coastal region of the country. The severity of salinity problem in Bangladesh increases with the desiccation of the soil. Recently, salinity both in terms of severity and extent has increased much due to the intrusion of saline sea water because of the diversion of the Ganges water in the dry season. However, even in such cases, the expected yield is reduced to a certain degree depending on the soil salinity concentration (Karim et. al. 1990).

9. Ground Water Level

Decreasing of the water table is a self-explanatory form of land degradation, brought about through tube well pumping of groundwater for irrigation and industrial use exceeding the natural recharge capacity. In Bangladesh, extraction of ground water has increased many folds due to rapid expansion of irrigated agriculture during the past three decades from 1967-1997 (BARC, 1999). Withdrawal of river water and unbridled extraction of groundwater have put the northern region at a risk of desertification through land degradation (MoEF, 2005).

10. Intensive and Mono-cropping

Growing too many crops with high chemical fertilizer and pesticides year after year on the same piece of land damages the soil structure and reduces the soil

fertility. Practicing monoculture for a long time causes depletion of nutrients in soil and cause land degradation. Cultivation of the same crop in the same piece of land continuously results in soil infertility and pest recurrence. The problem is enhanced by intensive land use without appropriate soil management. Intergrades soil fertility management forms a part of prevention, mitigation and restoration and land degradation (Divyalakshme et al. 2013).

11. Improper Cultivation in Hill Slopes

Shifting cultivation on the hills, locally known as 'Jhum', is a common practice among the tribal communities in the greater Chittagong Hill Tracts (CHT). Traditionally 'Jhum' cultivation is a slash-and-burn process where a certain area is cleared and cultivated. 'Jhum' cultivation is one of the major causes of land degradation.

12. Overgrazing

The cattle, sheep, goats and other animals take away the vegetation cover and expose the bare soil. Overgrazing destroys valuable plant species, leaving mostly unpalatable ones. Losses of vegetation and biodiversity threaten habitat for other species. This is driven by a number of factors, alone or in combination, such as tillage for agriculture; too many livestock on too little land; removal of crop residues for feed/construction use; deforestation for fuel wood and construction materials (MoEF, 2005).

13. Land Fragmentation

The existing inheritance law contributes to fragmentation of already small units. Such fragmentation reduces effective crop area and this is regarded as a kind of land degradation because total or optimal productivity of land decreases due to segmented land management (MoEF, 2005).

14. Deforestation

Deforestation results from removal of trees without sufficient reforestation, and results in declines in habitat and biodiversity, wood for fuel and industrial use, and quality of life (Nilsson, 1995). Forest degradation and deforestation are closely related as both can cause each other. The extent of forest cover and annual rate of deforestation are the subjects of deforestation. The occurrence of deforestation is widespread and serious in Bangladesh. Annual deforestation is about 0.3 mha and the country is losing about 3% of her remaining forest areas annually (Ahmed, 2008). Commercial agriculture is the most important driver of deforestation, followed by subsistence agriculture. Timber extraction and loggingdrives most of the degradation, followed by fuel wood collection and charcoal production, uncontrolled fire and livestock grazing (Hosonuma et al., 2012). In many countries, massive deforestation is ongoing and is shaping climate and geography. The sea-level rise, increasing salinity and availability of less fresh water are responsible for inland intrusion of saline water and creating favorable environment for shrimp farming in the region. As a result farmers are converting fallow lands to shrimp farming which is economically very beneficial. Important agricultural and non-agricultural lands also converted by homestead intended for increasing population of Bangladesh. There was only 398 sq km (only 5%) area covered by homestead during 1980. But the homestead covered area was increased about 1490 sq km (19%) at 2009. So, compared to the last 30 years 14% homesteads land cover areas are increased. There was not any astonishing changed in mangrove vegetation. Some mangroves areas were shattered and some other mangroves were full-fledged again in delta areas. The harmful land cover changes are not expectable for the natural environment. But it transpires by many natural and anthropogenic tricks now a day. So, the authority should seize initiatives to protect this category of catastrophe (Rahman and Begum, 2011). There was significant loss of forestland observed during 1976-2000, but on the other hand, forestland increases significantly during 2000-2010, this may be because of the initiatives by the government, awareness among the peoples especially of social forestry. Coastal plantation initiatives increased the mangrove area during 1976-2000 but it decreased largely during 2000-2010 due to human interferences and tropical cyclones (Hasan et al. 2013).

15. Soil mining in Agricultural Land

Sand and shingles are collected from agricultural lands in several places. After mining, the depressions are abandoned and left fallow (MoEF, 2005).

16 Unplanned Rural Infrastructures

As the food security is the main concern in Bangladesh, necessary steps should be taken to conserve agricultural land from shifting to non-agricultural uses and to develop integrated house-cropland-industrial expansion for social, economic and food security (Hasan et al. 2013). The country is losing more than one per cent crop land each due to urbanization, industrialization, unplanned rural housing and infrastructure building. Construction of river embankments, flood control structures and roads, improper sluice gate management, increased irrigation for agriculture and over exploitation of aquatic resources made huge negative impact. These enhance the loss of fish production and biodiversity in floodplain

ecosystems. As a result wetland dependent community people have lost their livelihoods. Brick kilns are mostly situated on good agricultural land as brick manufacture needs silty clay loam to silty clay soils with good drainage conditions, which is turning good agricultural land into unproductive lands. Brick kilns are spread all over the country, and are degrading land. Most of the biomass fuels used in brickfield comes from forests. Crop production has reduced from 70% - 80% in 3,000 acres affected by the emission of the gases from the brickfields (Hasan et al. 2013).

Preventive Measures for Forest and Land Degradation

Agronomic measures: Practice conservative tillage by using more organic matter in soil and Integrated Plant Nutrient System. Integrated soil fertility management is a set of agricultural practices adapted to maximize the efficiency of nutrient use and improve agricultural productivity (Divyalakshme et al. 2013). It also involves cultivation of diversified crops in the same field maintaining a crop rotation schedule. Rotation of crops is a good natural process to retain nutrients in the soil. Other beneficial practice include: efficient irrigation system, cultivation of green manure and cover crops, using mulches, particularly organic mulches; cultivation of drought and salinity tolerant crops; and crop diversification.

Afforestation: The Government of Bangladesh has promulgated the National Forest Policy, 1994 and approved the Forestry Sector Master plan (1995-2015). Both the documents have emphasized the afforestation program in the country with 20% coverage and increase the protected areas by 10% of the reserve forest land targeted in the Master plan by 2015 through the co-ordinated efforts of GO-NGOs and active participation of the people. Its objectives include preserving existing values, conserving plants and animal variety and ensuring maximum benefits to local people (MoEF, 2005). The effective implementation of forest laws and effective forest management are remedial measures of deforestation and degradation. Forest management should be modernized through forest master plans, acts, policies to preventing the extensive consumption of forest products and taking stringent measures for violating the forest laws. Gas/coal could be used in the brickfields instead of forest woods.

Mechanical measures: Growing a shelterbelt of forage, fuel and timber trees to protect the land from wind erosion. Plantation wind breaking trees to control reducing surface wind velocity. River bank stabilization against flash flood erosion is another urgently needed preventive measure.

Government policies: The national policies and laws are directly providing provisions to deal the issues viz. land degradation, soil erosion, deforestation, etc. (MoEF, 2005). These must be further strengthened and implemented effectively.

Conclusions

This paper describes key causes and management prospects of forest and land degradation in Bangladesh. Natural calamities occur almost every year and deforestation and land degradation are common problems in the country. Damaged to the soil structure and reduce soil fertility in various regions of Bangladesh occur due to salinity, drought, flood, excessive use of chemical fertilizers and pesticides, irrigation, sedimentation, over-cultivation and continuous submersion of agricultural fields. River bank erosion during the rainy season is a serious cause of land loss in many areas. The country is losing a significant level of the remaining forest areas annually. The Government of Bangladesh has emphasized a nationwide afforestation program. Some agronomic practices, mechanical measures and afforestation can reduce and prevent the land and forest degradation processes. The national policies and laws, which directly providing strategies to deal with the land degradation issue, need to be implemented effectively.

References

Ahmed, A.I.M.U. 2008. Underlying Causes of Deforestation and Forest Degradation in Bangladesh. A Report Submitted to the Global Forest Coalition (GFC), the Netherlands.

BARC (Bangladesh Agricultural Research Council).1999. Land Degradation Situation in Bangladesh, Soils Division, BARC, Farmgate, Dhaka, Bangladesh.

CUS.1988. Composite Score map of Socio- economic Development of Bangladesh by Upazila, Center for Urban Studies, Dhaka University, Dhaka, Bangladesh.

Divyalakshme, A., I.Divyagopalakrishnan, K. Nivethaa,G. Harini, and Kiruthika. 2013. The analysis and assessment of land degradation. Inter. J. Applied Engineering Res. 8 (16): 1923-1928.

Dregne, H. E. and N. Chou. 1994. Global desertification dimensions and costs. In "Degradation and Restoration of Arid Lands" (H. E. Dregne, Ed.), International Centre for Arid and Semiarid land studies.Texas Technical University, Texus, USA.

FAO (Food and Agriculture Organization), 2013. Bangladesh: Arable land and land under permanent crops availability (ratio per person), FAOSTAT. http://faostat.fao.org/site/666/default.aspx (accessed on November, 2013).

Farid, A. T. M., A. Iqbal, and Z. Karim. 1992. Soil erosion in the Chittagong hill tract and its impact on nutrientstatus of soil. B J Soil Sc. 23 (122), 92-101.

Gilman, E.L., J. Ellison, N.C. Duke, and C.Field. 2008. Threats to mangroves from climate change and adaptation options: A review. Aquatic Botany, 89, pp. 237-250.

Giri, C., Z. Zhu, L.L. Tieszen, A. Singh, S. Gillette, and J.A. Kelmelis. 2008. Mangrove forest distributions and dynamics (1975-2005) of the tsunami-affected region of Asia. Journal of Biogeography, 35(3), pp. 519-528.

Hasan, M.K. and A. K. M. A. Alam. 2006. Land Degradation Situation in Bangladesh and Role of Agroforestry.J. Agric. Rural Dev. 4(1&2), 19-25.

Hasan, M.N., M.S. Hossain, M.A. Bari and M.R. Islam. 2013. Agricultural land availability in Bangladesh. Soil Resources Development Institute (SRDI), Dhaka, Bangladesh.

Hosonuma, N., M. Herold, V.D. De Sy, R.S.D. Ruth, S. De Fries, M. Brockhaus, L. Verchot, A. Angelsen and E.Romijn. 2012. An assessment of deforestation and forestdegradation drivers in developing countries.Environ. Res. Lett. 7.

Hossain, M., A. Islam, and S.N. Seha. 1987. Floods in Bangladesh- Recurrent Disasters and People's survival, university research centre, Dhaka.

Islam, M.N. 1986. Alternative Adjustment to Natural Hazards; Implication for Bangladesh, Presidential Address at the 11th Annual Bangladesh Science Conference, Rajshahi, Bangladesh.

Islam, N. 2005. Environmental Issues in Bangladesh. An Overview. Pakistan J. Social Sciences 3(4):671-679.

Karim, Z., M.M.U. Mia, and S. Razia. 1994. Fertilizer in the National Economy and Sustainable Environmental Development, Asia Pacific Journal Environment and Development, 1 (2): 48-67.

Karim, Z., S.G. Hussain, and M. Rahman.1998. Chemical Fertilizer for Increase Crop Production Poses on Threat to Soil Pollution in Bangladesh, Bangladesh Agricultural Research Council, Dhaka, Bangladesh.

Karim, Z., S.G. Hussain, and M. Ahmed. 1990. Salinity problems and crops intensification in the coastal region ofBangladesh, Bangladesh Agricultural Research Council, Dhaka, Bangladesh.

Miah, M. M. U., A.K.M. Habibullah and M.F. Ali. 1993. Depletion of organic matter in upland soils of Bangladesh. In "Soil resilience and sustainable land use". Proceedings of international symposium, held on 28 September to 2 October 1992, Budapest, Hungary. pp. 70-79.

Milliman, J.D., J.M. Broadees, and F. Global. 1989. Environmental and Economic Impact of raising sea level and subsiding deltas. The Nile and Bengal Examples, Bangladesh Quest, 1.

MoEF (Ministry of Environment and Forest). 2001. Land Degradation. BANGLADESH: State of the Environment. Ministry of Environment and Forest Government of the People's Republic of Bangladesh.

MoEF (Ministry of Environment and Forest). 2005. National Action Programme (NAP) for Combating Desertification. Department of Environment, Ministry of Environment and Forest Government of the People's Republic of Bangladesh.

Nilsson, S.1995. "Do we have enough forests?"Paper presented in IUFRO World Congress on August 7, 1995 in Tampere, Finland. Updated in IUFRO Occasional Paper No.5 (March 2001).

Rashid, H.E. 1991. Geography of Bangladesh. University Press Limited. Dhaka.

Rahman, M.M. and S. Begum. 2011. Land cover change analysis around the Sundarbans mangrove forest of Bangladesh using remote sensing and GIS application. J. Sci. Foundation, 9(1&2): 95-107.

Rahman, A., Atiq and others. 1994. Environment and development in Bangladesh. Vol.II. UPL. Dhaka.

REIS.1985. Riverbank Erosion Study, Jahangirnagar University, Bangladesh and University of Manitoba, Canada.

Singh, P. 1994. Land degradation-a global menace and its improvement through Agroforestry.In "AgroforestrySystem for Sustainable Land Use".Oxford & IBH publshing Co. Pvt. Ltd., New Delhi, India. pp. 4-20.

Assessment of Impact of Attabad Disaster on Soil Physico-chemical properties of upper Hunza, Gilgit-Baltistan

Karamat Ali[1*], Farida Begum[1], Sultan Ishaq[1], Sher Ahmed[2], Salma A. Durrani[1], Shaukat Ali[1], Haibat Ali[1], Arif Hussain[3], Iqtidar Hussain[1]

Abstract

Natural disasters, such as landslides and floods cause major losses of human lives and property, the destruction of economic and social infrastructure, as well as environmental damage, and have a negative effect on agriculture land by reducing soil quality and crop productivity. This study evaluated the impact of Attabad disaster (land slide in 2010) on soil physico-chemical parameters in Gulmit and Shiskat village of Upper Hunza. The investigated soil properties were: pH, organic carbon (SOC), nitrate-nitrogen (NO3-N), electrical conductivity (EC), available phosphorus (P), exchangeable potassium (K), and sand, silt, and clay content (texture). Random sampling of the soil was done in both villages from disturbed and un-disturbed areas to a depth of 0-15cm. Soil samples were analyzed in the lab according to standard procedures. Independent t-test was applied to determine the significant differences of soil properties with respect to the disaster. SOC and NO3-N were significantly higher (p=0.002), (p=0.05) in un-disturbed compared to disturbed soil. Similarly soil texture also changed significantly due to the landslide. This preliminary study suggested that the Attabad disaster had significantly affected the soil properties, especially fertility, directly or indirectly by degrading soil quality. There is a dire need to undertake sustainable soil management practices, such as, application of animal manure and bio-fertilizer, to return the soil fertility, thus enhancing soil quality of disaster affected soil for sustainable management of the agriculture ecosystem.

Key words : Agro ecosystem, landslide, crop productivity, soil quality, sustainability

[1] *Department of Environmental Sciences, Karakoram International University, Gilgit, Pakistan*

[2] *Moutain Agriculture Research Centre, Juglot, Gilgit-Baltistan,*

[3] *Department of Biological Sciences*

[*] Corresponding Author; karamat03@gmail.com,

Introduction

Soil is major natural resource, having large diversity of ecosystem services and goods, which provide many tangible and intangible benefits to human being (Daily et al. 1997). During some last few decades researches on soil quality and education program have been increased all over the world (Karlen et al., 2003). Soil quality can be defined as "the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation" (Karlen et al., 1997). According to Mojori et al., 2011, after their studied of different articles on land use change effects on soil quality, they found that land use change and deforestation causes decrease in SOC, SOM and also in nutrient availability. According to Ayoubi et al., 2011 the clearing and cultivations of natural forest resulted in degradation of soil physiochemical properties as compared to the soil of well stocked natural forest. It was concluded that the clearing of the hardwood forest and the tillage practices during the period of 40 years have led to decrease in Soil organic matter by 71.5% and cultivation of reforested land decreased mean weight diameter 52% and increase the sand by 252%. Their study showed that natural forest clearing by cultivation of the loess slopes resulted in decrease of soil quality, while the reforestation in study are have improved them.

Soil quality is essential for determining agro-ecosystem sustainability, identifying land management practices, and land restoration (Moges, et al., 2013). Soil can be characterized on the basis of organic matter content as organic or mineral soil. Globally crop production has generally resulted in the decline of soil organic matter (SOM) and thus decline in soil fertility status. The land use conversion of natural grassland and forest ecosystems in to agricultural land results in the loss of up to 30% of soil organic carbon (Bot & Benites, 2005). Soil fertility and nutrient management affect vegetable production, food security and livelihoods (Perveen et al., 2010). Conversion of land use mostly from forest to agricultural land can increase the soil deterioration and loss of SOM (Oguike & Mbagwu, 2009). Land use change has a great impact on the loss of biota and also in decrease of soil carbon in the below ground ecosystems (Doran, 2000). Land use change also has a major impact on carbon flux, in natural ecosystems about 25 to 30% of carbon is loss by cultivation (Houghton & Goodale, 2004).

Soil quality indicators (SQIs) can be used to evaluate sustainability of land use and soil management practices in agroecosystems. SOC could play an important role for monitoring soil quality (Shukla et al.,2006) . The conversion of forest land into cropland can degrade the soil properties and leave the land vulnerable to soil

erosion. The erosion of soil can alter the properties by reducing the soil depth, altering the soil texture, and by loss of organic matter and nutrients (Çelik, 2005; Foster, 2001). Baber et al., 2004 conducted research on physic-chemical and fertility status of soil in Gilgit and found that soil texture varied from silt loam to silty clay, while EC varied from 0.06 to 0.5 ds/m, and pH ranged from 7.34 to 8.03. The total nitrogen values were less than 0.08%, indicating low fertility of these soils.

Historically, human societies have depended on the resources and amenities provided by nature like, clean water, clean air, fertile soil, and also regulation. All these factors which are required for any ecosystem are dependent to a large extent on the soil quality and soil and plant biodiversity. Hence, an understanding of soil physical, chemical and biological quality is essential for sustainable management of the land.

Materials and Methods

Study Area

The study was carried out in the two village of upper Hunza Gulmit and Shiskat valley. Geographically the study area is mountainous, and both the villages were badly affected by the Attabad land slide. The temperature of study is fall below the freezing point in winter, while in summer it may exceed from 25^{0}C. Upper Hunza mostly falls in Single cropping zone due to harsh climatic condition. The study area was good for potato before the disaster, while after the land sliding people mostly cultivate the Wheat and Corn. Mostly large area of Shiskat valley was submerged in the lake and compared with Gulmit valley. Forest was dominated with popular tree as well as the apricot trees were also dominated.

Sampling Design

Soil samples were taken by using random sampling method. The samples were collected from top soil up to depth 0 to 10cm in the dimensions of 10*10cm. Using a spade and or hand trowel the top cm layer of soil was carefully dug out. Soil samples were air dried and manually passed sieved with 2mm sieve prior to any analysis. The soil samples were taken to the lab (Mountain Areas Agricultural Center, Juglote; MARC) for the analysis of physiochemical and fertility status. The parameters include soil texture classes (SIC, hydrometric method), Soil pH was measured with 1:1 soil and water (McKeague, 1978; McLean, 1982). EC was measured by (electrical conductivity meter) the methodology which is given in US Handbook 60 (Richards, 1954). Soil organic carbon was measured by (Walkley, 1947). Soil NO_3-N, P, K was determined by the Ammonium Bicarbonate – DTPA Extractable method by (Sultanpour and Schwab, 1997).

Statistical Analysis

Significant difference between disaster and non-disaster soil were determine by applying Independent sample t-test.

Results and Discussion

The soil properties differed significantly in the disaster and non-disaster areas as shown by the analysis of variance below (Table 1).

Table 1 : T-test values and significance of soil properties with respect to disaster Disturbed and disaster non-disturbed soil.

Disaster Disturbed/ Non Disturbed	pH	SOC	NO_3-N	P	K	EC	Clay	Sand	Silt
	-1.26^{ns}	-2.438*	2.452*	-1.540^{ns}	-3.810***	-1.247^{ns}	0.712^{ns}	-0.137^{ns}	-0.797^{ns}

*Note: *, **, ***, and "ns" indicates p<0.05(5%), p< 0.01(1%), p<0.001 and "ns" non-significant respectively SOC, Soil Organic Carbon; NO3-N, Nitrate-Nitrogen; P, Phosphorus; K, Potassium; EC, Electric conductivity.*

The t-test showed that SOC, NO3-N and K differed significantly between disaster disturbed and disaster non-disturbed soil (Table 1). However pH, Available phosphorus, EC, sand, silt and clay are non-significant between disturbed and non-disturbed soil.

Soil physcio-chemical properties have also been analyzed to determine the impact of disaster on disaster disturbed and disaster un-disturbed soil.

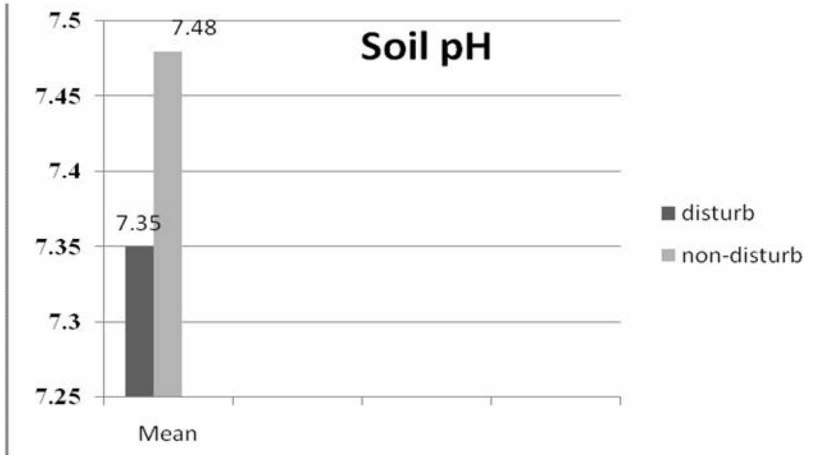


Figure 1 : The soil pH in disaster disturbed and un-disturbed soil.

Soil pH is an important soil chemical parameter, which affects the whole soil physiochemical properties; it depends on the farming practices. That's why soil pH is considered as one of the important soil chemical parameter to identify the impact of land use change (Idowu, et al., 2009; Schindelbeck, et al., 2008). The mean soil pH of disaster disturbed soil was (slightly higher than non-disturbed soil.

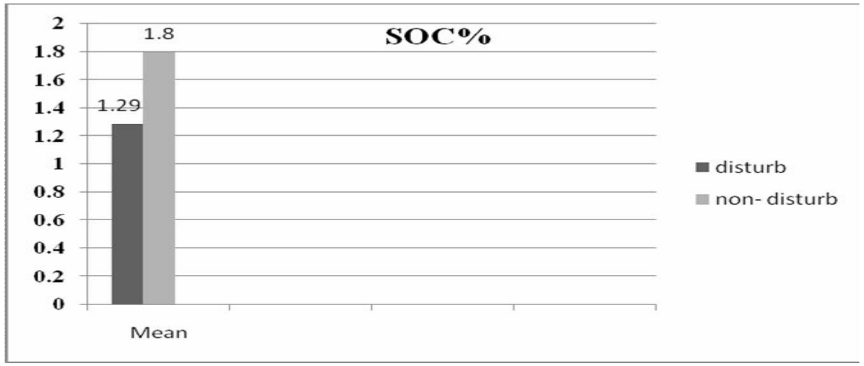


Figure 2 : Percentage distribution of soil organic carbon with respect to disaster disturbed and un-disturbed soil.

The SOC represents a significant constituent of the carbon cycle on the earth, and it plays important role in maintaining the soil physiochemical and biological properties. Management practices like conversion of crop lands to pasture land, tillage, intensive rotation and the use of green manure have got a great impact to maintain the optimum level of soil organic carbon (Paterson and Hoyle, 2011). There is a great difference between the SOC percentage of affected and non-affected soil. Soil organic carbon was significantly higher in non-disturbed soil. This result clearly showed that SOC completely affected by Attabad disaster.

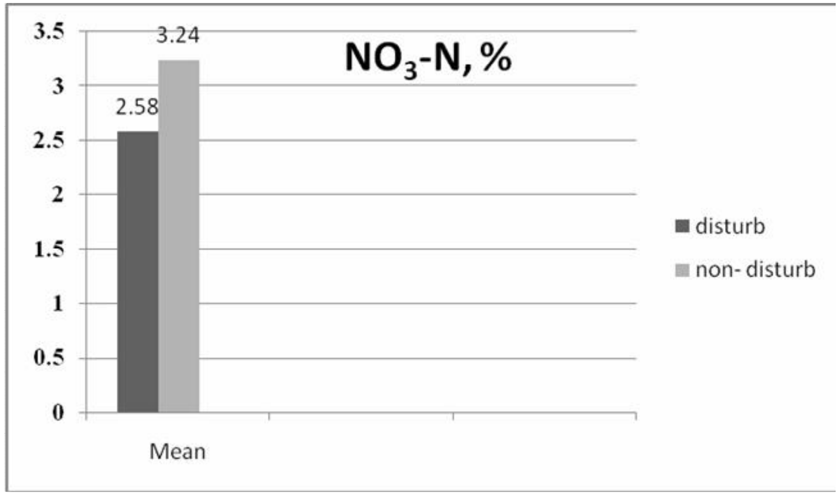


Figure 3 : Percentage distribution of Nitrate-Nitrogen (%) in disaster disturbed and non-disturbed soil.

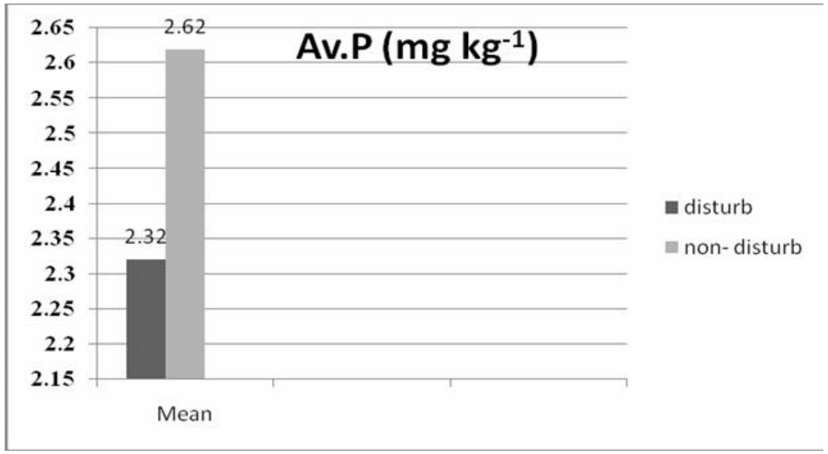


Figure 4 : Available phosphorus (mg kg-1) in disaster disturbed and non-disturbed soil.

There is a great difference between the Nitrate-Nitrogen and Available Phosphorus of disaster disturbed and disaster un-disturbed soil. NO3-N and Available Phosphorus was significantly higher in non-disturb soil than disturbed (Figures 3 and 4).

After Phosphorus and Nitrogen, Potassium is the third most vital plant nutrient, considered as very important parameter for plant growth and is very important for improving the quality of crops production. According to Bhatti (2011), most of the soil of Khyber Pakhunkhwa Province (KPK) of Pakistan clearly indicated the deficiency of potassium.

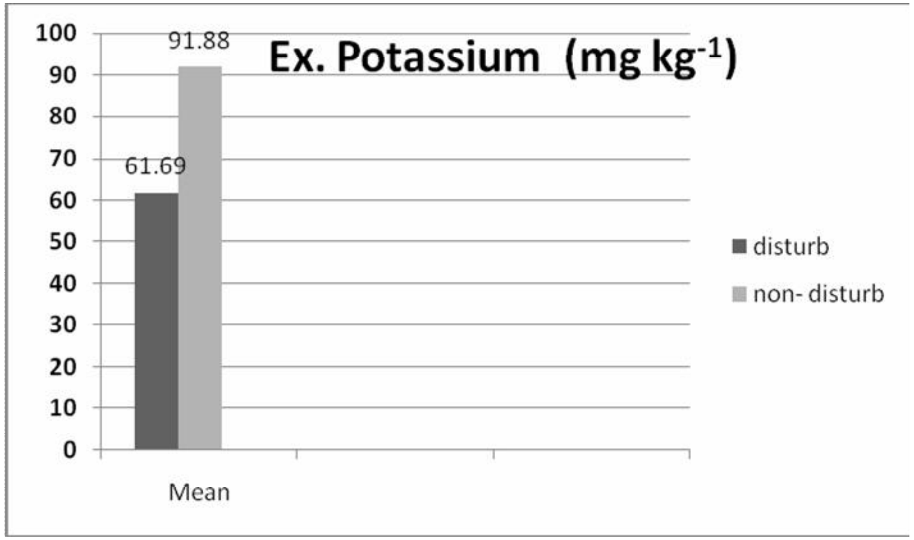


Figure 5 : Exchangeable potassium (mg kg-1) in disaster disturbed and un-disturbed soil.

Exchangeable Potassium was significantly higher at non-disturb soil this showed that disaster had greater impact on exchangeable potassium.

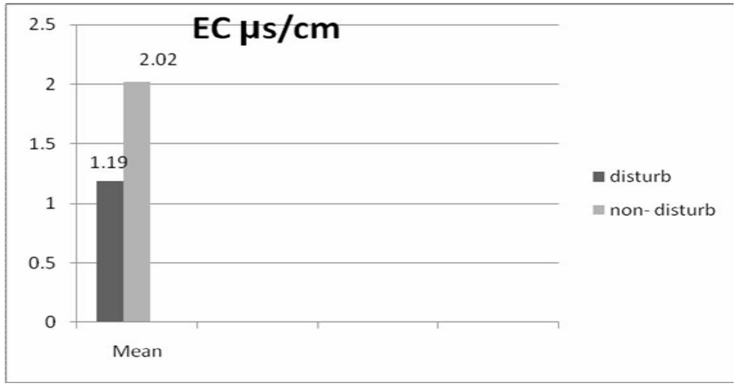


Figure 6 : Electrical conductivity (us/cm) of disaster disturbed and disaster un-disturbed soil.

Electrical conductivity of soil is is the ability of material to conduct and pass an electrical current (Ouhadi & Goodarzi, 2007). There was difference EC between disaster affected and non-affected soils. The mean EC was significantly higher at non-disaster than disaster soil (Figure 6).

Soil texture is an important soil physical parameter, which may alter the soil water holding capacity, structure, soil bulk density and also the soil consistency. It is actually the percentage distribution of sand particles, silt, and clay. Soil texture commonly used to differentiate the proportionate distribution of sand, silt and clay so it does not include any organic matter (OM) content. According to their size these mineral particles are separated in to groups (Brown, 2003).

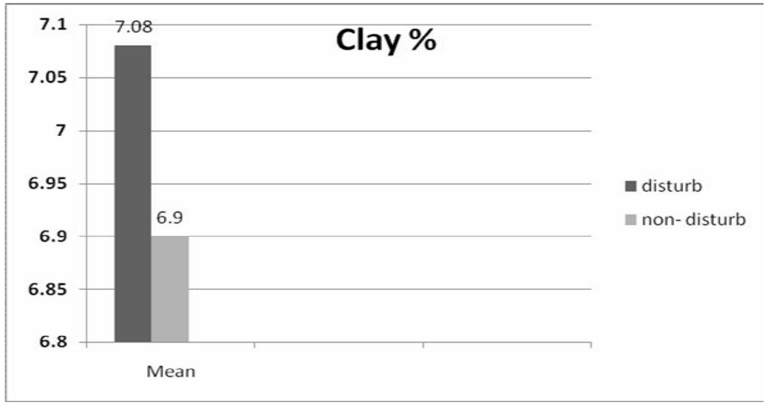


Figure 7 : Percentage distribution of clay in disaster disturbed and disaster un-disturbed soil.

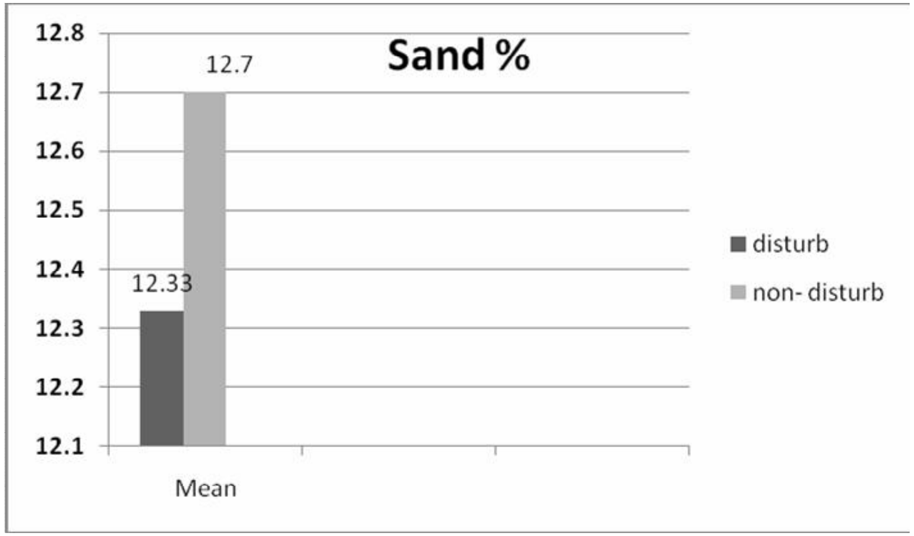


Figure 8 : Percentage distribution of sand in disaster disturbed and disaster un-disturbed soil.

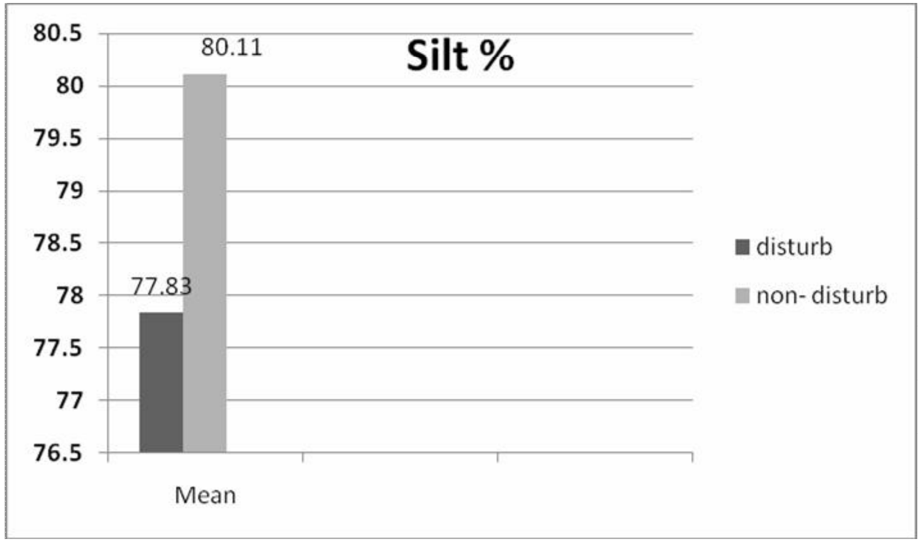


Figure 9 : Percentage distribution of silt in disaster disturbed and disaster un-disturbed soil.

The clay content in disaster disturbed soil was (7%) while in disaster un-disturbed soil was (6.91%). As well as the sand percentage in disaster disturbed soil was (12.3%) and disaster un-disturbed soil was (12.7%), Silt was (77.8%) in disaster disturbed while in un-disturbed it was (80.1%). Hence the soil textural class of disaster disturbed was (Silt loam) while textural class of disaster un-disturbed soil was (Silt) (Figures 7, 8, and 9) indicating a shift to higher coarse fractions (sand) due to the landslide.

Conclusions

The study evaluated the effect of Attabad landslide on the soil physiochemical and fertility status in Upper Hunza. Significant differences were observed in the soil properties due to disaster. SOC and Nitrate- Nitrogen and other fertility parameter were significantly decreased in the disturbed soil. Similarly soil texture also changed significantly due to the disaster. This preliminary study suggested that the Attabad disaster had significantly affected the soil properties directly or indirectly by degrading the soil quality.

References

Ayoubi, S., Khormali, F., Sahrawat, KL., & Rodrigues de Lima, AC. 2011. Assessing Impacts of Land Use Change on Soil Quality Indicators in a Loessial Soil in Golestan Province, Iran. Journel Agriculture. Sciences. Technology, 13: 727-742.

Baber, K., Khattak, RA., & Hakeem, A. 2004. Physico-chemical characteristics and fertility status of gilgit soils. Journel. Agriculture. Research , 305-312.

Bhatti, UA. 2011. Potash need assessment and use experience in Khyber Pakhtunkhwa (KP). Soil Environment. 30(1): 27-35.

Bot, A., & Benites, J. 2005. The impotance of Soil Organic Matter Key to drought-resistant soil and sustained food and production.Food and agriculture organization of the united nations.

Brown, BR. 2003. Soil Texture. Soil and Water Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL , 32611-0510.

Çelik, I. 2005. Land Use Effects on Organic Matter and Physical Properties of Soil in a Southern Mediterranean Highland of Turkey. Soil Tillage Research, 83:270-277. 10.1016/j.still.2004.08.001.

Daily GC, Alexander S, Ehrlich PR. 1997. Ecosystem services: benefits supplied to human societies by natural ecosystems. Issue Ecology. 2:18–24.

Foster, G. R. 2001. Keynote: Soil Erosion Prediction Technology for Conservation Planning.

Houghton, RA., & Goodale, CL. 2004. Effects of Land-Use Change on the Carbon Balance of Terrestrial Ecosystems. Ecosystems and Land Use Change Geophysical Monograph Series, 153, 85-98.

Idowu OJ., Van Es HM., Abawi GS., Wolfe DW., Schindelbeck, RR., Moebius-Clune, BN., Gugino, BK. 2009. Use of an integrative soil health test for evaluation of soil management impacts. Renewable Agriculture Food System 24, 214–224. 10.1017/S1742170509990068

Karlen, DL., Andrews, SS., Weinhold, BJ., Doran, JW. 2003. Soil quality: Humankind's foundation for survival. Journal of Soil and Water Conservation, 171-179.

Karlen, DL., MJ. Mausbach., JW. Doran., RG. Cline., RF. Harris., and GE. Schuman. 1997. "Soil quality: a concept, definition, and framework for evaluation," Soil Sci. Soc. Am. J., 61: 4–10, 10.2136/sssaj1997. 03615995006100010001x

Mclean, EO. 1982. Soil pH and lime requirement. In: A.L. Page (ed.), Methods of soil analysis, Part 2, Chemical and Microbiological properties. Am. Soc. Agron. Madison. WL. USA. P. 199-224.

Mckeague, JA (ed.). 1978. Manual on soil sample and methods of analysis. Canadian Society of Soil Science, 66-68

Moges, A., Dagnachew, M. & Yimer, F. 2013. Land Use Effects on Soil Quality Indicators: A Case Study of Abo-Wonsho Southern Ethiopia. Applied and Environmental Soil Science.http://dx.doi.org/10.1155/2013/784989

Mojiri, A., Emami, N., & Ghafari, N. 2011. Effects of Land Use Changes on Soil Quality Attributes (A Review). Research Journal of Agriculture & Biological Sciences, 7,

Oguike, PC. & Mbagwu, JS. 2009. Variations in Some Physical Properties and Organic Matter Content of Soils of Coastal Plain Sand under Different Land Use Types. World Journal of Agricultural Sciences, 5:63-69.

Ouhadi, RV. & Goodarzi, RA. 2007. Factors impacting the electro conductivity variations of clayey soils*.iranian journal of science & technology, transaction, engineering, 31:109-121

Perveen, S., Malik, Z. & Nazif, W. 2010. Fertility status of vegetable growing areas of Peshawer, Pakistan. Pakistan. Journal of Botany, 1871-1880.

Paterson, J., Hoyle, F. 2011. Soil organic carbon A Western Australian perspective. Department of Agriculture and Food.

Richards, LA. 1954. Diagnosis and improvement of the Saline and Alkali soils. USDA Agric, Handbook 60. Washington, D.C.

Shukla, MK., Lal, R. and Ebinger, M. 2006. Determining Soil Quality Indicators by Factor Analysis. Soil & Tillage Research. 87:194-204.10.1016/ j.still. 2005.03.011

Soltanpour, PN., and Ap. Schwab (ed.). 1977. A new soil test for simultaneous extraction of macro- and micronutrients in alkaline soils. Soil Sciences plant. Anal. 8:195-207

Schindelbeck, RR., Van, Es HM., Abawi, GS., Wolfe DW, Whitlow, TL, Gugino, BK, Idowu, OJ., Moebius-Clune, BN. 2008. Comprehensive assessment of soil quality for landscape and urban management. Landscape Urban Plan., 88:73–80. : 10.1016/j.landurbplan.2008.08.006

Walkley, A. 1947.A critical examination of a rapid method for determining organic carbon in soil ¬¬–effect of variations in digestion conditions and of it inorganic soil constituents. Soil Sci., 63:251-264.

The Gap Between Policy and Practice in Indonesia Forest Rehabilitation

Yonariza[1]*, Ganesh P. Shivakoti[2], Mahdi[1]

Abstract

Based on literature reviews as well as field observation in Indonesia's West Sumatra Province, this paper traces the forest rehabilitation policy focusing on policy since two decades ago till today. It then presents forest rehabilitation practice and discusses the gap between policy and practices. Importance policy issued by government was the collection of reforestation fund from forest concessionaires in 1990 and issuing government regulation on forest and land rehabilitation (FLR). Using these two policies, government launched national movement of forest and land rehabilitation (FLR) in 2003. However many studies found out that the reforestation fund was not effectively used and FLR was half-hearted implemented. At the end, community based forest restoration approach is proposed based on a case of volunteer carbon market (VCM) project in West Sumatera. The paper also suggests some recommendation for the future of forest rehabilitation in Indonesia under REDD+ mechanism.

Key words : production forest, reforestation fund, REDD, biodiversity, forest tenure.

Introduction

Forest rehabilitation including forest restoration, ecosystem restoration, and reforestation has become global agenda. Large areas of the world's forests have been degraded everywhere (Lamb *et. al* 2003). This worldwide problemwith annual estimates of forest loss being 9.4 million hectares throughout the 1990s and uncalculated degradation agreed to be higher. Tropical forest is the most severe losses(Dudley et al. 2005, p3). Forest loss createsacute threats to forest dependent biodiversity,has a series of direct social and economic costs because of the role of forests in supplying timber and many important nontimber forest products along with a wide range of environmental service such as the stabilization of soils and climate. Forest loss and degradation has already led to

[1] *Andalas University, Padang, West Sumatra Indonesia*

[2] *Asian Institute of Technology (AIT), Bangkok- Thailand*

**Corresponding author Email: yonariza@gmail.com*

the extinction of species, has altered hydrological regimes and has damaged the livelihoodsof millions of peoplewho rely on forests for subsistence. In many areas, protecting and managing the remaining forests are no longer sufficient steps in themselves to ensure that forest functions are maintained. Hence, reforestation is an essential component of any management strategy(Dudley et al. 2005, p4).

As Mansourian *et al*. (2005, p. v) put, the 21st century will be a time of forest restoration, since many forest habitats are already so damaged that their long term survival, and the ecological services they provide need to consider restoration if we are to achieve conservation and sustain the livelihoods of people dependent on nature. It is 'landscape-scale restoration measures are urgently required' (Page *at al.* 2009). Nevertheless, 'successful restoration of degraded forest must be grounded in scientific knowledge, relevant to socio-economic circumstances, and should not proceed without the consent and co-operation of local communities' (Page *at al.* 2009, p. 888). Brancalion *et al.* 2012, p. 41 provide guidelines that 'in human-modified landscapesin developing countries, tropical forestrestoration projects must not only assistthe recovery of ecosystems that have beendegraded, damaged or destroyed (the mostused definition of ecological restoration;SER, 2004), they must also bring economicrewards to landowners. However, it needs to keep in mind thatfinding the money for tropical forest restoration is a big challenge for tropical forest restoration (Brancalion *et al.* 2012), Indonesia, indeed, had accumulated reforestation fund from forest concessioners. Theoretically, Indonesia could self-financeher forest rehabilitation program.

As a recently venture, forest restoration is still in young development stage. Many existing restoration projects have partially or completely failed, often because the trees that they sought to establish have not survived or have been rapidly destroyed by the same pressures that have caused forest loss in the first place (Mansourian et al. 2005). Quoting Tompkins, S. (1989) Mansourian et al add that 'anyone working regularly in the tropics becomes accustomed to finding abandoned tree nurseries, often with their donor organizations' signboards still in place. Even when crops of trees have survived to maturity, they have not necessarily been welcomed, as evidenced by the widespread controversy over afforestation with exotic monocultures of conifers in much of western Europe.' (p.1).

Among tropical countries, Indonesian forest does not only face similar or even more acute problem of deforestation and forest degradation but also serious gap between policy and practice in forest rehabilitation. The loss of in Indonesia's foresthas significant effect on world forest.Since "Indonesia is a treasure chest of

biodiversity; it is home to between 10 and 15 per cent of all known species of plants, mammals and birds. Orang-utans, elephants, tigers, rhinoceroses, more than 1,500 species of birds and thousands of plant species are all a part of the country's natural legacy." (Green Peace, n.d). Unless forest rehabilitation and restoration are carried out in full swing, the mega diversity will gradually disappear do to exploitation.

Forest exploitation in Indonesia, started since colonial time, continues until today and caused serious deforestation and forest degradation, especially much of logging area became monoculture plantation areas or bare land. It made some of post logging areas has no longer feasible economically. Larger parts of forest landwere converted into agriculture and mining which further degraded and deforested the areas. Data from the Ministry of Forestry in 2000, the rate of degradation of natural forests in production forest, managed by concessionaires, is the highest (89%). Meanwhile, the level of damage in protection forest and conservation forest are; 46% and 38% respectively (Nawir *et al.*2008). It means lowland forest is almost disappeared and the remaining intact forest is only found in conservation forests which are found in mountainous areas.

Long before international community begun to tackle emission from deforestation and forest degradation as a strategy in mitigating climate change, Indonesia indeed had developed several policies on forest rehabilitation. The main purpose was to restore forest function after logging, fire, mining, and farming. The policies on rehabilitation strategies have also been improved realizing drawback of previous ones. Forest rehabilitation gains momentum after Indonesia made a commitment toreduce deforestation and forest degradation by 25% own her own and 41% with external supportby 2020. This is because Indonesia is one of main contributor for global carbon emission from deforestation and forest degradation. Greenhouse gas from land use change and forestry (LUCF) in Indonesia according to The Stern Report(2007) as much as 74% of total emission in the country(Wibowo 2010). Greenhouse Gas Emissions/ GHGoccurresin theIndonesianforestrysectorfrom deforestation(conversion of forests toother usessuch asagriculture, plantations, settlements, mining, infrastructure ofthe area) anddegradation(due to illegallogging, fires, over cutting, shifting cultivation (slash and burn), as well asencroachment(Nawir, *et al*.2008).Emissions from deforestation and land use change about 1.4 PgC/yrduring 1990 – 2010[3] (Ministry of Environment 2011).Since LUCF as main sources of emission, continuous deforestation and forest degradation require

[3]*Source of emission in Indonesia according to Second National Communication (2010) as follows; Energy 24%, Waste 11%, Agriculture 5 %, Industry 2%, Peatland 12%, and Land use change and forestry (LUCF) 46%.*

more rigorous forest rehabilitation efforts. Mitigation of climate changethatcanbe implementedat thesub-national level is forest rehabilitation (Wahyuni 2012,, p. 49).

Indonesia has paid attention in forest rehabilitation, different approaches have been implemented. Nawir, *et al*. (2008) report that from1950suntilthe 1970sthatthe approachusedinforest rehabilitation policiesgenerallytop-down, and then towards the end of the 1990s conceptually become more participatory. Between the 1980suntilthe mid-1990s, the initiatives are in transition. Rehabilitation began intensively manage dafter the Forestry Departmen became an independent departmentin 1983 (separated fromthe Ministryof Agriculture). Government divided rehabilitation effortsinto two categories, namely reforestation and affore station in forest areasand on community landsoutside theforest area. Sincereform era in 1998, the shiftfromlarge-scalecompany-based forest managementinto smaller scalecommunity-based forest managementbeganto gain momentum.

Despite long duration effort for forest rehabilitation, Indonesian forest continues to shrinking. Deforestation and forest degradation continue at alarming level, meanwhile forest rehabilitation fail. Recent publication by Nature Journal shows that in last decade alone, from 2000 to 2012, Indonesia lost her natural forest as big as 6.02 Mha and increased on average by 47,600 ha per year (Belinda, *et al.* 2014). Similar report published by Miettinen et al (2011) reveals that from period of2000-2010 the 'overall 1.0% yearly decline in forest cover in insular Southeast Asia (including the Indonesian part of New Guinea) with main change trajectories to plantations and secondary vegetation. They add that throughout the region, peat swamp forests experienced clearly the highest deforestation rates at an average annual rate of 2.2%, whilelowland evergreen forests declined by 1.2%/yr. In addition, the analysis showed remarkable spatial variation indeforestation levels within the region and exposed two extreme concentration areas with over 5.0% annual forest loss:the eastern lowlands of Sumatra and the peat lands of Sarawak, Borneo' (p 2261). This means there is a big gap between reforestation policy and practices.

Using literature reviews this study answering the following question; 1) what are major forest rehabilitation policy in Indonesia 2) How the rehabilitation policies were practiced; 3) what the gap between forest rehabilitation policy and practices, 4) what option is available to improve forest rehabilitation policy and practices.

Indonesian Forest Rehabilitation Policy

As far as policy guidelines, some form of rehabilitation rather than restoration is the preferred approach.In this case, 'there is an urgent need to both improve the

quality of forest restoration and rehabilitation at the site level and to find effective ways to undertake these activities in the context of broader environmental, social and economic needs and interests. Linking forest restoration and rehabilitation activities at the site level with the environmental, social and economic needs at the landscape and eco-regional level' (Lam and Gilmour 2003 p. i). Hence, rehabilitation must be context specific.

As mentioned earlier, the rate of deforestation in Indonesia is at alarming level, it is beyond capacity to rehabilitate. Forest rehabilitation became a policy to restore forest productivity and has been translated into forestry law regarding forest management that includes forest rehabilitation and reclamation. The Indonesia 1999 forestry law, article 40 defines objectives of forest rehabilitation namely; to recover, to maintain, and to increase forest and land function so that their carrying capacity, productivity, and their role as life supporting is well maintained. Article 41 lays down forest rehabilitation activities to include reforestation, re-greening, forest maintaining, forest enrichment, or application of land conservation silviculture techniques or using civil engineering on critical or unproductive lands.

The need for forest rehabilitation in last two decades is very clear when we compare Forestry Law No 41 year 1999 from its predecessor Forestry Law No. 5 year 1967 in which we found no single clausal regarding forest rehabilitation. In recent forestry law, the term forest rehabilitation appears 13 times and forest reclamation 7 times.

Deforestation and forest degradation had occurred much earlier during the forest exploitation period. Government had begun to focus on forest and critical land rehabilitation. In 1983 with issuance of Presidential Decree No. 4/M/1983, a new organ within Ministry of Forestry was created, that wasGeneral Directorate for Reforestation and Land Rehabilitation (FLR). However, it found out that social problem was one major characteristics of land rehabilitation. FLR then was adjusted and the name was changed into General Directorate for Land Rehabilitation and Social Forestry (Ministry of Forestry Decree No. 245/KPTS-II/1999). Later on it found out those complexities of problem related to land rehabilitation and social forestry, the organ dealing with these issues need new adjustment and the name changed into General Directorate of Catchment Management and Social Forestry (Ditjen BPDASPS) with the issuance of Presidential Regulation No. 24/2010 (Santoso, 2011).Recent forest rehabilitation policy adopts participatory and biophysical site specific approach. Participatory approach aims at empowering and developing community capacity and potency (article 42 forestry law). The policies also request the users of critical land to implement forest and land rehabilitation for protection and conservation (Article 43).

Government Regulation No. 76 was enacted in 2008 on Forest Rehabilitation and Reclamation to provide guidance for forest rehabilitation. The regulation lays down organizing principle of forest rehabilitation and reclamation (Article 4) covering: sustainable budgeting system (multi-year); clarity of authority; understanding of the tenure system; share of the cost (cost sharing); incentive systems; community empowerment and institutional capacity building; participatory approach; and transparency and accountability. Forest rehabilitation(Article21 paragraph shall be implemented throughreforestation; plantscare; plants enrichment; orapplication of soil conservation. The reforestationcan be carried out intheall types of forest function; protected forest; productionforests; orconservation forest.

Forest rehabilitation is one of the five policy priorities of the Ministry of Forestry (2009-2014). This policy aims to address the problems faced by the regional (district / city) associated with increasing environmental degradation, including deforestation. Reduced environmental quality can cause floods and landslides, drought, high levels of abrasion due to the destruction of mangrove forests and other environmental disasters. Forest and land rehabilitation policy (FLR) is intended to improve environmental carrying capacity, speed up recovery of critical forest areas and maintain/preserve the integrity of the forest and its functions. The policy needs is supported with funding, preparation of human resource, institutional as well as and community participation. Therefore the use of special forestry budget is directed to accelerate the region in implementing forest and land rehabilitation (MoF Decree P.3/Menhut-II/2009). Reforestation includes activities such as; seedbed nursery, planting, plant maintenance, protection, and supporting activities.

The rehabilitation policy stresses that maintenance ofplantin production forestsandprotected forests shall be fundedby the Government and implementedsince thefirst year until thethird year. Meanwhile, maintenance of plants in production forests and protected forests after the third year carried out by the local Government at district / city or Forests Management Unit (FMU). As will be shown later, this is aloop hole in forest rehabilitation practices where local governments do not play their role due to lack of funding and willing.

The policy on utilization of harvest of forest and land rehabilitation program depends on who carry out the rehabilitation. If it is funded by central government, provincial governments, district/city governments set up in accordance with the provisions of the legislation. Utilization of forest

rehabilitation results conducted by the holder of the rights or permissions are set in accordance with the provisions of the legislation. Utilization of the harvest of rehabilitation of land held by the right holder or permit holder. Utilization of harvest from land rehabilitation funded by the Government, provincial governments, and / or the district / city governed by regulations of the Forestry Minister. This provides clear incentives for those involve in forest rehabilitation.

Forest Rehabilitation Fund (Dana Reboisasi)

Understanding that forest rehabilitation need fund to invest, an important policy produced was the collection of reforestation fund. This was an awareness that when forest was heavily exploited, the government was aware that forest extraction must be followed by forest rehabilitation to which investment shall be made. This was prepared by collecting reforestation fund from logging concessioners in the form of Dana Reboisasi (DR) or Reforestation Fund (RF). Reforestation Fund is a fund collected from Forest Concession Holder, Harvest Forest and Wood Utilization Permit Holders through upstream Wood Processing Industry Owner to be used for reforestation, commercial plantation development, and forest land rehabilitation. It was decided the amount offundsfor Reforestationandforestregenerationof theforest concessionareawhich were: a.US. $.4, -(Four Statesdollars) foreachcubic meterof woodofallkindsproduced; b. US. $.0,50, -(FiftycentsUSD)foreachcubic meterchip woodproduced.

To strengthen legal basis of Reforestation fund, Government regulation No. 35 year 2002 on Reforestation Fund was issued. Reforestation fund is collected from forest concessionaires to be used for reforestation and land rehabilitation activities and its supporting activities. The fund is used by central and local government. The usage of fund by central government is for rehabilitation of forest land and land outside forest area in the non-RF collecting regions. Over the past 20 years, the RF has had aggregated (nominal) receipts of approximately US $5.8 billion, making it the single largest source of government revenues from Indonesia's commercial forestry sector (Barr*et al.*2010). With the cost of forest and land rehabilitation on average USD 43 per ha per ha (Nawir, *et al.* 2008), the collected RF would be enough to rehabilitate as much as 134,883,720.93 ha forest and land. Meanwhile, there degraded forest was 60 million ha. It is more than enough. But, how this fund was spent shows a big between policy and practice.

Forest Rehabilitation Practice

Given above mentioned policy on forest rehabilitation and reforestation fund collection, government through Ministry of Forestry has launched several programs. A big program was National Movement Forest and Land

Rehabilitation program (NM-FLR) as an effort to restore, maintain and improve the function of forest and land so that the carrying capacity, productivity and its role in supporting life system is maintained. **Reforestation** is the effort of planting forest tree species in degraded forest areas which is vacant land / open, reeds or scrub and mangrove forest to restore forest functions; **Reforestation enrichment** involve planting saplingson mangrove forest stands that have a seedling, sapling, pole and trees 500-700 stems/ha, with an objective to enhancing the value of forest stands both quality and quantity according to its function; while **Greening** is FLR activity conducted outside the forest area; (MoF Decree P. 3/Menhut-II/2009). Two main schemes of forest rehabilitation practices are presented here, Forest and Land Rehabilitation and Ecosystem Restoration.

National Movement on Forest and Land Rehabilitation (NM-FLR)

National Movement for Forestry and Land Rehabilitation (NM-FLR), began in 2003, aimsto rise society awareness on forestry functions for human survival (Nasution 2010). This was a significant practice of forest and land rehabilitation in Indonesia carried out by supposedly coordinatedactivitiesby utilizingall the potential andability of the government, provincialgovernment, district / city governments, businesses andcommunitiesin the context offorest rehabilitationonprioritywatersheds (Presidential Regulation No .89-2007 on National Movement forForest and Land Rehabilitation).

Implementation of NM-FLR was based on the principles of silvicultural systems and multiple years. Planting trees inside forest areas to be funded with State Budget, District Budget (regional budget) is implemented on contractualbasis in multiple yearsby mobilizing the potential of national companies or regional companies and involving the community. Implementation of NM-FLRby planting trees in certain forest area also taking into considerationspecific conditions such security issue, this is solved by involvement armyoperation. Implementation of forest and land rehabilitation NM-FLR through planting trees outside the forest area funded by regional budget or the state budget implemented based self-management of multi-year through Cooperation Agreements with farmers' group by mobilizing society's potential (Presidential Regulation No .89- 2007 on NM-FLR).

Article 17 (1) Operation NM-FLR in production forests and protected areas is delegated to the state-owned enterprises in forestry or forest management units financed by the state or the relevant Forest Management Unit. (2) The Government may assignstate enterprises to carry outNM-FLR on protected forest in their working area, with funds from the state budget. (3) Implementation NM-FLR in production forests and protected areas that beardforest utilization and use

permit areas funded by the license holder (Presidential Regulation No .89 -2007 on NM-FLR).

The activities of NM-FLRfor the year 2004, for example, include: a. provision of seed b. planting trees: 1) Reforestation protected forest and production forest 2) Reforestation of conservation forest 3) Forest for People 4) Mangrove Rehabilitation 5) Greening Cities 6) pillar Road c. Preparation of soil conservation infrastructures: 1) controllers Dam 2) retaining Dam 3) Control the abyss (gully plug) 4) infiltration Well 5) check dam d. plant maintenance e. Specific activities: 1) Planting with intensive silviculture systems 2) Development of Muna Teak 3) Renovation seed production centers and small-scale renovation of a permanent nursery 4) Research and development f. Institutional development, g. monitoring and control. (MoF Regulation No. P.02/Menhut-V/2004 on the implementation of NM-FLR).

Considering a huge area of degraded forest and land area of ± 40 million hectares and with a deforestation rate of ± 1.6 million per year, the government has set a forest policy for a period of 20 years to be directed to the degraded Rehabilitation of degraded forest and land (FLR) as part of the long-term policies. Unfortunately, over a period of 5 years (2003-2007) the Government could only plan FLRactivities for area of 3 million hectares (Akhdiyat 2008), which means 600,000 ha per year.But, it is hard to measure the rehabilitation performance that shows a big gap between policy and practices.

Ecosystem Restoration

The RHL experience shows that government is under capacity to rehabilitate 40 million degraded forest. A recent approach of forest rehabilitation is through restoration ecosystem (RE) program.In Indonesia, ecosystem restoration is defined as "an attempt to build in the area of natural forest especially production forest that has an ***important ecosystem functions*** that can maintainits function and their representation through maintenance, protection and restoration of forest ecosystems, including planting, enrichment, thinning, animal breeding, reintroduction of flora and fauna to restore the biological elements (flora and fauna) and non-biological elements (soil, climate and topography) in an area to the original type, in order to reach equilibrium and its ecosystem." (UKP-PPP 2011 cit in Burung Indonesia 2012).

Toward ecosystem restoration in production forest, Indonesian government invites investors; however the only available scheme is through mechanisms and procedures of Granting Forest Timber Business Licenses (IUPHHK-RE) in natural forest. This is unmatched situation as degraded forest need more time to rehabilitate and longer time for economic return. However, some conservation agencies, local and international are interested in taking this scheme, they are interested in forest ecosystem that has potential biodiversity and contains some endanger species, so the restoration is aimed at species preservation. Other production forest ecosystem that lack biodiversity richness may be left behind. Beginning only in year 2007, as of 2014, there are 12 the IUPHHHK-RE, unfortunately at field level, they find problems of tenure uncertainty as well as land conflict with local community and some overlap with business license.[4]" This replicates earlier timber concession problem.

Forest Ecosystem Restoration (FER) is expensive and need capital in advance to support initial investment with very long time payback period. As case in Berbak National Park, in Jambi province, it involves 16 key partners, aside from local there are DELTARES, Clinton Foundation, Tropical Forest Conservation Action Sumatra USA, DEFRA UK, Panthera Fund, Darwin Initiative-UK, 21 Century Tigers, US Fish and Wildlife Service and Segre Fund. The Project Developer is Zoological Society of London (ZSL).

Harapan forest, a FER in South Sumatra and Jambi province, is interested Bird Life International, a UK base NGO under patronage of British Royal Family, because there were at least 235 species of birds, 36 species of reptiles and amphibians, and 37 species of mammals identified. There is also an endangered species such as the endangered Sumatran tiger, and six types of forest, Asian elephants, tapirs, monkeys and other primates. While the types of plants that dominate most of the region, namely: Meranti (Shorea spp), Kempas (Koompasia excelsa), and Balam (Palaquium spp). There is also some protected tree species such as iron wood or Bulian (*Eusideroxylon zwageri*), Jelutung (*Dyera costulatia*) and Surian (*Toona sureni*)."Established in 2008 the Harapan Rainforest (HRF) ecosystem restoration concession is pioneering a new approach to restoring Indonesia's logged out production forests. HRF covers 98,555 ha of Sumatran lowland rainforest that straddles the borders of South Sumatra and Jambi provinces." http://burung.org/en/our-works/ecosystem-restoration/re-artikel.

From 2007 until 2013, there have been seven licenses of ERC in Indonesiawith total areas granted is 268,353 ha (BRPUK, 2013 cit in Mardiastuti 2013).[5]All of these seven forest restoration concessions received fund from abroad.

[4] *http://puskonser.or.id/index.php/detail/270/restorasi-ekosistem-mainstream-pembangunan-sektor-kehutanan-kedepan#.UzkfE_mSxhk*

[5] *These are;*

1 PT.Restorasi Ekosistem Indonesia (2007) South Sumatra 52.17 Ha

2 PT.Restorasi Ekosistem Indonesia (2010) Jambi 46.385 Ha

3 PT.Restorasi Habitat Orangutan Indonesia (2010) East Borneo 86.45 Ha

The Gap between Policy and Practice

Given the fact that forest rehabilitation policies have been formulated and rehabilitation programs have been implemented, but forest condition have not been improved, and at the same time deforestation continues. Forest statistics show that as of 2012, total deforested rate in Indonesia as much as352.532,2 haper year. (MoF 2014). However as Mulyana (2000) suspect forest rehabilitation programs have not been able to solve degraded and critical forest and land in Indonesia, contrary to the expectation deforestation rate is much higher than rehabilitation rate (see also Nawir *et al.* 2008). Influential variables to the failure of RHL among others are; farmer participation in program management starting from planning, product marketing, incentives of rehabilitation and integrated implementation rehabilitation with land use direction (Widiyastuti2010). Mulyana (2000) admitted that rehabilitation program needs technical as well as social engineering. Local people is very important element in forest rehabilitation specially when they perceive the forest land as cultivable land (Sawitri andBismark 2013).

This reflects a hug gap between policy and practice. One way to see the gap between policy and practice is by comparing the guideline with what was carried out (Zolala and Haghdoost, 2011).To close the gap seem impossible as policy was drawn under some assumptions, there is a need to narrow the gap. It also means more evidences need to be collected. For the case of forest rehabilitation policy and program in Indonesia, various research results assert that the failure of RHL implemented by the government due to its implementation still instruction (top-down approach), project-oriented, and lack of community involvement (Subarudi 2011). It has no doubt that Indonesia deforestation increased. Belinda Margono and Hansen cs study states, the period 2000 - 2012, Indonesia lost 6.02 million hectares of primary forest, the average increase in loss of 47.6 thousand hectares per year. In 2012, Indonesia lost an estimated 0.84 million hectares of primary forest or the equivalent of two times the rate of loss of Brazil in the same period (0.46 million hectares) (Saturi, S. 2014).

It is no wonder that critics on FLR were enormous. Hamiudin (2011) reports that's although forest rehabilitationactivitieswere directed to establish quality forests

4 PT. Ekosistem Khatulistiwa Lestari (2011) West Borneo 14.08 Ha

5 PT. Gemilang Cipta Nusantara (2011) Riau 20.265 Ha

6 PT. Rimba Raya Conservation (2013) Middle Borneo 36.331 Ha

7 PT. Sipef Biodiversity Indonesia (2013) Bengkulu 12.672 Ha and restoreits function, the targetof FLR, however, was assessed using wrong indicators, namely the volumeof seedsplantedandcultivatedland area. Realevidence, the report simplementation of rehabilitation has always conveya broadindicator ofthe amount of land plantedand seeds are embedded, has never providedan indicators, i.e whether theseedsimplantedare directly proportional to theabsorption ofrainfall intothe soil, improving air quality, soilerosionandlandslide-free, and there-establishment of forestecosystemas a whole. Expectationsorthe outputofthe implementation ofFLRshould be the change in degraded land and critical land coverboth inside andoutside theforestareabytype ofwoodandMPTS. In addition, to thereturn offorestqualityand function, these plantsmust striveto surviveindependentlyofanyrisk ofdeathin order to achievethe goalof FLRthat istoreturn thecritical areafunctions as alife support systemin terms ofpreventionof flood, erosion, landslidesandso on (Hamiudin 2011).

Since 2000, The level of rehabilitation is left behind by the rate of forest degradation and rehabilitation budget allocations are less effective. Over the last three decades, the Indonesian government appears to have attempted to address the growing rate of forest degradation, and the various consequences of this degradation. However, the government targeted to rehabilitate 18.7 million hectares from 1970 to 2004 was not achieved, so that the rest of degraded forest instead of 24.9 million ha, now it has doubled to 43.6 million ha. This suggests that during this period, activities and projects have not been successful, as well as existing policies and programs have not addressed the underlying causes of forest degradation (Nawir et al 2008).

The same also true for investment made using reforestation fund. In turn, during in May 2010, Norway and Indonesia signed a US$1 billion forest deal as part of REDD+ scheme, meanwhile if the Reforestation Fund was correctly managed, Indonesia does not need foreign countries help to carry on REDD+, as mentioned earlier government of Indonesia was able to accumulate RF more than USD 5 billion.Study by CIFOR (2011) found that Reforestation Funds Management executed using government regulation No. 35 set in 2002 to replace Regulation No. 6/1999. The regulations stipulate that forty percent of RF allocated back to the provinces that have contributed to the central government Reforestation Funds. Program established under this funding system called Special Allocation Funds - Reforestation Funds (DAK-DR). The program has been running since 2001 under the coordination of district governments. The purposes of the program were: facilitating community participation in rehabilitation by providing assistance for planning activities, institutional development and providing technical assistance in the implementation of the planned activities. In addition, Sixty percent of the funds collected are allocated to the Department of Forestry to fund rehabilitation projects in the non-contributing provinces (provinces which donot

contribute to the central government's Reforestation Fund). The allocation is based on 5 years of rehabilitation plan designed jointly by the Minister of Forestry and the Ministry of Finance. The funds are allocated to cooperatives, forest farmer groups, and other legal entities organizations to carry out rehabilitation projects directly through a loan scheme designed as a revolving fund (Nawir*et al.*.2008). Unfortunately, data regarding the realization of the total area rehabilitated through this program does not appear well (Nawir *et al*. 2008).

Community Based Forest Restoration, Case of Volunteer Carbon Market Near Singkarak Lake, West Sumatra-Indonesia

Government sponsored forest rehabilitation and restoration hardly bring forest back. Several factors contribute to this minimal results, among others; lack of tree tender, lack of tree and land tenure security, and unclear incentives. It is not specific case for Indonesia, lesson from previous restoration projects reveals 'too many restoration projects do not bother to find out what local people really want at all; if they do, then a collection of different and often opposing or mutually exclusive wants and desires emerge' (Mansourian et al. 2005, p. 6). Community based forest restoration with a clear incentives could be a model to follow. A case of a small famer group who deal with forest rehabilitation in West Sumatra may provide evidences if some barrier to successful forest rehabilitation are removed, rehabilitation bring good result.

Bukit Panjang Farmer Group

Located in degraded hills of Singkarak Lake in Solok District, West Sumatra Province, Bukit Panjang Farmer Groupinvolves in Voluntary Carbon Market (VCM) in 2013. They came into agreement with a Dutch CO_2BVbroker to restore imperata grass land into forest using Assisted Natural Regeneration (ANR) technique. CO2BV then sell sequestrated Carbon to small carbon emitter in Netherland using voluntaries carbon market (VCM).Theagreement last for five years where during that time farmers have to manage the regrown vegetation and maintain at least 700 trees per ha mix of natural vegetation and enriched with introduced economic tree species of their wish, timber and non-timber. During the agreement, no cutting is allowed. In turn, CO2BV provides investment and maintenance cost around IDR 10,000 (less than USD 1.00) per tree. This gives farmers IDR 7 mio per ha, while many trees grow naturally. The fund is disbursed three installments, first, second and third year, 50%:30%:20% respectively. The group uses the fund to prepare land, purchasing seedling and receiving daily allowance for working their land. The group constructed a hut, purchased equipment and tools such as grass-cutter, as well as paying the members for manual work Rp. 30,000 per day.

Farmers are actually in the intention to cultivate degraded forest but they are hindered by working capital. Usually, they would find ample time to work on the dry farm landafter they finish working in wetland and they need working capital for land rehabilitation. It is with the support of carbon market, the farmer get working capital and no need to use their deposit income for working capital. Hence there is meeting point between demand and supplyfor carbon sequestration. What happened in Paninggagahan village about community based rehabilitation corroborate with (Mulyana 2000)who said that rehabilitation must have achieve two objectives; community welfare and optimal forest function. This is a cost and benefit sharing principles. In a watershed-level study in northern Thailand, Wittayapak and Dearden (1999) found that collective action is likely to be more successful in smaller watersheds close to the communities with clearly demarcated boundaries and fewer users with high individual involvement in decision making (Gautam and Shivakoti 2005)

Conclusion and Recommendation

Continues forest degradation has reduced quality of life in Indonesia, due to drought and flood as consequences. Government adopts policy to slow down the deforestation and rehabilitate and restore the forest. However, the government sponsored forest rehabilitation and practice is not effective. This is ironic while many plantation are successful, reforestation which also follow activities similar to those in plantation failed.

Alternative course of forest rehabilitation is through Ecosystem Restoration where tenure security is given to multinational organization by granting them 100 years concession areas. Nevertheless, if incentives for forest rehabilitation and forest restoration are clear, community is a reliable actorto carry on forest rehabilitation and forest restoration aside from government and private sector. These alternatives are useful for REDD+ program.

Acknowledgment

Author express debt of gratitude to Toyota Foundation for funding provided to carry out this research.As usual, only authors are responsible for the content of the paper and the view presented in this paper is solely the author and not necessarily of Toyota Foundation. The presenter of this paper also thank Andalas University for providing travel grant to attend this conference.

Referrence

Barr, C., Dermawan, A., Purnomo, H. and Komarudin, H. 2010. Financial governance and Indonesia's Reforestation Fund during the Soeharto and post-Soeharto periods, 1989–2009: a political economic analysis of lessons for REDD+. Occasional paper 52. CIFOR, Bogor, Indonesia.

Belinda, A. M., Potapov, P. V., Turubanova, S, Stolle, F., and Hansen, M.C.2014. Primary forest cover loss in Indonesia over 2000–2012. Nature Climate Change. Published Online: 29 June 2014.

Brancalion, P.H.S., Viani, R.A.G., Strassburg, B.B.N., and Rodrigues, R.R. 2012. Finding the money for tropical forest restoration. Unasylva An international journal of forestry and forest industries Unasylva 239, Vol. 63, 2012/1The Power of Forests. 41 – 50.

Dudley, N., Mansourian, S. and Vallauri, D. 2005. Forest Landscape Restoration in Context. In Mansourian, S.,Vallauri,D., Dudley,N., eds. (in cooperation with WWF International). Forest Restoration in Landscapes: Beyond Planting Trees, Springer, New York, pp: 3-7.

Gautam, A.P., Shivakoti, G.P. 2005. Conditions for Successful Local Collective Action in Forestry: Some Evidence From the Hills of Nepal. Society and Natural Resources, 18:153–171, 2005.

Gautam, A.P., Shivakoti, G.P. 2005. Conditions for Successful Local Collective Action in Forestry: Some Evidence From the Hills of Nepal. Society and Natural Resources, 18:153–171, 2005

Green Peace International. n.d. Indonesia Forest.http://www.greenpeace.org/international/en/campaigns/forests/asia-pacific/)

Hamiudin, 2011. RHL : Target Volume Atau Terbangunnya Hutan? (National Movement in Forest and Land Rehabilitation). http://www.rimbawan.or.id/2011/06/rhl-target-volume-atau-terbangunnya-hutan.html access: 15/7/2014

IPCC, 2000 - Robert T. Watson, Ian R. Noble, Bert Bolin, N. H. Ravindranath, David J. Verardo and David J. Dokken (Eds.) Land Use, Land-Use Change and Forestry. Cambridge University Press, UK. pp 375. http://www.ipcc.ch/ipccreports/sres/land_use/index.php?idp=0 access 16 July 2014

Kurniawan, S.; Sari, N.P.; Nasution, A.H.; Asmadi, Fahriza, and Nursamsu. 2008. Menghentikan Deforestasi Hutan Alam di Kawasan Hutan Produksi Pendekatan ILEA (Curtailing deforestation in production forest, an ILEA approach). Pekanbaru: Jikalahari. November 2008

Lamb, D. and Gilmour, D. 2003. Rehabilitation and Restoration of Degraded Forests. IUCN, Gland, Switzerland and Cambridge, UK and WWF, Gland, Switzerland. x +110 pp

Mansourian, S.,Vallauri,D., Dudley, N., eds. (in cooperation with WWF International) 2005. Forest Restoration in Landscapes: Beyond Planting Trees, Springer, New York.

Maryani R, Agung P, Suyanto. 2012. REDD+ in Indonesia: a Historical Perspective. Working paper 154. Bogor, Indonesia: World Agroforestry Centre (ICRAF) Southeast Asia Regional Program. DOI: 10.5716/WP12053.PDF. 20p

Miettinen , J., Shi, C. and Liew, S.C. 2011. Deforestation rates in insular Southeast Asia between 2000 and 2010. *Global Change Biology* (2011) 17, 2261–2270.

Ministry of Environment, Republic of Indonesia. 2010. Indonesia Second National Communication under The United Nations Framework Convent ion on Climate Change.

Ministry of Forestry Republic of Indonesia (MoF). 2014. Statistik Kehutanan (Forestry Statistic). Jakarta: Ministry of Forestry.

MoF Regulation No. P.02/Menhut-V/2004 on the implementation of National Movement for forest and land rehabilitation (NM-FLR)

Mulyana, Y. 2000. Rehabilitasi Hutan dan Lahan dalam Era Otonomi Daerah (*Forest and Land Rehabilitation in Regional Autonomy Era*).Proceeding Forest Management Improvement.

Nasution, K. 2010. Alisis Ekonomi Masyarakat dan Kelestarian Hutan Dalam Gerakan Nasional Rehabilitasi Hutan Dan Lahan Di Kabupaten Karo (Community economic analysis of National Movement on Forest and Land Rehabilitation). Jurnal Ilmiah Abdi Ilmu Vol.3 No.2 Desember 2010

Nawir, A.A., Murniati, Rumboko, L.2008. Rehabilitasi hutan di Indonesia, Akan kemanakah arahnya setelah lebih dari tiga dasawarsa? (Forest rehabilitation in Indonesia, which direction after three decades?). Bogor: Center for International Forestry Research (CIFOR).

Page, S.; Hosciło, A., Wo, H., Jauhiainen, J., Silvius, M., Rieley, J., Ritzema, H., Tansey, K., Graham, L., Vasander, H., and Limin, S. 2009. Restoration Ecology of Lowland Tropical Peatlands in Southeast Asia: Current Knowledge and Future Research Directions. *Ecosystems* (12): 888–905

Ministry of Forestry Republic of Indonesia. 2004. PERATURAN MENTERI KEHUTANAN NOMOR : P.02/Menhut-V/2004 TENTANG PENYELENGGARAAN KEGIATAN GERAKAN NASIONAL REHABILITASI HUTAN DAN LAHAN TAHUN 2004 (On Implementation of The National Movement of Forest And Land Rehabilitation).

Ministry of Finance Republic of Indonesia. 2007. PERATURAN MENTERI KEUANGAN NOMOR 126/PMK.07/2007 Tentang Pedoman Umum Pelaksanaan Dana Bagi Hasil Sumber Daya Alam Kehutanan-Dana Reboisasi (Ministrial Decree on General Guidelines on The Implementation of Funds Forestry-Natural Resources Fund for Reforestation)

Santoso, H. 2011. Kebijakan Rehabilitasi Hutan dan Lahan (*Forest and Land Rehabilitation Policy*). Paper presented at Forestry Journalistic Orientation. Jakarta: Indonesia Ministry of Forestry.

Saturi,S. 2014. Riset Terbaru Temukan Deforestasi Indonesia Tinggi, Apa Kata Kemenhut dan BP REDD+? (Recent Research finds a high deforestation of Indonesia natural forest, what Ministry of Forestry and REDD+ Agency have to say?).Mongabay July 11, 2014. http://www.mongabay.co.id/2014/07/11/riset-terbaru-temukan-deforestasi-indonesia-tinggi-apa-kata-kemenhut-dan-bp-redd/access 17/7/2014.

Sawitri, R. *and* Bismark. M. 2013. Persepsi Masyarakat Terhadap Restorasi Zona Rehabilitasi di Taman Nasional Gunung Gede Pangrango (*Community Perception to Restoration of Rehabilitation Zone in Mt. Gede Pangrango National Park*). *Forest Rehabilitation Journal* Vol. 1 No. 1, September 2013: 91-112

Situmorang, A.W; Katodihardo, H. 2013. Indeks TaTa kelola Hutan, lahan, dan REDD+ 2012 di Indonesia (Forest Governance Index in Indonesia). @ UNDP Indonesia.

Subarudi. 2011. Rehabilitasi Hutan dan lahan Partisipatif, Pengalaman Restorasi Danau Toba, Sumatera Utara (Participatory forest and land rehabilitation, experience of Lake Toba Restoration, North Sumatra. Paper presented at FGD of Forestry Research and Development, 24 January 2011.

Suprianto, T. 2012. Menjaga, Melestarikan, Dan Memulihkan Taman Nasional Lore Lindu (Caring, preservation, and restoring Lore Lind National Park). Palu: Lore Lindu National Park Office.

Tseng, Vivian. 2012.Social Policy Report The Uses of Research in Policy and Practice. sharing child and youth development knowledge volume 26, number 2. 2012. Social Policy Report Volume 26, Number 2, 2012

Widiyastutik, E. 2010. Nilai Ekonomi Hasil Gerakan Nasional Rehabilitasi Hutan dan Lahan. (Economic Values of National Movement on Forest and Land Rehabilitation (NM-FLR) Results in Tirto Sub Watersheds, Central Java, Indonesia). Thesis. Graduate School, Bogor University of Agriculture.

Zolala, Farzaneh and Haghdoost, Ali Akbar. 2011. A Gap Between Policy and Practice: A Case Study on Maternal Mortality Reports, Kerman, Iran. *Int J Prev Med*. 2011 Apr-Jun; 2(2): 88–93.

Satuan Tugas Persiapan Kelembagaan REDD+ Indonesia (Indonesia REDD+ Task Force), September 2012. *Strategi Nasional REDD+* (National REDD+ Strategy), Jakarta, Indonesia.

Kuusipalo, J. 1996. Forest Degradation and Rehabilitation Prospects in Indonesia. Sustainable Forestry Challenges for Developing Countries. *Environmental Science and Technology Library* Volume 10, pp 175-186

Assessment of Soil Quality Under Different Land Use Practices in Altit Valley, Hunza Nagar, Gilgit-Baltistan

Sultan Ishaq[1*], Farida Begum[1], Karamat Ali[1], Sher Ahmed[2], Shaukat Ali[1], Rehmat Karim[1], Haibat Ali[1], Salma A. Durrani[1]

Abstract

Soil quality consists of Physical, chemical and biological properties that can be used for investigating the soil health. Soil health is important to support animal and plant productivity for sustainable management of agro ecosystem. The physiochemical properties and fertility status of Altit Hunza soils District Hunza-Nagar of Pakistan were investigated during 2013-2014, to assess the current fertility status of soil. The study area was divided into four clusters and from each cluster three major land use types, i.e., agriculture, forest and orchard, were sampled randomly. A total of 120 soil samples (4*3*10=120) were taken from three basic land use types to a depth of 0-15 cm. The investigated soil properties were pH, soil organic carbon (SOC), nitrate-nitrogen (NO3-N), electrical conductivity (EC), available phosphorus (P), exchangeable potassium (K), silt, sand and clay contents. Soil samples were analyzed in the lab using standard procedures. Two-way ANOVA was applied to determine the significant differences of soil properties with respect to clusters and land use. SOC and K were highly statistically significant ($p=0.03$ and $p=0.001$) while pH and EC were weakly significant ($p=0.07$ and $p= 0.06$) with respect to different land use. Soil pH, SOC, EC, P and NO3-N followed same trend (Agriculture > Orchard> Forest) with respect to different land use practices except K (Orchard > Forest > Agriculture). Higher SOC and fertility parameters in agriculture soil indicated higher soil quality due to input of organic manure (cattle manure with leaf litter and crop residue) or organic farming. Continued monitoring of soil properties is essential to sustain soil health or soil quality for environment, sustainable land management to enhance organic agricultural productivity.

Key words : organic manure, productivity, soil health, fertility, sustainability

[1] *Department of Environmental Sciences, Karakoram International University, Gilgit-Baltistan, Pakistan,*

[2] *Moutain Agriculture Research Centre, Juglote, Gilgit-Baltistan*

*Corresponding Author; Sultan.iq11@gmail.com, sultan.kaif11@yahoo.com

Introduction

Soil is an essential, non-renewable natural resource, which performs key environmental, social, and economic functions (Jin et al., 2011). This thin layer of 'dirt' which covers much of the land surface of the Earth is fundamental to the environment and very useful to our societies (European Commission 2011). It is an active living system which consists of diversity of flora and fauna including a wide range of microorganisms. Microorganisms are considered as the living pool of organic matter (OC), which is important for the maintenance of soil quality. The enzymatic activities of these microorganisms have a major catabolic role in the degradation of plant and animal residues in the environment (Defoet al., 2011). Soil quality is defined as the capacity of soil to, function in ecosystem, land use boundaries and to sustain biological yield to maintain environmental quality and to promote better food. Soil fertilization, cropping system, and farming practice are the main factors influencing soil fertility quality and yield production (Jin et al., 2011). Soil physico-chemical properties and the habitat conditions of different soil fauna become significantly changed when a natural ecosystem is converted to agricultural system. Continuous tillage of the soil and use of agro-chemicals have detrimnetal effects on soil quality and biodiversity (Begum et al., 2013; Paoletti et al., 1991).

In developing countries rapid urbanization has led to extensive land use changing (Khaledian et al., 2012). Extensive agriculture activities are also responsible for the destruction and degradation of soils, these land use changes are generally accompanied by decreasing in concentrations of SOC and nutrients availability and also degradation of soil structure (Emadi et al., 2009). Land use changes have major effects on the diversity and the amount of biomass returned to the soil, which also disorder the richness of nutrient restored to the soil. The changing in forest cover to other forms of land such as grasslands and plantation results in great variation of canopy cover, this effect the supply of SOC, due to change in soil temperature and moisture regimes (Dekoor et al., 2012). Soil organic carbon (SOC) is an important parameter affecting soil quality and agriculture sustainability. Land use type has a profound effect on SOC storage, it affects the quantity and quality of litter input and its decomposition rate, and stabilization of SOC. The soil organic carbon loss from different land use often leads to some negative impact on both aquatic and terrestrial ecosystems (Guangyu, et al., 2010). Land use practices have also profound impact on SOC and TN (Abera & Belachew, 2011). Conversion of land use mostly from forest to agricultural land can increase the soil deterioration and loss of SOM (Oguike & Mbagwu, 2009). It has also a great impact on the loss of biota and also in decrease of soil carbon in the below ground ecosystems (Doran, 2000). The present study aimed to evaluate the effect of different land use practices on soil quality.

Materials and Methods

Study Area

The study was carried out in Altit village; district Hunza Nager, Gilgit Baltistan, Pakistan. Geomorphologically the area is mountainous faming having mild slopes with small hills. The hilly areas (back slope) are covered with forest. The temperature of study area ranges from freezing point in winter to about 30ºC during summer. The soil morphology was different between the sites of study area. Three land uses, i.e., forest, agriculture and orchards were selected for comparison. The study area contain about 40% agricultural land for cultivation and grazing and forest area covered about 35% and 25% constitute settlement areas. The study area is more suitable for different crops, but major crops grown in study area are wheat, corn, maize and vegetables such as potato, mustard, pulses, bean, etc. The natural vegetation of Altit valley consists of tress, grasses and bushes. The major tree species found in study area are, willow, poplar, mulberry, apricot and Russian olive.

Sampling Design

Four replicate sites were selected from the village for soil sampling. Samples were collected during the month of October 2012 using a random sampling method. A total of 120 samples were collected from the top soil to a depth of 15cm. The top vegetative layer was removed by a spade and a hand trowel was used to dig out the soil, which were put into polyethylene bags for transport to the laboratory. Soil samples were air dried, crushed and passed through 2mm sieve before laboratory analysis. The chemical and fertility status of soil were analyzed at Mountain Agriculture Research Center (MARC) in Juglote in Gilgit-Baltistan. Soil pH was measured with 1:1 soil and water (McKeague, 1978; McLean, 1982). EC was measured by (electrical conductivity meter) the methodology which is given in US Handbook 60 (Richards, 1954). Soil organic carbon was measured by (Walkley, 1947). Soil NO_3-N, P, K was determined by the Ammonium Bicarbonate – DTPA extractable method by (Soltanpour and Schwab, 1977).

Analysis of Data

All the data regarding soil physical and chemical properties were recorded in respective excel spread sheet and SPSS (16). The main statistical tests applied

were two way ANOVA to determine significant difference with respect to land use and Clusters. This paper dealt with only land use data.

Results and Discussion

Influences of difference land use practices and location on soil physiochemical properties

The date was further analyzed to determine the, physiochemical and fertility status of soil by location wise difference. ANOVA results indicated soil organic carbon (SOC) and Exchangeable Potassium differed significantly with respect to land use. Our study is in accordance with many other studies conducted in different parts of the world (Chen et al., 1997; Fu et al., 2004; Begum et al., 2009; Begum et al., 2010). Soil pH, EC, TN and Available Phosphorus is not statistically significant with respect to land use.

Table. Two-way ANOVA F-test values and significance by land use.

	pH	EC	SOC	TN	Av-P	E-P
Land use	2.69 "ns"	2.77 "ns"	3.5*	1.51 "ns"	.058 "ns"	3.3 ***

*Note: *, **, ***, and "ns" indicates $p<0.05$(5%), $p< 0.01$(1%), $p<0.001$ and "ns" non-significant respectively; SOC; Soil Organic Carbon, NO_3-N; Nitrate-Nitrogen, P; Phosphorus, K; Potassium, EC; Electric conductivity*

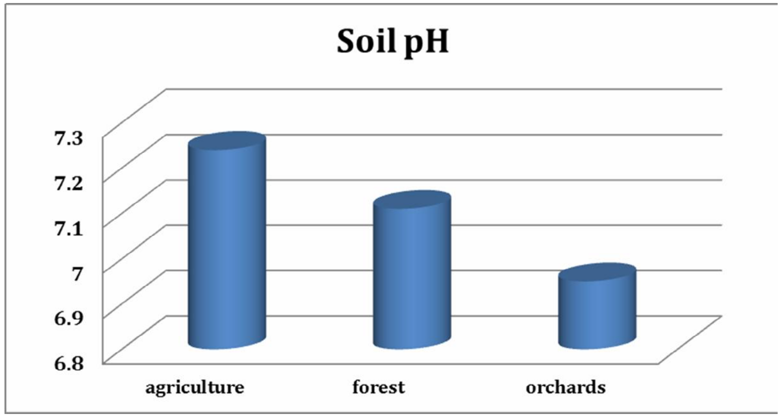


Figure 1 : Soil pH in different land uses of the study area.

Soil pH is a vital chemical parameter, since the nutrient availability of plant is highly dependent upon it (Begum et al., 2009). It may change because of variations in geology, soil biological activities, and slope pattern and also because of landscape position. Soil pH can affect the whole soil physiochemical properties; it depends on the farming practices. That's why soil pH is considered as one of the important soil chemical parameter to identify the impact of land use change (Idowu et al. 2009; Schindel beck et al. 2008). The soil pH was not significant different with respect to land use, however the mean pH was slightly differed between Agriculture (Alkaline, 7.2) and Forest (Alkaline, 7.1) while Orchard was found to be slightly acidic (6.9). Such difference possibly resulted from variation in nutrient cycling by the contrasting vegetation (Dahlgren et al., 1997; Begum et al., 2010).

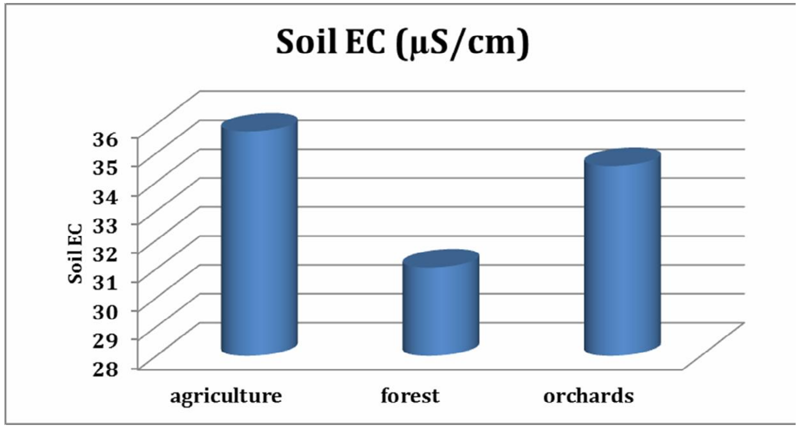


Figure 2 : Electrical conductivity in different land uses of the study area.

Electrical conductivity of soil is an important and vital parameter of soil chemical property. EC is the ability of material to conduct and pass an electrical current (Ouhadi and Goodarzi, 2007). Physiochemical and fertility status of Gilgit soil were evaluated during 1999- 2000 by Khan et al., (2004) for to formulate proper recommendation for agriculture production. The mean electrical conductivity they found was varied from 0.06 to 0.5 dS/m with mean value 0.19 ds/m in Gilgit. Their results revealed that the EC in Altit Valley was 0.18dS/m. The soil EC was weakly significant (P=0.07 or p>0.05) with respect to land use. Our results suggest that the area is free from saline problem.

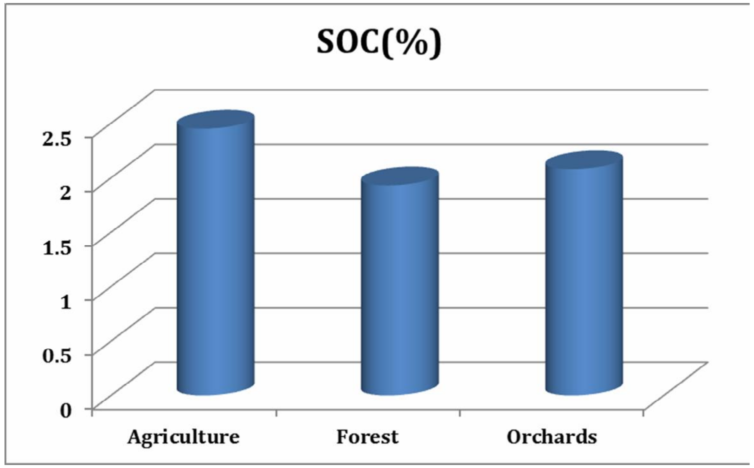


Figure 3 : Soil organic carbon in different land uses of the study area.

Soil organic carbon content of soil is also among a vital and commonly used parameter of soil quality and agronomic sustainability, because it alter the other soil physical and chemical parameters (Reeves, 1997). Management practices like conversion of crop lands to pasture land, tillage, intensive rotation and the use of green manure have got a great impact to maintain the optimum level of soil organic carbon (Paterson and Hoyle, 2011). Land use changing and its management practices may cause soil carbon to release into atmosphere as a greenhouse gas. Different land cover and land use pattern causes dissimilarity in the level of SOM concentration (Gebrelibanos and Assen, 2013). The present research showed that the soil organic carbon statistically significant along land use ($p<0.05$) and the highest soil organic carbon was found in agriculture (2.4%) followed by Orchard (2%) and lowest at Forest (1.9%). The lowest SOC was found in the forest area of Girum (residential area) 1.45% as compared to the forest areas of rest sites. This may because of greater influences of local people and animals (grazing) to the forest areas.

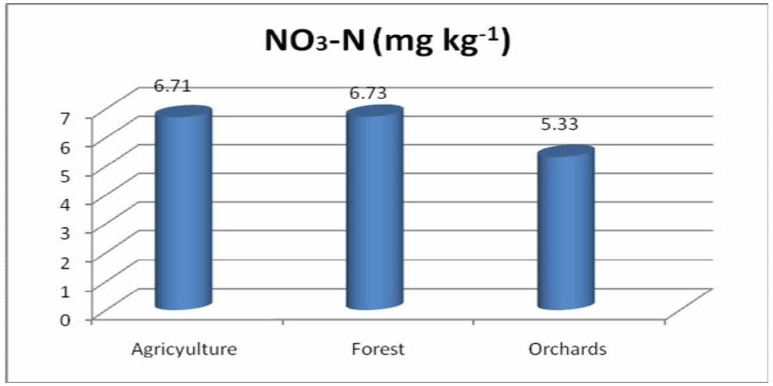


Figure 4 : Nitrate-nitrogen as affected by land use and location of the study area.

Nitrogen is a vital nutrient which is imperative for the growth and reproduction of any organism. Nitrogen influences the quality and grass growth more than any other nutrient. It present in soil in both organic and inorganic form (Camberato, 2001).Nitrogen is being applied to agricultural activities from last many years. If no manure or fertilizers are applied for plant, the ability of soil to supply plant available N becomes depleted (Sawyer, 2008). The mean Nitrate-Nitrogen was slightly higher in Forest 6.73 mg kg-1 followed by agriculture land 6.71 mg kg-1and lowest at Orchard 5.33 mg kg-1in Altit Hunza soil. According to a research done by Baber et al., 2004 Gilgit soils was deficient of nitrogen and having values less than 0.08%.

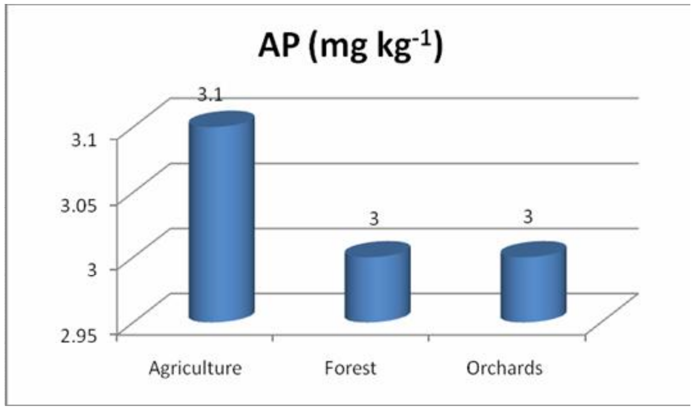


Figure 5 : Available phosphorus as affected by land use and location of the study area.

Soil management practices and fertilization are the important factors that greatly influence the soil properties (Sadej, et al., 2012). Phosphorus is an important parameter soil quality, which is more essential for plant growth. Proper management of phosphorus in soil fertility must depend on good knowledge about the phosphorus reserve and its bioavailability in soil (Dufey, et al., 2010). Soil pH is an important factor that affects the P availability in soil. Research reveals that Phosphorus is readily available in the pH between 6 to 7. Soil liming is also a factor that affects the soil P (Duncan, 2002). Monkiedje et al 2006 found significantly higher available Phosphorus and pH in cropland than in the forested soils. The higher concentration of Av-P was found in the agricultural soil 3.1 mg kg-1while the Av-P in forest and agriculture was same 3 mg kg-1. This may due to application of P-Fertilizers in the agricultural soil. The high concentration of available phosphorus in forest is because of high concentration of SOM which may result in the release of high organic phosphorus (Gebrelibanos and Assen, 2013).

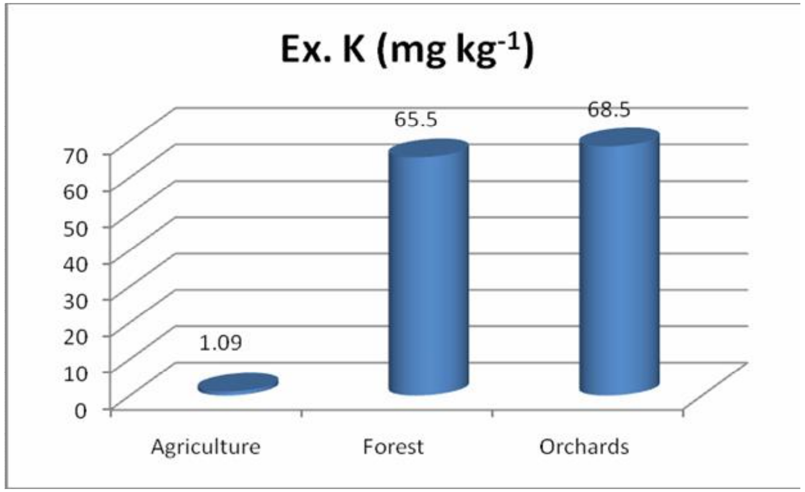


Figure 6 : Exchangeable potassium as affected by land use and location of the study area.

The status of Potassium and Phosphorus seems to be influenced by type and geology by other factors (Bajracharya and Sherchan 2009).Land use and land cover has significantly affected the soil qualities, the land use and land cover changes result in land degradation and result in the decline of soil productivity (Biro, et al., 2011). Soil exchangeable potassium is highly significant along land use ($p<0.001$) highest at Orchard followed by Forest and lowest at Agriculture

(Figure 6). Similar results were found by Biro, et al., (2011) that soil potassium was significantly different ($p<0.05$) across the land use and land cover.

Conclusions

The study revealed some of the physiochemical properties and its fertility status of Altit Hunza soil. Land use has significant influence on soil physio-chemical properties pH, SOC, EC, P and TN followed same trend (Agriculture > Orchard> Forest) with respect to different land use practices except K (Orchard > Forest > Agriculture). Higher SOC and fertility parameters in agriculture soil indicated higher soil quality due to input of organic manure (cattle manure with leaf litter and crop residue) or organic farming in the study area.

References

Abera, Y., Belachew, T. 2011. Effects Of Landuse On Soil Organic Carbon And Nitrogen In Soils Of Bale, Southeastern Ethiopia. Tropical and Subtropical Agroecosystems **14**, 229-235

Alfred, EH., Tom, VZ. 2008. Land Cover Change and Soil Fertility Decline in TropicalRegions. Turkish Journal Agriculture Forest **32**, 195-213.

Bajracharya, RM., Sherchan, DP. 2009. Fertility Status and Dynamics of Soil in the Nepal Himalaya: A Review and Analysis. Nova Sciences Pub: 111-135.

Begum, F., Bajracharya, RM., Sitaula, KB., Sharma, S. 2013. Seasonal dynamics, slope aspect and land use effects on soil mesofauna density in the mid-hills of Nepal. International Journal of Biodiversity Science,Ecosystem Services & Management , 1-8.http://dx.doi.org/10.1080/21513732.2013.788565

Begum, F., Bajracharya, RM., Sharma, S. 2009. Land Use Effects On Soil Quality Indicators In The Mid-Hills Of Central Nepal. International Conference on Emerging Technologies in Environmental Science and Engineering. Aligarh Muslim University, Aligarh, India. 488-495.

Begum, Farida.,Bajracharya, RM., Sharma, S., Sitaula, KB. 2010. 'Influence of slope aspect on soil physico-chemical and biological properties in the mid hills of central Nepal'. International Journal of Sustainable Development & World Ecology. **17**, 438 — 443. 10.1080/13504509.2010.499034

Biro, K., Pradhan, B., Buchroithner, M., Makeschin, F. 2011. Land Use/Land Cover Change Analysis And Its Impact On Soil Properties In The Northern Part Of Gadarif Region, Sudan. land degradation & development. Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/ldr.1116.

Camberato, JJ. 2001. Nitrogen in Soil and Fertilizers. SC Turf grass Foundation News.**8**, 6-10.

Chen, ZS.,Hsieh,CF., Jiang, FY., Hsieh, TH., Sun, IF. 1997. Relationship of soil properties to topography and vegetation in a subtropical rain forest in southern Taiwan. Plant Ecol. **132,**229-241

Dahlgren AR, Bottinger LT, Huntington LG, Amundson AR. 1997. Soil development along an elevation transect in the western Sierra Nevada, California. Geoderma. **78**, 207–236.

Defo, M A., Njine, T., Nola, M., Beboua, FS. 2011. Microcosm study of the long term effect of endosulfan on enzyme and microbial activities on two agricultural soils of Yaounde-Cameroon. African Journal of Agricultural Research. **6**, 2039-2050. 10.5897/AJAR10.068

Dekoor , TN., Iwara, A L., Ogundele, FO., Amiolemen, SO., Ita, AE. 2012. Changes in Soil Properties under Different Land Use Covers in Parts of Odukpani, Cross River State, Nigeria. Journal Environment and Ecology.**3**, 86-99.http://dx.doi.org/10.5296/jee.v3i1.2265

Doran, JW, Zeiss, MR. 2000. Soil health and sustainability: managing the biotic component of soil quality. Applied Soil Ecology.**15**, 3–11.

Dufey, J., Bock, L., Colient, G. 2010. Effects of parent material and land use on soil phosphorus forms in Southern Belgium. World Congress of Soil Science, Soil Solutions for a Changing World. Brisbane, Australia. 1-6.

Duncan, RM. 2002. Soil acidity and P deficiency, Management strategies for Northern tablelands of NSW. NSW Agriculture, Armidale. URL; http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/166384/nt-phosphorus_acidity.pdf

Emadi, M., Baghernejad, M., Memarian, HR. 2009. Effect of land-use change on soil fertility characteristics within water-stable aggregates of two cultivated soils in northern Iran. Journal Land Use Policy, **26**, 452-457.10.1016/j.landusepol.2008.06.001

European Commission. 2011. SOIL: the hidden part of climate cycle. Luxembourg: Publications Office of the European Union. 10.2779/30669

Gebrelibanos, T., Assen, M. 2013. Effects of Land-Use/Cover Changes on Soil Properties in a Dryland Watershed of Hirmi and its Adjacent Agro Ecosystem: Northern Ethiopia. International Journal of Geosciences Research ISSN 1929-2546,**1**, 45-57

Guangyn, C., Xin, C., Yi, S. 2010. Profile distribution of soil organic carbon under different land use type inSanjing Plain. World Congress of Soil Science, Soil Solutions for a Changing World. Brisbane, Australia, 183-185

Idowu OJ., Van Es HM., Abawi GS., Wolfe DW., Schindelbeck, RR., Moebius-Clune, BN., Gugino, BK. 2009. Use of an integrative soil health test for evaluation of soil management impacts. Renewable Agriculture Food System. **24**, 214–224. 10.1017/S1742170509990068.

Jin, Jw., Xu, Yf., Ye, Hc., Shen, Cy., & Huang, Yf. 2011. Effect of land use and soil management practices on soil fertility quality in North China cities' urban fringe. African Journal of Agricultural Research, **6**, 2059-2065. 10.5897/AJAR11.174

Khaledian**, Y.,** Kiani**, F.,** Ebrahimi**, S.** 2012. The effect of land use change on soil and water quality in northern Iran. Journal of Mountain Science , **9**, 798-816.10.1007/s11629-012-2301-1

Khan B., Khattak, RA., & Hakeem, A. 2004. Physico-Chemical Characteristics And Fertility Status Of Gilgit Soils. Journel. Agriculture Research ,**42,** (3-4), 305-312.

Mckeague, JA (ed.). 1978. Manual on soil sample and methods of analysis. Canadian Society of Soil Science : 66-68

McKenzie, HR. 2003. AGRI-FACTS. Soil pH and Plant Nutrients. Practical Information for Alberta's Agriculture Industry.

Mclean, EO. 1982. Soil pH and lime requirement. P. 199-224, In A.L. Page (ed.), Methods of soil analysis, Part 2: chemical and microbiological properties. Am. Soc.Agron. Madison. WL. USA.

Monkiedje. A., Spiteller. M., Fotio. D., Sukul. P. 2006. The Effect of Land Use on Soil Health Indicators in Prei-urban Agriculture in the Humid Forest Zone of Southern Cameroon. Journal of Environmental Quality, **35**, 2402-2409.10.2134/jeq2005.0447

Oguike, PC., & Mbagwu, JS. 2009. Variations in Some Physical Properties and Organic Matter Content of Soils of Coastal Plain Sand under Different Land Use Types. World Journal of Agricultural Sciences ,**5**, 63-69.

Ouhadi, RV., Goodarzi, R A.2007. Factors impacting the electro conductivity variations of Clayey Soils*. Iranian Journal of Science & Technology, Transaction B, Engineering,**31**, 109-121

Paoletti MG, Favretto MR, Stinner BR, Purrington JE, Beter. 1991. Invertebrates as bioindicators of soil use. Agriculture Ecosystem Environment. **34**, 341–362.

Paterson, J., & Hoyle, F. 2011. Soil organic carbon; A Western Australian perspective. Western Australian Agriculture Authority.

Reeves, DW. 1997. The role of soil organic matter in maintaining soil quality in continuous cropping systems. Soil & Tillage Research **43**, 131–167

Richards, LA. 1954. Diagnosis and improvement of the Saline and Alkali soils. USDA Agric, Handbook 60. Washington, D.C.

Sadej, W., Kosewska, A., Sądej, W., Nietupski., M. 2012.Effects of fertilizer and land-use type on soil properties and ground beetle communities. Bulletin of Insectology**65**, 239-246.

Sawyer, J. 2008. Agronomy Extension Soil Fertility.Iowa State University. Also available on Website: http://www.agronext.iastate.edu/soilfertility/

Soltanpour, PN., and Schwab Ap (ed.). 1977. A new soil test for simultaneous extraction of macro- and micronutrients in alkaline soils. Soil Science plant. Anal. **8**, 195-207

Walkley, A. 1947. A critical examination of a rapid method for determining organic carbon in Soil –Effect of Variations in Digestion Conditions and of It Inorganic Soil Constituents. Soil Science**63**,251-264,

Litterfall Dynamics in a Permanent Plot at Mount Papandayan, Indonesia

Noviana Budianti*, Endah Sulistyawati, Devi N. Choesin, Yoyo Suhaya

Abstract

This study was aimed at quantifying litter production rate, comparison of rates among litter groups, observe litter production dynamics, and indentify the main environmental factors affecting production rates in a 1-ha permanent plot at Mount Papandayan (2.262 m a.s.l; montane zone). The permanent plot contained 31 trees species (18 families) with the density of 902 individuals per hectare. The dominant tree species was *Distylium stellare* Kuntze (26.49% of the total individuals). Litterfall dynamic was measured by spreading 20 traps (size: 1 x 1 m2; made of nylon web with the mesh size of 2 mm) systematically within the permanent plot. Litters were collected every 14 days during April 2013-March 2014 and, subsequently air-dried to decrease water content. The air-dried litters were divided into five groups: dominant leaves (DD), mixed leaves (DC), small woods (B), reproductive organs (OR), and epiphytic bryophytes (L). These groups of litter were oven-dried at 70 °C until constant weight to obtain biomass. The biomass data were analyzed to present the rate of litter production in 28-days intervals using kg ha-1 as the unit of measurement. The environmental factors (microclimates and edaphics) were also monitored at 14-day intervals, at the same time as litter collection. The results indicated that the rate of litter production varied among the sampling intervals, both in total and within each litter group. Annually, the total litter production rate was 4,895 kg ha-1 and the highest rate was observed on 11th interval (527.5 kg ha-1), while the lowest rate was observed on 3rd interval (259.1 kg ha-1). The production rate of each litter group also varied during one year measurement. Therefore, the forest litter was dominated by DC followed by B, DD, OR, and L. According to the statistical analysis, litter production of this permanent plot correlated with air temperature and light intensity.

Keywords : litter production, temporal variation, tropical montane forest, *Distylium stellare*

School of Life Sciences and Technology, Institut Teknologi Bandung, Indonesia

* *Corresponding Author: Email- budianti@students.itb.ac.id*

Introduction

Nutrient cycling is an important mechanism that affects other processes in ecosystems by providing nutrient for primary production. It includes nutrient input and output and internal transfer between various ecosystem components. One of the internal transfer mechanisms is nutrient flow through litter production, which is the largest transfer process in ecosystem, reaching 80% of total nutrient release from vegetation. In addition, plant litter is a primary resource for soil organic matter and nutrient availability in a forested ecosystem (Chapin III et al., 2002 and Molles, 2008).

Litter is a dead plant tissue that recently fallen to the soil surface in condition of undecomposed or started to be decomposed. Generally, litter was produced by senescence mechanism, which is a programmed destruction process of tissues. Senescence locations are controlled physiologically to eliminate useless tissues (Berg and McClaugherty, 2007 and Chapin III et al., 2002). Litter production can be used as an indicator of forest condition because this process reflects the interaction between tree biological heredity and the impacts of environmental fluctuation (Barton and Northup, 2011; Celentano et al., 2011; Coleman et al., 2004; Guo and Sims, 1999; and Zhou et al., 2007).

According to some researches, rate of litter production was affected by various factors, both endogen and exogenous. Endogenous factors consist of plant physiology and phenology. While, exogenous factors including some climatology and edaphic variables, successional stages, and structure community of vegetation. But, recently, the impact of those factors on litter production is still debated since every parameter caused various responses at different places. Chave et al. (2010) found that litter production rates in most of North American tropical forest were affected by soil fertility, altitudinal location, and successional stage, but were not correlated with precipitation. On the other hand, litter production in Sepilok Forest (Malaysia) was affected by precipitation and nutrient content in soil (Dent et al., 2006).

This study aimed to observe litter production dynamic in general by quantify litter production rates at 2-week intervals, comparing the production rates between the litter groups, and indentifying environmental factors that significantly affect production rates in a 1-ha permanent plot at Mount Papandayan Nature Reserve, Indonesia. We hypothesized that litter production in 1-ha permanent plot at Mount Papandayan Nature Reserve, both total and group, varied during the research period and would be affected by environmental factors.

Study Area

Mount Papandayan Nature Reserve is located in Garut Regency, about 65 km south east of Bandung, the capital city of West Java Province, Indonesia. This study was conducted in 1-ha permanent plot that is located at 2.262 m above sea level, at 07°17′56″ S latitude and 107°43′34.9″ E longitude, and classified as montane zone with mean annual precipitation reached 3,000 mm. This plot is a mixed natural forest ecosystem with a tree stand density of 902 ind. ha-1 containing 31 species of trees (belonging to 18 families) and was dominated by *Distylium stellare* Kuntze (Iqbal, 2012). Some canopy gaps were found randomly around the plot area and caused the understory plants to grow densely. In addition, with high rate of precipitation, all of trees were covered by epiphytic bryophyte, mainly on the woody parts.

Methods

Litter Production Measurement

Litter production was measured by litter trap method by spreading 20 traps systematically. The size of traps was 1 x 1 m2 and the traps were made of nylon web with the mesh size of 2 mm. These traps were installed 50 cm above soil surface to minimize incoming litter from understory plants (Dent et al., 2006 and Ostertag et al., 2008 with modification). Litterfall was collected every 14 days during April 2013 to March 2014. All samples were air-dried to reduce water content (Rosleine et al., 2006) and classified into five groups (Dent et al., 2006 with modification): dominant leaves (DD; D. stellare), mixed leaves (DC; excluding D. stellare leaves, as well as stipules and petioles), small woods (B; including twigs of diameter < 20 mm and bark of length < 20 mm), reproductive organs (OR; including flowers, fruits, and seeds), and epiphytic bryophytes (L). These grouped samples were then oven-dried at 70°C to obtain constant weight (Zheng et al., 2006). This litter biomass was used to analyze production rates in kg ha-1 (per 2-week observation interval). Rate of litter production was calculated for 28-days intervals, so there were 12 intervals during the research period.

Environmental Factors Measurement

Microclimates were monitored at each interval for air temperature (°C), light intensity (Lux), and air relative humidity. The air temperature and light intensity were measured by data logger (Hobo UA-002-64), while air relative humidity (%) was measured by sling psychrometer. Edaphic factors consisted of soil temperature (°C), pH, and relative humidity (%). The soil temperature was measured by alcohol thermometer, while soil pH and relative humidity were measured by soil tester (Demetra PAT 193478). All environmental factors, except air temperature and light intensity, were measured at 14-day intervals along with with litter collection. The air temperature and light intensity were measured throughout the research period and analyzed to obtain weekly temperature and light intensity. In addition, soil nutrient (nitrogen and phosphorus) content (%) was measured at the end of the sampling period on soil samples take from 0-20 cm depth. Chemical analysis was conducted at the Chemistry Laboratory of Padjadjaran University.

Statistical Analysis

Differences in litter production rates among the litter groups were analyzed by one way ANOVA and Tukey's post hoc test. Also, correlations between litter production rate (both total and group) and environmental factors were analyzed using 2-tailed Pearson's correlation. To run the Pearson's correlation, air temperature was divided into maximum (Tmax), minimum (Tmin), average (Tavrg), and variation (Tstdv) value. In addition, light intensity was also divided into maximum (ICmax), average (ICavrg), and variation (ICstdv) values.

Results

Temporal Variation of Total Litter Production

Generally, total litter production in this permanent plot fluctuated along the research period ranging from 259.12 to 527.51 kg ha-1 per interval with the mean production of 375.51 ± 90.71 kg ha-1. Annually, the plot produced 4,506.08 kg ha-1 litter biomass. In addition, rate of total litter production always increased from the start to the end of research period with the highest rate being achieved during the 11th interval (Figure 1).

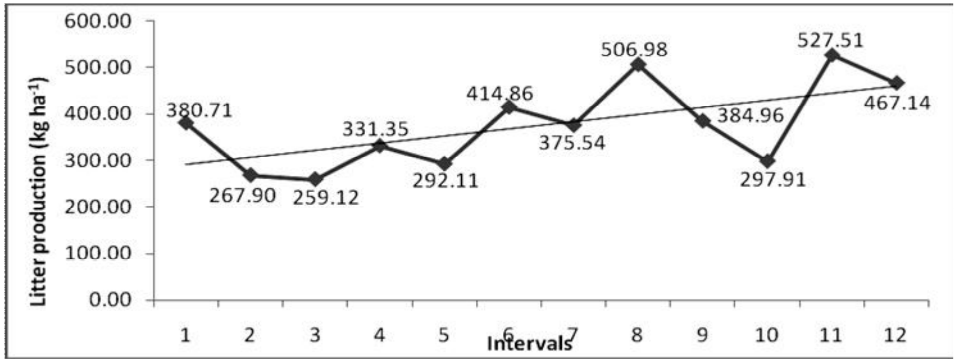


Figure 1 : Temporal variation of total litter production in 1-ha permanent plot

Comparison of Production Rates between Litter Groups

Based on the results of one way ANOVA and Tukey's test, the litter production rate could be divided into three groups (a, b, and c) that were significantly different ($p < 0.05$). The highest rate was achieved by DC, followed by B, DD, OR, and L. During the research period, DC always dominated the litter with high proportion of about 43-68% (Table 1).

Table 1 : Litter production rate and proportion of each litter groups

Litter groups	Production rate (kg ha-1)		Proportion (%)	
	Mean	Annual	Range	Mean
Dominant leaves (DD)	71.25 ± 42.15 a	855.05	7.76-36.02	18.88 ± 9.08
Mixed leaves (DC)	203.42 ± 34.98 b	2,441.06	43.56-67.63	55.47 ± 8.19
Small woods (B)	78.90 ± 51.99 a	946.74	9.14-40.66	19.84 ± 8.25
Reproductive organs (OR)	11.28 ± 4.14 c	135.31	1.69-5.34	3.07 ± 1.11
Epiphytic bryophytes (L)	10.66 ± 5.33 c	127.92	1.00-4.11	2.73 ± 0.99

Correlation between Litter Production Rate and Environmental Factors

Based on 2-tailed Pearson's correlation analysis, rate of total litter production was affected by Tmin ($p < 0.01$), Tavrg, and Tstdv ($p < 0.05$). Tmin and Tavrg had positive correlation with litter groups, while Tstdv had negative correlation. Various correlations were found in every litter groups that had only slightly difference with total litter (Table 2).

Table 2 : Correlation between litter production rate and environmental factors

Litter groups	Microclimates								Edaphic		
	Tmax	Tmin	Tavrg	Tstdv	ICmax	ICavrg	ICstdv	RHu	TT	RHT	pHT
Total	0	+	+	-	0	0	0	0	0	0	0
DD	0	0	0	0	0	0	0	0	0	0	0
DC	-	+	0	-	0	0	0	0	0	0	0
B	0	+	+	-	+	0	+	0	0	0	0
OR	-	0	0	0	0	0	0	0	0	0	0
L	0	+	+	-	+	0	0	0	0	0	0

Description:

Tmax	: maximum air temperature	RHu	: air relative humidity
Tmin	: minimun air temperature	TT	: soil temperature
Tavrg	: average air temperature	RHT	: soil relative humidity
Tstdv	: variation of air temperatur	pHT	: soil acidity
ICmax	: maximum light intensity	+	: positive correlation
ICavrg	: minimum light intensity	-	: negative correlation
ICstdv	: variation of light intensity	0	: no correlation

Discussion

Temporal Pattern of Total Litter Production

Rate of litter production in this permanent plot was found lower than other studies (Table 3), although the annual rainfall was higher (3,000 mm) than other areas (1.131-2,975 mm). The lower rate of litter production might be due to the higher altitudinal location of our plot. This permanent plot is located at 2,262 meter above sea level, while others were at the lower altitudes. This tendency was supported by the study of Zhou et al. (2007) which reported that the higher the altitudinal location, the lower the rate of litter production. Such a trend was likely caused by the lower temperature in the higher altitude.

Table 3 : Comparison of litter production rate with other study areas

Parameters	Budianti (2014)	Rosleine et al. (2006)	Dent et al. (2006)	Burghouts et al. (1998)	Zheng et al. (2006)
Location	Mount Papandayan Nature Reserve	Mount Tangkuban Parahu Nature Reserve	Kabili-Sepilok Forest Reserve, Sabah, Malaysia	Danum Valley Conservation Area, Sabah, Malaysia	Manglun Nature Reserve, Southwest China
Forest type	Montane tropical forest	Montane tropical forest	Lowland tropical forest	Lowland tropical forest	Lowland tropical forest
Altitude (m asl)	2,262	2,020	0-170	210-240	650
Mean annual rainfall (mm)	3,000	2,868	2,975	2,800	1,131
Tree density (ind. ha^{-1})	902	-	941-1,656	-	796
Sampling area (m^2)	20	7.5	189	21	4
Plot area (m^2)	10,000	3,000	360,000	40,000	2,500
Mean annual litter production (Mg ha^{-1} $tahun^{-1}$)	4.89	8.76	6.9	11.05	10.08

Lower rate of litter production was also caused by higher content of nutrients in the soil. Soil chemical analysis indicated that this permanent plot had higher nitrogen and phosphorus content than other study areas. It contained 0.45 ± 0.15% N and 0.35 ± 0.06% P. Meanwhile, soil in Chanthaburi tropical forest

(Thailand) contained only 0.11-0.14% N and 0.0028-0.0018% P (Glumphabutr et al., 2007). In addition, soil in Sabah tropical forest (Malaysia) also contained lower nutrient i.e. 0.39 ± 0.09% N and 0.02 ± 0.004% P (Burghouts et al., 1998). This soil nutrient content could describe the lower rate of litter production in relation to equilibrium mechanism of nutrient requirement and nutrient availability in environment. Chapin III et al. (2002) stated that litter was produced to meet nutrient requirement of plants. Consequently, litter will be produced in higher rate when nutrient availability in soil is depleted.

Comparison of Production Rates between Litter Groups

Differences in production rate for each litter group were closely related to the rate of plant tissues turnover. High rate of litter production might indicate high turnover rate of plant tissues. Leaves (DC and DD) always dominated the total litter because they were released from plant more frequently than other tissues. Defoliation mechanism has various objectives, for example to reduce transpiration when drought occurs, or to balance nutrient requirement when soil fertility became depleted. In addition, with high nutrient content, leaves will be more vulnerable to parasite, pathogen, and herbivore attacks. Hence, defoliation also helps the plant to maintain its viability (Chapin III et al., 2002).

Meanwhile, the age of woody parts were longer. Consequently, litter production of this group would always be lower than leaves. But, generally, small wood litter (B) production would increase if plants were damaged physically by strong winds or storms. Hence, this litter production was not due to tissue senescence, but caused by physical damage (Chapin III et al., 2002). Beside affected by tissue turnover rate, litter production was also influenced by plant phenology, particularly on reproductive organ (OR) production. This litter group would be produced at a high rate when plant entered reproduction period, i.e., when flowers and fruits were produced excessively. This differed from other litter groups that were produced independently, epiphytic bryophytes (L) production was significantly dependent to woody litter production ($p < 0.05$). Most of bryophytes litters were found covering the woody parts with relatively high biomass. Consequently, epiphytic bryophytes production rate would show positive correlation with woody parts (B) production rate.

Correlation between Litter Production Rate and Environmental Factors

Even though the total production rate correlated with three temperature variables, production rate of each litter showed various correlations. Moreover, dominant leaves (DD) litter group showed no correlation with environmental

factors, both microclimates and edaphics. Hence the correlation analysis indicated various physiological responses of plants to environmental conditions. Zhang et al. (2014) stated that litter production was closely related with physiological mechanism and environmental variables. Thus, temporal pattern of litter production is affected by forest type and tree species that dominate the ecosystem.

In tropical forest, litter production generally affected by precipitation and solar radiation. But, this study showed a different result because air temperature was the main environmental factor that affected the litter production rate. This might be have been caused by the relatively high and constant precipitation in this plot. Thus, role of precipitation in limiting litter production was replaced by air temperature that showed high daily and weekly variation (Figure 2). For example, weekly minimum temperatures were ranging from 5.86 to 12.40 °C with range of daily temperatures were 6.47-17.57 °C. Differences due to precipitation and solar radiation still affected the litter production rate of some groups for similar reasons with air temperature. For example, weekly maximum light intensities ranged from 5,339 to 115,734 Lux.

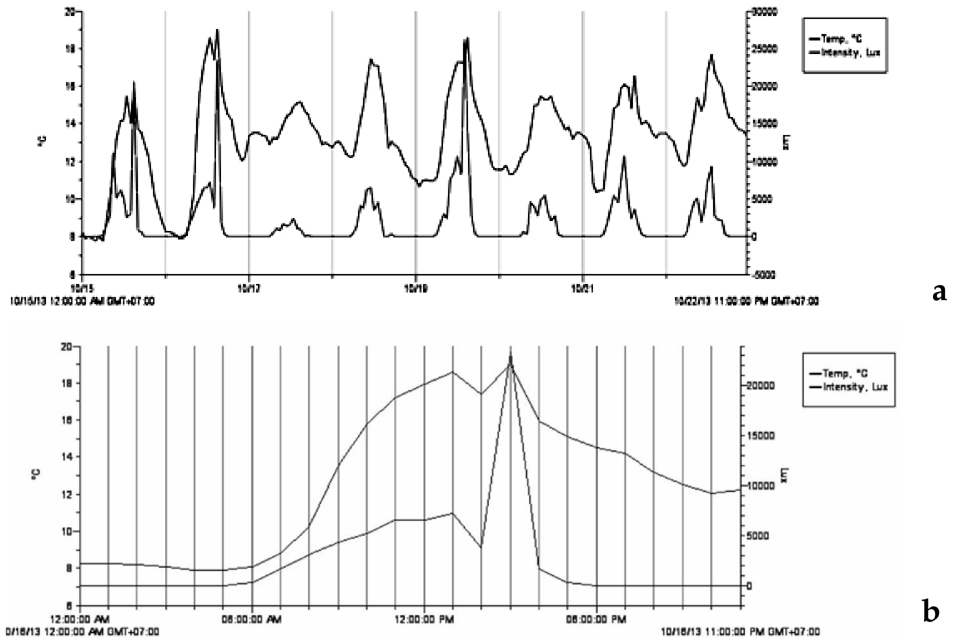


Figure 2 : Weekly (a) and daily (b) variation of air temperature and light intensity

Conclusions

Generally, total litter production rate fluctuated along the research period with high variation ranging from 259.12 to 527.51 kg ha-1 per interval and, annually, 4,506.08 kg ha-1 litter was produced. In addition, litter production always dominated by mixed leaves (DC), followed by woody parts (B), dominant leaves (DD), reproductive organs (OR), and epiphytic bryophytes (L). In relation to environmental factors, total litter production was affected by minimum, average, and variance of air temperature, while each groups of litter showed various correlations with microclimate and edaphic factors.

Acknowledgement

This research was funded by Osaka Gas Foundation of International Cultural Exchange and supported by Natural Resources Conservation Agency of West Java, Indonesia.

References

Barton, L.L. and D.E. Northup. 2011. Microbial Ecology. New Jersey: Wiley-Blackwell.

Berg, B. and C. McClaugherty. 2008. Plant Litter: Decomposition, Humus Formation, Carbon Sequestration. 2nd Edition. Heidelberg: Springer-Verlag.

Burghouts, T.B.A., N.M. van Straalen, and L.A. Bruijnzeel. 1998. Spatial Heterogeneity of Element and Litter Turnover in a Bornean Rain Forest. Journal of Tropical Ecology, 14: 477-506.

Celentano, D., R.A. Zahawi, B. Finegan, R. Ostertag, R.J. Cole, and K.D. Holl. 2011. Litterfall Dynamics under Different Tropical Forest Restoration Strategies in Costa Rica. Biotropica, 43 (3): 279-287.

Chapin III, F.S., P.A. Matson, and H.A. Mooney. 2002. Principles of Terrestrial Ecosystem Ecology. New York: Springer-Verlag.

Chave, J., D. Navarette, S. Almeida, E. Alvarez, L.E.O.C. Aragão, D. Bonal, P. Châtelet, J.E. Silva-Espejo, J.Y. Goret, P. von Hildebrand, E. Jiménez, S. Patiño, M.C. Peñuela, O.L. Phillips,

P. Stevenson, and Y. Malhi. 2010. Regional and Seasonal Patterns of Litterfall in Tropical South America. Biogeoscience, 7: 43-55.

Coleman, D.C., D.A. Crossley, Jr., and P.F. Hendrix. 2004. Fundamentals of Soil Ecology. 2nd Edition. New York: Elsevier Academic Press.

Dent, D.H., R. Bagchi, D. Robinson, N. Majalap-Lee, and D.F.R.P. Burslem. 2006. Nutrient Fluxes via Litterfall and Leaf Litter Decomposition Vary Across a Gradient of Soil Nutrient Supply in a Lowland Tropical Rain Forest. Plant Soil, 288: 197-215.

Glumphabutr, P., S. Kaitpraneet, and C. Wachrinrat. 2007. Nutrient Dynamics of Natural Evergreen Forests in the Eastern Region of Thailand. Kasetsart J. (Nat. Sci.), 41: 811-822.

Guo, L.B. and R.E.H. Sims. 1999. Litter Decomposition and Nutrient Release via Litter Decomposition in New Zealand Eucalypt Short Rotation Forest. Agriculture, Ecosystems and Environment, 75: 133-140.

Iqbal, A. 2012. Struktur dan Komposisi Floristik Pohon pada Sensus Awal Plot Permanen Satu Hektar di Cagar Alam Gunung Papandayan, Garut, Jawa Barat (Tree floristic Structure and Composition at Early Census in One Hectare Permanent Plot at Mount Papandayan Nature Reserve, Garut, West Java. Thesis of Biology Undergraduate Program. Bandung Institute of Technology.

Molles Jr., M.C. 2008. Ecology: Concepts and Applications. 4th Edition. New York: Mc Graw Hill.

Ostertag, R., E. Marín-Spiotta, W.L. Silver, and J. Schulten. 2008. Litterfall and Decomposition in Relation to Soil Carbon Pools Along a Secondary Forest Chronosequence in Puerto Rico. Ecosystems, 11: 701-714.

Rosleine, D., D.N. Choesin, and E. Sulistyawati. 2006. The Contribution of Dominant Tree Species to Nutrient Cycling in a Mixed Forest Ecosystem on Mount Tangkubanperahu, West Java, Indonesia. International Conference on Mathematics and Natural Sciences (ICMNS). Bandung: 29-30 November 2006.

Zhang, H., W. Yuan, W. Dong, and S. Liu. 2014. Seasonal Patterns of Litterfall in Forest Ecosystem Worldwide. Ecological Complexity, article in press.

Zheng, Z., P. Shanmughavel, M.C.L. Sha, and M. Warren. 2006. Litter Decomposition and Nutrient Release in a Tropical Seasonal Forest if Xizhuangbanna, Southwest China. Biotropica, 38 (3): 342-347.

Zhou, G., L. Guan, X. Wei, D. Zhang, Q. Zhang, J. Yan, D. Wen, J. Liu, S. Liu, Z. Huang, G. Kong, J. Mo, and Q. Yu. 2007. Litterfall Production Along Successional and Altitudinal Gradients of Subtropical Monsoon Evergreen Broadleaved Forests in Guangdong, China. Plant Ecol., 188: 77-89.

Aquilaria Malaccensis Plantation as a Livelihood Security in North East India

Rajib Kr. Borah*, Monisha Neog and Priyakshi Das

Abstract

Aquilaria malaccensis Lamk. is one of the 15 tree species of the genus Aquilaria belonging to Thymelaeaceae family and a precious floral wealth of North East India. Locally known as Sasi, Agaru or Agarwood, it is a potential aromatic plant of the region, better known for its exalted perfumery raw material obtained from the infected wood formed due to host fungus interaction. The essential oil from agarwood is valued for preparation of several pharmaceutical and cosmetic products and its cost is extremely high depending on the oleoresin content of the wood. The extremely high prices paid for high quality agarwood and the essential oil results in indiscriminate felling of agar tree thereby posing a potential threat to the very existence of the species. As per survey conducted by Assam Forest department during 2003-04, more than 90, 00,000 agar plants of different age classes were enumerated in the non forest land. Due to abundance of agar trees in North East India, the trade of agarwood has become a fascinating industry in this area. It is recorded that more than 9100 agar oil extraction units exist in Assam requiring more than 7, 28, 000 trees of agar which is continuously supplied by the agar farmers. More than 50,000 workers and farmers are involved in the agar business and while another 1.5 lacs benefit from it indirectly. Farmers involved in the farming receive about Rs. 144 crores annually. A. malaccensis also has been identified as a potential agroforestry species in homesteads plantations as well as in community lands, in combination with patchouli (*Pogostemon cablin*), sarpagandha (*Rauvolfia serpentina*), Jatropha, pepper (*Piper longum*), Pine apple, tea, turmeric, areca nut and with other agricultural crops. It is reported that the average cost of a mature tree in home gardens in Upper Assam fetches the price from Rs 28,986 (US$ 580) to 20, 08,238 (US$ 40,165) with an average of Rs 2, 49,090 (US$ 4,982). Low input and flexibility in sites requirement, improved economic opportunities for people and intercropping opportunities make agar as a potential candidate for cash crop in the home gardens of the region.

Key words : Aromatic plants, agarwood, agr- forestry, medicinal plants, Assam.

Rain Forest Research Institute, Jorhat, Assam, India
(Indian Council for Forestry Research and Education)

* *Corresponding Author Email- borahrk@icfre.org*

Introduction

The North East Region has a unique eco-system and is a treasure trove of varied species of flora and fauna. It provides ample scope for biodiversity prospecting as the region harbors matchless plant wealth of endemic species. Aquilaria malaccensis (Syn A. agallocha Roxb.) locally known as agar or Sasi is the principal producer of the dark brown agar wood or eaglewood, produced within heartwood as a result of host-fungus interaction. The genus Aquilaria Lamk. belongs to the family Thymelaeaceae consisting of about 15 species of woody trees mostly distributed in Bangladesh, Bhutan, North-eastern India through Myanmar to Peninsular Malaysia, Sumatra, Bangka, Borneo, Philippines, Singapore, Indonesia, and Thailand. Agar tree is a tropical deciduous tree, of about 18 to 20 m. Sometimes, the tree can grow up to a height of 40 m and reach a diameter of 60 cm. *A. malaccensis* is commonly found in primary and secondary forests, typically found in mixed forest habitat at an altitude between 0-1000 m above the sea level mainly in plains but also on foot hills and ridges up to 750 m altitude. India is home to two Aquilaria species viz., A. khasiana and A. malaccensis. A. malaccensis is native to North-eastern states of India while A. khasiana is found mainly in Khasi Hills of Meghalaya only.

Agarwood is a resinous, fragrant wood formed as a result of host fungus interaction in the heartwood of Aquilaria malaccensis L. Agarwood formation is the resinification of accumulated oleoresins due to the action of microorganisms. The infection of fungus occurs when stem is injured or bored by larvae of a stem borer (Zeuzera conferta Walker.) The borer makes tunnels inside the tree trunks. Fungus enters the plant through this vertical hollow sometimes-zigzag tunnel inside the stem, which serves the initial sites of infections.The fungal infection takes long time to mature and trees about 50 years old have the highest concentration (2.5-5.0 kg/tree).

The people of North eastern India in general and Assam in particular had the knowledge of agar wood or 'Sasi Kath' since ancient times. Its pleasant aroma and costly medicinal values have been the cause of attraction of people since time immemorial. Religious books or "Puthi" written on the specially treated bark glorified its position in the society and people started its plantation in the back yards of their homes and within the campus of 'Thans' and "Satras". It gradually became a part of culture in Assamese society. In Far East Asian countries, charring of agar-candle is an indispensable part of worshiping. Commercial use of this particular tree also began in ancient times. Kings, Nawabs and the people in the higher echelon in the society bought and used the fungal infected chips and oil of Agar as perfumery items and trading thereof have developed into a lucrative phenomenon from those days.

Arabians traditionally use perfumes. Agar chips and agar oil always had a place in their society since long back due to its aroma. Since then, the Arabian began to use agar chips and agar oil as perfumery items. As a result, large-scale consumption of agar started giving vent to present business dimension. Agar wood is valued in high class perfumery as a fixative and is much priced by European perfumer for mixing their best grade scents (Baruah et al., 1982). Agar wood and its products are also described as aphrodisiac, alternative anodyne, antidiarrhoeal, antiasthmatic, astringent, carminative, cordial diuretic, laxative stomachic and tonic (Dey, 1980) and enter into the preparation of several pharmaceutical and cosmetic products (Kirtikar and Basu, 1991).

After the independence, people of various parts of Assam took up this business and Hojai, a small town of Nagaon district grew into a nerve centre of this trade and commerce including Naharani and Namti in upper Assam. The economy of upper Assam is agriculture –based and homegardens are a prominent land system of the state (Devi and Das 2010). Although rice (*Oryza sativa* L.), Sugarcane (*Saccharum officinarum* L.) and Tea (*Camellia sinensis* L.) (O. Kuntze) are the major crops of the region, with the passage of time, thousands of people in Assam have been engaging themselves in this business. As per survey conducted by Assam Forest department during 2003-04, more than 90, 00,000 agar plants of different age classes were enumerated in the non forest land (private land). It is recorded that more than 9100 agar oil extraction units are working in Assam requiring more than 7, 28,000 trees of agar which is continuously supplied by the agar farmers. More than 50,000 workers and farmers are involved in the agar business and while another 1.5 lacs benefit from it indirectly. Farmers involved in the farming receiving about Rs. 144 crores annually (Saikia, 2006).

Due to abundance of agar trees in North East India, the trade of agar-wood has become a fascinating industry in this area. The three grades of oil are being extracted from the agarwood namely Boya, Boha and Khara. The rate also varies from Rs. 500/- to 12000/- per tola (11.62 g) in the North-East India. However, in the international market, the value of first grade agarwood is extremely high. Prices range from a few dollar per kilo for the lowest quality to over thirty thousand US dollars for top quality oil and resinous wood. Traders even quote prices for pure agarwood oil as high as USD 30000/kg. *A. malaccensis* is a vulnerable species as per the current IUCN Red List. As per the Information collected during studies undertaken by RFRI, it is observed that overexploitation remains a significant concern. Chakrabarty et al. (1994) accredited India's trade in agarwood and concluded that *A. malaccensis* is highly threatened in that country due to exploitation of the species for commercial purposes.

It has been noticed that rural economy of three districts of Upper Assam viz., Jorhat, Golaghat and Sivsagar are mostly dependent on Agar cultivation. Barring few reports as reported by Saikia and Khan (2012), information on socio economic aspects of Agar cultivation in North East India is scanty. Keeping this in mind, we assessed the home gardens of Upper Assam with special reference to dependence of rural population on *Aquilaria malaccensis* plantation for their livelihood.

The objectivesof this study was to assess the home gardens of Upper Assam with special reference to dependence of rural population on *Aquilaria malaccensis* plantation for their livelihood.

Materials and Methods

The study was carried out in selected homegardens of Golaghat, Sivsagar and Jorhat districts of Upper Assam in North East India. Survey was conducted in different villages of the three districts based on the availability of agar trees. The climate is tropical with a hot and humid weather prevailing during most of the summer and monsoon months. The average annual rainfall in Golaghat, Sivsagar and Jorhat are 1300 mm, 2350 mm and 2244 mm respectively. The summer temperature ranges from 25-40 ºC and minimum winter temperature ranges from 8-10 ºC. The information regarding the socioeconomic status of villagers and benefits of *A. malaccensis* plantation was collected by interactive questionnaries focusing on the home garden size, main source of income, age of agar plantation, total numbers of trees, numbers of harvested trees, price of individual agar tree, principal plantation crop, total annual income contributed by agar, total annual income contributed by other home garden products etc along with other relevant information on agar. Vegetation study was carried out by laying out quadrate of 10 X 10 m size. The Relative Frequency, Relative Density, Relative Dominance and Important Value Index (IVI) were calculated by following formulae.

Relative Frequency = (Frequency of a given species / Sum of the frequencies of all the species) X 100.

Relative Density = (Density of a given species / Sum of the density of all the species) X 100.

Relative Dominance = Basal area of a given species / Sum of the basal areas of all the species) X 100

Important Value Index (IVI) = Relative Frequency + Relative Density + Relative Dominance.

Results and Discussion

Studies on vegetation in the home gardens revealed that the dominant tree species (>10 cm GBH) were Aquilaria malaccensis, Musa paradisiaca, Cocos nucifera, Areca catechu, Artocarpus heterophyllus, Mangifera indica, Terminalia chebula, Ziziphus jujube, Litchi chinensis and Phyllanthus emblica. Besides, some other economically important trees were also recorded such as Camellia sinensis, Bambusa sp, Colocasia esculenta, Piper nigrum, Piper betle, Curcuma longa, Hibiscus esculentus, Zingiber officinale, Ananas comosus and Capsicum sp.

Table 1 : List of dominant tree species found in home gardens along with *A. malaccensis* L.

Species	Relative Density (individuals ha-1)	Relative Frequency	Relative Domin-ance	IVI	Home gardens of occurrence (%)	Uses
Aquilaria malaccensis	98.248	30.473	02.690	131.411	100	Cash crop
Musa paradisiacal	00.134	09.373	04.708	14.295	30.76	Fruit & cash crop
Cocos nucifera	00.050	07.030	12.780	19.86	23.07	Fruit & cash crop
Areca catechu	01.361	18.750	10.986	31.097	61.53	Cash crop & Domestic use
Artocarpus heterophyllus	00.038	07.030	14.125	21.193	23.07	Cash crop & fruit
Mangifera indica	00.124	11.720	23.991	35.835	38.46	Fruit
Terminalia chebula	00.005	03.123	04.46	07.588	10.25	Fruit & Medicinal use
Ziziphus jujube	00.008	05.467	03.811	09.286	17.94	Fruit
Litchi chinensis	00.022	04.686	01.569	06.277	15.38	Fruit & cash crop
Phyllanthus emblica	00.006	02.343	02.914	05.263	07.69	Fruit & Medicinal use

Table 1 represents the list of dominant tree species found in home gardens along with *A. malaccensis*. And it was observed that among all the listed ten species, *A. malaccensis* has the highest percentage of occurance in the home gardens i.e, 100% followed by *A. catechu* (61.53%). *A. malaccensis* has also the highest Important Value Index (IVI) of 131.411 followed by *M. indica* (35.835), *A. catechu* (31.097). From the table, it is also clear that *A. malaccensis* has the highest relative density of 98.248 in comparison to other tree species. Hence, the economy of the people of these districts is mainly based on Agar.

Dependence of Rural populace of three different district of Upper Assam on agar cultivation was further represented in Table 2. From the table 2, it is clear that average home garden size is highest in Sivsagar district i.e, 0.15 ± 0.12 ha

followed by Golaghat and Jorhat district. Likewise, average density of agar trees in home gardens of Sivsagar district was recorded to be the highest i.e., 11889.91 ±142518.72 ha-1 followed by that of Golaghat and Jorhat district.

From the table 2, it is also evident that the average annual income contributed by agar was found to be the highest in Sivsagar i.e, Rs. 199818.18 ±142518.72 followed by Golaghat and Jorhat i.e, Rs. 132933.33 ±379061.71 and 10000 ±2828.43 respectively. The result is in corroboration with the report of Saikia and Khan (2012) according to which the average cost of a mature tree in home gardens of Upper Assam fetches the price from Rs. 28,986 (US$ 580) to 20, 08, 238 (US$ 40, 165) with an average of Rs. 2,49,090 (US$ 4,982).

The density of agar in home gardens (individuals ha^{-1}) was also found maximum in Sivsagar district i.e, 11889.91 ±9498.42 secondly in Golaghat 5840.07 ±5411.47 and it was noticed surprisingly very low in Jorhat 800 ±282.84, these variation may be due to climatic factors of the region and the natural presence of borer in Sivsagar and Golaghat. In general, the number of tea gardens is more in Jorhat than that of Golaghat and Sivsager. So, the reason for least density of agar tree in Jorhat district may be attributed to more dependency of people of Jorhat on tea cultivation rather than agar cultivation. However, economic benefits from agar cultivation depend on the rate of natural infection, which is, in general, highest in Sivsagar district. Even the small seedlings are attacked by the stem borer resulting in early death of trees, which is a major problem faced by the cultivators of Sivsagar district particularly in Amguri, Shamoguri and Namti areas.

Table 2 : Dependence of rural populace of three different districts of upper Assam on Agar cultivation.

Parameters	Range	Mean (±SE)		
		Golaghat	Sivsagar	Jorhat
Home garden size (ha)	0.04 - 0.66	0.145±0.173	0.150±0.121	0.045±0.007
Cultivation of agar in home gardens (years)	5 - 35	18.866±6.74997	17.727±7.734	11.00±1.141
Harvested trees (no.)	3 - 500	37.4±30.368	143.409±118.8299	13.5±2.121
Total money earned (Rs.)	6000 - 2,000,000	284066.66 ±276063.26	893136.363 ±561743.23	42500±10606.601
Price of individual tree (Rs.)	1000 -10,000	4733.33±2242.978	4045.454±2240.902	2500±707.106
No. of trees yet to be harvested (no.)	30 - 3000	399.333±294.047	133.363±818.561	35±7.071
Density of agar in home garden (individuals ha-1)	230 - 33,333	5840.066±5411.467	11889.909±9498.421	800±282.842
Appox. amount of money to be earned (Rs.)	60,000 - 1,60,00000	1778666.667±1392340.612	5393181.818±4421088.41	90000±42426.406
Average annual income contributed by agar (Rs.)	8000 - 15,00,000	132933.33±379061.711	199818.181±142518.716	10000±2828.427

Conclusions

From the above study, it can be concluded that substantial revenue can be earned from agar cultivation and it can be enhanced further by adopting scientific methods of agar production. Considering the economic benefits from agar cultivation, of late, more and more areas are covered under agar cultivation, which is a very good sign for the rural economy of the region. As there is no clear cut policy on harvest and trade of agarwood, the farmers are compelled to be involved in illegal trading. So, Government should frame a clear cut policy on harvest and trade of agarwood which will give a boost to the agarwood industry of North East India.

Acknowledgements

The authors acknowledge the financial assistance from National Medicinal Plant Board (NMPB), Govt. of India through the research project entitled "Development of descriptors and evaluation of artificial inoculation in Aquilaria malaccensis L." We also acknowledge Dr.N.S.Bisht, Director, Rain Forest Research Institute (RFRI), Jorhat for his constant encouragement and necessary support. Thanks also to Mr. Niren Das, Shifting Cultivation Division, RFRI Jorhat for his help in statistical analysis.

References

Baruah, J.N., Mathur, R. K., Jain, S. M. and Kataky, J. C. S. 1982. Agarwood. In Cultivation and Utilization of Aromatic Plants. Eds. C. K. Atal and B. M. Kapur, RRL, Jammu-Tawai, pp. 662-667.

Chakrabatry, K. Kumar , A and Menon, V. 1994 . Trade in agar. Traffic India and WWF-India, New Delhi, 51p.

Devi, N.L.and Das, A. K 2010. Plant species diversity in the traditional homegarden Meitei community: a case study from Barak velly, Assam . J Trop Agric .,48: 45-48. .

Dey, A.C. 1980. Indian Medicinal Plants used in Ayurvedic Preparation, Bishan Singh & Mohendra Pal Singh publication, Dehradun, India, pp. 122.

Kirtikar, K. R. and Basu, B. D. 1991. Indian Medicinal Plants Periodical Expert Book Agency, New Delhi, India, Vol. III, pp. 2171- 2172.

Saikia, G. 2006. Aquilaria agallocha (Agar wood): Prospect & Problems, Regional Workshop on Forestry Extension, July 14, 2006, Rain Forest Research Institute, Jorhat, Assam.

Saikia, P and Khan, M.L. 2012 Agar (Aquilaria malaccensis Lam.): a promising crop in the home gardens of Upper Assam, northeastern India, Journal of Tropical Agriculture 50 (1-2): 8-14.

Theme 2

Governance and Management of Natural Resources

Effect of Seaweed Extracts on the Productivity and Economics of Summer Sesame Cultivation on Lateritic Soil of West Bengal

Mahua Banerjee*, A. Ghosh, G.C.Malik, Debtanu Maiti, Tanmoy Shankar

Abstract

Seaweeds are one of the most important marine resources of the world. The use of seaweed as manure is common in coastal areas throughout the world. A field experiment as well as demonstration trial was conducted to evaluate the performance of sea weed extracts on the productivity and economics of summer sesame cultivation in the lateritic soil of West Bengal, during the pre-kharif season of 2013 at the farmer's field in ChellaKamarpara village, Birbhum, West Bengal. The soil was slightly acidic and it was low in Nitrogen and medium in phosphorus and potassium. The concentration of sap application varied from 2.5%, 5.0 %, 7.5%, 10 %, 15 %, (v/v basis) as per treatments in the experimental plot consisting of ten treatments which was replicated thrice. The concentration of sap application was 5 % (v/v basis) in the farmer's field. The quantity of water applied was 600 litre/ha in each spray. The Recommended dose of fertilizer (RDF) applied was 80:40:40 kg N:P2 O5:K2O/ha.

The results showed that the no of branches/plant, no of capsules/plant was highest in Kappaphycus sap treated plants at 60 DAS but at harvest, the Gracillaria sap treated plants recorded marginally higher average number of branches /plant and no of capsules/plant over that of Kappaphycus sap treated plants. In both the cases, the lowest number of branches was recorded in water treated plants. The data revealed that the no. of seeds /capsule values were highest in Kappaphycus sap treated plants and it was marginally higher than that of Gracillaria sap treated plots and the lowest number of seeds/capsule was observed in water treated plants. The result indicated a marked influence of sea weed sap sprays on the seed and stick yield of sesame. Crop sprayed with Kapphaphycus sap produced the highest amount of seed and stick yield. The value of seed yield as recorded in crop sprayed with Kapphaphycus sap showed marginally higher values over that of Gracillaria sap treated crop. But the stick yield value in crop sprayed with Kapphaphycus sap was higher than that recorded in Gracillaria sap treated crop. However, in both the cases, the lowest values were reported by the crop sprayed with water. From the present trial it can be concluded that in this Lateritic region of West Bengal, the sesame crop variety Rama give good responses to the spray application of sea weed saps during the critical growth stages like branching, flowering and capsule development. Thus, in future, the use of sea weed can be popularized in the farmer's field and it may reduce the fertilizer consumption which may prove beneficial under the changed climate situation also.

Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal, 731236, India

* *Corresponding Author : Email- mahua.banarjee@visva-bharati.ac.in*

Introduction

Seaweeds are one of the most important marine resources of the world. The use of seaweed as manure is common in coastal areas throughout the world and particularly in France and Scotland. Although 434 species of red seaweeds, 194 species of brown seaweeds and 216 species of green seaweeds naturally occur in India, it was not until the beginning of the twenty-first century that the country made any concrete progress towards organized seaweed farming. The slow progress was due to a number of factors including locational disadvantages, inconsistent performance of species for commercial exploitation, absence of a complete package of farming practices, and industial and policy support. Seaweedextracts have been marketed for several yearsas fertilizer additives and beneficial results from their use have been reported (Booth, 1965). Seaweed extract is definitely capable of promoting growth in both higher plants and prokaryotic organisms (Venkataramanand Mohan, 1994, 1997). These extracts have increased the yield of crops, seed germination, resistance to frost and fungal and insect attacksand uptake of inorganic constituents. Seaweed extracts have been used as soil conditioners and as a foliar spray to increase growth, yield and productivity of many crops (Norrie and Keathley, 2006). The can improve crop growth through various mechanisms like the provision of phytohormones (auxins, gibberellins, cytokinins and abscisic acid), macronutrients (N, P and K), micronutrients (Fe, Cu, Mo, Mn, Zn, Co, and Ni), and secondary metabolites as amino acids and vitamins (Challen and Hemingway, 1965).

Materials and Methods:

A field experiment was conducted to evaluate the performance of sea weed extracts on the productivity and economics of summer sesame cultivation in the lateritic soil of West Bengal, during the pre-kharif season of 2013 at the agricultural farm of Institute of Agriculture, Visva-Bharati, Sriniketan, Birbhum, West Bengal which is situated at N 23º40.167′ latitude and E 087º39.492′ longitudes.Another demonstration trial was also conducted at the farmer's field in ChellaKamarparavillage, Chella G.P, Chella Mouza of Illambazar Block, Birbhum, West Bengal which is situated at 23º37.374′ latitude and 87º37.170′E longitudes with an average altitude of 58.9 m above mean sea level under sub-humid, sub-tropical belt of West Bengal. Under both the conditions the soil was slightly acidic and it was low in Nitrogen and medium in phosphorus and potassium.

The agronomic experiment was conducted in Randomized Block Design (RBD) having ten treatment combinations, replicated thrice. The sea weed saps of

Kapphaphycus and Gracilaria as per treatments were sprayed in the agricultural farm on 18.04.2013 (36 DAS), on 28.04.2013 (46 DAS) and on 19.05.2013 (67 DAS). The concentration of sap application varied from 2.5%, 5.0 %, 7.5%, 10 %, 15 %, (v/v basis) as per treatments. The concentration of sap application was 5 % (v/v basis) in the farmer's field. The quantity of water was @ 600 litre /ha in each spray. The water spray in the control plot was also done on the same days with the same amount of water. Adjuvants were mixed in the tanks before spraying. For each spray, about 6-8 labours were hired. The average wage of labours is Rs. 140/ eight hours.

Results and Discussion

Data recorded on no of branches/plant, no. of capsules/plant, no.of seeds/capsule and test weight have been presented in Table 1. The result showed that the numbers of branches/plant at 60 DAS and at harvest were not significantly affected by the treatments. The results presented in Table 1 showed that the no of capsules/plant was highest in 15%G +RDF treated plants at 60 DAS and it was statistically at par with 10%G +RDF.

Table 1 : Effect of spraying of sea weed sap on the yield components of sesame at the agricultural farm of Sriniketan.

Treatments	Branches/plant		Capsules/plant		Seeds/capsule	Test weight
Sap type & mixture	At 60 DAS	At harvest	At 60 DAS	At harvest		
2.5% K+RDF	7.63	8.67	15.00	44.00	59.67	3.15
5%K+RDF	8.00	10.00	16.67	45.33	60.33	3.16
10%K+RDF	8.17	10.33	16.33	46.00	65.67	3.25
15%K+RDF	7.33	11.00	16.00	40.00	66.67	3.40
2.5%G+RDF	8.33	9.00	15.67	51.00	62.00	3.21
5%G+RDF	8.67	10.00	16.00	43.00	65.67	3.30
10%G+RDF	9.00	10.00	17.00	52.00	62.00	3.42
15%G+RDF	9.00	11.33	18.00	43.33	63.00	3.22
WS +RDF	5.00	8.33	15.00	43.00	60.00	3.08
7.5 % K +50% RDF	5.23	9.00	12.00	36.00	58.00	3.11
SEm(±)	0.94	0.72	0.4	1.30	1.84	0.035
CD at 5 %	2.79 (NS)	2.13 (NS)	1.4	3.87	5.48	0.105
CV	19.9	16.54	25.9	6.60	6.66	2.47

At harvest, the highest no of capsules/plant was reported in 10%G+RDF treated plants and it was statistically at par with 2.5%G +RDF. In both the cases, the lowest number of capsules/plant was recorded in 7.5 % K +50 %RDF treated plants. The number of seeds per capsule was highest in 15 %K+RDF and it was

statistically at par with all other treatments except 2.5 % K+RDF, 5 % K+RDF, WS +RDF and 7.5 % K+50 % RDF. The lowest number of seeds/capsule was obtained in 7.5%K + 50 % RDF and it was statistically at par with plots sprayed with water only(WS+RDF).In general, it was observed that, with increased concentration of the K and G sap, the yield components value increased progressively upto 10 % concentration and thereafter, it increased only marginally on application of 15 % conc.

Table 2 : Effect of spraying of sea weed sap on the seed yield, stick yield, and Harvest Index of summer sesame at the agricultural farm of Sriniketan.

Treatments	Seed yield (kg/ha)	Stick yield (kg/ha)	Harvest index
2.5% K+RDF	1631.64	3040.00	34.83
5%K+RDF	1909.06	3400.00	35.39
10%K+RDF	2246.93	3626.00	38.26
15%K+RDF	2218.28	3460.67	39.24
2.5%G+RDF	2147.27	3219.33	39.54
5%G+RDF	2163.90	3295.67	39.89
10%G+RDF	2460.32	3426.00	41.63
15%G+RDF	2211.87	3561.33	38.20
WS +RDF	1459.72	3039.33	32.72
7.5 % K +50% RDF	1296.23	2707.33	32.48
S Em(±)	174.68	228.82	1.92
CD at 5 %	509.03	679.8	5.72
CV	19.92	15.72	11.65

The seed yield, stick yield and harvest index recorded at harvest have been presented in Table 2. The result showed marked influence of sea weed sap sprays on the seed and stick yield of sesame. Crop treated with 10%G+RDF recorded the highest seed yield which was however ststistically at par with all other treatments except application of 2.5 % K +RDF, 5 % K +RDF, WS +RDF and 7.5 % K+50% RDF.The highest stick yield was obtained in plot treated with 10%K+RDF which was statistically at par with all other treatments except application of WS +RDF and 7.5 % K +50% RDF. The lowest value was obtained in 7.5 % K +50% RDF which was statistically at par with WS +RDF, 2.5% K+RDF and 2.5 % G +RDF. The harvest index was highest in 10%G+RDF which was statistically at par with all other treatments except application of 2.5 % K +RDF, 5 % K +RDF, WS +RDF and 7.5 % K +50% RDF. The lowest harvest index was however recorded in 7.5 % K +50% RDF and it was statistically at par with 2.5 % K +RDF, 5 %

K+RDF, WS +RDF.It was also observed that the value of seed yield as recorded in crop sprayed with Gracillaria sap showed marginally higher values over that of Kapphaphycus sap treated crop. But the stick yield value in crop sprayed with Kapphaphycus sap was sufficiently higher over that recorded in Gracillaria sap treated crop.

Data recorded on no of branches/plant, no. of capsules/plant, no.of seeds/capsule and test weight have been presented in Table 3. The results showed that the no of branches/plant was highest in Kappaphycus sap treated plants at 60 DAS but at harvest, the Gracillaria sap treated plants recorded marginally higher average number of branches /plant over that of Kappaphycus sap treated plants. In both the cases, the lowest number of branches was recorded in water treated plants.The results presented in Table 3 showed that the no of capsules/plant was highest in Kappaphycus sap treated plants at 60 DAS and at harvest. The no.of capsules/plant in the Gracillaria sap treated plants recorded marginal increase at harvest over that at 60DAS, but the number of capsules /plant at harvest increased magnificantly in case of Kappaphycus sap treated plants over that reported at 60 DAS. In both the cases, the lowest number of capsules/plant was recorded in water treated plants and the number of capsules/plant increased slightly at harvest over the values observed in 60 DAS.The data revealed that the no. of seeds /capsule values were highestinKappaphycus sap treated plants and it was marginally higher than that ofGracillaria sap treated plots and the lowest number of seeds/capsule was observed in water treated plants.

Table 3 : Effect of spraying of sea weed sap on the yield components of sesame on farmer fields.

Spray details	No of branches/plant	No of capsules/plant	No of seeds/capsule	Test weight (g)
	At harvest	At harvest	At harvest	
K sap	12	168	75	3.12
G sap	11	162	64	3.11
Control	11	155	53	3.09

The seed and stick yield recorded at harvest have been presented in Table 4. The result showed marked influence of sea weed sap sprays on the seed and stick yield of sesame. Crop sprayed with Kapphaphycussap produced the highest amount of seed and stick yield. The value of seed yield as recorded in crop sprayed with Kapphaphycus sap showed marginally higher values over that of Gracillaria sap treated crop. But the stick yield value in crop sprayed with Kapphaphycussap was sufficiently higher over that recorded in Gracillaria sap treated crop. However, in both the cases, the lowest values were reported by the

crop sprayed with water.The harvest index results have been presented in Table 4. The harvest index values were not much affected due to the spray treatments. It varied from the highest value of 32.90 recorded in water applied plots to the lowest value of 32.20 in the Kapphaphycussap treated plots.

Table 4 : Effect of spraying of sea weed sap on the yield and harvest index of sesame on farmer fields.

Spray details	Seed Yield (kg/ha)	Stick yield (kg/ha)	Harvest index
K sap	2500	2250	52.60
G sap	2200	2120	50.92
Control	2050	1980	50.86

Higher leaf area, leaf area indices, engaged in photosynthesis throughout the growth period of the crop in case of Kapphaphycussap treated plants produced greater dry matter accumulation and higher number of capsules/plant and ultimately led to greater productivity as compared to those obtained inGracillaria sap treated plant and water sprayed plant. Since, the saps are rich in potash content, supply of additional amount of nutrients and growth stimulating substances in the sea weed saps probably resulted in better nutrition of the crop and ultimately resulted in higher yield.Pramanick.et.al (2012) also reported the effect of seaweed liquid fertilizers obtained from Kappaphycus sap (K) and Gracilaria sap(G)on green gram.

Economics of the Treatments

The cost of cultivation, gross return, net return, and return per rupee invested have been worked out and presented in the Table 5. It was found that the cost of cultivation was lowest in 7.5 % K + 50% RDF. It was also observed that the gross return was lowest in 7.5 % K +50% RDF which was statistically at par with WS +RDF and 2.5 % K +RDF. The highest gross return was found in 10 %G+RDF and it was statistically at par with all other treatments where sap was applied in combination with RDF except 2.5 % K +RDF. The net return was also lowest in 7.5 % K + 50% RDF which was statistically at par with WS +RDF and 2.5 % K +RDF. The highest net return was found in 10 % G+RDF which was statistically significantly different from all other treatments where sap was applied in combination with RDF except 2.5 % K +RDF. The return per rupee invested was highest in 10 % G +RDF.

Table 5 : The economics of spraying of sea weed sap on summer sesame cultivation.

Treatments	Cost of cultivation	Gross return	Net return	Return per rupee invested
2.5% K+RDF	22065	34153	12088	1.55
5%K+RDF	22290	39881	17592	1.79
10%K+RDF	22720	46752	24032	2.06
15%K+RDF	23160	46096	22936	1.99
2.5%G+RDF	22065	44555	22491	2.02
5%G+RDF	22290	44926	22636	2.02
10%G+RDF	22720	50919	28199	2.24
15%G+RDF	23160	46018	22858	1.99
WS +RDF	21400	30714	9314	1.44
7.5 % K +50% RDF	20386	27279	6892	1.34
S Em(±)		3551	3551	0.16
CD at 5 %		10551	10551	0.47
CV		19.44	42.3	19.46

Conclusions

From the present trial conducted on farmer's fields with one of the popular sesame variety Rama grown with recommended dose of fertilizer and following standard package of practices, it can be concluded that in this Lateritic region of West Bengal, the sesame crop variety Rama gave good responses to the spray application of sea weed saps during the critical growth stages like branching, flowering and capsule development. In terms of growth parameters and yield, among the two different kinds of sea weed saps. In general, the crop gave better responses to the application of Kappaphycus sap. The values improved strikingly upto the application of 10 % concentration thereafter the values were mostly statistically at par with the 15 % concentration of both the saps. From economic point of view also, the application of K and G sap was found to be more remunerative at 10 % G +RDR. Thus, in future, the use of sea weed can be popularized in the farmer's field and it may reduce the fertilizer consumption which may prove beneficial under the changed climate situation also.

References

Booth, E. (1965). The manurial value of seaweed. Bot Mar., 8: 138-143.

Challen, S.B. and J.C. Hemingway. (1965). Growth of higher plants in response to feeding with seaweed extract:Proceedings of 5th International Seaweed Symposium. 25-28.

Norrie J, Keathley J.P, (2006). Benefits of Ascophyllum nodosum marineplant extract applications to 'Thompson seedless' grape production. Acta. Horticul. 727:243-247.

Pramanick,B., Brahmachari .K, and Ghosh,A., (2012) Effect of seaweed saps on growth and yield improvement of green gram: African journal of agricultural research :315–320

Venkataraman .K, Mohan V.R., (1997). The effect of liquid Seaweed extracts in agriculture and horticulture: Biology of Agriculture and Horticulture 8:309-324.

Soil Properties and Carbon Stock Quantification in Coffee Agroforestry of Mid-Hills Nepal

Ngamindra Dahal[1*], Roshan Man Bajracharya[1] and Juerg Merz[2]

Abstract

Coffee agroforestry is a rapidly expanding land use practices in midhills of Nepal with a significant scope of carbon storage in the forms of tree biomass and soil organic carbon. Prosperity of coffee farmers, however, is linked to health of soil among other factors. Analysis of basic properties of soil, therefore, is essential to identify deficiency in soils and provide necessary inputs as soil amendment.

This paper presents key findings of a recent study on soil properties and carbon stocks from privately run coffee agroforestry farms in Panchkhal of Kavrepalanchok District, Talamarang of Sindhupalchok District and Chandanpur of Lalitpur District, which represent some of the diverse eco-climatic regions of midhills Nepal. These findings indicate two major points for further investigation and policy consideration. First, in all the three coffee farms, soils were acidic in the range of 5.4 to 6.6 pH, the SOM ranged from 2 to 8%, nitrogen N (572 to 5860ppm), phosphorus P (33 to 528 ppm) and potassium K (51 to 585 ppm). The results indicate that soil nutrients and conditions are one of the constraints for maintaining productivity of the crop (coffee). Second, the agroforestry farms have a significant pool of carbon in the forms of biomass and SOC, which are largely unaccounted for in the carbon market.

Introduction

Tracking physical and chemical properties of soils in agricultural lands is crucial to make decisions on selecting a crop variety and maintaining sustainable productivity. Soil properties, however, may change over times due to natural causes e.g. weather, climate change, and geological processes; and, anthropogenic causes e.g. irrigation, tillage, mulching, applications of fertilizers, as well as, soil amendments and other practices including land use changes. In the context of

[1] *Kathmandu University*

[2] *HELVETAS Swiss Intercooperation Nepal*

**Corresponding Author: Email- ngamindra@gmail.com*

changing climate, there are growing interests on carbon pools and their trends in terms of changes in stocks and permanence.

A sizable population of Nepal midhills still depends on agriculture in the largely non-irrigable or rainfed agricultural lands called *bari*. Various human and natural factors are attributed for changes in conventional agricultural practices which are reported to be declining. They include severe droughts, growing water scarcity linked which are also linked to increased number of high intense rainfalls in recent decades. Degradation of soil quality and growing aridity are also widely reported. Crop intensification is a new trend though size of fallow lands is also reported to be growing for the lack of irrigation facility. Against all odds, farmers are trying to be innovative and turning to cash crops such as coffee.

Coffee farming in bari has been a popular practice among the midhill farmers in recent decades. This has offered new source of income and has contributed to reduce poverty and enhance quality of life of many farmers. Expanding rural road networks have offered opportunities of better market access. However, the coffee based agroforestry has seen new set of challenges in terms of maintaining productivity against declining soil fertility and emerging diseases. Coffee based agroforestry is also likely to contribute enhancing carbon sequestration through tree biomass and soil organic carbon. Steady growth of demand of Nepali coffee in local and international market indicates a sustainability of coffee agroforestry. The coffee grown in midhills Nepal has already earned wide recognition as 'organic coffee' and has earned a niche for itself in the international market. The coffee agroforestry farms are expanding through the midhills and have a potentiality to grow into an attractive scheme for carbon sequestration.

In recent years, rapid infestation of stem borer in grown up coffee trees has been a key concern to majority of farmers in some pockets of coffee grown areas for which no cure or preventive measures are available. Concern technicians have advised farmers to remove and burn down the disease infested tree in isolation.

Rationale of the study lies on the need of monitoring soil health to identify nutrient deficiency in order to remove a key constraint for maintaining productivity of coffee, and, importance of bringing agroforestry into the carbon market so that the coffee farmers could benefit from the compensation received to them for contributing to carbon sequestration.

In this context, the purpose of this paper is to share basic results of soil properties of three research sites and carbon stocks of coffee trees in the three different eco-climatic zones which paves the way to estimate potential size of carbon stocks available in the coffee agroforestry in midhills of Nepal.

Methods and Materials

Research sites and sampling design: This study is based on field experiments conducted in three research plots each located in Chandanpur (Lalitpur), Panchkhal (Kavrepalanchok) and Talamarang (Sindhupalchok) of midhill Nepal (Fig 1).

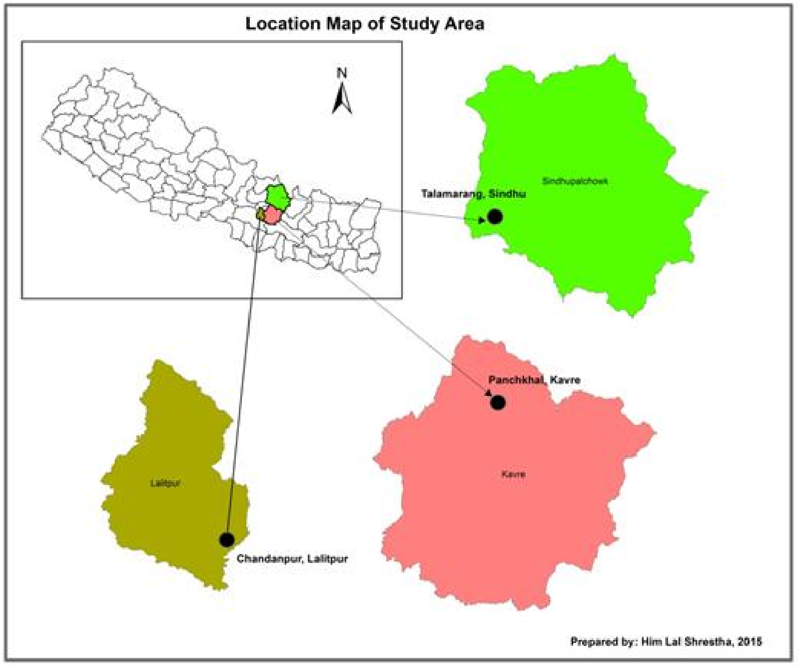


Figure 1 : Location of research plots

The plots belong to the smallholders who grow organic coffee with technical support from HELVETAS Intercooperation at initial phase. Among the coffee growing farmers, one or two households in each village were selected for the experiment based on their willingness to participate voluntarily in biochar making and application on the plots as per the guidelines provided by the authors. Accordingly, farmers offered their full cooperation to identify plots, tag sampled trees and collect soil samples from the designated plots. Soil samples were collected between March to July 2013 from each of the sites. This followed by three subsequent visits in each site between January to July 2014 when 40 fruiting coffee trees were tagged in each site. Of them 20 were provided with 150gm biochar in each tree (at rate of 20% of recommended farmyard manure), and, rest 20 were left without biochar for control.

Collection and analysis of soil samples: Five samples were collected from each of the three research plots in three layers – 0 to 15, 15 to 30, and, 30 to 60 cm. A five cm diameter corer was used to extract bulk density from each layer. The samples size was 45 (3 sites *5 replications *3 layers). Eight soil parameters were analysed, which include pH, SOM, CEC, soil bulk density, texture type, and concentration of N, P, and K. Lab analysis of the samples were conducted in the lab of Aquatic Ecology Centre in Kathmandu University complex at Dhulikhel. Methods applied for analysis of each parameter are tabulated (table 1).

Table 1: References of methods used for analysis of 8 parameters

S.N.	Soil Parameter	Analysis Method	Reference
1	Bulk density	Core method	Blake and Hartge (1986)
2	Texture	Soil hydrometer method	Gee and Bauder (1986)
3	Porosity/AWC	Water saturation method	Approx.
4	Soil pH	Digital pH meter with glass-calomel electrode	McLean (1982)
5	Organic matter/carbon	Dry combustion	Nelson and Sommers (1982)
6	Total nitrogen	Kjeldahl method	Bremner and Mulvaney (1982)
7	Available phosphorus	Modified Olsen method	Olsen and Sommers (1982)
8	Exchangeable potassium	Ammonium acetate extraction	Knudsen, D., Peterson, G.A. and Pratt, P.F. (1982)
9	Cation exchange capacity	NH_4OAc-KCl extraction	Rhoades, J.D. (1982)

Monitoring of biomass stock of coffee trees: Height and, dbh of the 40 sampled coffee trees were taken in order to estimate biomass stock in each tree. In the absence of specific biomass equation for the coffee plant grown in Nepal, aboveground tree biomass (AGTB) was estimated employing two methods by Chave et al (2005) and Ketterings et al (2012) as follows:

a) Chave et al (2005) suggested the following equation for above ground tree biomass

AGTB = ρ DH

where D is the diameter at breast height (cm), H is the height of the tree (m) and ρ is wood density (g/cc).

b) Ketterings et al (2005) used the following equation to estimate the tree biomass:

Tree biomass (W) = 0.11 $\rho D^{\wedge 2+c}$, where ρ is the wood density and the coefficient c is based on the allometric relation between tree height (H) and diameter at breast height D : H = aDc (default value for c = 0.62).

Estimation of SOC stocks: The total pool of soil organic carbon (TPSOC) is expressed as mega grams per hectare for a specific depth, and was computed as a product of C concentration, bulk density, and depth (Pearson et al., 2007) as follows:

- TPSOC = SOC /100 * BD * SD * 10000 Mg ha^{-1}
- Where,
- TPSC = total soil carbon stock, Mg ha^{-1} (which is equivalent to ton/ha)
- SOC = concentration of soil organic carbon in %.
- BD = bulk density, gcm^{-3}; and, SD = soil depth, m.

Results and Discussions

In this section, intermediate results of the sample analysis are presented in tables. We call this intermediate because monitoring of the sample plots are still on progress and the results presented here are subject to change based on availability of longer term field data. Attempts are also made to interpret the results and draw insights as findings.

Characteristics of soils: In all the three research sites, the soils are generally acidic between mean pH level 6.0 (Chandanpur) to 5.4 (Talamarang) (table 2). Chandanpur soils also contain rich soil organic matters (SOM) with 7.2% followed by Talamarang (4.7%) and Panchkhal (3.4%). However, Panchkhal soils stand first on nitrogen and phosphorus contents with 2100ppm and 505ppm respectively followed by Talamarang with 1617ppm and 320ppm. Panchkhal is relatively poor on these vital resources for fertility of soil. In texture type, Chandanpur and Panchkhal soils contain higher proportions of silt with 63% and 52%, and belong to silt loam in the texture classification of the soil. The silt content in Panchkhal is 34% where the dominant soil type is sandy loam. The percentages of clay in Chandanpur, Panchkhal and Talamarang are 9, 22 and 14 respectively. These details generally indicate that Talamarang soils are relatively in more degraded condition that require some soil amendment actions.

Table 2 : General soil properties of three research plots as depicted by mean values of seven parameters

S.N.	Parameters	Chandanpur (1460m, Lalitpur)	Panchkhal (925m, Kavrepalanchok)	Talamarang (860m, Sindhpalchok)
1	pH	6.0	5.9	5.4
2	SOM (%)	7.2	3.4	4.7
3	SOC (%)	4.6	2.2	3.0
4	Total Nitrogen (ppm)	1113	2100	1617
5	Available Phosphorus (ppm)	129	505	320
6	Available Potassium (ppm)	216	149	175
7	Soil bulk density (gm per cm^3	0.878	2.1	1.94
8	Texture			
	Clay (%)	9	22	14
	Sand (%)	28	25	51
	Silt (%)	63	52	34
	Texture class	Silt loam	Silt loam	Sandy loam

Stocks of soil organic carbon: SOC stock was estimated up to 30 cm depth of soil in all the three sites. Among the sites, Chandanpur recorded relatively lower amount of soil carbon with 120.5 ton per hector followed by Panchkhal with 137 ton and Talamarang with 173 ton in each hector.

Carbon stock in coffee agroforestry: Baseline monitoring of coffee trees in the respective research plots provides indicative stocks of carbon in each of the coffee plants. The mean height and diameter of coffee trees in Chandanpur vary between 220 and 250 cm; and, 3.3 and 3.7 respectively (table 3). In Panchkhal the trees are relatively of shorter heights and thinner stems, which vary between 175 and 195, and, 3.2 and 3.3 cm. However, in terms of tree height and thickness, Talamarang comes first. The mean heights range from 260 to 271cm, and, diameters at breast height range from 3.6 to 3.8cm. The mean aboveground carbon stock per coffee tree ranges from 16 to 20.4kg in Chandanpur, 8.8 to 11.6kg in Panchkhal and 16.1 to 22.9kg in Talamarang (table 3).

Here, the differences between the size of coffee plants in the plot amended with biochar and without biochar (control) do not hold significance because these data were collected at the initial phase of research before application of biochar. However, continuous monitoring of the sampled trees in subsequent years is expected to serve as baseline for any changes to take place as the effect of biochar on plant growth, productivity and soil properties.

Table 3 : Carbon stock of coffee plants

Parameters	Chandanpur		Panchkhal		Talamarang	
	Biochar plot	Control	Biochar plot	Control	Biochar plot	Control
No of coffee trees	20	20	20	20	20	20
Average dbh (cm)	3.7	3.3	3.3	3.2	3.6	3.8
Average height (cm)	250.1	220.1	174.6	194.9	262.0	270.8
C stock in Kg *	407.5	363.6	232.4	204.0	458.0	430.1
C stock in Kg **	320.5	350.9	219.1	175.2	341.7	321.7
Carbon per tree in Kg *	20.4	18.2	11.6	10.2	22.9	21.5
Carbon per tree in Kg**	16.0	17.5	11.0	8.8	17.1	16.1

**Based in Chave et al, (2005); **Based on Ketterings et al, (2001)*

Some issues associated with the current studies: A number of issues have emerged since this study was initiated in March 2013. They are mainly associated with expectations of farmers to address their immediate challenges of controlling deadly diseases in their coffee plants such as rapid infestation of white stem borer, quick solutions to reverse declining fertility of their soils and simplified mechanism for producing biochar. There are also issues related with ensuring quality of biochar, which may require linking this initiative to a support program for building capacity of farmers involved in biochar making and applications. During field experiments, a couple of small coffee farmers also reported that they noticed reduced infestation of red ants on potatoes where biochar was applied. Though the report needs verification through further research, this offers a good research question for future study.

Conclusions and Ways Forward

Coffee farming is one of the rapidly expanding agroforestry practices in Nepal midhills particularly in non-irrigated farmlands *(bari)*. Coffee growing farmers, however, are facing challenges of declining soil fertility (thus requiring additional inputs to soil amendment) and new types of diseases (e.g. white stem borer) in their fruiting plants. As biochar is gaining wide acceptance as an effective soil amendment agents throughout the world to address degrading quality of soil in agriculture lands, this study has initiated study whether biochar is effective to reverse or slow the trend. Analysis of soil properties in the study areas clearly indicates deficient nutrient status requiring significant inputs for soil amendment, without which farmers are likely to suffer recurrent productivity loss.

The carbon stock of coffee plants grown in three research sites provides a necessary clue to undertake carbon stock of coffee agroforestry into account. This offers a way to compensate the coffee growers through a carbon sequestration scheme, which is absent to date. This study also highlights the need of a biomass equation for Nepali coffee species, hence a recommendation for further research. In the absence of a biomass equation to fit Nepali a coffee plant grown in midhill Nepal, biomass stock has been estimated through the use of other equations designed elsewhere for similar plant species.

References

Blake, G.R., and Hartge, K.H. (1986) Bulk density. In: page, A.L. (ed). Methods of soil analysis part 1 (2nd edition)

Physical and mineralogical methods agronomy monographs. ASA; SSSA. Madison. WI, USA, p. 425-442.

Bremner, J.M. and Mulvaney, C.S. (1982) Nitrogen Total. In: A. L. Page, R. M. Miller and D. R. Keeney, (eds.)

Methods of Soil Analysis Part 2 (2nd edition) Chemical and Microbiological Properties. American Society Agronomy

Monograph No. 9, ASA-SSSA, Inc., Madison, WI, USA, p.595-610.

Chave, J., Andalo, A., Brown, S., Cairns, M.A., Chambers, J.Q., Eamus, D., Fo¨ lster, H., Fromard, F., Higuchi, N., Kira,

T., Lescure, J.-P., Nelson, B.W., Ogawa, H., Puig, H., Rie´ ra, B., Yamakura, T., 2005. Tree allometry and improved

estimation of carbon stocks and balance in tropical forests. Oceologia 145, 87–99.

Gardner, W.H. (1986) Water Content. In: A. Klute (ed.) Methods of Soil Analysis, Part 1. (2nd Edition) Physical and

Mineralogical Methods-Agronomy Monogram No. 9. American Society of Agronomy- Soil Science Society of

America, Madison, WI, USA, p. 493-544.

Gee, G.W. and Bauder, J.W. (1986) Particle Size Analysis. In: A. Klute (ed.) Methods of Soil Analysis, Part 1 (2nd

edition) Physical and Mineralogical Methods-Agronomy Monogram No. 9 (2nd Edition). American Society of

Agronomy- Soil Science Society of America, Madison, WI, USA, p. 383-411.

Helvetas, 2014: http://nepal.helvetas.org/en/our_projects/copp.cfm

Ketterings, Q. M., Coe, R., van Noordwijk, M. et al., Reducing uncertainty in the use of allometric biomass equations for predicting above-ground tree biomass in mixed secondary forests, Forest Ecology and Management, 2001, 120: 199_209.

Knudsen, D., Peterson, G.A. and Pratt, P.F. (1982) Potassium. In: A. L., Miller, R. H., Keeney, D.R. (Editors). Methods of Soil Analysis Part 2 (2nd edition), Chemical and Microbiological Properties, ASA/SSSA, In. Madison.USA. 225:246.

McLean, E.O. (1982) Soil pH and lime requirement. Methods of soil analysis Part 2 (2nd edition) Chemical and

microbiological properties. American Society of Agronomy. Monograph No. 9. Madison (WI): ASA-SSSA, Inc.,

Madison, WI, USA, p. 199-224.

Nelson, D.W., and Sommers, L.E. (1982) Total Carbon, Organic Carbon and Organic Matter In: A. L. Page, R. M.

Miller and D. R. Keeney, eds. Methods of Soil Analysis Part 2 (2nd edition) Chemical and Microbiological Properties,

American Soc. of Agron. Monograph No. 9, ASA-SSSA, Inc., Madison, WI, USA, p. 539-580.

NTCDB, 2009: Kafeema lagne pramukh rog ra tin ko prangarik byawasthapan (Common diseases of coffee plants

and managing them organically, in Nepali language) by Nepal Tea and Coffee Development Board.

Olsen, S.R. and Sommers, L.E. (1982) Phosphorous. In: A. L. Page, R. M. Miller and D. R. Keeney, eds. Methods of

Soil Analysis Part 2 (2nd edition) Chemical and Microbiological Properties, American Soc. of Agron. Monograph No.

9, ASA-SSSA, Inc., Madison, WI, USA, p.403-416.

Rhoades, J.D. (1982) Cation Exchange Capacity. In: A. L. Page, R. M. Miller and D. R. Keeney, eds. Methods of Soil

Analysis Part 2 (2nd edition) Chemical and Microbiological Properties, American Soc. of Agron. Monograph No. 9,

ASA-SSSA, Inc., Madison, WI, USA, p. 149-158.

Assessing Indonesian Commitments and Progress on Emission Reduction from Forestry Sector

Mahdi[1]*, Ganesh P. Shivakoti[2], Yonariza[3]

Abstract

Indonesia promises to reduce emission by 26% if there is business as usual through national effort, and by 41% with international support by 2020. Indonesia which is the biggest emitter contributing 38% of the total emission promises to change the status of forestry sector from net emitter to net sink sector by 2030. In this paper, we assess the possibility of Indonesia to actively participate and compliance on delivered-target from certainty of policy continuation within internal political-economy and incentives. We also compare the commitment in emission reduction and economic development target to find both the concurrencies and conflicts between them. We found that, Indonesia's national policies on emission reduction are not included into and not becoming policy mainstreaming yet in long term national plan. There are some gaps between national policies on emission reduction and actions on the ground level. The main reason is economic growth is still likely the main goal of recent Indonesian economic development, which is highly dependent on land clearing and frontier clearance. Internal political dynamic and economic development trend as well as available institutions are not in line with the policy for REDD+. Based on these findings, it is crucial to find any additional incentives, especially from international trade mechanism, for significant participation and compliance on REDD+ agreement. In addition, educating the people on REDD+ and its impact on the poor can rise awareness, so that they might push the government to be more REDD+ friendly policy. Furthermore, national policies on forest-related have to be synchronized, built firm and strong consensus with the main stakeholders in the field level, providing a direct incentive to individuals both guards of protection forest and land rehabilitation.

Keywords : GHGs abatement, institutional development, emitter sector, sink sector, Indonesia

[1]*Faculty of Agriculture, Andalas University.KampusLimauManis Padang, Indonesia.*

[2] *School of Environment,Resources and Development, Asian Institute of Technology, Thailand.*

[3] *Faculty of Agriculture, Andalas University.KampusLimauManis Padang, Indonesia.*

_Corresponding author e-mail: kuteihmahdi@gmail.com

Introduction

There has been long way for multilateral negotiation on emission reduction since United Nations Framework Convention on Climate Change (UNFCCC),in 1992, was accorded. Some multilateral agreements have been inked during the last three decades to find acceptable incentives for the GHGs abatement till the last Conference of Parties (COP) 19, in Warsaw, Poland, November 2013. Although UNFCCC Secretariat has compiled the pledges of the parties of UNFCCC-ratified countries on emission reduction target (UNFCCC, 2011a, , 2011b), the real fighting against global warming at the field level is not giving optimism that our generation could achieve the global emission reduction target. International Panel for Climate Change (IPCC), in its fifth report 2013, publishes that accumulation of carbon and other biogeochemical in atmosphere had been increasing for 0.9±0.8 pgC.yr-1 during 2002-2011 (IPCC, 2013).

Indonesian pledges to reduce its GHGs emission by 26% if there is business as usual through national effort, and by 41% with international support by 2020.The pledge was announced at the G20 summit in Pittsburgh on September 2009. The attention mostly goes to forestry sector, as this sector is the biggest emitter contributing 38% of the Indonesia's total emission. So, Indonesian president promises to change the status of forestry sector from net emitter to net sink sector by 2030. Then, the pledge is written down in Indonesia's REDD+ National Strategy (Indonesian REDD+ Task Force, 2012).

In this paper, we assess the possibility of Indonesia to actively participate and compliance on delivered-target within recent available incentive context, especially from forestry sector. We do assessment from political dynamic and economic development perspectives. From political dynamic perspective, we assess certainty of policy continuation within the changing government administration. In addition, we also assess the incentives for Indonesian government to come with above target emission reduction. From economic development perspective, we assess the possibilities of target achievement in comparison with current economic development trend, especially the role of forest and forest related sectors in Indonesia's economy. We compare the commitment in emission reduction target and economic development target to find both the concurrencies and conflicts between them.

We structured this paper into three parts. First, we briefly analyze political economic of REDD+ at international arena that provides incentives for every party, including Indonesia, to participate in this multilateral effort. Second, we analyze Indonesian political dynamic and economic development that bring Indonesia to above pledges. In third part of the paper, we describe the progress of Indonesian REDD+ implementation and discuss the possibilities of commitment continuation, as outcomes interaction international and national political economic dynamic. Then, we end the paper with conclusion.

The Politics of Redd+ at International Arena

All parties under UNFCCC aware that climate change is our common problems.However the significant participation and compliance on the agreement strongly influent by incentives, which are pursuing by each actors (Barrett &Stavins, 2002).Taking the behavior of other countries as given, each country can do better by mitigating only up to the point where its own marginal benefit equals its marginal cost. As long as global marginal benefits exceed every nation's own marginal benefits, all countries will either want to avoid participating or avoid full compliance if they do participate(Barrett &Stavins, 2002)

After long negotiation under UNFCCC, Conference of the parties (COP) third in Kyoto, Japan in 1997, concluded with Kyoto Protocol that provides specific GHGs emission commitment for 39 developed countries (UNFCCC, 2008), who have historically contributed most to the accumulation of GHGs in the Earth's atmosphere must take the first steps to reduce their emissions (UNFCCC, 1992). Because of this reason, US, the biggest world polluter, did not ratify the protocol. Then, China and India (the second and third biggest emitters) also rejected to ratify the protocol (Clemencon, 2008). Rejection of these three world biggest emitters threatened the future of UNFCCC negotiation till COP 13, Bali Indonesia in 2007, concluded with Bali Road Map that mandates that the developing countries also responsible to reduce their emission with and without support from developed countries. One responsibility of developing countries is reducing emission from deforestation and forest destruction (REDD) (UNFCCC, 2008). Then, the parties in Copenhagen accord, in 2009, identified the need for ''immediate establishment of amechanism'' to enable REDD+ especially drawing on financial resourcesfrom developed countries and countries later submitted emissions reductions pledges or mitigation action pledges. However very few firm commitmentsfor international actionhas been made (Loxton *et al.*, 2013). Each party likely waits and sees what other parties action before taking its owned action.

In Cancun Agreements, in 2010 (COP16), UNFCCC secretariat has compiled the parties pledges on emission reduction target (UNFCCC, 2011a, , 2011b). All industrialized countries and more than 40 developing countries had submitted official emission reduction targets and actions by COP17. But, in the big picture, the international response was still lacking in a critical area. The sum total of official emission reduction pledges from all countries amounted to only around 60 percent of what was needed to limit the temperature increase to 2 degrees Celsius, the temperature ceiling that would give us a reasonable chance of avoiding the worst impacts of climate change (UNFCCC, 2011c).

Indonesian pledges to reduce emission by 26% in 2020 lower than business as usual and 41% with international support, is also likely pursuing incentives by announcing it during G20 summit in Pittsburg, in 2009. Then, Norway pledged support and assistance up to US$ 1 billion to Indonesian government for preparation and emission reduction from deforestation and forest destruction. Norwegian government signed the letter of intent (LoI) on 26 May 2010, on 'Cooperation on reducing greenhouse gas emissions from deforestation and forest degradation (REDD+)'. UN agencies of the UN-REDD Programme (FAO, UNDP, and UNEP) and Indonesia's Ministry of Forestry had been worked collaboratively for Indonesia's REDD+ readiness. They worked for several key areas related to REDD+ readiness, including: the development of national policies and stakeholder engagement; methodologies and provincial piloting; and preparation for implementation at the district level. These are two main international support on Indonesia REDD+ program beside other partners as AusAID, Forest Carbon Partnership Facility (World Bank), USAID, World Agroforestry Centre (ICRAF), German Society for International Cooperation (GIZ).

Political Economy of Indonesian Forestry and Redd+

Brief Historical Background of Indonesia Forest Policy

Indonesian forestry policy is hugely affected by the political and economic development. From Dutch Colonial era to the beginning of 1960s, Indonesian policy on forest had been dealing with finding balance allocation between forest cover and agricultural land (Galudra&Sirait, 2006; Lindayati, 2003). However, by the end of 1960s, forest and forest resources were changed to be the main component of economic development as the Soeharto regime began the power (Wardojo&Masripatin, 2002). It was clearly mentioned in five years development planning of the regime (Rencana Pembangunan Lima Tahun/REPELITA) that put forest resources were the main sources of foreign exchange earning, supporting national development. Centralized political and decision making gave the regime full authority to enact the policy through forestry law no 5/1967 (Mahdi *et al.*, 2013). Forest management means, at that time, as the extraction of timber and of others resources for capital accumulation to support other sector in economic development (Siscawati, 1999). GoI lacked the capital for economic development because it was faced with several political challenges especially on

power consolidation in order to unify diverse ethnic cultures, religion and political orientation for its big territory from Aceh to West Papua since the declaration of independence in 1945. At that time, one abundant source of capital was forest resources, especially timber. Thus, forest extractive management was a central concern in forestry law no 5/1967 (Mahdi *et al.*, 2013).

This authoritarian regime diminished in 1998 that led to change directly the institutional framework for forestry governance of Indonesia. New democratically elected government of Indonesia came with new paradigm of development that encourage wide participation in more decentralized decision making. Law no 22/1999, then changed to law no 32/2004, mandated that central government has to decentralized decision making and share the right and benefit in natural resources management including forest management. In addition, mind-set on forest management also shifted from resources extraction to emphasize on integrated approach, acknowledges the rights of local customary rules, and benefit sharing among all stakeholders (Mahdi *et al.*, 2013; Yonariza&Shivakoti, 2008).

In line with regional government autonomy, GoI introduced new forestry law no. 41/1999. Article 66 of the law stipulates that forest management should be transferred to the local government. It means that the law encourages the adoption of a decentralized management model. The ministry of forestry has no direct line with local government for forest service. Instead, the forest service of the district government is likely more independent in decision making. Furthermore, the new law provides a greater chance for the participation of all stakeholders. The district government was given the authority to manage the forest within its territory, while the provincial government was given the authority over trans-districts boundaries. The central government was relegated to the role of national planning and providing guidance for forest management (Mahdi *et al.*, 2013).

Within this framework, Ministry of forestry promotes social forestry, a forest management system that encourages people at the local level to participate actively in forest management. It seeks to improve the livelihood of local people based on available resources while at the same time ensuring forest sustainability (Lindayati, 2002). Social forestry is also the approach to link forestry development and poverty reduction. The introduction and strengthening of some social forestry programs are commons presently in Indonesia such as customary forest (Hakim, 2010).

Furthermore, Ministry of Forestry is now also establishing forest management unit (KesatuanPengelolaanHutan/KPH) throughout the country in order to effectively manage the state-owned forest to lowest level (Mahdi et al., 2013). The KPH coordinates, and controls forest management activities, including social forestry, forest concession and other activities within state-owned forest areas. In addition, KPH also has right to extract forest benefit in sustainable way.

Forest-related National Agencies are not Clear and Mutually Supportive

Forest-related national agencies in Indonesia are a lot in number and have differences interest on forest resources and forest management. They are including Ministry of Forestry (MoF), Ministry of Agriculture (MoA), Ministry of Energy and Mineral Resources (MEMR), State Ministry[6] and Board of National Planning (SMBNP), State Ministry of Land Management (SMLN), National Board for Investment (NBI), Ministry of Industry and Trade (MIT). Recently, REDD+ Agency was established in 2013 as the mandate for Indonesia to adopt and implement REDD+ scheme. These agencies need clear mandate for doing well their responsibilities. However, due to different mandates and responsibilities, it may big possibilities for conflict each others.

Consequently, some issues rise as following:

- Conflict among agencies in pursuing their owned interest as mandated
- Policies and regulation on each agencies are not mutually supportive. MoA is mandated to increase agriculture produces in pursuing more foreign exchange and meet domestic demand on agriculture produces such as palm oil, natural rubber, etc. The policy leads to increasing deforestation.
- The political and administrative changes since 1997/98, particularly relating to decentralization have resulted in ongoing competition and conflicts of interest between different administrative layers of the forestry service
- Head of districts (bupati) quickly established themselves as key power figures controlling forest resources and their utilization after 1998. This is a process that was accelerated by decentralization regulations of 1999 and rising community claims.

In addition, two systemsof forest managementexacerbates the weak of institution. First is the forest area that managed by ministry of forestry. Second is the forests which are out of forest area that the land right belong to private and communities. Forest law and allocated government resources for forest are direct

[6] *State Ministry in Indonesia is the ministry that coordinate among different ministry which have related responsibilities and interaction.*

to forest area. The forest out of the forest area is also out of ministry of forestry attention.

NGOs such as WALHI and AMAN have been working intensively to rise the issue of local and indigenous right on forest and forest resources benefit. They contested state-owned forest against "masyarakatadat" or customary right on forest and forest land as mentioned in forestry law no 41/1999, to supreme court. Fortunately "masyarakatadat" got their right as supreme court decision no 35/PUU-X/2012, that announced on Tuesday 26th March 2013. Supreme court mandates the GoI has to exclude adat forest (claimed customary owned forest) from state-owned forest.

Economic Development and Emission Reduction Target through REDD+

GoI policy on forestry is still ambiguous. On the one hand it would like actively participate and compliance in international-announced pledges on emission reduction through REDD+. On the other hand it still depends the state revenue from wood and forest-related industries. GoI received Rp. 2.8 trillion revenue from forestry sector and increased to be Rp. 4.2 trillion in 2013 (Ministry of Finance, 2014). Furthermore, economic development policy encourage business communities to expand agricultural land especially for oil palm plantation. There are recorded 423 forest concessions operating in Indonesia that cover more than 13 million ha forest (APHI, 2014). Oil palm plantation grows by 4.58% annually for last five years (Directorate General of Estate, 2013). Peat land fire is still happen regularly for last five years due to land clearing for plantation

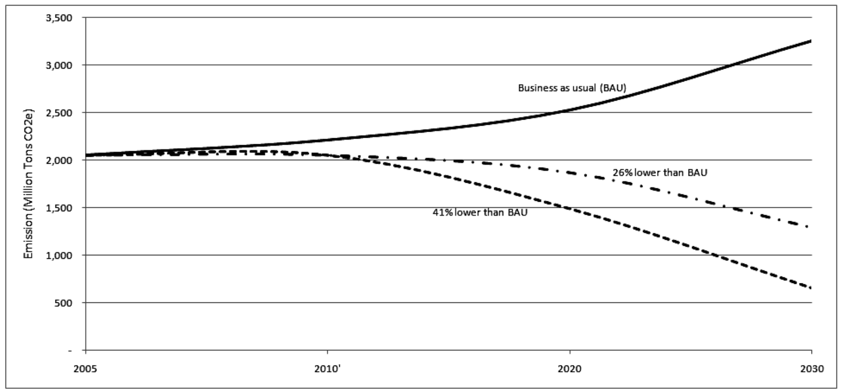


Figure 1 : Indonesian total emission projection with three scenarios

DewanNasionalPerubahanIklim (DNPI)[7] or national council for climate change came with detail target for Indonesia's emission reduction in each economic sector in 2010, a year after announcement of the commitment (DNPI, 2010). Figure 1 shows the projection of Indonesian emission by the DNPI till 2030 within three scenarios: BAU, lower than 26% and 41% than BAU. As the LULUCF and peat land sectors are the main source of emission, Indonesia puts special attention on this sectors. The President even mentioned clearly that will change the sector from emitter to sinker in 2030. DNPI's projection shown in figure 2. In comparison with economic development trend, the target is likely too ambitious. More investment and effort are extremely needed. Although DNPI has predicted the potential activities which could reduce and sink the carbon as shown in figure 3, but there is no trusted-report that forest sector has reduced the emission, as peat land forest fires, agricultural land expansion, issuance of forest concessions are still continuing. Indonesia extremely needs to expand land for food production to meet food demand for growing population (Greenpeace Southeast Asia – Indonesia, 2012).

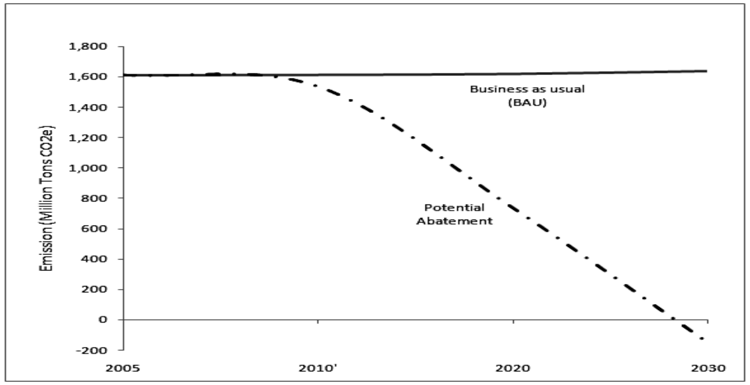


Figure 2 : Indonesian forestry sector emission and potential abatement

The opportunity cost to compliance the pledges is much higher than do BAU. Irawan*et al*., (2013) reported that opportunity cost of oil palm plantation on mineral soil is much higher than compensation from REDD+ scheme, except oil palm plantation on peat land. It is hard for Indonesia and Indonesian people to compliance on announced-target from economic development perspective.

[7]*DNPI was established with presidential regulation (Keppres) No. 46/2008 as the legal basis. It works for the president office in assisting policy formulation regarding GHGs reduction and climate change.*

Business lobby is not tire to get concession license and even bribed the officials (Dermawan *et al.*, 2011).

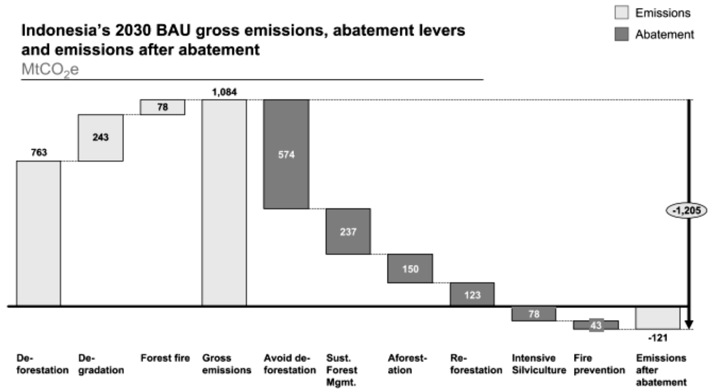


Figure 3 : Avoiding deforestation, sustainable forest management, afforestation, and reforestation could turn the LULUCF sector into a net carbon sink by 2030 (Source: DNPI, 2010)

In addition, GoI has issued permit moratorium policy in 2011 which purposely stops deforestation. However, the policy was not effectively implemented on the ground level mainly due to unresolved conflict of interest among stakeholders. Although central government banned for license issuance within certain state-owned forest area, as shown in figure 4, the deforestation within the area is continuing. The forest was convertedto be palm oil plantationboth by private companies and by local communities. Ambiguity policy at national level is seen from the google image in figure 4, where the private companies can get the permit for palm oil plantation within moratorium area, and the forest was already cleared up. Furthermore, local communities also cleared the forest beside for economic reasons, it is also to strengthen their communal-owned land (*tanahulayat*)claim over the forest area. Unfortunately, local politicians played to attract local communities voting by constructing agricultural road that speed up deforestation within the area. In addition, forest permit moratorium does not provide direct incentive for local government to protect the forest. Interplay of multi-interest among private companies, corrupt officials at national beaureaucracy, local communities and local politicians lead to in-effective implementation of national policy on the ground level.

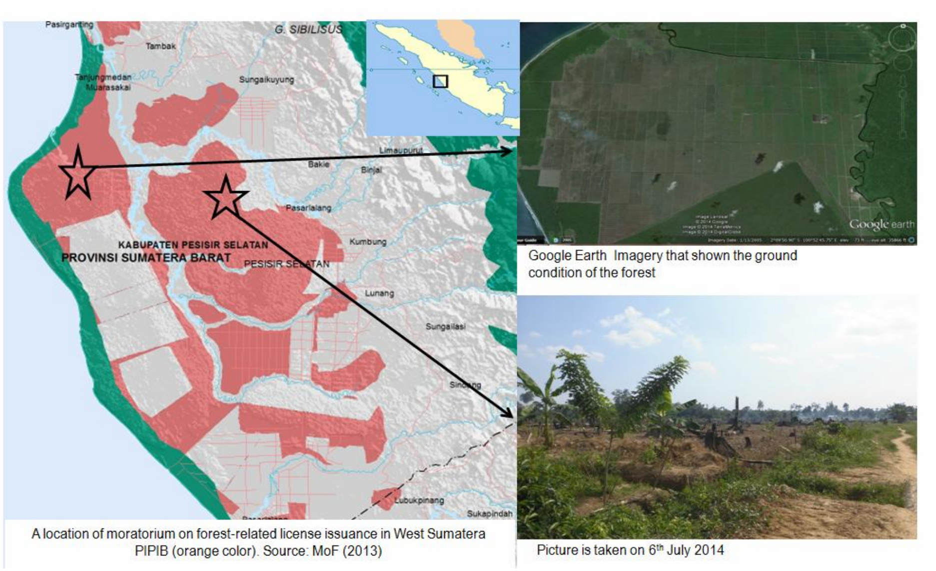


Figure 4 : A location of permit moratorium in west Sumatera which were already converted to be palm oil plantation both by private companies and by local communities

This study also found a good news from Paninggahan Village, Solok District, West Sumatra.Under voluntary carbon market mechanism (VCM), group of farmers received cash money from carbon broker as compensation for forest land rehabilitation using assisted natural regeneration (ANR) by planting multipurpose tree species. The broker, CO2BV sells carbon certificate to voluntary buyer in Netherland, pays farmers in cash through respective farmer group.This positive development occurred because local communities benefit directly from the land rehabilitation activities. It is in stark contrast to the results of land rehabilitation carried out by the government previously.

Institutionalization of Redd+: Readiness Progress

Institutionalization of REDD+ has been taken actually at early steps of Indonesia's participation in UNFCCC negotiation. Ministryof Forestry (MoF) has been concentrating on plans toimplement REDD+ in Indonesia since 2007. MoFreleased a policy setting out the implementationstages and a related timeline: a preparedness phase(2007), transition/pilot activities (2008–2012) andfull implementation (2012 – depending on a COPdecision) (Indrarto *et al.*, 2012). Indonesian climate change trust fund (ICCTF) was established in

September 2009, under Bappenas, National Development PlanningAgency. Letter of Intent (LoI) with Norway speeded up the process of institutionalization. GoI responded the LoI by establishing "REDD+" task forces in 2010 (Keppres 19/ 2010). The task forces responsible in:

1. Formulating REDD+ national strategy;
2. Preparing establishment of permanent REDD+ agency;
3. Preparing financial instruments and mechanism;
4. Preparing establishment of independent MRV institution for REDD+;
5. Formulating criteria and selecting for REDD+ pilot province;
6. Executing actions related to readiness Indonesia-Norway LoI implementation.

REDD+ Task Force has done its assignment at least on the paper. It has selected Central Kalimantan as the province pilot in 2010, finalized the REDD+ national strategy by the end of 2011, prepared establishment of permanent REDD+ agency in 2012 (Indonesian REDD+ Task Force, 2012). However, the task force did not complete her assignment on clear financial instruments and mechanism, and establishment MRV institution (Greenpeace Southeast Asia – Indonesia, 2012).

Furthermore, some regulations and policies were also issued to implement the LoI as following:

1. Min. of Forestry Regulation 68/2008 on REDDDemonstration Activities
2. Min. of Forestry Decree 30/2009on REDD mechanism procedures
3. Law 4/2009 on Mineral and Coal mining
4. Min. of Agriculture Decree 14/2009 on Peat for oil palm plantation
5. Min. of Forestry Decree 36/2009 on Licensing procedures of projects on carbon sequestration and/or storage in production and protected forest
6. Presidential Instruction 10/2011 on moratorium on granting of new licenses and improve of natural primary forest and peat land governance

Possibilities of Commitments Continuation

Continuation of commitment is under question as following reasons:

1. REDD+ policy is not included into and not becoming policy mainstreaming in long term national plan yet. Above established organizations and issued regulation are vulnerable to be changed when new government is formed because their legal basis is presidential

decrees and instructions as well as ministerial decrees. Because of these legal status, the implementation of the policy is also weak.

2. New elected president prioritize his policy on increasing food security by expanding land for paddy and other food crops. He pledges to construct 1 million ha of paddy field for next five years. To meet this pledge, more forest land will be cleared up.

3. Economic growth is still likely the main goal of Indonesia economic development. So, business communities' roles is becoming more influential in economic development decision making. The ambiguous policy on REDD+ is still continuing. It is exacerbate with international trade where Indonesia and others ASEAN countries will enter ASEAN economic community (AEC) by the end of 2015 that more ASEAN foreign investor look at to Indonesia's plenty and fertile land for oil palm plantation.

Conclusion

Considering internal political dynamic and economic development as well as institution in developing countries is crucial to find any additional incentives for their significant participation and compliance on REDD+ agreement. For the case of Indonesia, getting international support is the main incentives for announcing the target in G20 summit in 2009. However, it is still need longer time and harder work than predicted to deliver promises even on Indonesia-Norway LoI. Internal political dynamic and economic development trend as well as available institutions are not in line with the policy for REDD+.

Based on these findings, we conclude that more attractive incentives from international are likely needed to increase participation and compliance. In democratic and low income societies, like Indonesia, people tend to vote for the candidate who promise to increase their welfare in short term. So, educating the people on REDD+ and its impact on the poor can rise awareness, so that they might push the government to be more REDD+ friendly policy. In addition, further international trade negotiation, like AEC, has to consider and provide incentive for REDD+ implementation within each country members.

Some policies at national and local level need to be adjusted. The policiesarea national policy synchronization, build firm and strong consensus with the main stakeholders in the field, providing a direct incentive to individuals both guards of protection forest and land rehabilitation implementer in the field, and raise awareness of the cost due to forests of damage directly to the community.

Acknowledgment

Authors thank to Toyota Foundation for funding the research which produces this paper. The view presented in this paper is solely the authors and not necessarily of Toyota Foundation. Our thanks also goes to Andalas University for providing travel grant to attend this conference.

References

Barrett, S., &Stavins, R. (2002). Increasing Participation and Compliance in International Climate Change Agreements [Electronic Version]. *Social Science Research Network Electronic Paper Collection*. Retrieved June 1, 2014 from http://www.feem.it/userfiles/attach/Publication/NDL2002/NDL2002-094.pdf.

Clemencon, R. (2008). The Bali Road Map: A First Step on the Difficult Journey to a Post-Kyoto Protocol Agreement. *The Journal of Environment Development, 17*(1), 70-94.

Dermawan, A., Petkova, E., Sinaga, A., Muhajir, M., &Indriatmoko, Y. (2011). *Preventing the risks of corruption in REDD+ in Indonesia*. Bogor, Indonesia: Center for International Forestry Research (CIFOR).

DewanNasionalPerubahanIklim Indonesia. (2010). *IndonesIa's greenhouse gas abatement cost curve*. Jakarta: DewanNasionalPerubahanIklim Indonesia.

Galudra, G., &Sirait, M. (2006). *The Unfinished Debate: Socio-Legal and Science Discourses on Forest Land-Use and Tenure Policy in 20th Century Indonesia* Paper presented at IASCP 2006 Conference. Retrieved June 1, 2006. from http://www.iascp.org/bali/papers.html.

Greenpeace Southeast Asia – Indonesia. (2012). *The Indonesia - Norway Agreement to reduce greenhouse gas emissions from deforestation and forest degradation. Greenpeace Assessment of Progress.* Jakarta: Greenpeace Southeast Asia – Indonesia.

Hakim, I. (2010).OrientasiMakroKebijakan Social Forestry di Indonesia. In S. Anwar & I. Hakim (Eds.), *Social Foretsry: MenujuRestorasi Pembangunan KehutananBerkelanjutan* (pp. 1-31). Bogor, Indonesia: Pusat Penelitiandan Pengembangan Perubahan Iklimdan Kebijakan.

Indonesian REDD+ Task Force. (2012). *REDD+ National Strategy*. Jakarta, Indonesia: Indonesian REDD+ Task Force.

Indrarto, G. B., Murharjanti, P., Khatarina, J., Pulungan, I., Ivalerina, F., Rahman, J., et al. (2012).*The context of REDD+ in Indonesia: Drivers, agents and institutions* (Vol. 92). Bogor, Indoneisa: Center for International Forestry Research (CIFOR).

International Panel for Climate Change (IPCC). (2013). *Climate Change 2013: The Physical Science Basis*. Cambridge: International Panel for Climate Change (IPCC).

Irawan, S., Tacconi, L., & Ring, I. (2013). Stakeholders' incentives for land-use change and REDD+: The case of Indonesia. *Ecological Economics, 87*(0), 75-83.

Lindayati, R. (2002). Ideas and Institution in Social forestry policy.In C. J. P. Colfer& I. A. P. Resosudarmo (Eds.), *Which Way Forward? - Forests, Policy and People in Indonesia* (pp. 36-59). Washington DC: Resources for The Future (RFF).

Lindayati, R. (2003). Shaping Local Forest Tenure in National Politics. In N. Dolsak& E. Ostrom (Eds.), *The Commons in the New Millennium: Challenges and Adaptations* (pp. 221-264). Cambridge: The MIT Press.

Loxton, E. A., Schirmer, J., &Kanowski, P. (2013). Designing, implementing and monitoring social impact mitigation strategies: Lessons from Forest Industry Structural Adjustment Packages. *Environmental Impact Assessment Review, 42*(0), 105-115.

Mahdi, Arbain, A., Senatung, M., &Helmi. (2013). *Developing Organizational Structure of KesatuanPengelolaanHutan (KPH) Limapuluh Kota District, West Sumatra, Indonesia, for Sustainable Forest Management*. Paper presented at Commoners and the Changing Commons: Livelihoods, Environmental Security, and Shared Knowledge, the Fourteenth Biennial Conference of the International Association for the Study of the Commons. Retrieved. from http://dlc.dlib.indiana.edu/dlc/handle/10535/8928.

Siscawati, M. (1999). *Forest Policy Reform in Indonesia: Has addressed the underlying causes of deforestation and forest degradation?* Paper presented at the 3rd IGES International Workshop on Forest Conservation Strategies for The Asia and Pacific Region, Tokyo, Japan. .

United Nations Framework Convention on Climate Change (UNFCCC). (2008). *Kyoto Protocol Reference Manual On Accounting of Emissions and Assigned Amount*. Bonn, Germany: Climate Change Secretariat (UNFCCC).

United Nations Framework Convention on Climate Change (UNFCCC). (2011a). Compilation of economy-wide emission reduction targets to be implemented by Parties included in Annex I to the Convention (Vol. FCCC/SB/2011/INF.1/Rev.1): United Nations Framework Convention on Climate Change (UNFCCC) Secretariat.

United Nations Framework Convention on Climate Change (UNFCCC). (2011b). Compilation of information on nationally appropriate mitigation actions to be implemented by Parties not included in Annex I to the Convention (Vol. FCCC/AWGLCA/2011/INF.1): United Nations Framework Convention on Climate Change (UNFCCC) Secretariat.

United Nations Framework Convention on Climate Change (UNFCCC). (2011c). Report of the Conference of the Parties on its sixteenth session, held in Cancun from 29 November to 10 December 2010 (Vol. FCCC/CP/2010/7/Add.1): United Nations Framework Convention on Climate Change (UNFCCC) Secretariat.

United Nations on Framework Convention on Climate Change (UNFCCC). (1992). *United Nations on Framework Convention on Climate Change (UNFCCC)*. Bonn, Germany: United Nations on Framework Convention on Climate Change (UNFCCC) Secretariat.

United Nations on Framework Convention on Climate Change (UNFCCC). (2008). Report of the Conference of the Parties on its thirteenth session, held in Bali from 3 to 15 December 2007 (Vol. FCCC/CP/2007/6/Add.1*): United Nations on Framework Convention on Climate Change (UNFCCC).

Wardojo, W., &Masripatin, N. (2002).Trends in Indonesian Forest Policy.*Policy Trend Report* 77-87.

Yonariza, & Shivakoti, G. P. (2008). Decentralization policy and revitalization of local institutions for protected area co-management in West Sumatra, Indonesia. In E. L. Webb & G. P. Shivakoti (Eds.), *Decentralization, Forests and Rural Communities: Policy Outcomes in South and Southeast Asia* (pp. 128-149). New Delhi: Sage.

Analyzing Thailand Forest Policy Practice Gaps with Emission Reduction in Retrospect

Shubhechchha Sharma*, Ganesh P. Shivakoti and
Kanda Sakayarote

Abstract

Thailand forest policy is based on the principles of sustainable forest management with a focus on environmental protection on the basis of which the government plans to implement incentive based carbon projects. However, the scepticism on success of these mechanisms arisen with lack of existing policy to address various drivers of deforestation. At national level, unclear benefit sharing mechanisms and identifying national parks as pilot sites for REDD+ have created situation of conflicts between civil society and the government. Lack of clarity on existing policies and confusion over tenure arrangements has further aggravated the situation. Here, we have reviewed the existing policy provision with implications to REDD+. We have further tried to analyze the policy practice gaps in Thailand through comparing existing legal provisions with prevailing practices in Farmer's network fromMahasarakham and SakhonNakhon, and community forestry from Nan province. Small plantation growers from these networks are contributingto reducing deforestation and degradation by conserving natural forest area while still using them;but the issue rests on mainstreaming these practices on national policy formation process. The public participation and decentralization in policy planning in Thailand are still rather narrow and this can pose serious implication in REDD+ mechanisms.

Keywords : REDD+, Forest Governance, Benefit sharing, Policy Planning

Introduction

Forest management in Thailand is based on forest policy and legislation with a general subscription to sustainable forest management and environmental protection. Forest polices are under administration of Natural Resources Management Policy where most of the policies are being determined by the central government and then passed to regional, provincial and then local agencies (Masawat and Toongtawanreongsri, 2012). The office of natural

Natural Resources Management, School of Environment,Resources and Development, Asian Institute of Technology, Thailand.

**Corresponding Author : Email - shubhechchha.sharma@gmail.com*

resource and environmental policy and plan is responsible for policy formulation and solve problems and maintain the environmental quality following the promotion and protection of national environmental act 1992 which is the legislative framework for conservation on environmental quality. The environmental policies and plans must be in accordance with the national strategy, which includes government policies, the national economic and social development plan NESDP and the strategy formulation as frameworks to determine guidelines for management of natural resources and environment.

The policy formulation procedure as mentioned above does not respond to the needs and problems of local people especially the needs of the community living inside the conservation area. This is because most of the policies formulated are top down and consensus from local people having not been taken into considerations. As such, the policies do not represent the real problem. In addition, lack of people's participation in policy formulation, lack of personnel and budget add up to make the situation worse particularly in forest management.

In this current backdrop, government of Thailand is planning to implement REDD+ (Reducing emissions deforestation and forest degradation) without acknowledging the fact that forest management is a social-ecological interactions that involves institutions, political pressures and users actions that have come up through experiences and methodologies. Success of REDD+ is impossible if locals are not involved in implementation process. Though, REDD+ is directed to benefit forest and indigenous people, still has ambiguity on poorly defined forest tenure and appropriate incentive agreed upon by the consensus building process. In addition, unwillingness of government to devolve to communities in the past history also fears that REDD+ could decentralize well-functioning community forest (Phelps et al. 2010).

Prior to implementing REDD+ it is important to know existing legal policies and their effectiveness in terms of REDD+ benefit sharing and creating scope for better livelihood through forest restoration. Information related to effectiveness of these policies in people's practices should be known in order to find out whether policy could change people's practices. If the policy has no effect on people's practices, only formulating policies cannot be beneficial. Situations with least policy practice gap, new modifications could be made suited to REDD+. Hence, this paper seeks to review policy briefs of Thailand in terms of forest governance and find the policy practice issues and gap of the forest dependent communities.

Methodology

As the paper intends to review the existing forest policies and their impact on local communities, we focused our desk policy review. Policies relevant to forest governance and REDD+ were then selected and reviewed. While selecting indicators for governance, framework developed by, the program on forests food and agriculture organization (PROFOR) is used.

This framework has been developed since 2009, by intensive discussions to test the forest governance (Kishor and Rosenbaum, 2012). By 2010, major international forestry organizations further identified workable governance indicators for forestry sector at a meeting organized by European Union and Food and Agriculture Organization of the United Nations (ibid). These developed indicators were further improved on the basis of what REDD+ should monitor by UN-REDD and lastly by the end of 2010, FAO, World Bank and SIDA further improved the framework and agreed on a set of criterion for monitoring forest governance (ibid). The framework has 3 pillars, 13 components and subcomponents and indicators(ibid). For study purposes, not all the indicators with respective pillars, components and sub-components are considered.

Then, four sites from different forest management regime were selected. Prior to selection of these sites, experts from ALRO (Agriculture Land Reform Office), Royal Forest Department (RFD) and Department of National Park, Wildlife and Plant Conservation (DNPWPC) were consulted.These sites have been undergoing REDD+ piloting schemes through different organizations.These four sites were:SorPorKor management regime of MahasarakhamProvince, Inpang-Networks from SakhonNakhon Province, Community Forestry from Nan Province and KaengKrachan National Park ofPetchaburi province. Communities from these sites were visited and information regarding policy effects in their forest conditions and livelihood improvements were gathered through focus group discussions and compared with existing norms in policies. The information gathered was further triangulated in a provincial level workshop including donors, CBOs and governmental agencies. Queries aroused in the field and provincial workshop forum were further discussed in regional workshops.

Results and Discussions

Existing Policies that Regulate Forest Use and Management with Implication to Redd+

Formal legislation governing the forest sectors includes: (1) The Forest Act of 1941, which governs the management of state forests, regulates logging and sets

procedures for licenses and royalty payments(Thailand law forum, 2010b); (2) The National Parks Act of 1961, governing the designation, management and protection of National Parks (Thailand law forum, 2010 a); (3)The National Reserved Forests Act of 1964, governing the designation, management and protection of National Reserved Forests (Pakorn and Nilpra S. 2005b); (4) The Commercial Forest Plantation Act of 1992, which requires the registration of commercial forests and regulates the cutting and sale of timber in commercial plantations; (5) The Forest Plantation Act of 1992, which facilitates the creation of private-sector plantations of degraded forest (Pakorn and Nilpra S. 2005a); and (6) The Community Forest Bill of 2007, which gives forest-dwelling communities who can prove they lived in the forest prior to 1997 rights to preserve and manage forest land under strict guidelines. Forest communities must be registered and must develop an approved forest management plan.

Clarity on these Policies

There exist numbers of policies, their amendments through cabinet decisions. These laws overlap with each other and at times difficult to implement. For instance, according to the National Reserved Forest Act 1964 in order to declare reserve forest public consultation and consent is voluntary. But, the constitution of Thailand and Environmental Quality act of 1992 enables local people to participate in planning and decision making in forest control and management. Another such inconsistent examples can be taken by definition of forest itself. According to Forest Act of 1941, “forest means land which has not been taken up or acquired by anyone under the Land Law” but The National Reserved Forest Act 1964 provides more detailed definition for forests. This indicates that “forest means land which includes mountain, creeks, swamps, canals, marshes, basins, waterways, lakes, island or seashore which has not taken up or acquired by a person in accordance with the law.” Both of those laws have the objective to protect forests, but use an inconsistent definition of forest. Unrealistic forest related legal requirement can also lead to complexity. The community forest act of 2007 tends to legalize the community forest but prior to that, local people residing there needs to prove their settlement before the forest was actually considered as state property. There are so many policies that overlap with each other and create confusion among each other. REDD+ implementation with major basis on these existing forest legal and policy background would make situation further chaotic.

Extent to which these Policies Support Adaptive Forest Management

The initial forest policy reported in 1962 clarified that 50 percent of total land area needs to be forested, while other related policies were formulated to support this policy. These policies were made by the government themselves. Some of them are formed in the name of reducing natural catastrophe while others by cabinet and RFD. The public is never provided with the details of the policies nor is any consent taken through the public. Most of the policies are ad hoc and there is no adaptive learning process involved. On the contrary, in order to improve forest conditions, REDD+ should be implemented in such a way that local needs and aspirations are not compromised. This fact cannot be envisioned through these policies.

Consistency of Laws with International Oobligations and Commitments

Thailand is a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the Convention on World Heritage, the Ramsar Convention, the Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD), and the International Tropical Timber Agreement (ITTA) (Nalampoon, 2003). Focal points to deal with these conventions or agreements have been selected in various RTG agencies. Besides sending delegations to annual meetings, Thailand has hosted many meetings under these conventions. Participation in other conventions like the Convention to Combat Desertification (CCD) and the Convention on the Conservation of Migratory Species of Wild Animals (CMS) is being considered (Nalampoon, 2003). In 1989, government have positioned logging ban to conserve existing natural resources with active help from donors and local people. Government of Thailand supports diverse international conventions and agreements through which most of the rules and laws are imposed in order to show dedication towards these conventions. Especially in north east Thailand, people living inside the conservation area are thrown out just to proclaim the forest as world heritage sites (Hares, 2009). In order to implement REDD+, the rights of the local people should not be compromised.

Extent to which Law Recognizes Property Rights and Right to Carbon

Thailand's Constitution (Section 56) provides that communities have the right to protect their traditions and to participate in the management, maintenance,

preservation and exploitation of natural resources, the environment, and biodiversity in a balanced and sustainable fashion. But, state owns all forests in Thailand. The details on how this shared management relationship would work and what resources local communities have the right to manage are still under debate. There is no special policy in Thailand distinguishing the rights of indigenous peoples, who live largely in the northern highlands and occupy traditional holdings that lie within classified forests. Disputes between forestry officials and these groups are common. Some observers believe that one result of the land titling program has been the loss of unprotected common property resources. As the pressure to grant farmers title to forestland increased, the Forest Department attempted to consolidate its authority by classifying more forest as protected areas or tree plantations. The climate change policy does not talk about carbon rights.

Extent of Conflict Resolution Mechanism

There are a number of conflicts between Thai government and the community. Conflict is arising from protected area system, where governments use laws to preserve forests and evict people from those areas. Conflicts between the government and the concessionaires, or conflicts between the government and people who are affected by commercial plantation (such as who are evicted from forests or whose farming yields are affected by plantations).The conflicts between government and concessionaires can in part be explained by agency theory. The Thai government delegates their power over logging and commercial plantations to private companies. Those companies concentrate on how to maximize their forestry utilization, to earn profits from logging and commercial plantations. In pursuit of this they may avoid complying with or breach laws so as to maximize their own benefit. This can have a number of adverse effects on forests.Conflict is also arising from concessions for logging and commercial plantations.No, policies talks about conflict resolution mechanism. However, the national park act has strong rules but, being rigid they do not offer conflict mechanism at local level.

Extent to which the Forest-related Mandates of National Agencies are Clear and Mutually Supportive

Ministry of Natural Resources and the Environment (MNRE) assess Thailand's total natural resources and develop plans to protect and sustain them. Initially RFD was under Ministry of Agriculture and Cooperative is currently under MNRE. "The RFD has oversight authority over the country's forests (excluding protected areas) and has primary responsibility for: management of forest conservation; logging; forest product collection; utilization of forest land; and enhancement of public participation" (Phromlah, 2011). The National Park, Wildlife and Plant Conservation Department are responsible for conservation and management of flora and fauna, especially in protected forest areas. The department is also responsible for community forest management programs within its. The Watershed Conservation Management Office (WCMO) is attached to the Department of National Parks Wildlife and Plant Conservation and is responsible for watershed rehabilitation through reforestation, development of land-use plans to reduce the practice of shifting cultivation, and conflict management.

But, there are few overlaps in the administrative functions and inconsistent government policies. An example is the protected area system. The RFD, DNWPC are empowered to identify protected areas. Prior to announcing protected areas, the land titles on such areas have to be proven. This involves five departments: the RFD, Department of Public Welfare, and Department of Cooperative Promotion. The work of these departments must be coordinated in order to issue land titles to people, which is a complex administrative process that is difficult for the normal citizen to achieve. Contradictory responsibility between these agencies also occurs. The RFD, DNWPC, and the ONEP have a role to conserve forest lands, while the LD, ARLO, Department of Public Welfare, and Department of Cooperative Promotion are charged with allocating such land to people.

Adequacy, Predictability and Stability of Forest Agency Budgets and Organizational Resources

Financing climate change comes from various sources. Through the Convention, Technical and financial supports have been given to Thailand in preparing the national communication to the Convention and maintaining the national capacity. Supports to enhance national capacity also come from bilateral and multilateral cooperation such as the US Country Study Program, ADB's ALGAS project and World Bank National CDM Strategy Study. National budget also contributes substantially to the climate change actions in Thailand. Through national budget, research and development, information dissemination and public awareness in climate change have been steered. The country has recently, finalized the "structure of action plan to address education, training and public awareness under the Convention (Article 6 of the Convention)" (National Reporting Guidelines for CDS, 2005). Despite the domestic and international supports, there is still a wide range of issues on climate change that need to be addressed. "Technical and financial supports for technology transfer and capacity

building on environmentally sound technologies are vital for Thailand" (National Reporting Guidelines for CDS, 2005).

Availability and Adequacy of Information, Technology, Tools and Organizational Resources for the Pursuit of Agency Mandates

According to the constitution of Kingdom of Thailand, section 58,

"A person shall have the right to get access to public information in possession of a State agency, State enterprise or local government organization, unless the disclosure of such information shall affect the security of the State, public safety of interests of other persons which shall be protected as provided by law"(Opassiriwit, 2001).

Also, according to Section 81 of the same document,

"The State shall provide and promote the private sector to provide education to achieve knowledge alongside morality, provide law relating to national education, improve education in harmony with economic and social change, create and strengthen knowledge and instill right awareness with regard to politics and a democratic regime of government with the King as Head of the State, support researches in various sciences, accelerate the development of science and technology for national development, develop the teaching profession, and promote local knowledge and national arts and culture"(Opassiriwit, 2001; Office of the Council of State, 1997).

All rules, policies and directives are published and available but not necessarily outside Bangkok. Forest related court papers are usually published in complex written language which is not understood by normal people. Recently, GoT have submitted RPP to World Back which considers changes in laws and policies for REDD to achieve its objective but most of the forest dependent people is not aware of this.

Equity in the Distribution of Access to Forest Resources, Rights and Rents

Forest Act, BE 2484 (1941 AD) talks about Royal Proclamation on Teak and other timber species amongst with royalty to be paid. This royalty is to be paid to government, as all the forest in Thailand belongs to the state. Nowhere, the law mentions that the money received is ever distributed in equitable manner. Likewise, according to the National Park Act, Chapter 1 section 6, anytime the government can demark any land into national park, without having any provisions for rehabilitating or giving incentives to the public depending on that forest.

However according to, Cabinet Resolution on 30th June 1998, communities settled after the date of establishment as a protected area shall be moved to suitable area. Whereas, if the communities could not be moved to the suitable areas, they should be staying in the existing areas in harmony without being expanded.But, the communities have been compelled to leave the present residing area without any incentives, the communities having no other options are bound to haphazardly destroy forest and temporary settle there.

Openness and Competitiveness of Procedures, Such as Auctions, for Allocation of Forest Resources

Section 3 of Forest Act of 1941 has clearly mentioned procedures for forest timber sale and allocation. These provisions are only focused on timber sale and timber transportations. There are many other acts in support of this act. But these acts are again only limited to sale and allocation of timber. Other forest products are not prioritized. REDD+ is probably coordinated and managed by the national governments, promoted by public and private actors, and cooperation with government agencies or through mutual combination of both (Corbera and Schroeder, 2011). With this current policy background with only timber being prioritized REDD+ cannot achieve openness and undergo competitiveness in procedures.

Participation in Planning and Decision Making

The current constitution of Thailand recognizes the rights of the people to manage natural resources. According to Article 46 of Thai constitution 1997, "Person so assembling as to be a traditional community shall have the right to conserve or restore and participate in the management, maintenance, preservation and exploitation of natural resources and the environment in a balance fashion and persistently as provided by the law"Likewise Article 56 says the right of person to participation in the preservation and exploitation of natural resources ……" Additionally, article 79 of the Constitution of Thailand says, "the state shall promote and encourage public participation in the preservation, maintenance and balanced exploitation of natural resources" (Shytov, 1997).

In order to enhance participation, there requires the process of enhancing administration and managing natural resources in systematic way which requires amendment of few legal and regulatory framework for effective

administration and management of natural resources and recognition of rights and responsibilities of local people to demonstrate ownership of resources.

The Community Forest Bill is under consideration by parliament. The objective is allocating forestlands to local communities to be managed by local people to suit their own needs. Forest products from each community forest are to be shared among local people. Any benefits will be returned to the locals. Community has many committees that require preparation of forest management plans corresponding with local basic needs. Nevertheless, RFD still capitalizes the legal right to oversee protected areas because they are common property and need a considerable amount of human and financial resources to manage.

There was no public consultation process for promulgating forest-related laws such as National Park Act 1961, National Forest Reserve Act 1964, and Wildlife Conservation and Protection Act 1992 which established forest areas as reserves (Phromlah, 2011; Nalampoon, 2003). Consequently, a number of people who had previously settled and practiced agriculture within the areas that became reserve areas were categorized as illegal forest encroachers. These people were forced to relocate from those protected areas. Sometime those now landless people become criminals if they continue living in the forests and can suffer heavily lives or imprisonment.

Transparency

Even though Forest Act clearly talks about marketing and distribution of natural resources, Market transparency is limited in the log trade; small-scale producers often do not have a clear understanding of the value of their timber crops and have limited negotiating. The RFD has developed a variety of ways to support local communities in managing their forests, albeit only at a pilot level. Nonetheless, the forthcoming of community forests is in doubt because the government cannot guarantee their long-term status control with purchasers. Forest wood dimension measurement practices are beyond control electively by sellers and therefore provide opportunities for misuse. The establishment of producer cooperatives or associations would help protect the interests of growers.

The present statistical reporting in the forestry sector in Thailand is far from satisfactory. Information is a powerful tool in managing the sector but it has been neglected in the past. There is no overall strategy for information management. The purpose of data collection is unclear to middle-level staff , which tends to perceive it as an administrative burden rather than a management tool. The entire forest statistical system needs to be reviewed.

There appears to be no capacity in the country for technical and vocational forest-related training, and concerned organizations and companies have taken on the responsibility of developing their own human resources. However, there is a particular need to provide further training for supervisors and other middle managers of wood and specifically the furniture industry. This is one of the key constraints in industrial and commercial expansion. MNRE has completeaccountability for forests appear to have no plan for developing a forestry extension program. This is unfortunate, given that the management of forest resources and production is shifting to the private sector and communities.

Most RFD funds go towards maintaining infrastructure and paying staff salaries, with little left over for training or other outreach activities.

Provisions in RPP (REDD Readiness Preparation Proposal): Government of Thailand has submitted RPP to MSI. Thailand's RPP has identified national park as the perfect site for REDD+ piloting as Department of National Parks, Wildlife and Plant Conservation (DNP) were given responsibility of finalizing RPP. First and foremost, REDD+ revolves in the principals of sustainable forest management where RFD needs to be involved; REDD+ focused on protected areas is less likely to enhance carbon growth and improve livelihood. Even if so, National Park with high state of conflicts need to be identified, whereas protected areas with reduced confrontation is selected as piloting areas. According to Thai Climate Justice Working Group, "RPP has violated the principles of free, prior and informed consent; RPP has undergone participation of local people". RPP has not been friendly to small farm holders mentioning that they are increasing temperature though deforestation without any factual information (Lang, 2013). Similarly, the issue of land right is most concern for forest communities in every forum; this has not been mentioned in the RPP.RPP has not been able to highlight true problems existing within the country. As much of the people live inside the forest that have been declared as conservation area has led to much conflict. RPP fails to highlight this urgent need. Unless these procedures are not clear REDD cannot be successful.

Policy Practice Gaps

Owing to the fact that, government has formulated forest polices and implemented them on their own ways; but local stakeholders are unaware of it. This reflects a hug gap between policy and practice. One way to see the gap between policy and practice is by comparing the guideline with what was carried out (Zolala and Haghdoost, 2011). On the basis of above stated policy details, we have tried to list the observation practices at the local level shown in (table 1).

Table 1 : Policy practices on diverse forest management approaches

Practices in the field			Governance indicators
National Park	Community Forestry	SorPorKor/INPANG	
No information exists on government related policies and documents			Clarity on policies
No scope for adaptive forest management	No adaptive management in policy formation; however localsembrace adaptive forest management according to existing social norm and values.		Policy supporting adaptive management
Possiblethrough declaring conservation area.	Confiding to international obligations has jeopardized forest dependent population by declaring world heritage sites.		Consistency of laws with international obligations
No such rights given.	Likely to pursue property and carbon rights if community bill gets endorsed	Has right to harvest and manage;no sale rights. And locals are following the provisions	Extent to Law recognizing property and carbon rights
No such mechanisms; obligatory to park rules	Smaller conflicts managed by community. Conflicts requiring government's attention are unsolved		Extent of conflict resolution mechanism
Supportive ; but no consideration to indigenous people	Not supportive; reason for unsuccessful community forest bill	No co-ordination among these SorPorKor agencies	Extent of forest mandates and agencies supportive
Regular budgets; no provisions for indigenous people	Past experiences on project lacks sustainability		Adequacy of budgets and resources
The locals residing inside the park have no access.	Very less information flows and technology tools. Forest policies written in complex language not available outside Bangkok.		Availability information, technology and tools
No such provisions given for indigenous people residing inside the national park	Equitable at local level		Equity to rights and rents
	Unknown at national provision; practice openness at community level through their own means		Openness resource allocation
There is no public consultation process	Participation in operational planning no involvement in constitutional and policy planning		Participation in planning
No transparency mechanisms.	Local users are highly transparent on resource allocation and operational planning.		Transparency

In order to document the relative differences on the degree of policy practices; focus group discussions signed an index value from 3 (maximum) to 0 (minimum) for each site. For the sites with no difference in national level policies and practices on the field the minimum value was assigned and vice versa. These index values were presented in provincial level meetings and triangulated with experts.

Table 2 : Policy practice gapIndex

National Policy Provisions	Practices in the field			Governance indicators
	National Park	Community Forestry	SorPorKor/ Inpang	
No clarity	0	2	0	Clarity on policies
Does not support	0	2	2	Policy supporting adaptive management
Consistent	2	1	1	Consistency of laws with international obligations
Does not recognize	0	1.5	2	Extent to Law recognizing property and carbon rights
No conflict resolution mechanism	1	1	1	Extent of conflict resolution mechanism
Supportive for National Park	2.5	0	1	Extent of forest mandates and agencies supportive
	2.5	1	1	Adequacy of budgets and resources
Least available	0	0.5	0.5	Availability information, technology and tools
Not equitable	0	2	2	Equity to rights and rents
Does not exist	0	1	1	Openness resource allocation
No participation	0	2	2	Participation in planning
Does not exist	0	2	2	Transparency
	0.67	1.33	1.29	Average

The huge policy application gaps are seen especially in the national park areas. Thai Forest dependent communities are capable of undertaking good practices in forest management but they should be brought up in the planning process.At present, some 1.2 to 2 million people are reported to be living in and around protected areas (national parks and wildlife sanctuaries) and rely on forests for livelihoods ("FCPF", 2011). In addition, another 20 to 25 million people are reported to live near national forest reserves and use them for forest products both for household consumption and to sell them in markets for cash income (Witchawutipong, 2005). For the sake of conservation the livelihood of these

forests dependent people are taken away. Increased forest encroachment and not being able to establish forest bill has led to question of feasibility of REDD+. REDD+ requires local communities, local organization, government and civil society to come together. Of the whole country, there are more than ten thousand villages which involved in managing community forest, of which 7,090 communities are reported to have formally registered with the RFD, covered the area of 400,000 hectares ("FCPF", 2011). Community forest organizations have built up their networks in each region and formed their network at national level that includes ethnic groups. The national community forest network is an important stakeholder for participation in the national REDD+ mechanism. But the current community forestry under the RFD is quite likely to create problems leading to management and land use conflict.

REDD+ itself is new topic and with such complexities inefficiency in policy compliance is almost sure and may foresee corruption. Likewise, overlapping, complexity and contractions in responsibility of forest agencies accordingly increases transaction cost due to ineffectively use of power. Secure forest tenure along with clearly defined forest carbon rights provides incentive to manage forest effectively. Local forest dependent population have been settled in forest for a longer period of time and bear skills to identify biodiversity to be preserved, products to be utilized and know traditional ways to protect against fire. This knowledge should be effectively incorporated in forest governance and policy. If the right is given to local people they will have an opportunity of applying this knowledge. To make sure that the forest laws and acts have fulfilled the required objective there should be monitoring and timely assessment should be conducted.

REDD+ is probably coordinated and managed by the national governments, promoted by public and private actors, and cooperation with government agencies or through mutual combination of both (Corbera and Schroeder, 2011). But as per the Thai policy provisions REDD+ is likely to be benefited only to the government as it does not encourage local stakeholder to participate in the REDD process. The institutions and organizations that managed the forest are ill-equipped to overcome the challenges of global transformations. There requires a system that can transcend from national boundaries, interconnect different governance levels and allows both traditional and modern policy actors to cooperate. Such system emphasizes integration of both formal and informal rules making mechanism and actor linkages in every governance stages which steer towards adapting and mitigating to local and global environmental change (Corbera and Schroeder, 2011). Recognizing REDD+ governance requires understanding of organization, norms, institutions and decision making mechanisms (Biermann et al, 2010), and examines performance and effectiveness in relations to reducing emissions. But Thai government fails to do so; instead it considers indigenous institutions as the primary drivers of deforestation.

Conclusion

Thailand forest polices are determined by central government where the needs and problems of people living inside the national park is not addressed. Though government have identified national park as the potential piloting site for REDD+ implementation, the real issues is not taken under consideration. The supportive document based on which the government is undertaking REDD+ is full of discrepancies and irregularities. There are so many policies that are formed that overlap with each other and create situation of confusion and make situation chaotic.Overlapping and complexities can increase transaction cost in law enforcement, requires further investigation and information. Most of these policies are ad hoc and no adaptive learning process involved. Disputes between community groups and forestry officials is common and rather than having a strong conflict resolution mechanism, conflict related to boundary gets lingered at court and most of these courts are not in reach of resource poor. This situation is further aggravated by overlapping of administrative function and inconsistent government development agendas. There are no good governance features in forestry sector prominent through lack of equity and participation in forest resource allocation. Especially these discrepancies are more in national park.

REDD+ mechanisms cannot be implemented successfully with the available provisions in the policy. Especially, the practice gap is more with the National Park/Conservation area. This prominently shows that RPP has been formed without rigorous consultation with diverse stakeholders. Rather than focusing on formulating new policies attempt should be made to monitor the effectiveness of existing policies. However, small holders are contributors to sustainable forest management in Thailand. They are contributing to carbon sequestering carbon through managing small area plantations and restoring the degraded land through SorPorKor /Inpang networks and community forestry; whereby the local traditional ways of forest conservation is being used. Though the link of these SorPorKor and Inpang network is unknown; but can aid in REDD+ initiative because the practices is based on the principles of free prior and informed consent and social safeguards. But the challenge involves around monitoring at small areas especially at geographically dispersed areas. Government initiative in promoting these small holders can involve using GIS and satellite data to aggregate plantations under community based management.

Acknowledgement

This paper is the part of study research funded by Toyota Foundation. The author would like to thank Toyota Foundation for the financial grant.

References

Biermann, F., Betsill, M., Gupta, J., Kanie, N., Lebel, L., Liverman, D., Schroeder, H., and Siebenhuener, B., 2009. Earth System Governance: People, Places and the Planet. Science and Implementation Plan of the Earth System Governance Project.Earth System Governance Report 1, IHDP Report 20,Bonn, IHDP.

Bureau of Technical and International Cooperation, 2007.Constitution Of The Kingdom Of Thailand, B.E. 2550 (2007) Unofficial translation. Secretariat General of the Administrative Court. Available online: http://www.isaanlawyers.com/constitution%20thailand%202007%20-%202550.pdf

Corbers, E. and Schroeder, H., 2010. Governing and Implementing REDD+.Environmental science & policy 14 (2011) 89–99.

(FCPF), F. C. 2011.Readiness Preparation Proposal (R-PP). The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD).

Forest Carbon Partnership Facility, 2013.REDD Readiness Preparation Proposal. The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD).

Kishor, N and Rosenbaum K. 2012. Assessing and Monitoring Forest Governance: A user's guide to a diagnostic tool.Washington DC: Program on Forests (PROFOR)

Lang, C. 2013. Thai Climate Justice Working Group slams Thailand's Readiness Preparation Proposal: "The participatory process was problematic and the content of the draft was defective". http://www.redd-monitor.org/2013/03/19/thai-climate-justice-working-group-slams-thailands-readiness-preparation-proposal/

Masawat J. and Roongtawanreongsri, S., 2012. Policy on Forest Management in Thailand: A case study of Kho Hong Hill in South Thailand. DOI: 10.7763/IPEDR. 2012. V52. 19

Nalampoon, A. 2003.National Forest Policy Review, Thailand.in P. B. Durst Ed., "An overview of forest policies in Asia," FAO, Bangkok, pp. 293–311, 2003. Available Online: ftp://ftp.fao.org/docrep/fao/005/AC921E/AC921E11.pdf

National Reporting Guidelines for CDS, 2005. Available online: http://www.un.org/esa/agenda21/natlinfo/countr/thai/atmosphere.pdf

Office of the Council of State, 1997.Constitution of the Kingdom of Thailand (Translated). Published in the Gazettee, Vol 114. Available online: http://www.law.yale.edu/rcw/rcw/jurisdictions/asse/thailand/Thai_Const_Eng.pdf

Opassiriwit, C.2001. Thailand: A case study in the interrelationship between freedom of information (FOI) and Privacy. Available online: http://www.oic.go.th/content_eng/privacy.html

Pakorn and S. Nilpra, 2005a.Commercial Forest Plantation Act, B.E. 2535(1992).Thailand Acts of Parliament Panwa's Series. Available online http://www.lawreform.go.th/lawreform/images/th/legis/en/act/1992/28477.pdf

Pakorn and S. Nilpra, 2005b.National Reserve Forest Act, B.E.2507(1964). Thailand Acts of Parliament: Panwa's Series. Available online: http://www2.austlii.edu.au/~graham/AsianLII/Thai_Translation/National%20Reserve%20Forest%20Act.pdf

Phelps, J., Webb, E. L. and Agrawal, A., 2010. Does REDD+ threaten to recentralize forest governance. Science, 328(5976): 312-313. DOI: 10.1126/science.118777

Phromlah,W. 2011. Reforming Governance for Sustainable forest management in Thailand.Working paper, University of New England, Australia.Availabale online: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1869418

Forest Carbon Partnership Facility, 2013.REDD Readiness Preparation Proposal. The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries(UN-REDD).

Shytov, A. 1997.Public Participation in Enviornmental Protection and Thai Folk Wisdom.Thailand Law Forum. Available online: http://www.thailawforum.com/articles/publicpart.html

Thailand law forum, 2010a.National Park Act, B.E.2504.Authorized Official Translation. Available online http://www.thailawforum.com/database1/national-park-act.html

Thailand law forum, 2010b.The Forest Act, B.E.2484 (A.D.1941). AuthorizedOfficalTranslation.Available onlinehttp://www.thailawforum.com/database1/forest-act.html

Witchawutipong, J. 2005. Thailand Community Foresty. Bangkok: Royal Forest Department.

Zolala, FarzanehandHaghdoost, Akbar. 2011. A Gap Between Policy and Practice: A Case Study on Maternal Mortality Reports, Kerman, Iran. Int J Prev Med. 2011 Apr-Jun; 2(2): 88–93

Theme 3

Remote Sensing and GIS

Assessing Land Use Dynamics with Climate Change Indicators : A Case Study of Madi Khola Sub-watershed of Kaski District

Nabin K. Yadav*, Binod P. Heyojoo

Abstract

Land use and land cover change have major impacts on the global environment and climate. Remote sensing and GIS technology are very useful tools and important for monitoring changes. It is accepted worldwide that warming of the globe is responsible for unprecedented climate events posing a number of direct and indirect threats to mountain environment. This study aimed to assess land uses dynamics with climate change indicators and the major causes and effects of climate change on land use in Upper Madi khola Sub-watershed of Kaski district. Landsat satellite images of year 1988 and 2012 were used for quantifying changes using supervised classification method. Household surveys, key informant interview, GPS point and indirect field observation were carried out to agglomerate social, economic and bio-physical data.

Results showed that the forest cover has increased at an annual rate of 0.23% and other (barren land, settlement, water) increased by 0.88% per annual. Similarly, snow cover has decreased at an annual rate of 1.5%. The maximum, minimum and average annual temperature in the study area were found increasing at the rate 0.0147 °C, 0.0396 °C, and 0.0271 °C respectively. Precipitation trend is also increasing by 8.622 mm per annum. Melting of snow, expansion of glacial lake, occurrence of landslide and invasive species moving upper elevation are some distinctly noticed effects of climate within the watershed. Land use/Land cover change in the study area should be monitored and updated regularly and agriculture land of the area should be protected from further transformation which creates food scarcity to the study area.

Keywords: land use dynamics, Climate change, Sub-watershed

Introduction

Land use /land cover (LULC) changes are very dynamic in nature and have to be monitored at regular intervals for sustainable environment development. Remote Sensing data is very useful because of its synoptic view, repetitive coverage and real time data acquisition. The digital data in form of satellite imageries, therefore, enable to accurately compute various LULC categories and help in maintaining the spatial data infrastructure (SDI) which is very essential for monitoring and change detections studies. In other words, the remote sensing satellite data in multi-resolution and multispectral means to provide spatial information for LULC at different levels for various aspects as built-up land, agricultural land, forests, wastelands and water bodies etc. Land use is one of the main factors through which human influence the environment. Land use involves both the "manner in which the bio-physical attributes of the land are manipulated and the intent underlying that manipulation – the purpose for which the land is used" (Turner *et al.*, 1995).

Land cover corresponds to the physical state of the ground surface, such as forest, grassland etc. whereas land use reflects human activities such as the use of the land for different purpose such as industrial zones, resident zones. This definition established a direct link between land cover and the action of the people in their environment i.e., land use may lead to land cover change (Phong 2004). Likewise, land cover refers to features of land surface, which may be natural, semi-natural, managed, or manmade. On the other hand land use refers to the activities on land or classification of land according to how it is used, such as residential, industrial, commercial, agriculture, recreational, urban, rural, etc. To make sound planning for land use purpose, accurate and meaningful contemporary data on land use are essential.

Global warming, early decades of the twenty-first century will see a moderate warming of 1-2 resulting in reduced crop yields in seasonally dry and tropical regions, while crop and pasture yields in temperate region may benefit. Further warming in the second half of the century will negatively affect all regions, although agriculture in many developing countries in semi-tropical and tropical region will bear the brunt of the effects (Easterling et al., 2007). Climate monitoring efforts and communication of information is essential to convince farmers those climate changes projections are real and require response actions. Information services should include surveillance of pests, diseases and other factors of important to production system (Howden et al., 2007).

Primary indicators are the instrumental observation of climate over time such as temperature, rainfall, humidity, cloud cover etc. Secondary indicators are systems/ organization change in response to condition change. According to OECD (1993) an indicators is a parameter which provides information about the state of phenomenon/environment/area with significance extending beyond that directly associate with a parameter value. Thus, indicators provide information about phenomenon that are regarded typical to the environment quality.

Institute of Forestry, Pokhara, Nepal

* *Corresponding author : Email- navin_link@hotmail.com*

Indicators of climate change should give an overview of the climate and its development (Sweeney, 2002).

The displacement of present vegetation belts towards higher altitudinal or latitudinal areas may serves as a simplistic theoretical construct to demonstrate that climate change induces shift in the vegetation zonation (Walther *et al.*, 2002).

The proposed research in this context is useful to assess the LULC changes linking measureable climate change indicators.

Objectives

The general objective of the study is to assess the LULC change from 1988 to 2012 as well as climate change indicators (precipitation and temperature) from 1980 to 2012 in Upper Madi khola Sub-watershed of Kaski district.

The specific objectives are:

- Mapping of LULC changes in Upper Madi khola sub -watershed using Landsat imageries.
- To assess the indicators of climate change within watershed.
- To explore out the causes and effects of climate change on land.

Material and Methods

Study area

The part of Upper Madi khola watershed (28°32'9.69"N-28°19'33.58"N latitude, 84° 7'11.83"E-84° 5'22.22"E longitude) covering about 39,950 ha lies in 23 km north-east from Pokhara, of Kaski district (Fig.1). The study area is presently covered by agriculture, forest, snow, rocks, settlement, and water bodies. It represents features of mountain watershed and has fragile geology with rugged topography.

Fig. 1 : Map of study area

Data Collection

Both Primary and secondary data were collected and used for analysis.

Primary Data

Satellite Images

The primary data for this study were Landsat Thematic Mapper (TM) and Enhanced thematic mapper (ETM) satellite imageries of two different dates1988 and 2012. Criteria to the selection of the multi-temporal Landsat data set involved assessment of cloud cover percentage, time of acquisition, and sensor type so that LULC mapping and change detection scope could be optimized. Google earth and topographical map (scale 1:25000) of the study area were used for boundary delineation, extracting Area of Interest (AOI) from whole map and ground truth information were gathered for supervised classification of 1988 satellite image and accuracy assessment of classification of 1988 satellite image.

Bio-physical Data

Reconnaissance Survey

A reconnaissance survey was carried in order to get the general understanding of land use status of the study area before starting the field work.

Training Samples

For acceptable classification results training data must be both representative and complete. All the spectral classes constituting each information class must be adequately represented in the training set statistics used to classify an image (Lillesand *et al.,* 2004). Training samples were collected with the help of GPS during field visit. These training samples were used for the supervised classification of the 2012 satellite image. Stratified random sampling where each land use category was considered as stratum used (Lilesand *et al.,* 2004). Ten samples from each stratum were taken for using as the training sample for supervised classification.

Socio-economic Data

Household Survey

In this research, 56 household (5% sampling intensity) were selected for the purpose of household survey. The household survey plan was prepared incorporating different aspects of socio-economic condition especially the people including gender, ethnicity, education and geographic location.

Key Informant Interview

Informal key informant interviews were carried out with local old leader, teacher etc to document the secondary indicators of climate change, agriculture change pattern, emergence of new invasive species, occurrence of extreme climatic events etc. Perception of the people about the role of climate change on climatic hazards, agricultural change pattern, cropping and harvesting time and duration between them, vegetation shift, water sources availability, flowering time, invasive species and their invasiveness were taken as the secondary indicators of climate change.

Focus Group Discussion

Discussion were conducted with different groups of people like committee members, disadvantaged group and women group about the research issue.

Climate Data

Climatic data (1980 to 2012 for a period of more than 30 years) such as monthly maximum and minimum temperature, monthly precipitation of Sikles station was collected from meteorology department which was used for trend analysis of temperature and precipitation pattern and finally, social data were linked to technical data. Finally, obtained social data and climatic data from meteorological station were linked to verify people's perception.

Least Square curve fitting technique was used to find linear trend in the data. The linear trend between the time series data(y) and time (t) is given in the equation

$y=a+bt$ Where, y=temperature or rainfall, t=time (year) "a" and "b" are constant estimated by the principal of least square

Secondary Data

Relevant literatures from different publication, report, library, and journal were referred from different sources such as Institute of Forestry (IOF) library, District Soil Conservation Office (DSCO) and District Forest Office (DFO) of Kaski. Statistical data was accumulated from central Bureau of statistics, Department of survey, Department of forest research and survey and from the World Wide Web.

Data Entry and Data Analysis

Data collected from different sources were entered into SPSS 16. Primary Socio-economic data from household survey, climatic data from the meteorology department and secondary data from Central Bureau of statistics (CBS) and DSCO were entered, analyzed and interpreted on SPSS 16 whereas ground truth

data by GPS and training samples were fed, analyzed and interpreted on ArcGIS 10and ERDAS IMAGINE 8.4. GPS Utility of GIMIS was used to download and convert the GPS points and tracts to the ESRI shape file. For the change detection, Spatial Analyst on the ArcGIS was used. Quantitative data were analyzed in descriptive manner and qualitative data were analyzed by various appropriate tools and presented in charts and graphs. Climatic data obtained from Department of Hydrology and Meteorology (DHM) were analyzed using software's like Excel and SPSS.

Digital Image Processing

Image Pre-processing

Perfect remotely sensed data from satellites have not yet developed. So it is expected that error creeps into the data acquisition process and can degrade the quality of the remote sensor data collected (Lunetta et al., 1991 cited in Jensen 1996). Radiometric error in remotely sensed data might be introduced by the sensor system itself when the individual detectors do not function properly or due to atmospheric attenuation that the energy recorded by the sensor does not resemble that which was reflected by the terrain (Jensen 1996). To improve visible interpretability of an image by increasing apparent distinction between the feature in the scene digital enhancement level slicing, spatial filtering and histogram equalization were carried out by the help of image enhancement tools of ERDAS imagine software (ERDAS). The images were normalized. The spectral distribution of TM bands of Landsat ETM 2012 were normalized to Landsat TM 1988, which was chosen as a standard scene. This radiometric correction was conducted because it is impossible to obtain radiometric measurements for historical Landsat images. In such cases the only way to have images with approximately the same radiometric characteristics is to run image match equation. The purpose of image normalization was to reduce variations in pixel brightness between different images acquired at different dates so that variation in spectral reflectance could be interpreted as real change on the landscape. The strip line of Landsat 7 ETM 2012 scene was corrected by using focal analysis tool of ERDAS IMAGINE.

Pre-classification Processing

Sub-setting the Satellite Image

The study area was separated out from the whole scene of 172*183 Km^2 of the Landsat satellite images of both dates (1988 and 2012) using shape file obtained from digitization. Extract by mask tools of ArcGIS was used for this process. These separated area were used as AOI for the research study.

Training site Selection

Five to ten training sites for each class were collected and merged to give the best representation of the class spectral reflectance. Much care was taken to sub-divide semi-natural areas to two classes to reduce the topographic effect, hence, semi-natural areas in the shade shows different spectral reflectance from semi-natural areas exposed and illuminated by the sun. It was obvious that introducing prior knowledge especially about the topography aided in collecting separable signatures. Much attention was given to pick homogeneous areas in the Landsat image to ensure good classification results. The ancillary data were converted from shape file format to Arc / Info format, which is readable on remote sensing software. These files were then displayed over the Landsat scenes to aid in picking representative training sites.

Digital Classification

Supervised classification approach was applied for the image classification. Algorithm, maximum likelihood classifier (MLC) with parametric test was used for supervised classification (Lilisand et al., 2004). Thresholding was also done which is the process of identifying the pixels in a classified image that are the most likely to be classified incorrectly. The distance image and output thematic raster layer produced by MLC were used for thresholding. The tails of histograms (pixels that are most likely to be misclassified have the higher distance file values at the tail of the histogram of the distance image) were cut off interactively and saved and the removed pixels were viewed. Consequently there were only a few small speckles of the removed pixels. Once the collected signatures were comparatively satisfactory, multiple signatures were merged into one signature for a given LULC category and used for the classification. Data of the different classification items i.e. land use classes obtained from field study was used as training sample for supervised classification of image 2012 and that of topographical map was used for supervised classification of image 1993. The land use classes that were considered in image classification are forest land, agriculture land, and other (rocks, settlement, barren land and water bodies).This classification was used to prepare land use maps.

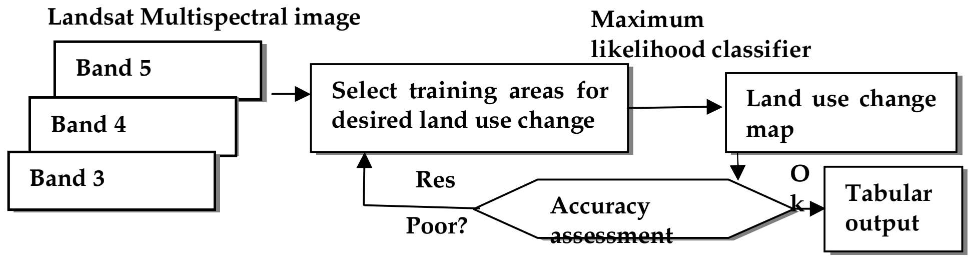


Fig. 2 : General workflow for a supervised LULC classification of a Landsat image

Accuracy Assessment

Once the classification was done, further knowledge of the area was obtained through the use of previous data collected from the field. High resolution topography map and Google earth were used as valuable source of data for the purpose of validating the classification accuracy. ERDAS imagine was used for the accuracy assessment.

Detection of Land Use Change

The raster grids of 1988 and 2012 images were overlaid using Spatial Analyst on the ArcGIS. Land use change was calculated by using raster calculator. Finally, the area converted from each of the classes to any of other classes were computed. The analysis and interpretation of different aspects of the numeric data of land use change were done on Microsoft excel.

Social Change Analysis

The social data collected from household survey was entered on SPSS. The analysis and interpretation of different aspects of the social data was done on SPSS and Microsoft Excel. The result were presented in the easily understandable forms such as tables, graphs and charts.

Results

Land Use/Land Cover Change Detection

1988 Image Classification Result

The classification of the Landsat TM 1988 scene (Fig.3) shows that the forest was the major land cover including 18857.25 Ha (47.20%) followed by other (barren, Settlement, rock and water bodies) 10133.82 Ha (25.3%), Snow 8200.62 Ha (20.53%) and Agriculture 2759.13Ha (6.91%)

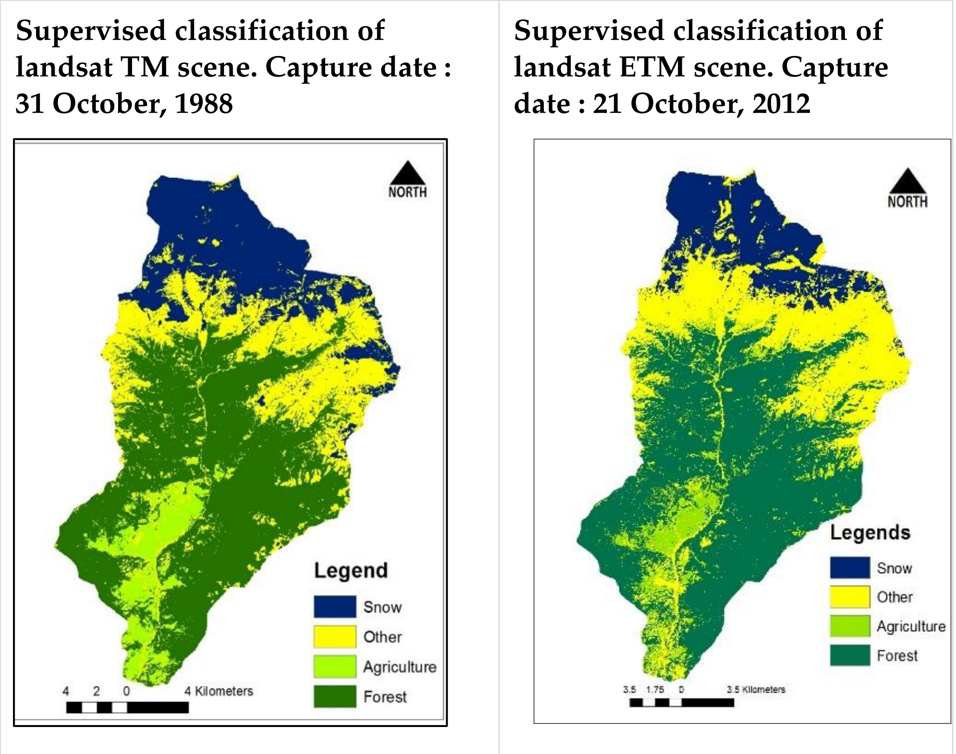


Fig. 3 : Supervised classification of landsat TM left side and supervised classification of landsat ETM on the right side.

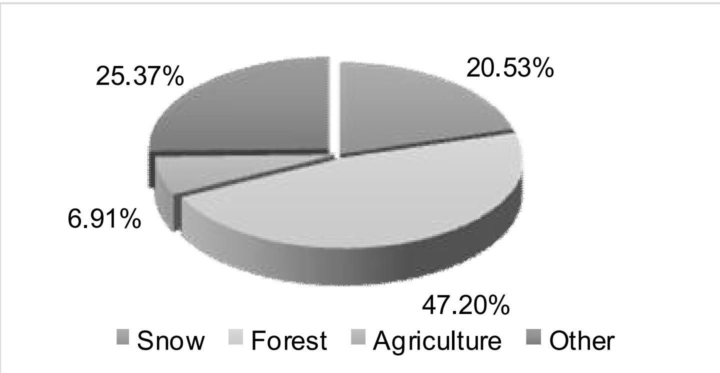


Fig. 4 : Land cover statistics derived using supervised classification of landsat TM 1988 of Upper Madi Khola Sub-watershed

2012 Image Classification Result

The classification of the Landsat ETM images (Fig.5) of the 2012 shows that forest area was the major LULC including 19938.06 Ha (49.91%) followed by others (barren land, settlement rocks and water bodies) 12516.12 Ha (31%), snow 5694.21 Ha (14%) and agriculture 1802.43 Ha (4%) (Fig.5).

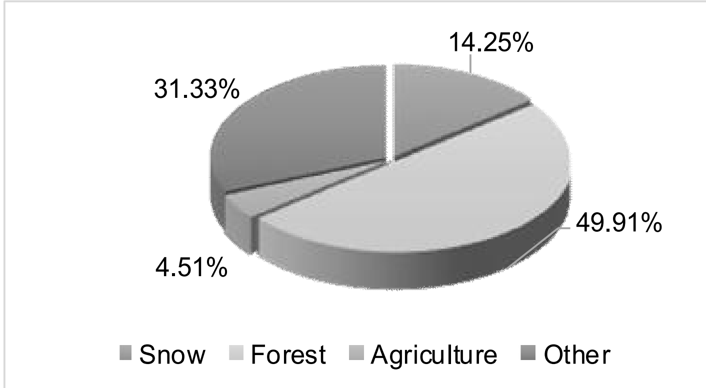


Fig. 5 : Land cover statistics derived using supervised classification of landsat ETM 2012 of the Upper Madi Khola Sub-watershed

Land Use/Land Cover Change

Table 1 below shows that the forest and other has increased during this time period whereas agriculture and snow have decreased. The highest decrease is on snow by 6.27 % followed by agriculture with 2.39%. Similarly the highest increase is on others (barren, settlement, rock and water bodies) by 5.96% followed by 2.71% on forest.

Table 3 : Land use/land cover change

Land use	Landsat TM 1988		Landsat ETM 2012		Increase		Decrease	
	% Cover	Area(Ha)	% Cover	Area(Ha)	% Cover	Area(Ha)	% Cover	Area(Ha)
Snow	20.53%	8200.62	14.25%	5694.21	-	-	6.27%	2506.41
Forest	47.20%	18857.25	49.91%	19938.06	2.71%	1080.81	-	-
Agriculture	6.91%	2759.13	4.51%	1802.43	-	-	2.39%	956.7
Others	25.37%	10133.82	31.33%	12516.12	5.96%	2382.3	-	-
Total	**100%**	**39950.82**	**100%**	**39950.82**	**8.67%**	**3463.11**	**8.67%**	**3463.11**

Table 4 : Land use dynamics table

Land use	Snow	Forest	Agriculture	Others	Total 1988
Snow	5406.84	116.01	0.18	2914.14	8437.17
Forest	0.09	17273.79	80.1	1471.23	18825.21
Agriculture	-	702.9	1127.79	898.92	2729.61
Others	169.74	1669.86	558.99	7560.27	9958.86
Total 2012	5576.67	19762.56	1767.06	12844.56	39950.85

Table 2 Show that the dynamics on land use change within the watershed for a period 30 years. The main reason for decrease in snow cover in the study site is attributed to temperature rise melting of snow and formation of glacial lake. Others (barren land, settlement, and water bodies) increase is due to increase in population, construction of dam/rural roads, landslides and soil erosion. Similarly, agriculture land has decreased in the study area due to shortage of labor as most of people migrated to city area and foreign country.

Climate Data Interpretation

For climate data, two variables such as temperature and precipitations were collected from Sikles station. Missing data were calculated fitting trend line.

Maximum, Minimum and Average Temperature Trend

The maximum, minimum and average annual temperature in the study area were found increasing at the rate 0.0147 c. 0.0396°c and 0.0271°c respectively as shown in the Fig.6.

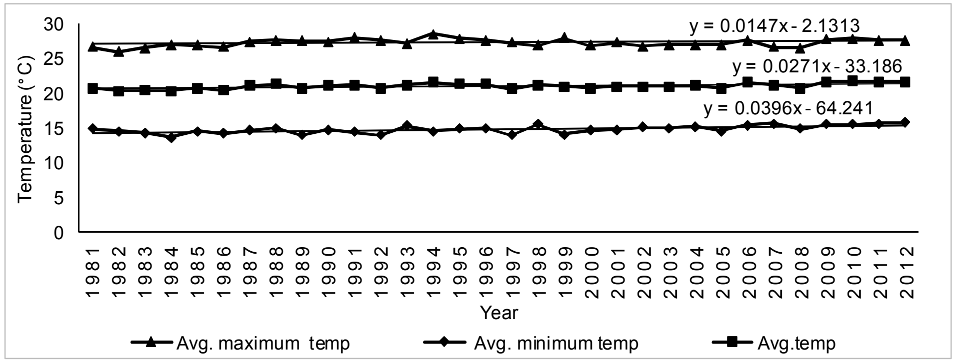


Fig. 6 : Maximum, minimum and average temperature trend

Precipitation Change

Analysis of precipitation data between (1980-2012) confirmed the minimum rainfall in the years 1992, 1980 and 2009 and maximum in the year 1990, 1995 and 2003, respectively. The average rainfall for this period was 300.7 mm.

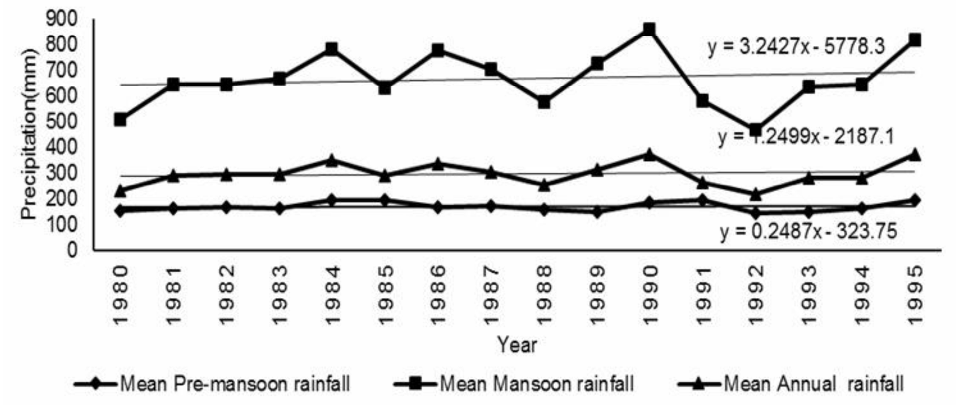


Fig. 7 : Mean yearly seasonal rainfall from 1980 to 1995

In the first period, mean monsoon rainfall increased by 3.24 mm, mean pre-monsoon rainfall increased by 0.24 mm and mean annual rainfall went up by 1.24 mm. In this period, monsoon, pre-monsoon and annual rainfall increased resulting in more wetness (Fig.7).

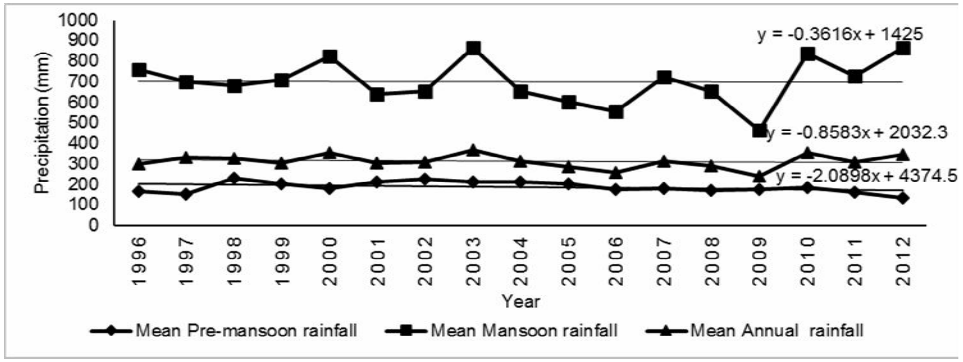


Fig. 8 : Mean yearly seasonal rainfall from 1996 to 2012

Similarly, in the second period, data showed a gradual decline in mean monsoon rainfall, mean pre-monsoon rainfall and mean annual rainfall by 0.36mm, 2.08mm and 0.85mm respectively.

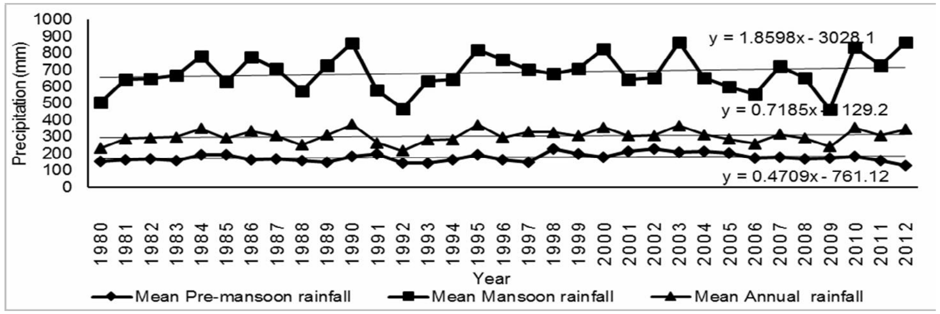


Fig. 9 : Trend of mean annual and seasonal rainfall from 1980 to 2012.

The analysis revealed that there is a variation in monsoon and pre-monsoon rainfall patterns. Fg.9 illustrates that mean annual monsoon rainfall of the period had an increasing trend (1.85 mm $year^{-1}$). This diagram depicted large inter-annual variation in mean monsoon rainfall.

From the analysis of precipitation trend, it is evident that mean annual, monsoon and pre-monsoon rainfall were in an increasing trend (0.72 mm, 1.86 mm, 0.47 mm $year^{-1}$ respectively) over the period.

People's Perception on Climate Change

The respondent in the study included representation of ethnicity, profession, cast to include inclusive perception. It seem that all the categories of the respondent are facing problem with natural hazards due to climate change as shown in Fig 10.

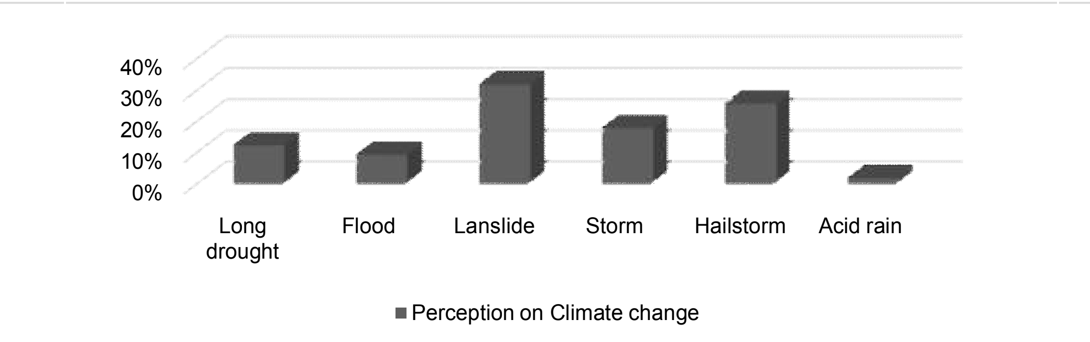


Fig. 10 : Inclusive perception on climate change and their impact

Occurrence of landslide was voted first followed by occurrence of hailstorm and log. Whereas, flood, and acid rain are the minor hazardous factor faced during the time period of 30 years in their daily life.

Climate Change Impact Assessment on Land Use/Land Cover

Major Causes of LULC Change in the Study Area

Response exercise were carried out to find out the respondent opinion causes of LULC change in the study area. Fig. 11 shows that population growth (43.2 %) is the major causes of LULC change in the study area followed by climate change (33.3%), policy (12.3 %), migration (7%) and Infrastructure development (4.2 %). Migration of people from upper part of the study area to the lower more developed area and different policies like introduction of community forest, alternative energy sources, stall feeding system etc. help change the land uses of that area.

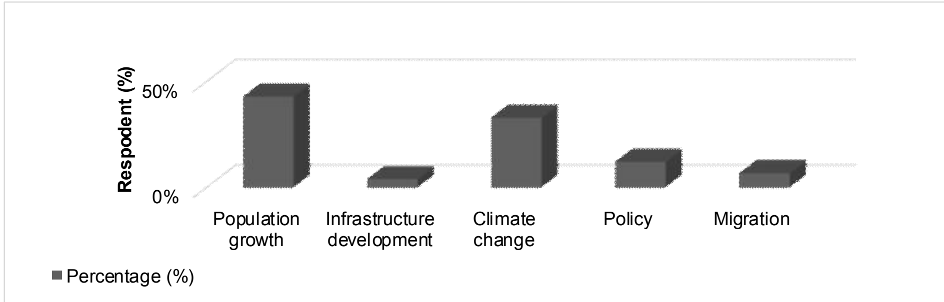
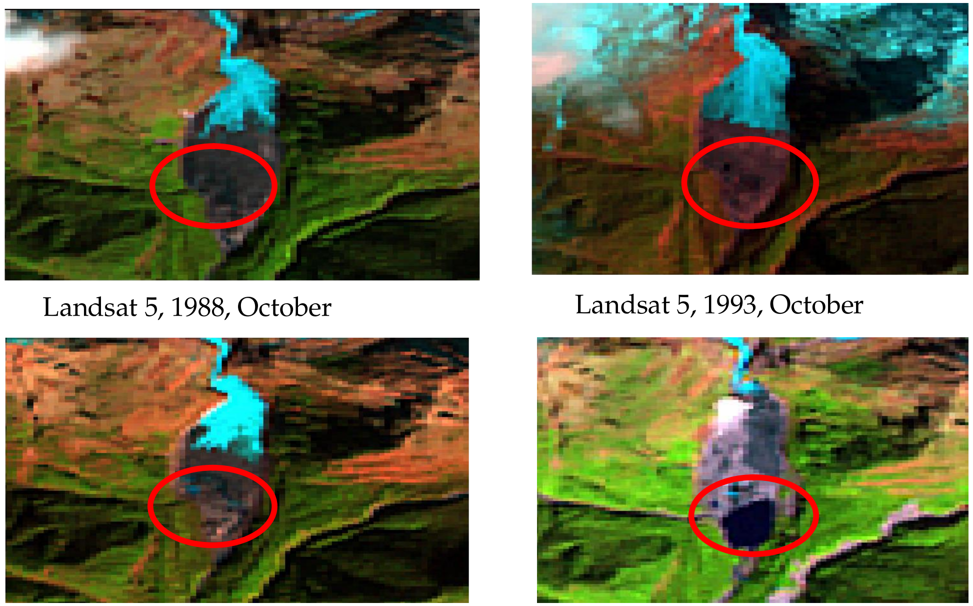


Fig. 11 : Causes of LULC change

Melting of Snow and Glacial Lake Formation

One of the most prominent and best visible evidence of climate change are glaciers (Benn & Evans 2010). Glaciers react sensitively to global climate changes.



Landsat 5, 1988, October

Landsat 5, 1993, October

Landsat 7, 2003 October

Landsat 8, 2013, October

Fig. 12 : Accelerated glacial melt and retreat, giving birth to hazardous glacial lakes in the study area.

The glacial lakes are increasing in number and size that we can see the size of Kopuche glacial lake continuous increasing (Fig. 12).

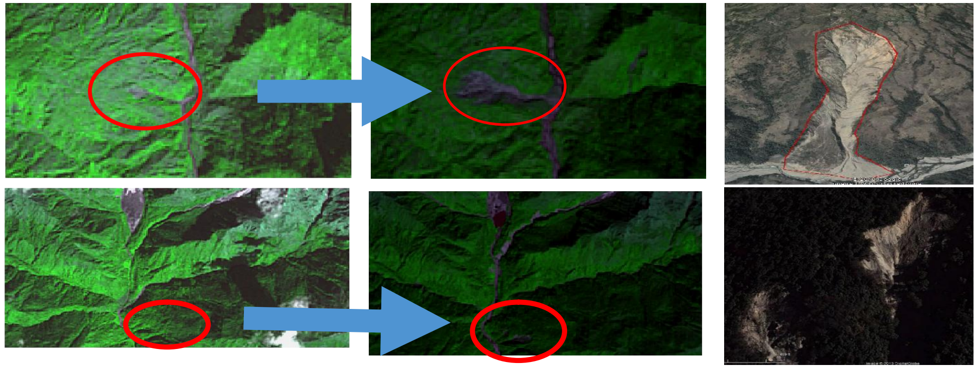
Rapid Proliferation of Unwanted Weeds

Unwanted weeds have outgrown in most agriculture and forest lands. Many new plants which have invasive character were observed at the watershed area in recent years. Some of the examples include: *Ageratum adenophora* (Kalo Banmara), *Chromolaena odorata* (Seto Banmara) and (*Commelina benghalensis)* Kane Jhar. It is found from the key informant's interview that the invasive species are moving gradually to the upper elevation.

Land Slides

Occurrences of landslides were increasing according to respondents. The image of two dates 1988 and 2012 shows that occurrence of landslides at different places (Fig. 13).

Climate acts as a complex agent on the magnitude and frequency of landslides via the nonlinear soil water system (Bogaard & van Asch, 2002).



1988 Image

2012 Image

Google Earth Image

Fig. 13 : Occurrence of landslides at different places

Spread of Insects and Pests

The increase and decrease spread of insects and pests can also be taken as secondary indicators of the changing climate. Based upon the key informant's interview, it was found that there was increasing and widespread evidence of the insects that were common to the area are gradually disappearing but new species types of insects and pests are emerging. According to respondents mosquitoes and *Liohippelates spp.* were not seen before but now these insects are commonly occurring in the area.

Change in Flowering Time

During formal and informal interview, the old and experienced persons, who have been observing the environment of the study area, shared their experience about the change in flowering and fruiting time of the plants giving the examples of the seasonal vegetables and plants. The flowering time of *Bombax ceiba* has been changed i.e. it is about a month earlier than that of past.

Conclusions/Recommendations

The dynamics of LULC change between 1988 and 2012 depicted from analysis of remote sensing images coupled with analysis of long term climate data and local people's observations confirm impacts of climate change in the study area. The forest cover has increased at an annual rate of 0.23% and other (barren land, settlement, water) increased by o.88% per annual. Similarly, snow cover has decreased at an annual rate of 1.5%. The decreased of snow cover is due to rise of temperature as result melting of snow and formation glacial lake. This study has provided important insights into the dynamics of the major four land use classes (forest, snow cover, agriculture others (barren land, settlement and water) between 1993 and 2010 using remote sensing and GIS.

The maximum, minimum and average annual temperature in the study area were noted to be increasing at rates of 0.0147 ºC, 0.0396 ºC and 0.0271ºC, respectively. The precipitation trend also indicates an increase by 8.622 mm per annum. The measurement of the climate parameters temperature and rainfall provided evidences of change in climate. Melting of snow, expansion of glacial lake, occurrence landslides and invasive species moving upper elevation are some distinctly noticed effects of climate change within the watershed. Increase in insects and pests such as mosquitoes, gnats and flies, change in composition of herbs community, earlier flowering of the plants are some secondary indicators (or the distinctly noticed effects) of climate change which were pragmatic at local level within watershed.

The study thus recommends that LULC change in the study area should be monitored and updated regularly, and agriculture land of the area should be protected from further transformation which would lead to food scarcity in the study area. Furthermore, awareness of climate change and adaptation strategies should be enhanced at the local level.

Acknowledgements

COMFORM, IOF Project is gratefully acknowledged for its financial support to carry out the research. We also thank to the organizer of International Conference on Forest, Soil and Rural Livelihood in a Changing Climate for accepting this paper to present in the conference.

References

Bogaard, T.A & van Asch Th.W.J. 2002. The role of the soil moisture balance in the unsaturated zone on movement andstability of the Beline landslide, France. Earth Surface Processes and Landforms 27: 1177-1188.

Benn, D. I. & Evans, D. J. A. (2010). *Glaciers and Glaciation*. 2nd ed utg. London: Taylor & Francis Ltd. 1 online resource (817 s.)

Easterling, W.E. *et al.*, 2007. *Food, fibre and forest products*. In: Climate Change 2007: Impacts,Adaptation and Vulnerability. Contribution of WG II to the Fourth Assessment Report of the IPCC, M.L. Parry *et al*. (eds.), Cambridge University Press, UK, pp. 273-313.

Howden, M., Soussana, J.F. & Tubiello, F.N. 2007. Adaptation strategies for climate change. Proc. Nat. Ac. Sciences 104:19691-19698.

IPCC, 2007.Climate Change 2007: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, J.T. Houghton,Y. Ding, D.J. Griggs,M. Noguer, P.J. van der Linden, X. Dai, K. Maskell and C.A. Johnson, Eds.,

Jenson J.R., (1996). *Introduction digital image processing*: a remote sensing perspective. (Second Edition) United States of America: Perntic-Hall, Inc.

OECD. 1993. OECD core set of indicators for environment performance reviews. Environment Monographs 83.

Phong LT (2004) Analysis of Forest Cover Dynamics and Their Driving Forces in Bach Ma National Park and Its Buffer Zone Using Remote Sensing.

Lillesand, T.M., Kiefer, R.W. And chipman, J.W. 2004.Remote Sensing and Image Interpretation. John wiley &Sons, New York, USA. 31.

Sweeney, J., Donnelly, A., Meetwain, L. and Jones, M. 2002. Climate Change indicators for Ireland (2000- LS- 5.2.2-MI). Final report, Environment Protection Agency, Ireland.

Turner, B.L., Skole, D., Sanderson, S., Fisher, G., Fresco, L. and Leemans, R. 1995. Land -Use and Land Cover Change, Sceince/Research Plan. IGBP report No. 35. HDP report No. 7. IGBP and HDP, Stockholm and Genava.

Walther, G.-R., E. Post, P. Convey, et al. 2002. Ecological responses to recent climate change. Nature **416**:389-395.

Prospects of Multiple Benefits from Forests through REDD+ Implementation in Nepal

Him Lal Shrestha, [1]* Roshan Man Bajracharya[1],
and Bishal K. Sitaula[2]

Abstract

Forests, grasslands and agro-ecosystems are major resources for sustaining the livelihood of the local people. Forests not only provide tangible goods and services to the local communities but also provide ecosystem services as well maintain the environmental stability, promote water recharge, accumulate carbon, etc. Moreover, the forests, grasslands and agro-ecosystems offer a viable opportunity for climate change mitigation through carbon sequestration, both in the short-term and long-term scenarios. Forests and soils are considered as terrestrial sinks for CO_2 as they tie up carbon through photosynthesis in woody tissue and soil humus. This paper explores the multiple benefits of forests and allied ecosystems in terms of carbon and non-carbon benefits. The study quantified and mapped the carbon benefits and ecosystem services. Above-ground carbon, soil organic carbon, and species richness were analyzed under different management systems in 3 watersheds of Nepal, i.e., Kayarkhola (Chitwan), Ludikhola (Gorkha) and Betrawati (Rasuwa). Selected CFUGs and their surrounding agro-forestry practices were also sampled. The field measured results were compared with the global data whever possible. A geospatial approach to mapping was applied using remote sensing data along with field measured data.

The result of the study showed that AGB-carbon was highest in Betrawati Watershed (Rasuwa) in CF (BZ) where SOC level was medium. The SOC level was highest with 375 tons/ha in CF of the Ludikhola watershed where the AGB-carbon was medium. Compared the global dataset, it was bit higher than the field estimates as 363 tons/ha. The species richness was highest in Chitwan having a diversity index of more than 1.2. It could be concluded that there is scope of application of field measured data and remote sensing data to estimate and map the various benefits from forests and allied ecosystems. The assessment could determine carbon, as well as, non-carbon benefits including ecosystem services and social systems to provide a complete picture of multiple benefits as a part of REDD+ mechanism.

Key Words : Geospatial approach, co-benefits, aboveground biomass, SOC, species richness

[1] *Kathmandu University, Dhulikhel, Nepal*

[2] *Norwegian University of Life Sciences, Norway*

* *Corresponding author: Email - hlshrestha@gmail.com*

Introduction

Forests in the Himalayan region are generally regarded as the source of natural products required by the local people for their daily sustenance and livelihoods. Forests provide not only the tangible products needed for livelihood but also various ecosystem and environmental services. Stern's Economic Review showed that forests of the world have a impact on the processes of global warming and climate change. The international community agreed upon devising the emission reduction program in the forestry sector considering the forest has almost 18% contribution in the GHG emission to the atmosphere. Due to the anthropogenic activities, global forests are becoming depleted day by day and releasing carbon dioxide to the atmosphere because of deforestation and forest degradations. IPCC (2013) further determined the current trend of the deforestation is contributing to more than 10% anthropogenic global carbon emissions.

Developing country parties to the UNFCCC have been encouraged to contribute to mitigation actions in the forest sector through five activities generally referred to as REDD+: reducing emissions from deforestation and forest degradation, conservation of forest carbon stocks, sustainable management of forests and enhancement of forest carbon stocks. Land-use change also has a range of additional consequences for the goods and services that forests provide. Depending on how REDD+ policies are implemented, they could have negative social and environmental impacts, such as restricting local people's access to forest products or financing forest management strategies that harm biodiversity. The increasing understanding is that the REDD+ implementation has the potential to promote delivery of multiple benefits beyond carbon sequestration for climate change mitigation (Dickson et al., 2012). Maintaining and restoring forest areas under the REDD + implementation could ultimately lead to biodiversity conservation, water regulation , soil erosion control, enhanced supply of ecosystem services and goods to the local people's livelihoods, i.e., timber or non-timber products (Väänänen et al., 2014)

Within the current discussion on the REDD+ mechanism, the forest could be either a source or a sink for carbon. With adequate conservation and management, forests behave as a net sink for atmospheric carbon. However, REDD+ discussions consider numerous other issues and regard forest not only in terms of carbon sequestration. They are considered as having scope also for non-carbon benefits (Bastos et al., 2014). Carbon benefits are mostly accounted for in term of live biomass in the trunks, branches, roots, twigs and leaves; whereas, the non-carbon benefits from the forest are mainly understood as the services and opportunities during the forest management, such as, biodiversity preservation, species richness, forest quality and intactness, ecological, social, institutional, and governance opportunities (Bernando et al., 2014).

Multiple benefits from the forest are considered in term of goods and services. The goods are materials like timber, fuelwood, fodder, grass, and non-timber forest products (NTFPs), mostly providing economic and resource value (UNREDD, 2011). The services provided by forest are: carbon sequestration, water balance, greenery/aesthetic value, biodiversity conservation, oxygen from photosynthesis, etc. However, these goods and ecosystem services are highly spatially variable and dynamic. For the quantification of such spatio-temporal variations of the services from forest resources, a geospatial approach comprising GIS, remote sensing and GPS techniques offer good resolution and versatility. The remote sensing approach helps to capture the temporal variation in the goods and resource as it avails the past to current data. GIS analysis provides a means to visualize the spatial variability of the goods and services. The spatial data and map can be generated not only for the AGB, BG and SOC but also we for the goods and services availability and delivery from the forest (Baral et al., 2012).

Rationale

The Monitoring, Reporting and Verification (MRV) systems for the REDD+ have been in development in many less developed countries, but not yet fully workable due to diverse monitoring requirements. The recent discourse on the REDD+ mechanism demands an MRV system which incorporates the multiple benefits provided by forests (Doswald et al., 2010). Nepal, in particular, has limited capability to monitor even the forest and soil carbon in a consistent and standardized manner at the national or sub-national level (Herold et al., 2009). Much work is still needed to be able to monitor the social and co-benefits aspects of REDD+ required for social and environmental safeguards, which is essential nowadays for effective implementation of REDD+. Thus, the scope of this work is to determine carbon stocks and co-benefits in view of the fact that these benefits are more geographically distributed in nature and influenced by local effects of climate, geography, topography and land features. On the other hand, co-benefits are more focused on the services availed by the local communities, such as, biodiversity preservation, eco-tourism, ecosystem services, climate change mitigation, etc. (Baral et al., 2012). Hence, the aim of this study is to quantify the potential multiple benefits from forests considering the spatial and temporal variations using a geospatial approach with the tool suggested by UNREDD.

Study Area

Three watersheds from 3 districts of Nepal namely Gorkha, Chitwan and Rasuwa were selected for the study. The study sites fall in 3 eco-regions among the 200 Global Eco-regions. Thus during the selection of study sites difference in vegetation types, difference in altitudinal variations and difference in physiographic zone in Nepal were considered. The study site inside the Betrawati watershed of Rasuwa district represents the temperate forest in the middle mountains, Ludikhola watershed of Gorkha district represents the hill Sal (Shorea robusta) forest at moderate altitudes and Kayarkhola watershed of Chitwan district represents the low altitude forest in the foot hills of Nepal with Shorea robusta and associated species.

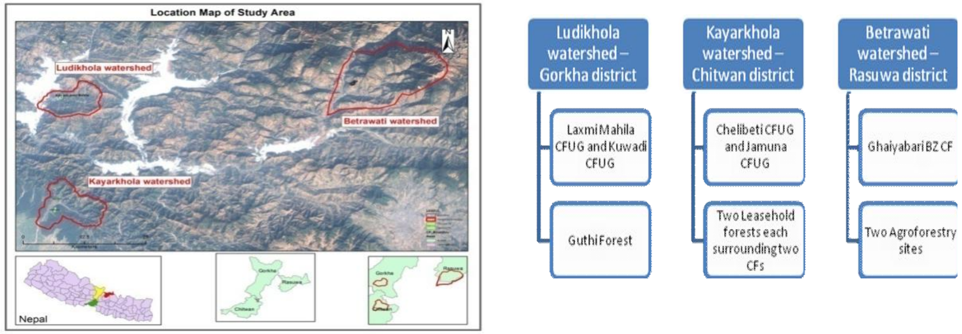


Figure 1 : Location map of Study Area

Table 5 : Description of study sites

Watershed	Usergroups	Altitude	Ecoregion	Forest type
Kayarkhola watershed	Jamuna CF Chelibeti CF	Below 500m	Himalayan Sub-Tropical	Subtropical moist broadleaf forest
Ludikhola watershed	Laxmi Mahila CF Kuwadi CF	500 to 1000 m	Himalayan Sub-Tropical	Subtropical moist broadleaf forest
Betrawati watershed	Ghaiyabari BZ CF	1000 to 1500 m	Eastern Himalayan	Temperate Broadleaf and mixed forest

Materials and Methods

Data Used

The required data for the analysis of benefits from the forest were obtained from different sources. The details of the data used in the study are described in the following table i.e. Landsat Data, HWSD, Global biomass data, field sampling.

Table 6 : Details of Data used

Data	Characteristics	Source
Landsat Data	Open, 30 m , MSS Bands, Scene	http://earthexplorer.usgs.gov/
HWSD	Global, 5 km	FAO, 2012
Global Biomass	Global, 1 km	Kindermann et al., 2008
Field sampling data	Forestry parameters, soil parameters	Field Survey, 2011 Field Survey, 2012

Tools used

The REDD Tool of Exploring Multiple Benefit tool developed under UNREDD was used for the analysis which is mainly based in the ArcGIS 10.0 Environment.

Table 7 : Details of tools used for the analysis

Tool	Characteristics	Source
ArcGIS	Provides the opportunity to apply spatial analysis	www.esri.com
Exploring Multiple benefit tool	Provides the opportunity to apply grid based extrapolation of field measured data based on remote sensing and supporting vector data	http://www.un-redd.org/Multiple_Benefits_GIS_Mapping_Toolbox/

Conceptual Framework of the Study

The conceptual framework of the study includes the entire methodology of the study which mainly incorporates the geospatial approach of quantification of land use change, carbon quantification and modeling carbon and land use change for the future. The methodology also comprises the acquisition, pre-processing and image processing to get the land use land cover map for the study.

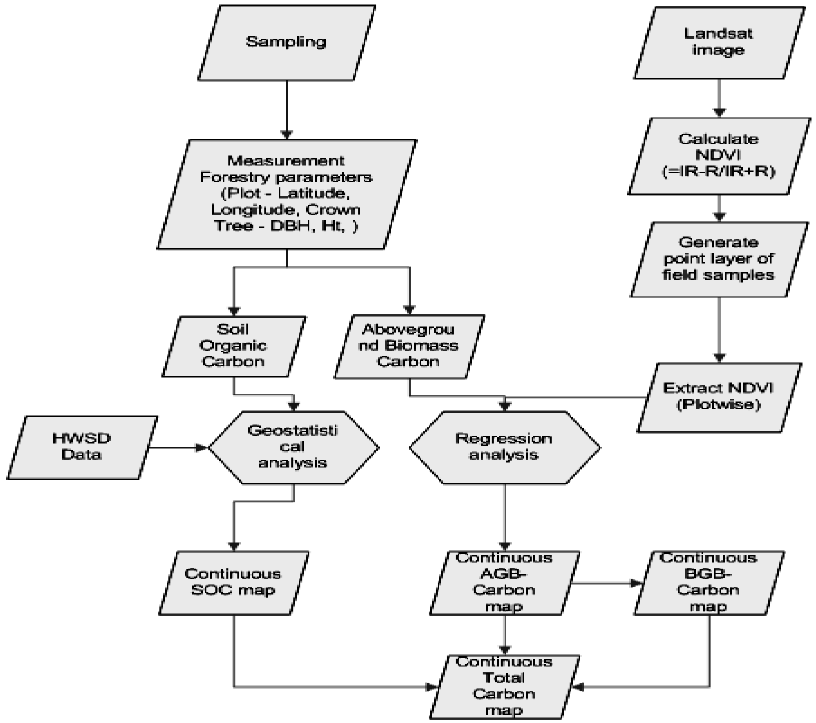


Figure 2 : Conceptual framework of the study

Carbon Stock in Different Carbon Pools and Quantification Methods

Field Sampling and Measurement

The random sampling was carried out maintaining four samples in each of the land management types i.e. Agriculture, Leasehold forest, and community forest and agroforestry practices. The field sampling inventory for forest was carried out where Diameter at Breast Height (DBH), Height of the tree, crown cover and other necessary information were collected. The circular sample plots were of 12.56 m radius to maintain the sample plot size of 500 m^2.

The soil sampling was taken from the center of each sample plots in the forest and agroforestry and soil samples from agriculture were collected using the point sample from random locations.

Above Ground tree Biomass (AGTB)

AGTB Carbon was further calculated using the following allometric equation suggested by Chave et al. (2005) as the study areas are not in heavy rainfall areas to generate the AGTB using diameter at breast height (dbh, cm), height (m) and wood-specific gravity δ (g/cm^3) of the trees. Allometric equations are established in a purely empirical way on the basis of exact measurements from a relatively large sample of typical trees (Brown et al., 1989) thus the use of this equation satisfies the estimated which basically over the other available equations at national level in Tamrakar (2000) and Sharma and Pukkala (1990).

AGTB= $0.059*\delta D^2H$……………………………(1)

δ= wood specific gravity (g cm^{-3})

D= tree diameter at breast height (cm)

H=Height of the tree (m)

Leaf Litter, Herbs, and Grass (LHG)

All the litter (dead leaves, twigs, and so forth) within the 1m^2 sub plots are collected and weighed. Approximately 100 g of evenly mixed sub-samples were brought to the laboratory to determine moisture content, from which total dry mass was calculated. Likewise, herbs and grass (all non woody plants) within the plots are collected by clipping all the vegetation down to ground level, weighing it, placing in a sample weighing bag and bringing it to the laboratory to determine the oven dry weight of the biomass.

For the forest floor (herbs, grass, and litter), the amount of biomass per unit area is given by:

LHG= $\frac{W_{field}}{A} \cdot \frac{W_{subsample\ dry}}{W_{subsample\ wet}} \times 1000$………………………………..(2)

LHG= biomass of leaf litter, herbs, and grass [t ha^{-1}];

W_{field}= weight of the fresh field sample of leaf litter, herbs, and grass, destructively sampled within an area of size A (g);

$W_{subsample\ wet}$= weight of the fresh sub-sample of leaf litter, herbs, and grass taken to the laboratory to determine moisture content (g)

$W_{subsample\ dry}$= weight of the oven dried sub-sample of leaf litter, herbs, and grass (g)

The carbon content in LHG, is calculated by multiplying LHG with the IPCC (2006) default carbon fraction of 0.47.

Soil Organic Carbon (SOC)

The soil samples were taken from the center of each laid plots in the forest and agroforestry plots whereas randomly from agriculture area, without laying the plots at 0-15cm, 15 – 30cm, 30-60 cm and 60-100cm depths. The core samples were used for determination of the bulk density and SOC content of the soil. Samples were transported to the laboratory and oven dried (105^0 C) until constant weight to determine water content.

The carbon stock density of soil organic carbon is calculated as (Pearson et. al, 2007):

SOC= ∂*d*% C………………………………… (3)

Where,

SOC= soil organic carbon stock per unit area [t ha-1],

∂= soil bulk density [g cm^{-3}],

d= the depth interval at which the sample was taken [cm], and

% C= carbon concentration [%].

Total Carbon Stock Density

The carbon quantity from all measured carbon pools were summed up to produce the amount of total carbon at plot level. AGTB calculated per plot per ha biomass was converted to the carbon contents in terms of tones per ha. Carbon content in BGB was then calculated using AG carbon content using the root shoot ratio in particular eco-regions. LHG carbons were subsequently converted into tones of carbon per ha in each plot. SOC was also converted into tones of carbon per ha by summing up the depth-wise carbon stocks.

Remote Sensing Indices and Mapping

Image Analysis

Recent Landsat images were acquired from the freely available data portal of USGS Earth Explorer. Normalized Differential Vegetation Index (NDVI) from the Landsat images were generated. The sample plots plotted after the GPS points were buffered with a radius of 12.56 m and calculated average NDVI value for both sets of images for each of the plots.

Statistical Analysis

The statistical analysis was done to come up with the tree level measurement of carbon stock in different carbon pool to the plot level and per hectare average stock for the stand. Soil carbon was also analysed carbon in each plot at different horizon. The summation of the all horizon represents the carbon stock at particular sample point representing 500 m^2.

Regression Analysis of Field Data and Remote Sensing Indices

The plot-wise carbon stocks were correlated with the remote sensing indices, i.e., NDVI and fit the regression equation to estimate the carbon stock for non-enumerated areas as well.

Mapping Wall to Wall Carbon Map Based on the Remote Sensing

The image calculator technique was used to come up with the wall to wall carbon stock map using the NDVI image and the regression equation fitted based on the field driven carbon estimation. On the same way the map layer of below ground biomass were also prepared. Soil map layer was prepared mostly using the HWSD data and field measurement data.

Species Richness Data were Generated by Applying the Kriging Techniques Based on the Plot Level Estimate.

The assumption is that where the diversity increases, there will be the increase in the species richness. Species richness is a measure of the number of species found in a sample. Since the larger the sample, the more species we would expect to find, the number of species is divided by the square root of the number of individuals in the sample. This particular measure of species richness is known as D, the Menhinick's index (Whittaker, 1977).

$$D = s/\sqrt{N} \text{-------------------------- (4)}$$

Where s equals the number of different species represented in your sample, and N equals the total number of individual organisms in your sample.

Results and Discussion

Estimates of Carbon-benefits

The AGTB and SOC were observed and mapped as a carbon benefit from the forest. The field estimates shows the AGB is highest in Buffer Zone Community forest in Rasuwa district where as the SOC level is medium. The SOC is highest in Community forests in Gorkha district where the AGB is medium.

Table 8 : Findings from the field AGB carbon and SOC in different management in different watershed (District)

	Total_AGB (tons per ha)	STDV total_AGB	SOC (tons per ha)	STDV SOC
Chitwan				
AGF	141	131	87	76
CF	159	128	162	88
Gorkha				
AGF	8	2	43	7
CF	121	111	375	142
Rasuwa				
AGF	206	161	278	60
CF	647	281	238	64

AGF-Agroforestry, CF-Community forests, AGB-Aboveground Biomass Carbon, SOC-Soil Organic Carbon,

STDV-Standard Deviation

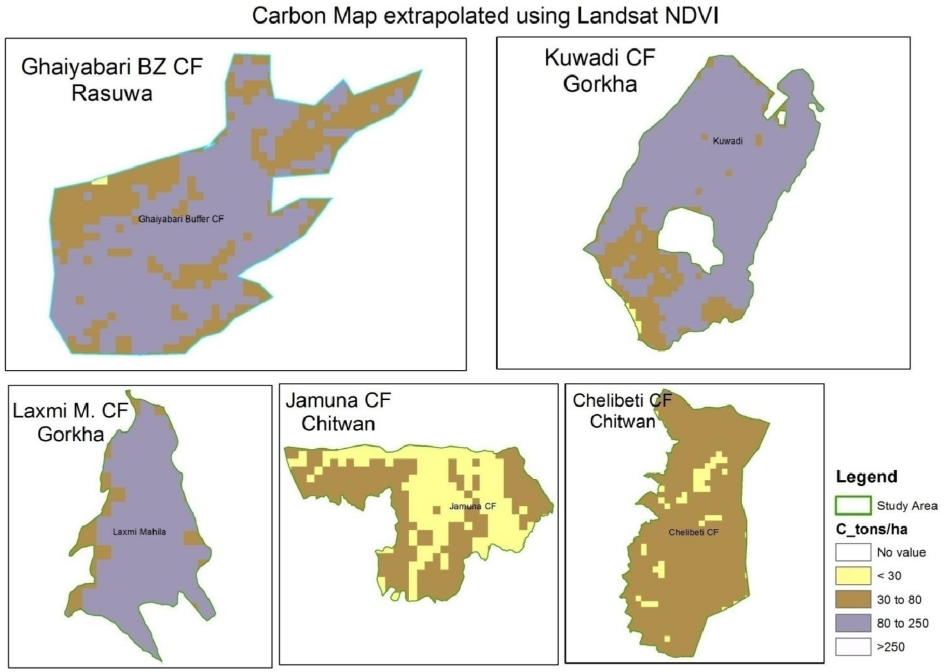


Figure 3 : Above ground biomass carbon map in different CF

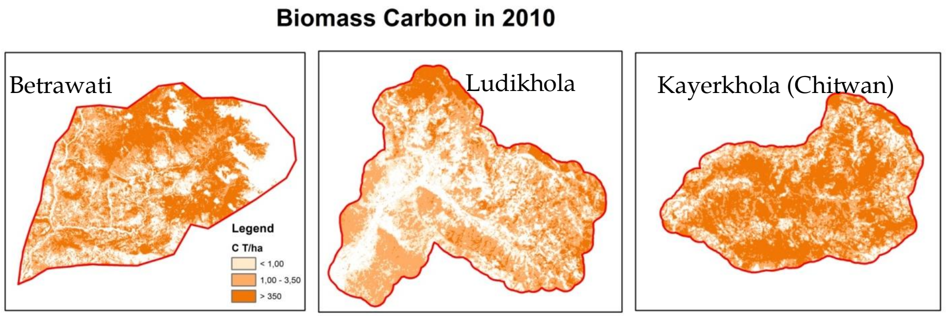


Figure 4 : Biomass carbo map from the current year (2010) at watershed level

Soil Organic Carbon Map

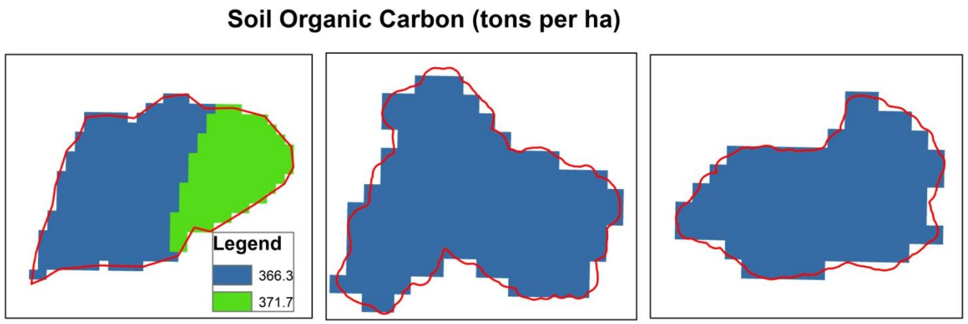


Figure 5 : SOC Map prepared using HWSD data (Watershed level)

Table 9 : Comparison of HWSD and field sampled SOC

	Field sampling	HWSD
Chitwan	162	363
Gorkha	375	363
Rasuwa	238	363 – 371

A comparison of the SOC stock measured in the field with HWSD data, similar resuts were noted for the data of Gorkha district, whereas, Chitwan and Rasuwa districts gave somewhat lower estimates as compare to the HWSD data. This might be due to the young age and poor condition of the forest stands.

Species Richness Map for the Three Sub-watersheds

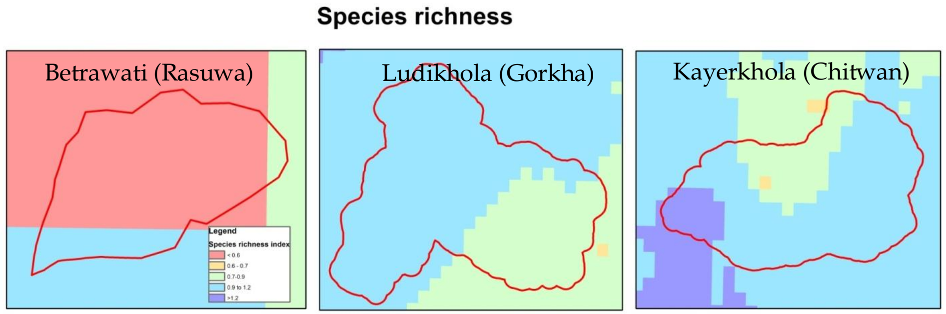


Figure 6 : Species richness map prepared from field data (Watershed level)

Table 10 : Total number of trees, observed number of species and menhinick's index value (based on field data)

Study site	Total Trees Count	Observed Number of Species	Menhinick's Index of Species Richness
Chitwan	148	45	3.698977
Gorkha	238	54	3.5003
Rasuwa	126	40	3.563483

The species richness was observed to be higher at the Chitwan district study site but also had higher of 3.6 compare to 3.5 at Gorkha and Rasuwa. The reasons behind the low diversity are comparatively cold climate and the altitudinal variability. Kayarkhola watershed in Chitwan has higher altitudinal variability and known for the complex watershed.

Table 11 : Application of remote sensing for the analysis of multiple benefits from the forest (Adopted from UNREDD, 2010)

Methodology	Sensors	Carbon stock information	Multiple benefits information
Coarse to medium resolution	Passive Remote Sensing	Land use categories, forest cover, deforestation	Topography, forest cover and location and boundaries of different forest or ecosystem types
High resolution	Passive Remote Sensing	Forest degradation, conservation and enhancement of forest carbon stock	Forest fragmentation, continuity of streams
Multispectral Imagery	Active Remote Sensing	Forest type or species differentiation, indicator of growth rate, vegetation cover and density, NDVI, soil types	Composition and thermal properties of ground, turbidity, temperature or pollution of lake and/or river
RADAR/LIDAR	Active Remote Sensing	Biomass, tree height	Degree of vulnerability of land to floods, landslide, erosion or subsidence
Ground Based Measurement	Ground	Calibration of RS, additional information (DBH, Carbon pools, allometric equations, BECF)	Timber, non-timber forest products, biodiversity, soil, water and air quality

Source : UNREDD, 2010

The assessment of spatial and temporal variability in the various benefits from the forest suggested that it has implications for the vulnerability of the system and local communities. The forest ecosystem and agro-ecosystem are the intrinsic for the local people to sustain their livelihood not for the goods and services from the forest and other ecosystem services but also to plan and mobilize their financial resources and economic activities. Most of the economic activities of the local people depend on forest, pasture and agro-ecosystems. Thus, the assessment of the various benefits from the forest and allied ecosystem are the basis of social and bio-physical vulnerability of the people in the context of changing climates (Chitale et al., 2014). Such an assessment could further develop and adopt appropriate adaptation strategies in a location specific manner. The AGB carbon stock is an indicator of the health of the forest which could be used for decision-making to balance mitigation option on the one hand and also adaptation alternatives on the other, by availing the goods and services from the forests.

The SOC stocks in the soil of each ecosystem type serves as a proxy for the long-term sequestration of the carbon, which reflects the climate change mitigation capacity and the productivity of the soil for food and livelihood security. The remote sensing data, such as first level products, i.e., raw image with ortho-rectification and derived products, i.e., Normalized Differential Vegetation Index (NDVI), Vegetation continuous Field (VCF), above ground and below ground carbon pools, SOC and other properties (HWSD) could play a useful role in quantifying the multiple benefits from forest and allied ecosystems.

Conclusions

The spatial variability of ecosystem services from the forest are observed from the analysis at different levels within and among the watersheds in terms of above ground forest carbon, below ground carbon, soil organic carbon and species richness. The local data collected from the field offers a basis to verify the global data derived from different remote sensing data such as Net Primary Productivity (NPP) of MODIS data.

The forests are the function of environmental and social interactions. Thus, it provides multiple benefits in terms of both carbon capture and co-benefits. Carbon sequestration helps to deal with the climate change mitigation where as co-benefits enables the adaptations of local communities to the impacts of climate change. The ecosystem services provided by forests include: tangible goods, water balance, carbon storage, biodiversity conservation and social mobilization. This study indicated that remote sensing data coupled with field measurements could be used to determine carbon, as well as, non-carbon benefits including ecosystem services and social systems to provide a complete picture of multiple benefits as a part of REDD+ mechanism.

Way Forward

In this study limited field plots were measured, thus the weak relationship of field measured parameters were observed with the remote sensing parameters. There is scope of field cruising with high sampling intensity and with the spatially well distributed samplings. The estimates can also be precise if we use high resolution satellite imageries either to represent ground scenario and for future projection. Besides the bio-physical benefits, the inclusion should be made non-carbon benefits in the analysis with spatially enabled system.

Acknowledgements

The authors gratefully acknowledge FORESC Project implementation at Kathmandu University in collaboration of Norwegian University of Life Sciences (UMB) for enabling this study. We also thank students and researchers at the Department of Environmental Science and Engineering who worked on this research and the contribution of AEC and ICIMOD colleagues for their valuable inputs. Last but not least we acknowledge the contribution of local farmers from different sites who offered their time and assisted in the field.

References

Baral, H., et al., (2012) Spatial assessment of ecosystem goods and services in complex production landscapes: A case study from south-eastern Australia. Ecol. Complex. (2012), http://dx.doi.org/10.1016/j.ecocom.2012.11.001

Bastos Lima,G. M., Braña-Varela, J., Gupta,A., Visseren-Hamakers , I., Huynh ,B. T., Kleymann , H., Dexter , V. K., Belecky, M. (2014). Promoting Non-carbon Benefits in REDD+ Actions. Policy Brief No. 1.

Bernardo, B. N., Strassburg., Agnieszka E., Latawiec ., Creed, A., Nguyen, N., Sunnenberg, G., Miles, L., Lovett, A., Joppa, L., Ashton, R., Scharlemann, J. W., Cronenberger, F., and Iribarrem, A. (2014). Biophysical suitability, economic pressure and land-cover change: a global probabilistic approach and insights for REDD+. Sustain Sci 9: page 129–141.

Chave et al., 2005 Tree allometry and improved estimation of carbon stocks and balance in tropical forests, Ecosystem Ecology, Oceologia, 145, pp 87-99

Chitale, V. S., Shrestha, H. L., Agarwal, N. K., Choudhurya, D., Gilani, H., Dhonju, H. K., and Murthy, M. S. R.: Forest climate change Vulnerability and Adaptation Assessment in Himalayas, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XL-8, 1291-1294, doi:10.5194/isprsarchives-XL-8-1291-2014, 2014.

Colwell, R. K., A. Chao, N. J. Gotelli, S.-Y. Lin, C. X. Mao, R. L. Chazdon, and J. T. Longino (2012). Models and estimators linking individual-based and sample-based rarefaction, extrapolation, and comparison of assemblages. Journal of Plant Ecology 5:3-21.

Dickson, B., and Kapos, V., (2012). Biodiversity monitoring for REDD+. (UNEP-WCMC), 219 Huntingdon Road, Cambridge, CB3 0DL, UK.

Doswald, N., Osti, M., Miles, L. (2010). Methods for assessing and monitoring change in the ecosystem-derived benefits of afforestation, reforestation and forest restoration. Multiple Benefits Series 6. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge.

FAO/IIASA/ISRIC/ISSCAS/JRC, 2012. Harmonized World Soil Database (version 1.2). FAO, Rome, Italy and IIASA, Luxemburg, Austria.

Hagelberg, N. (2013). Data needs & mapping the non-carbon benefits of REDD+, UN-REDD Programme. UNEP.

Hausler, T., Gomez, S., Siwe, R. (2012). Satellite Data and Monitoring Systems for REDD.

IIASA (2009). Reducing Emissions from Deforestation and Forest Degradation: A Systematic Approach. Schlossplatz 1, A-2361, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria

IPCC (2014), Climate Change 2014: IPCC Fifth Assessment Synthesis Report, Inter-Governmental Panel on Climate Change (IPCC)

IPCC, 2003. Good Practice Guidance for Land Use, Land Use Change and Forestry. Hayama, Kanagawa, Japan.

Kindermann, G.E., McCallum, I., Fritz, S. & Obersteiner, M. 2008. A global forest growing stock, biomass and carbon map based on FAO statistics. Silva Fennica 42(3): 387–396.

Lee, D., Granzin, S. J., Neeff, T., Göhler, D., Liss , M. B.,and Busch, A. (2011). Maximizing the Co-benefits of REDD-Plus Actions. Discussion paper for a Regional Expert Workshop supported by the German International Climate Initiative , Subic, Philippines.

Mackenzie, C., (2012). REDD+ SOCIAL SAFEGUARDS AND STANDARDS REVIEW . Forest Carbon, Markets and Communities Program (FCMC) Tetra Tech 159 Bank Street, Suite 300 Burlington, Vermont 05401 USA.

Miles, L., Kapos, V., Dunning, E. (2010). Ecosystem services from new and restored forests: tool development. Multiple Benefits Series 5. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge, UK.

Miles,L.,Trumper,K.,Osti,M.,Munroe,R., and Santamaria,C. (2012) UN-REDD Programme Policy Brief. REDD+ and the 2020 Aichi Biodiversity Targets Promoting synergies in international forest conservation efforts. Châtelaine, Geneva, Switzerland.

Mohren , MJ. G., Hasenauer, H., Köhl, M., and Nabuurs, J. G.(2012). Forest inventories for carbon change assessments. Current Opinion in Environmental Sustainability 4:686–695.

Moss, N., and Nussbaum, R., with input from Muchemi, J. and Halverson, E. (June 1, 2011). A REVIEW OF THREE REDD+ SAFEGUARD INITIATIVES. Jointly commissioned by the UN-REDD Programme and the Forest Carbon Partnership Facility's Facility Management Team.

Murphy, D., (2011). Safeguards and Multiple Benefits in a REDD+ Mechanism, International Institute for Sustainable Development 161 Portage Avenue East, Winnipeg, Manitoba, Canada.

Narloch, U., Bertzky, M., Kapos, V., Miles, L. (2012). Towards a holistic assessment of national REDD+ options:

Occasional Paper 81. CIFOR, Bogor, Indonesia.

Paudel, N.S., Khatri, D.B., Khanal, D.R. and Karki, R. (2013). The context of REDD+ in Nepal: Drivers, agents and institutions.

Pham, T.T., Brockhaus, M., Wong, G., Dung, L.N., Tjajadi, J.S., Loft, L., Luttrell C. and Assembe Mvondo, S. (2013). Approaches to benefit sharing: A preliminary comparative analysis of 13 REDD+ countries. Working Paper 108. CIFOR, Bogor, Indonesia.

Ravilious, C., Bertzky, M., Miles, L. (2011). Identifying and mapping the biodiversity and ecosystem-based multiple benefits of REDD+. A manual for the ExploringMultipleBenefits tool. Multiple Benefits Series 8. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge, UK.

Ravilious, C., Runsten, L. and Osti, M. (2013). Using spatial information to support decisions on safeguards and multiple benefits for REDD+. Step-by-step tutorial: How to georeference a scanned map or image with open source using QGIS 1.8. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge, UK.

REDD+ Safeguards Working Group (2014). NON-CARBON BENEFITS IN REDD+ PROVIDING INCENTIVES AND ADDRESSING METHODOLOGICAL ISSUES. 38th Session of the Subsidiary Body for Scientific and Technological Advice UN Framework Convention on Climate Change Bonn.

Rey, D., Roberts, J., Korwin, S., Rivera, L., Ribet, U. and Ferro, P. (2013). A Guide for Consistent Imple-mentation of REDD+ Safeguards. ClientEarth, London, United Kingdom.

Robert J. Whittaker, Katherine J. Willis and Richard Field (1977) Scale and species richness: towards a general, hierarchical theory of species diversity, Journal of Biogeography, 28, 453 - 470, University of Oxford, Mans®eld Road, Oxford, UK.

Sy , D. V., Herold ,M., Achard, F., Asner, P. G., Held4, A., Kellndorfer, J. and Verbesselt, J. (2012). Synergies of multiple remote sensing data sources for REDD+ monitoring. Current Opinion in Environmental Sustainability, 4:696–70.

Teobaldelli, M., Doswald, N., Dickson, B. (2010). Monitoring for REDD+: carbon stock change and multiple benefits. Multiple Benefits Series 3. Prepared onbehalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge, UK.

The Nature Conservancy and Union of Concerned Scientists (2014). Clarifying the Role of Non-Carbon Benefits in REDD+. Conservation International, Environmental Defense Fund, National Wildlife Federation, Rainforest Alliance,

UNREDD (2011). Identifying and mapping the biodiversity and ecosystem-based multiple benefits of REDD+ : A manual for the ExploringMultipleBenefits tool .

UN-REDD Programme. (2012). REDD+ Beyond Carbon: Supporting Decisions on Safeguards and Multiple Benefits. UN-REDD Programme Policy Brief; Oct. 10, 2012.

Väänänen, E., Runsten, L., Blyth, S., Mugumya, X., Mwebesa, M. and Mant, R. (2014). Supporting planning for multiplebenefits from REDD+ in Uganda: Exploring synergies with the Aichi Biodiversity Targets. UNEP-WCMC, Cambridge, UK. Available online at: http://wcmc.io/Uganda_REDD_multiple_benefits

World Bank (2008). Monitoring and Information Systems for Forest Management. in Forests sourcebook : practical guidance for sustaining forests in development cooperation / World Bank Chapter 7. p. cm. — (Agriculture and rural development)Page 243 – 247. ISBN 978-0-8213-7163-3 — ISBN 978-0-8213-7164-0 (electronic)

M. Herold (2009). An Assessment Of National Forest Monitoring Capabilities in Tropical Non-Annex I Countries: Recommendations for Capacity Building, Final Report submitted to The Prince's Rainforests Project and The Government of Norway.

Pearson, T R H, Brown, S. L. and Birdsey, R. A.(2007) Measurement Guidelines for the Sequestration of Forest Carbon, USDA FOREST SERVICE.

Sharma, E.R., Pukkala, T., (1990). Volume equations and biomass prediction of forest trees in Nepal. Forest Survey and Statistics Division.

Theme 4

Ecosystem and Biodiversity

Forest Biomass Carbon of Panchase: A Middle Mountain Forest Area

Ichchha Thapa[1*], Prakash Chandra Aryal[2] & Subin Kalu[1]

Abstract

The measurement and assessment of aboveground biomass carbon (AGBC) plays vital role in understanding the adaptation and interaction of trees with environment and its significant implications in global carbon cycle, climate change and forest management. This study analyzed AGB of 1385 trees along an altitudinal gradient of 1000 m in southern and northern aspects of Panchase Protected Forest Area. AGBC, mean dbh and tree abundance significantly increased along altitudinal gradient in both aspects explained by polynomial regression model and generalized linear model and was also correlated with soil pH, temperature and moisture. Soil pH was strongly and significantly correlated with AGBC in the north aspect. The species diversity was found comparatively high in the southern aspect. The results indicated that AGBC varied with spatial environmental gradients in middle mountain forest ecosystem. Continued measurements of the biomass over a long period could provide a potential basis for future forest management aspect and modeling of forest production under different varying climate and environmental conditions. For a good understanding of the past and better prediction of forest productivity, consideration of temporal gradient stands crucial.

Key words : Aboveground biomass carbon, altitudinal gradient, forest management, species diversity

Introduction

Forest has been the most important component of terrestrial ecosystem. Owing to anthropogenic impacts and changing climate, changes in forest dynamics has been rapid thus precise assessment of biomass changes and understanding of its causes stands crucial to sustain and enhance the multiple ecosystem services on which humanity depends on (Vayreda et al. 2012). Forest stores approximately 638 Gt carbon in ecosystem and 283 Gt carbon in biomass thus, global climate is found to be affected by the changes in carbon sequestered by the forest (Keeling and Phillips 2007). AGB, the most visible carbon pool of a terrestrial ecosystem

[1] *Central Department of Environmental Science, Tribhuvan University, Kirtipur, Kathmandu*

[2] *Master's Program in Environmental Science, Golden Gate International College, Kathmandu*

* *Corresponding Author : Email- ichchhathapa12@gmail.com*

(Gibbs et al. 2007) accounts for the significant proportion of total carbon pool of a tree with vital role in the global carbon cycling (Alves et al. 2010).

Thus, AGB is an important indicator to assess the status of ecosystem process and functioning as it provides a basis to understand the associated carbon sequestration patterns, ecosystem services and vegetation response to climate change (Kale and Roy 2012). AGB varies both along spatial and temporal scales which enables the potential of future research of carbon flux modeling on a regional basis (Laan et al. 2014). International treaties such as Kyoto Protocol and follow up protocols have also emphasized on the information on spatial distribution of forest and its associated biomass, which could be supported by an example, that change in forest biomass might occur without any change in forest area (Kindermann et al. 2008). A better understanding of the carbon fluxes in spatio-temporal scale is fundamental to interpret current patterns and future trends of productivity.

Mountains, with unique physiographic and topographic variability alters patterns of temperature, precipitation, wind circulation and influences regional and local climate forming local micro climates (Pan et al. 2013) which in turn governs forest biomass and productivity (Sharma et al. 2011). Nepal's middle mountain is not an exception of such diversified microclimates. Altitude and aspect have been known as an important proxy of the spatial variation of environmental factors influencing vegetation composition, structure and productivity (Stage and Salas 2007). Altitude corresponds wide array of climatic variables along with the varied soil properties (Sharma et al. 2009b).

Thus, studies pertaining to the vegetation responses along the spatial extent could reliably be used to predict the effect of rising temperature known as climate change as it reflects how the vegetation responds to the varying environmental conditions. Therefore, this study was carried out along the altitudinal gradient of the Middle Mountain Forest of Panchase with the objectives (i) To study the altitudinal and aspect variation in AGBC and species richness (ii) To correlate the AGBC with soil parameters

Methods

Study Area

This study was carried out in Panchase Mountain located in the middle mountain physiographic region spreading over three districts- Kaski, Parbat and Syangja in the Western Development Region of Nepal. Panchase Middle Mountain constitutes a crucial link as a corridor between the protected areas in lowland Chitwan National Park to the south and Annapurna Conservation Area to the north (Maren et al. 2013).

The Forest of Panchase Mountain, a national forest was designated as Panchase Protected Forest Area (PPFA) in 2011 recognizing its rich biodiversity, forest resources as well as spiritual and cultural values. Department of Forest has delineated 68.86% of forest as 'protected'. Of the total PPFA, 79 % has been handed over to 144 Community Forest User Groups (CFUGs) and 21 % as Government Managed Forests (GMFs) (GoN 2013).

The PPFA is bounded by 28°10'55" to 28°15'56" N latitude and 83°48'03" to 83°49'53" E longitude, covering a total area of 5775.73 hectares (ha) with buffered fringe area covering 3,740.60 ha and core area covering 2.035.13 ha above 900 m (GoN 2013). Four types of forest (i) Upper Mixed Hardwood (*Rhodendron-Daphniphyllum*) forest (ii) Chir Pine (*Pinus roxburghii*) forest (iii) Katus-Chilaune (*Schima-Castanopsis*) forest and (iv) Hill Sal (*Shorea robusta*) forest are predominant from 1450 m to 2517 m asl. Sub-tropical, warm temperate and cool temperate climatic zones characterizes the PPFA with average total precipitation of 4062 mm over the period of 25 years (1985-2010) and average annual temperature (1981-2011) range from 21°C to 11°C (GoN 2013).

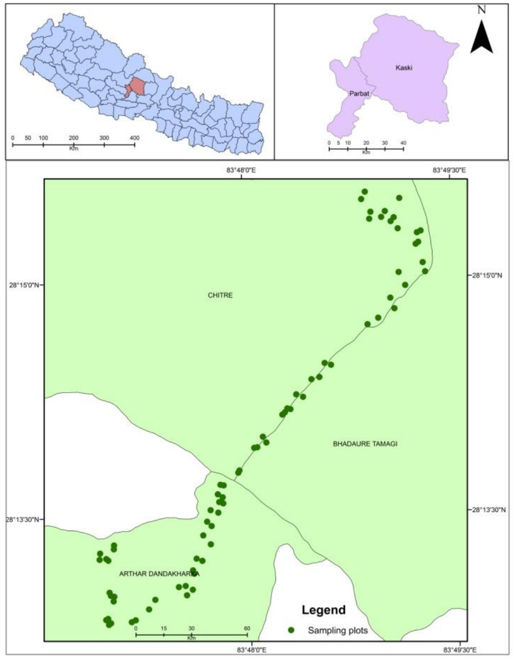


Figure 1 : Map of study area

Panchase Mountain as a sacred religious site also provides a multitude of cultural and aesthetic services. The ethnic composition is the indigenous Gurung and

Magar, together with Brahmin, Chhetri and Dalits with settlements located on middle to lower part of the Panchase Mountain.

Experimental Design

This study was conducted in October, 2013. PPFA was sampled using stratified random sampling where sampling plots were laid out along two different aspects (northern and southern) of Panchase Mountain. Two vertical transects were laid down on each aspect between altitudinal range from 1500 m to 2500 m. Then, each transect was stratified into altitudinal bands; each sampling plot vertically 50 m apart and at a distance of 10-20 m from the edge of the existing forest trail on either side to eliminate the sampling of the relatively disturbed vegetation (Hussain et al. 2008). A total of 76 plots (38 in northern and 38 in southern aspect) measuring 8.92 m radius (250 m^2) circular plots for trees and one nested plot of 0.56 m radius (1m^2) for herbs (Subedi et al. 2010) were laid down along two vertical transects in both aspect. The sampling points are shown in Figure 1.

Structural parameters including DBH (<10 cm), height of each tree and number of trees in each sampling plot were recorded. The AGB of each tree was then acquired using the allometric equations (Chave et al. 2005). The principal measure of species diversity was species richnes. Shrubs, seedlings, saplings, climbers and epiphytes were not included in the present study. Spherical densiometer was used for estimating the total canopy openness at the centre of the sampling plot in four different directions.

For the soil parameters, each transect was stratified into 5 homogenous bands of 200 m each. A total of 10 samples were taken from both aspects for the analysis of effect of edaphic factors on AGBC of the forest. Soil samples were collected with the help of core sampler from the depth 0–15 cm and 15–30 cm soil layers were collected and sealed in air-tight containers for laboratory analysis. Samples were then air dried and processed for further analysis (Trivedy and Goel 1984).

Table 1 : Laboratory analysis of soil parameters

S.N.	Soil Parameters	Methods/Instruments
1	Soil Temperature	Soil Thermometer
2	Soil Moisture	Gravimetric method
3	Soil pH	pH meter (Wagtech pH/mV/oC Meter)

Data Analysis

Structural parameters measurements were converted into estimates of coarse wood biomass, using allometric equations for moist forest stands, which is most widely accepted and recommended by Intergovernmental Panel on Climate Change (Chave et al. 2005). The wood density for the tree species was adopted from Manual of Afforestation in Nepal (Jackson 1994). The measured biomass was converted to the C content by multiplying with the IPCC (2006) default carbon fraction of 0.47. Most commonly used Shannon-Wiener Index (H') was used as the measure of diversity indices (Magurran 2004).

Statistical analysis was completed in R (R-CoreTeam 2013). Data exploration was used to study the nature and distribution of the forest stand characteristics and to explore the relationship between AGB, species richness and environmental variables. Regression and Generalized Linear Model (GLM) were used for the spatial variation in forest AGBC. Analysis of Variance (ANOVA) was used to test the models that better explained the relationship of the variables. The Karl Pearson Correlation was used to correlate edaphic factors and forest AGBC.

Results

The mean dbh distribution of trees was positively skewed in the northern aspect with mean dbh range of large number of trees ranged within 15 to 35 cm. Whereas, in the southern aspect reversed J shaped distribution of mean dbh for most of the trees ranged within 15 to 25 cm.

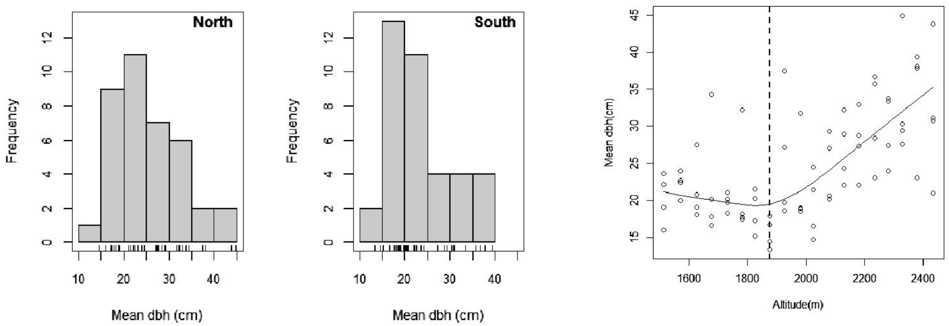


Figure 2 : Altitudinal variation in mean dbh and its distribution in different aspects

The mean dbh and altitude relationship was explained better by the polynomial regression model. Mean dbh of the trees was found to increase significantly ($P < 0.001$, $R^2 = 0.421$) by the rate of 0.0000291 cm with each metre rise in altitude.

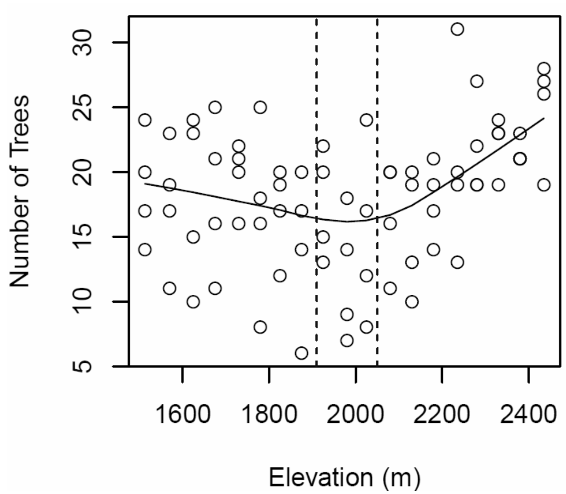


Figure 3 : Altitudinal variation in tree abundance

The relationship of tree abundance along the altitudinal gradient was observed through Generalized Linear Model because the relationship didn't fit to any other regression model. The number of trees was found to increase significantly ($P < 0.001$) after an altitude of 2025 m by the rate of 0.0002778 individual with each metre rise in altitude.

Table 1 : Observed and estimated species richness and diversity in different aspects

	Species Richness		
Aspect	Observed	Estimated (Jack2)	Shannon-Weiner Diversity Index (H')
North	24	25.998	2.463
South	25	29.918	2.625

Overall, the species diversity was found to be high in both the north (2.46) and south (2.62) aspects. Furthermore, as shown in (Table 1) the observed species richness was found to be 24 in the north and 25 in the south aspects. However, the jackknife estimator of species richness showed 26 and 30 species richness in the north and south respectively. The jackknife estimator reduces bias and estimates species richness independent of abundance of the species (Smith and Pontius 2006).

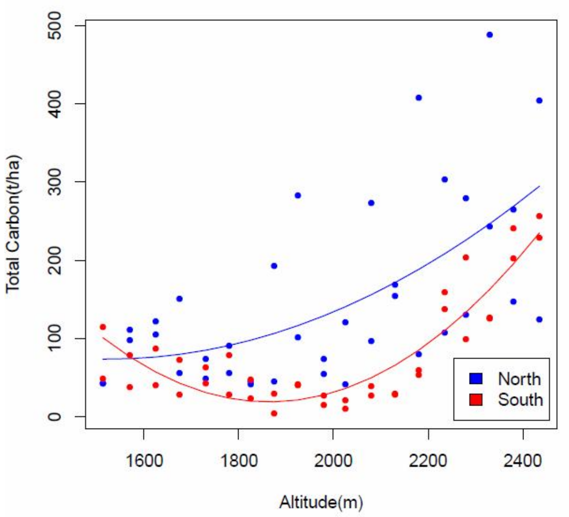


Figure 4 : Altitudinal variation in total AGBC in different aspects

The total above ground biomass carbon of the forest constitutes the aboveground biomass carbon of trees and biomass of LHG. Overall relationship was defined by polynomial regression (Figure 4). In the northern aspect, total AGB was found to increase significantly with the increase in altitude ($P < 0.001$, $R^2 = 0.378$) by the rate of 0.000267 t/ha with each metre rise in altitude. Similarly, in the southern aspect total AGB was also found to increase significantly with the increasing altitude ($P < 0.001$, $R^2 = 0.812$) by the rate of 0.000664 t/ha with each metre rise in altitude. Overall AGB was found to rise starting from an altitude of 1950 m in northern aspect whereas from 2,100 m in southern aspect.

Table 2 : Correlation analysis of AGB and soil parameters in North

	Soil temperature(°C)	Soil pH	Soil Moisture (%)
AGBC (ton/ha)	-0.982	0.998*	-0.080

**Correlation significant at 0.05 level*

Table 3 : Correlation analysis of AGB and soil parameters in South

	Soil temperature(°C)	Soil pH	Soil Moisture (%)
AGBC (ton/ha)	-0.903	-0.517	-0.135

In the northern aspect, AGBC as positively and significantly correlated with soil pH ($r = 0.998$, $P < 0.05$) only. In the southern aspect, soil pH, moisture and temperature were found to have negative and insignificant relation with the AGBC.

Discussion

In this study, it should be noted that altitude is treated as a way of presenting data along a gradient, not as a direct controlling factor (Girardin et al. 2014). Vegetation responds to varied changes in environmental factors such as precipitation, moisture, solar radiation, temperature, nutrient availability along rising altitude which in turn alters the microclimatic condition of forest (Kumar et al. 2013). Most of the studies have showed pattern of decreasing aboveground biomass with increase in altitude (Sundqvist et al. 2013). However, this study found an opposite pattern along 1000 m altitudinal gradient. Total AGBC was found to increase from lower to higher altitudes (Figure 4). The mean dbh was also found to have significant increasing trend from lower to higher altitudes (Figure 2). This might be due to the dominance of old growth temperate Oak forest characterized with large dbh at higher altitudes. The dbh distribution in studied forest patch was found to increase significantly after an altitude of 1900 m.

The increase in total AGBC could be related with increasing dbh because dbh stands as an important predictive parameter of biomass (Chave et al. 2005). The positive relationship between altitude and AGBC might also be due to the increase in walking distance from the nearest human settlement as the altitude rises because it has already been reported that villages occur between 1400 to 2000 m bordering the forest of Panchase (Maren et al. 2013). The Panchase Protected Forest Area (PPFA) within the vicinity of settlements and villages is buffered fringe areas designated as 'intensive use zone' (GoN 2013).

It is likely that forest in higher areas and conservation areas are less impacted by anthropogenic factors due to the difficulty in its access. Strong positive relationship was also found for AGBC and altitude in the study of conserved forests of Borneo supports this result (Laan et al. 2014). Furthermore, the PPFA also embrace multitude of cultural and aesthetic values as a sacred religious site. This notion of Panchase as a sacred site might have contributed to the conservation ethics of the local people for protecting forest patches which is supported by the findings from formal protected areas and 25 sacred grooves of Indian sub continent (Bhagwat et al. 2005). Thus, the increasing trend of AGB within altitudinal range of 1500-2500 m showed consistency with the above mentioned findings in different protected forests.

Tree abundance was found to decrease at mid altitude and increase significantly in temperate climatic zone along higher altitudes (Figure 3). This might be due to the past history which revealed that some patches at the mid lands in southern aspect of Government Managed Forests, suffered deforestation and were converted to tree less openings dominated by grasses and bushes (*Berberis* spp.) due to its free access (Maren et al. 2013) and anthropogenic pressure was also reported high at low and mid-altitudes (1750-2250 m) of Himalayan gradient in Eastern Nepal (Carpenter 2005). Tree abundance was also found higher at higher altitudes along Eastern Himalayan altitudinal gradient of India (Acharya et al. 2011). Thus, the increase in number of trees in higher altitudes might be due to the zoning of core protection in higher altitudes and the conservation ethic driven by cultural values.

Species diversity and species richness was found higher in this study (Table 1). Shannon Weiner's index values ranging from 2.476 to 2.624 is in accordance with the values reported for other temperate forests (Sharma et al. 2009b; Sharma and Raina 2013). Little changes have been found in species richness and diversity between 1500-2500 m in Nepalese Himalayas (Grytnes and Vetaas 2002). Thus, the results for the altitudinal variation in forest stand structure, richness and biomass are in parallel with other findings within altitudinal range of 1500-2500 m (Acharya et al. 2011; Bhagwat et al. 2005; Culmsee et al. 2010; Laan et al. 2014; Maren et al. 2013; Sharma and Raina 2013).

Aspect has been found to exert significant influence on soil moisture and spatial distribution characteristics of vegetation of forest ecosystem by forming a range of microclimates in multifaceted landscapes (Astrom et al. 2007; Gallardo-Cruz et al. 2009; Olivero and Hix 1998; Sharma et al. 2011; Sharma et al. 2010; Sternberg and Shoshany 2001).

Distribution of trees under different dbh classes was skewed to right in both aspects of Panchase Mountain which was comparable with the peak at dbh class of 15 to 25 cm (Figure 2). Relatively small number of trees can be expected to have high dbh. In comparison, large number of trees with high dbh range indicated that the forest is dominated by the large trees and somewhat at matured stage in the northern aspect. Whereas in the southern aspect, the pattern of most of the trees in smaller dbh range revealed that the forest is dominated by relatively small girth trees and the forest is still in developing phase.

This might be due to reported notion of local people of Panchase that there used to be severe forest deforestation and degradation in the past during open access GMFs and the consequence was even more intensified along steep terrain in southern aspect (Maren et al. 2013). This could be the reason behind the regenerative phase of forest in southern aspect after the designation of forest as protected forest. In general, trees growing on southern aspect are also exposed to harsh and drier climatic conditions and are prone to various natural disturbances which hinders their growth (Sharma et al. 2010).

This differences of dbh in different aspects might be attributed to the occurrence of moisture and more favorable opportunities for growth of tree species on the northern aspect as reported by (Sharma et al. 2010; Sharma and Raina 2013). Steep slopes considerably limits the plant growth (Gallardo-Cruz et al. 2009). This observation is in parallel with results of previous study in Panchase (Maren et al. 2013) as well as with the findings of (Sharma et al. 2011) which reported higher values of stem density on southern aspects.

Based on the differences in dbh, aspect wise variation in total AGBC could be expected. AGBC was found to comparatively higher in northern and southern aspect (Figure 4). Distribution and presence of relatively tall and high girth trees in northern aspect might have resulted in high AGBC content. Decrease in AGB was found to be driven by decrease in tree height and increase in stem density in Andean forests (Girardin et al. 2014). Studies in temperate forests of Himalayas have reported significant higher values of tree biomass on northern aspects compared to southern aspects which were attributed with relatively cooler and favorable climate for tree growth and facilitates accumulation of large amount of biomass on these aspects (Sharma et al. 2011; Sharma et al. 2010). Total AGB was also found higher in north facing slopes than the south facing slopes in Mediterranean (Sternberg and Shoshany 2001).

Maren et al. (2013) reported the prevalence of tree less openings dominated by bushes in some patches at the mid altitudes in southern aspect as a consequence of deforestation in the past history. Despite its gregariousness and exceptionally hard wood of Oak species, persists in the form of scrub when exposed to adverse disturbances (Sharma et al. 2009a). This might be the reason behind lower AGBC in the southern aspect.

Ample literatures have acknowledged that environmental heterogeneity has been recognized as one of the explanations for variation in species diversity (Panthi et al. 2007; Sharma et al. 2009b; Sharma and Raina 2013). Species diversity and both observed and estimated species richness was found to be higher in southern aspect comparative to northern aspect (Table 1). This might be due to the dominance of *Daphniphyllum himalense* from lower to higher belts of north facing slopes. Stainton (1972) reported *Daphniphyllum himalense*, a successional species likely to colonize fallow lands near settlements and appeared to be replacing Oak-Rhododendron forest to Daphniphyllum- Rhododendron forest at higher altitudes (Maren et al. 2013).

The findings of aspect variation in species richness in this study is in contrast with the findings of Panthi et al. (2007) from trans-Himalayan inner valley of Central Nepal. However, the occurrence of comparatively high species richness in warmer southern aspect has been supported by findings from north western Himalayas (Sharma and Raina 2013).

Although ample evidences have been observed for diversity-productivity relationship (DPR), however various factors are likely to affect the relationship (Jacob et al. 2010; Morin et al. 2011; Vilà et al. 2005; Waide et al. 1999; Zhang et al. 2012; Zhang et al. 2011). High diversity has been reported to cause high production of AGB (Vilà et al. 2005; Zhang et al. 2012).

Relating these findings with the observed findings of this study, overall high species richness and diversity in both aspects might also be the reason for high AGBC. However, while comparing DPR in two different aspects, higher AGBC has been found for northern aspect despite its low species richness and diversity relative to southern aspect. This contrast might be due to the past disturbance and management regime of the forest in different aspects, some of which have already been discussed above and is in parallel with other studies in temperate and sub-alpine forests (Jacob et al. 2010; Zhang et al. 2011).

Studies in Asia have found relatively weak relationship between soil temperature and AGB and are governed by varying cofactors (Lewis et al. 2014). Soil pH was found to have strong and significant positive correlation with AGBC ($r < 0.5$) in northern aspect (Table 2) whereas, negative and insignificant correlation with AGBC in southern aspect (Table 3). This finding is supported by (Panthi et al. 2007) which relates soil pH with availability of soil nutrients. The north aspect was characterized by the sufficient soil temperature and the humidity which might aid the decomposition rate and resulted in high nutrient content. Furthermore, hundreds of non-milk-yielding buffaloes are found grazing in the forest of Panchase all year round (Maren et al. 2013). The occurrence of their faecal matter could also have aided in high organic matter in the forest.

As Lewis et al. (2014) stated that the impact of various soil properties on AGB is highly complex and since we do not fully understand the mechanisms that create and maintains AGBC with soil parameters, based on the correlation analyses alone, it is difficult to jump into concrete conclusions.

Conclusion and Recommendation

Middle mountain forests represent an ideal laboratory for detecting the changes in forest ecosystem structure and various environmental parameters. The forest stand in the north represented a good forest stand with even aged trees whereas the forest stand in south represented a regenerative forest. This study as a baseline research in Panchase has documented the biomass production status of

the forest in different aspects. Continued measurements of the biomass over a long period could provide a potential basis for future forest management aspect and modeling of forest production under different varying climate and environment. The dominancy of *Daphniphyllum himalense* in the forest of Panchase has been found to shift upwards to replace native Rhododendron-Oak forests and could possibly have negative consequences on the species diversity of the forests. Further, the observed decrease in tree number and low AGB in the southern aspect supports the previous findings of degraded forest. Thus, based on the findings of this study and the literatures reviewed, higher species diversity needs to be maintained for the promotion of resilient forest ecosystem to buffer out the impacts and disturbances associated with changing environmental conditions.

This study somehow presents an understanding of the AGBC along altitudinal gradient and different aspects. In addition, multitude of ecosystem services provided by the forests needs to be sustained through integration of biomass production estimates in changing environmental conditions and maintenance of diversified species which might buffer out the impacts and associated changes in the environment in forest management strategy which would form the natural solution for the ecosystem adaptation. A comprehensive study of all carbon fluxes of the forest ecosystem and in temporal scale would unarguably increase the understanding of current patterns and predicting the future trends of forest productivity.

Acknowledgements

We would like to acknowledge the Enhance knowledge on Ecosystem based Adaptation through research and integrate them in curriculum Project for the research fellowship. We would like to thank the Panchase Protected Forest Committee for providing the permission to carry out this research in Panchase and the people of Panchase for their benign co-operation. We also are thankful to the Central Department of Environmental Science for providing the platform for the research.

References

Acharya, B. K., Chettri, B., and Vijayan, L. (2011). "Distribution pattern of trees along an elevation gradient of Eastern Himalaya, India." *Acta Oecologica*, 37, 329-336.

Alves, L. F., Vieira, S. A., Scaranello, M. A., Camargo, P. B., Santos, F. A. M., Joly, C. A., and Martinellic, L. A. (2010). "Forest structure and live aboveground biomass variation along an elevational gradient of tropical Atlantic moist forest (Brazil)." *Forest Ecology and Management*, 260, 679-691.

Astrom, M., Dynesius, M., Hylander, K., and Nilsson, C. (2007). "Slope aspect modifies community responses to clear-cutting in boreal forests." *Ecology*, 88(3), 749–758.

Bhagwat, S. A., Kushalappa, C. G., Williams, P. H., and Brown, N. D. (2005). "The role of informal protected areas in maintaining biodiversity in the Western Ghats of India." *Ecology and Society*, 10(1).

Carpenter, C. (2005). "The environmental control of plant species density on a Himalayan elevation gradient." *Journal of Biogeography*, 32, 999-1018.

Chave, J., Andalo, C., Brown, S., Cairns, M. A., Chamber, J. Q., Eamus, D., lster, H. F., Fromard, F., Higuchi, N., Kira, T., Lescure, J.-P., Nelson, B. W., Ogaw, H., Puig, H., Rie´ra, B., and Yamakura, T. (2005). "Tree allometry and improved estimation of carbon stocks and balance in tropical forests." *Oecologia*, 145, 87-99.

Culmsee, H., Leuschner, C., Moser, G., and Pitopang, R. (2010). "Forest aboveground biomass along an elevational transect in Sulawesi, Indonesia, and the role of Fagaceae in tropical montane rain forests." *Journal of Biogeography*, 37, 960-974.

Gallardo-Cruz, J. A., Perez-Garcıa, E. A., and Meave, J. A. (2009). "Beta-Diversity and vegetation structure as influenced by slope aspect and altitude in a seasonally dry tropical landscape." *Landscape Ecology*, 24, 473–482.

Gibbs, H. K., Brown, S., Niles, J. O., and Foley, J. A. (2007). "Monitoring and estimating tropical forest carbon stocks: Making REDD a reality." *Environmental Research Letters*, 2, 13.

Girardin, C. A. J., Farfan-Rios, W., Garcia, K., Feeley, K. J., Jørgensen, P. M., Murakami, et al. (2014). "Spatial patterns of above-ground structure, biomass and composition in a network of six Andean elevation transects." *Plant Ecology & Diversity*.

GoN. (2013). Ecosystem and Ecosystem Services of Panchase: An Overviews. GoN.

Grytnes, J. A., and Vetaas, O. R. (2002). "Species Richness and Altitude: A Comparison between Null Models and Interpolated Plant Species Richness along the Himalayan Altitudinal Gradient, Nepal." *The American Naturalist*, 159(3), 294-304.

Hussain, M. S., Sultana, A., Khan, J. A., and Khan, A. (2008). "Species composition and community structure of forest stands in Kumaon Himalaya, Uttarakhand, India." *Tropical Ecology* 49(2), 167-181.

IPCC. (2006). IPCC Guidelines for National Greenhouse Gas Inventories Volume - IV Agriculture, Forestry and other and-use. Institute of Global Environmental Strategies (IGES), Hayama, Japan.

Jackson, J. K. (1994). "Manual of Afforestation in Nepal", D. o. Forest, (ed.). City: Forest Survey and Research Office: Kathmandu, Nepal.

Jacob, M., Leuschner, C., and Thomas, F. M. (2010). "Productivity of temperate broad-leaved forest stands differing in tree species diversity." *Ann. For. Sci.* , 67.

Kale, M. P., and Roy, P. S. (2012). "Net Primary Productivity estimation and its relationship with tree diversity for tropical dry deciduous forests of central India." *Biodiversity Conservation*, 21, 1199-1214.

Keeling, H. C., and Phillips, O. L. (2007). "The global relationship between forest productivity and biomass." *Global Ecology and Biogeography*, 16(618-631).

Kindermann, G. E., McCallum, I., Fritz, S., and Obersteiner, M. (2008). "A Global Forest Growing Stock, Biomass and Carbon Map Based on FAO Statistics." *Silva Fennica*, 42(3), 387-396.

Kumar, S., Kumar, M., and Sheikh, M. A. (2013). "Carbon Stock Variation of Pinus roxburghii Sarg. Forest Along Altitudes of Garhwal Himalaya, India." *Russian Journal of Ecology*, 44(2), 131-136.

Laan, C. V. d., Verweij, P. A., Quiñones, M. J., and Faaij, A. P. (2014). "Analysis of biophysical and anthropogenic variables and their relation to the regional spatial variation of aboveground biomass illustrated for North and East Kalimantan, Borneo." *Carbon Balance and Management* 9(8).

Lewis, S. L., Sonke, B., Sunderland, T., Begne, S. K., Lopez-Gonzalez, G., Heijden, et al. (2014). "Above-ground biomass and structure of 260 African tropical forests." *The Royal Society B*.

Magurran, A. E. (2004). "Measuring Biological Diversity". City: Blackwell Science Ltd.: United Kingdom.

Maren, I. E., Bhattarai, K. R., and Chaudhary, R. P. (2013). "Forest ecosystem services and biodiversity in contrasting Himalayan forest management systems." *Environmental Conservation*.

Morin, X., Fahse, L., Scherer-Lorenzen, M., and Bugmann, H. (2011). "Tree species richness promotes productivity in temperate forests through strong complementarity between species." *Ecology Letters*, 14, 1211–1219.

Olivero, A. M., and Hix, D. M. (1998). "Influence of aspect and stand age on ground flora of southeastern Ohio forest ecosystems." *Plant Ecology* 139, 177–187.

Pan, Y., Birdsey, R. A., Phillips, O. L., and Jackson, R. B. (2013). "The Structure, Distribution, and Biomass of the World's Forests." *Annu. Rev. Ecol. Evol. Syst.* , 44, 593–622.

Panthi, M. P., Chaudhary, R. P., and Vetaas, O. R. (2007). "Plant species richness and composition in a trans-Himalayan inner valley of Manang district, Central Nepal." *Himalayan Journal of Science*, 4(6), 57-64.

R-CoreTeam. (2013). "R: A language and environment for statistical computing". City: R Foundation for Statistical Computing: Vienna, Austria.

Sharma, C., Gairola, S., Baduni, N., Ghildiyal, S., and Suyal, S. (2011). "Variation in carbon stocks on different slope aspects in seven major forest types of temperate region of Garhwal Himalaya, India." *Jounal of Bioscience*, 36(4), 701-708.

Sharma, C. M., Baduni, N. P., Gairola, S., Ghildiyal, S. K., and Suyal, S. (2010). "Effects of slope aspects on forest compositions, community structures and soil properties in natural temperate forests of Garhwal Himalaya." *Journal of Forestry Research* 21(3), 331−337.

Sharma, C. M., Ghildiyal, S. K., Gairola, S., and Suyal, S. (2009a). "Vegetation structure, composition and diversity in relation to the soil characteristics of temperate mixed broad-leaved forest along an altitudinal gradient in Garhwal Himalaya." *Indian Journal of Sciene and Technology*, 2(7), 39-45.

Sharma, C. M., Suyal, S., Gairola, S., and Ghildiyal, S. K. (2009b). "Species richness and diversity along an altitudinal gradient in moist temperate forest of Garhwal Himalaya." *Journal of American Science*, 5(5), 119-128.

Sharma, N., and Raina, A. K. (2013). "Composition, structure and diversity of tree species along an altitudinal gradient in Jammu province of north-western Himalayas, Jammu and Kashmir, India." *Journal of Biodiversity and Ecological Sciences*, 3(1), 6-14.

Smith, C. D., and Pontius, J. S. (2006). "Jackknife Estimator of Species Richness with S-PLUS." *Journal of Statistical Software*, 15(3).

Stage, A. R., and Salas, C. (2007). "Interactions of Elevation, Aspect, and Slope in Models of Forest Species Composition and Productivity." *Forest Science* 53(4), 486-492.

Sternberg, M., and Shoshany, M. (2001). "Influence of slope aspect on Mediterranean woody formations: Comparison of a semiarid and an arid site in Israel." *Ecological Research* 16(2), 335-345.

Subedi, B. P., Pandey, S. S., Pandey, A., Rana, E. B., Bhattarai, S., Banskota, T. R., Charmakar, S., and Tamrakar, R. (2010). *Forest Carbon Stock Measurement: Guidelines for measuring carbon stocks in community- managed forests*. Asia Network for Sustainable Ariculture and Bioresources (ANSAB), Federation of Community Forest Users (FECOFUN), International Centre for Integrated Mountain Development (ICIMOD) and Norwegian Agency for Development Cooperation (NORAD), Kathmandu, Nepal.

Sundqvist, M. K., Sanders, N. J., and Wardle, D. A. (2013). "Community and Ecosystem Responses to Elevational Gradients: Processes, Mechanisms, and Insights for Global Change." *Annual Review of Ecology, Evolution and Systematics*, 44, 261-280.

Trivedy, R. K., and Goel, P. K. (1984). *Chemical and biological methods for water pollution studies*, Karad, India: Environmental Publications.

Vayreda, J., Gracia, M., Canadell, J. G., and Retana, J. (2012). "Spatial Patterns and Predictors of Forest Carbon Stocks in Western Mediterranean." *Ecosystems*, 15, 1258–1270.

Vilà, M., Inchausti, P., Vayreda, J., Barrantes, O., C Gracia, Ibáñez, J. J., and Mata, T. (2005). "Confounding Factors in the Observational Productivity–Diversity Relationship in Forests", in D. D. Czeschlik, (ed.), *Forest Diversity and Function: Temperate and Boreal Systems*. New York: Springer-Verlag Berlin Heidelberg, pp. 65-83.

Waide, R. B., Willig, M. R., Steiner, C. F., Mittelbach, G., Gough, L., Dodson, S. I., Juday, G. P., and Parmenter, R. (1999). "The Realtionship between Productivity and Species Richness." *Annu. Rev. Ecol. Syst.* , 30, 257–300.

Zhang, Y., Chen, H. Y. H., and Reich, P. B. (2012). "Forest productivity increases with evenness, species richness and trait variation: a global meta-analysis " *Jouurnal of Ecology*, 100(3), 742-749.

Zhang, Y., Duan, B., Xian, J., Korpelainen, H., and Li, C. (2011). "Links between plant diversity, carbon stocks and environmental factors along a successional gradient in a subalpine coniferous forest in Southwest China." *Forest Ecology and Management*, 262, 361-369.

Evaluating Carbon Stocks and Plant Biodiversity Relationship in Tree outside Forests of Terai, Nepal

Ram Asheshwar Mandal[1]*, Bijay K. Yadav[2], Sujit K. Jha[3] and Ramesh K. Giri[4]

Abstract

Tree outside forests (ToFs) is major source of timber and firewood for farmers living distant from the forests in Tarai (plain), Nepal. Importantly, the ToFs can also reduce the pressure on natural forests which may be the potential candidate under Reducing Deforestation and Forest Degradation (REDD+) mechanism so carbon stock assessment is essential. Equally, biodiversity conservation is other significant global concern but no any study was done yet to assess the relationship between carbon stock and plant biodiversity especially in ToFs. Thus this research has main objective to assess the relationship between carbon stock and plant biodiversity. Altogether, 161 sample plots of 10m*10m quadrates were established using Global Positioning System (GPS) coordinates and collected from ToFs of Pipara and Sahodawa villages of Mahottari district maintaining 1% sample intensity applying multistage random sampling. Height and diameter at breast height (DBH) of plants were measured, soil samples were collected from 0-0.1, 0.1-0.3 and 0.3-0.6m depths and species were counted. Biomass was calculated using equation of Chave et al and converted into carbon. The soil carbon was analyzed in laboratory. After estimating the biodiversity indices, the relationship between carbon and biodiversity was developed. The estimated carbon stock of ToFs was the highest 65.57 t ha^{-1} in rich households in Pipara village while it was the lowest 43.30 t ha^{-1} in poor households in Sahodawa village. The values of Shannon-Weiner Biodiversity Index ranged 1.66-2.08 and no any significant relationship existed between carbon stock and biodiversity. Thus, the REDD+ mechanism should emphasize on biodiversity conservation.

Key words: tree outside forests, biodiversity, carbon, REDD+

[1] *Ph D candidate Trichandra College, Kathmandu.*

[2] *Assistant Forest officer, department of forests.*

[3] *Department of Forests, Babarmahal, Kathmandu.*

[4] *Assistant Forest Officer Department of Forests*

* *Corresponding Author : Email- ram.mandal@gmail.com*

Introduction

Trees outside forests (ToFs) mean the trees available on trees outside the forests which are generally detached with the contiguous forest block like trees on alley, orchard, park, bank of the pond, canal, lake and river, along roadside, home garden, office compound, agricultural land and parks. FAO defined ToF as trees available on lands which is not defined as 'forests' or 'other wooded land' (FAO 2005). In India, ToF is defined as all those trees, which have attained 10 cm or more diameters at breast height, available on land, which is not notified as forests (FSI 2011). Though, there is no any legal definition of ToF in Nepal, it includes the tree in other wooded land than the forest (DFRS/FRA, 2014).

Tree outside forests (ToF) is the major source of timber and firewood for farmers (Longi et al, 1999, Singh et al, 2012) living distant from the forests in Tarai (plain) Nepal, because they have not enough and easy alternatives to meet their demand of forest products. The consequences are reducing the pressure on natural forest in one way and carbon enhancement and species diversity in other way (Singh et al, 2009, Thompson, et al, 2009). This can meet the important goal of Reducing Emission from Deforestation and Forest Degradation (REDD+) mechanism.

Record of carbon is the main threat to carbon stock and biodiversity. Annually, there was -5.2 million ha of forest loss in the world between 2000 and 2010. It was more than 0.9 million ha forest area shrink in Southeast Asia in the last 10 years (FAO, 2010). The estimated annual deforestation was 16,500 ha in Terai forest in between 2001 to 2010. Meanwhile, the recorded forest cover loss was 32,000 ha between1991 to 2010. Thus, the annual deforestation rate was 0.44% and 0.40% between 2001 to 2010 and 1991 to 2010 respectively (FRA/DFRS, 2014). Infact, the depletion in forest affects negatively on carbon stocks and biodiversity together (Sedjo, 2001).

Plantation in trees outside forest has been playing positive roles in carbon enhancement and biodiversity conservation (Leah, et al, 2010). Globally, estimated total plantation area was 264 million ha in 2010 which has capacity to store about 1.5 gigatonnes of carbon annually. Specifically, almost half of the agricultural land has trees cover more than 10% in the world (more than 1 billion ha), they are ToF. Net gain of forest was reported more than 2.2 million ha per year in Asia between 2000 to 2010 because of large scale of afforestation in China (FAO, 2010). Though, there was no clear record of ToF in Nepal, mostly the private plantation is considered as ToF. Estimated record of ToF was 10,240 ha in the country (DoF, 2005). These all plantations offer to store and capture the carbon and ultimately support to ease the people's pressure on national forests

(Gibbs et al, 2007), this concept is aligned with the main purpose of REDD+ mechanism (Skutsch et al, 2009, Corbera, 2010). But, it is fact that the choice of species for plantation clearly depends up on the farmer's preference and value of the products. The consequence may be monoculture species which is the major threat to biodiversity.

The over exploitation of forest and impacts of climate change are creating a great threat to plant species. Approximately 8000 tree species, or 9% of the total number of tree species worldwide are under threat of extinction (Singh et al, 2005). The continuous deforestation is the high threat for the biodiversity in the tropics (FAO, 2010). Though, the land surface area of Nepal is only 0.1 % of the world's area, she harbors 136 ecosystems, about 2 % of the flowering plants, 3 % of the pteridophytes, and 6 % of bryophytes of the world's flora. Unfortunately, 8 species are suspected to be extinct, 1 species is endangered, 7 species are vulnerable and 31 species fall under the IUCN rare species category in Nepal (MFSC, 2000).

Infact, the REDD+ mechanism has primarily focus on the carbon enhancement but biodiversity is considered as co-benefit. It may mislead the understanding of valuing the biodiversity compared to carbon while they have parallel importance under United Nations Framework Convention on Climate Change (UNFCCC). In addition, establishment of monitoring reporting and verification (MRV) and reference emission level and assessing the strategy of social and environmental impacts assessment (SESA) need robust and intensive data of forest carbon and biodiversity (Corbera et al, 2010). Besides, biophysical characteristics of forest are generally correlated to the forest carbon stock. Hence, a remarkable question is raised that, whether there is any relationship between the carbon stock and biodiversity in ToF? This research tries to answer this question because such research has not been done yet in ToF especially in Tarai (plain), Nepal. Therefore, the objective of the research is to assess the carbon stock and biodiversity of ToF and relationship between them.

Materials and Methods

Research site: Pipara and Sahodawa villages were selected for the study sites (Figure 1) which are situated far from the forest in Mahottari district, Nepal. This district lies in 26° 36' to 28°10' N and 85°41' to 85° 57' E. It has tropical and subtropical climate. The record of minimum temperature shows 20°C and maximum 45°C and the average annual rainfall has been recorded between 1100-3500 mm however they are not common every year.

There were about 28 tree species in ToF in both villages. The most dominant species were Mangifera indica, Eucalyptus camaldulensis, Dalbergia sissoo, Tectona grandis while other species were Psidium guajava, Syzygium cumini, Gmelina arborea, Dalbergia latifolia.

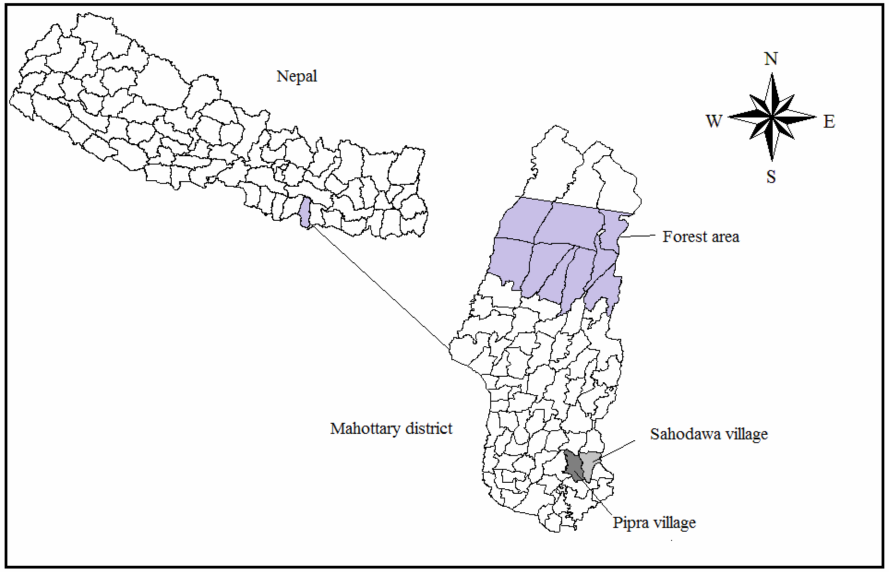


Figure 7 : Map of research site of ToF in Sahodawa and Pipara villages

Data collection: Basically, socioeconomic and biophysical data were collected for this research work.

<u>Socio- economic data:</u> Due to diverse nature of ToF area, total households were categorized into three main groups: rich, medium and poor. Generally, large sizes (areas > 0.17 ha) of ToF owned by rich family while home garden belonged to poor family semi orchard (areas < 0.17 ha and home orchard too) were with medium family. Thus, after collecting the record of total households of Pipara and Sahodawa villages, they were categorized into rich, medium and poor family applying participatory well being ranking process. The criteria for dividing household category were types of house, employment, land holding, cattle keeping, education, income source (business) and food security (Chapagain and Banjade, 2009). If household has annual income about US$ 1000- 2000, Khapada (roofing burnt clay tile), 1 employee, 1 ox and 1 cow and educational qualification at least class 10 pass are categorized under medium family while having more than that grouped under rich and less than that are kept under poor household

(HH). There were 454, 576 and 605 HHs in rich, medium and poor respectively in Pipara village while they were 420, 540 and 540 correspondingly in Sahodawa village. The purpose of this is to conduct design the experiment and carry out the representative sampling.

Next, list of ToF holding farmers were prepared and their ToF areas were recorded. Then considering the ToF areas as a sample unit or one block, 1% sample area of ToF from each household category were sampled applying multistage random sampling. Thus the randomized block design (RBD) was set. About 31, 29 and 23 samples were collected from ToF of rich, medium and poor HHs respectively of Pipara village. Similarly, 27, 27 and 24 samples were collected from that of rich, medium and poor HHs correspondingly of Sahodawa village. Total area of ToF was 66.00 ha, in Pipara village, Out of this 23, 15, 8 ha were with rich, medium and poor HHs correspondingly in this village while total it was 66 ha in Sahodawa village out of this 38, 21 and 7 ha were with rich, medium and poor HHs correspondingly.

Biophysical data : The centre point coordinates of selected ToF areas were located on the map for samples and their coordinates were uploaded to GPS reciever. Then, rectangular sample plots for tree, pole and sapling (dbh>5cm) of 10m*10m and sapling (dbh<5cm) and seedling, herbs and grasses of 5m*5m were established. The height and diameter at breast height were measured and recorded. Then, sapling (5cm >dbh >1cm), seedlings, herbs and shrubs were counted and fresh weights of their samples were recorded (Mandal et al., 2013). Simultaneously, soil samples were also collected from three different depths 0-0.1, 0.10-0.3 and 0.3-0.6m in order to determine the soil carbon (Eggleston, 2006). Meanwhile, the list of tree species was prepared to assess the biodiversity.

Data Analysis:

Calculation of carbon: It is prerequisite to estimate the forest biomass for calculation of the carbon except soil. Therefore, the Above Ground Tree dry Biomass (AGTB in kg) was determined by using

$AGTB = 0.0509x\ \rho\ D^2H$ (Chave et al, 2005)

where D is the diameter at breast height (cm), H is the height of the tree (m) and ρ is wood density (g/cc).

Moreover, the biomass of dbh<5cm was quantified applying equation developed by Tamrakar's (2000) but this equation gives only the fresh weight so collected

related samples were dried in the laboratory at 105 ^{0}C until they showed the constant weight.

$Ln\ (AGSB) = a + b\ ln\ (DBH)$

Where AGSB represents the above ground sapling biomass (kg), Ln is natural log, a & b are constants, DBH (cm) is diameter at breast height.

Similarly, dry weight of samples of seedling, leaf litter, herbs and grass (LHG) were recorded. Additionally, the root shoot ratio 0.125 was used to calculate the root biomass (MacDicken, 1997). The multiplying factor 0.47 was used to convert the biomass into carbon (Chabbra, 2002)

Soil carbon was estimated by applying the Walkley Black Method (Walkley et al., 1958).

Bulk Density (BD g/cc) = (oven dry weight of soil)/ (volume of soil in the core)

SOC= Organic Carbon Content % * Soil Bulk Density (Kg/cc) * thickens of horizon.

Total Carbon= Total Biomass carbon + Soil carbon (Mini, 2011)

Biodiversity calculation: biodiversity indices were calculated using following formulae.

Species richness S: is the number of species in the community or sample

Simpson's evenness $E = \frac{D}{S}$, Where *D* is the Simpson's diversity index, *S* is the species richness

Shannon-Weiner Biodiversity Index, $H = -\sum_{i=1}^{s}(pi)(\ln pi)$, where pi is the total individuals in a species community (Barlow et al, 2007).

Relationship between carbon (biomass) and biodiversity: Regression analysis was carried out to determine the correlation between carbon stock and biodiversity. For this, only biomass carbon was used. So, the relationship between carbon stock and species richness as well as carbon stock and Simpson evenness was developed so that REDD+ policy implication may be worthwhile.

Statistical analysis: Likewise, only total carbon stock was used for statistical analysis. The variation in carbon of ToF belonging to different household categories were tested applying one way ANOVA, Tukey’s test and t-test by using software EBM SPSS 21 (Rocky et al, 2012).

Results and Discussion

Types of Plantation and Species:

There are four types of plantations in Tree outside forests in Nepal. The Alley plantation, Orchard plantation, Homestead garden which are owned mainly by private owners and and Public plantation that is owned by other institutions like school, VDC, and government offices. Mainly, *Dalbergia sissoo, Eucalyptus camaldulensis, Aziderácta indica* are very common in alley plantation while *Mangifera indica, Dalbergia sissoo, Eucalyptus camaldulensis* are very widespread in orchard plantation. Similarly, *Psdium guajva, Phoenix humilis, Litchi chinensis* and *Anthocephalus chinensis* are regular in homested garden (table 1).

Table 1 : List of species in TOFs

Types of plantation	Species planted	Remarks
Alley plantation	*Dalbergia sissoo, Eucalyptus camaldulensis, Aziderácta indica*	Private land
Orchard plantation	*Mangifera indica, Dalbergia sissoo, Eucalyptus camaldulensis, Artocarpus lakoocha, Artocarpus heterophyllus, Ceiba pentendra, Leucaena leucocephala, Azadirachata indica, Cocos nucifera, Gmelina arborea, Bauhinia purpuria, Syzygium cumini, Madhuca indica, Bombax ceiba*	
Home garden	*Mangifera indica,Psdium guajva, Phoenix humilis, Litchi chinensis, Anthocephalus chinensis,*	
Public plantation: On public site like riverain area, edge of pond, roadside	*Mangifera indica, Acacia catechu, Dalbergia sissoo, Eucalyptus camaldulensis* and *Azadirachata indica, Saaca indica*	Common land

In addition, common places namely riverain area, edge of pond, roadside are used for plantation as ToFs. The main species like *Mangifera indica, Acacia catechu, Dalbergia sissoo, Eucalyptus camaldulensis* and *Azadirachata indica* were found in these sites.

Carbon Stock in Tree Outside Forest

Carbon stock of tree outside forest varied in two different villages. Based on the areas of ToF, total carbon stock of tree outside forests of both villages was 6835.15 t. Out of this, carbon stock of tree outside forest was 4005.94 t in Sahodawa village and 2829.21 t in Pipara village. Moreover, there were 1508.11, 938.7 and 382.4 t C stocks in ToF of rich, medium and poor households respectively in Pipara village while they were 2472.66, 1230.18 and 303.1 t in ToF of rich, medium and poor households correspondingly in Sahodawa village. Besides, the estimated C stock ha^{-1} of ToF of rich house hold of Pipara village was the highest 65.57 t and it was the lowest 43.30 t of ToF of poor family of same village (Table 2).

The variation in carbon stock ha^{-1} of ToF of rich and other households depend up on the age of the plantation, species, spacing and soil fertility. Generally, the plants found in ToF of rich households were older than that of other household category. Moreover, *Mangifera indica, Eucalyptus camaldulensis, Dalbergia sissoo* and *Tectona grandis* which have more wood density were commonly found in ToF of rich families. Similarly, the spacing of plants in ToF was also maintained by this family while ToF of other household category was not taken seriously about these things. Singh et al, (2012) stated that urban (rich) community is especially interested on variety of ToF species planting. They reported that, the value of carbon stock (except soil) of ToF ranges in 7- 45.21 t ha^{-1} in semi-arid region of southern Haryana India. The values of carbon stock (plant biomass) t ha^{-1} were found within this limit. Other study done in public plantion in Mahottari district by Mandal et al (2012) showed the average soil carbon was 32.25 t ha^{-1}, this value is very close to the values of soil carbon of ToF owned by rich HH in Pipara village.

Table 2 : Total carbon stock in tree outside forests

Sahodawa HH type	Area ha	No of hh	Sample no	AGTB ton C/ha	Root carbon	Soil carbon	Total C ton/ha	Grand total
Rich	38	420	23	29.35	4.4	31.32	65.07	2472.66
Medium	21	540	29	26.41	3.96	28.21	58.58	1230.18
Poor	7	540	31	19.2	2.88	21.22	43.3	303.1
Pipara village								
Rich	23	454	24	28.51	4.28	32.78	65.57	1508.11
Medium	15	576	27	27.21	4.08	31.29	62.58	938.7
Poor	8	605	27	20.78	3.12	23.9	47.8	382.4

Comparison of Carbon Stocks in ToF

The one way ANOVA showed that, there were significant differences in carbon stock t ha^{-1} of ToF of rich, medium and poor households at 5% level of significant in both villages. Similarly, Tukey's HSD test showed that, the carbon stock of ToF of poor household was differed from other households at 5% level of significant in both villages (Table 3). The major reason behind this was the age and number of plants ha^{-1} in ToF. The plants were younger having lower diameter (DBH< 30 cm) and number of plants ha^{-1} was lesser than in ToF of poor households compared to others.

Table 3 : Tukey's HSD test for household wise comparison of carbon stocks in ToF

Village	Family types	Family types	Mean Difference	Std. Error	Sig.
Pipara	Rich	Medium	6.50	3.52	0.16
		Poor	21.77(*)	3.47	0.00
	Medium	Rich	-6.50	3.52	0.16
		Poor	15.28(*)	3.26	0.00
	Poor	Rich	-21.77(*)	3.47	0.00
		Medium	-15.28(*)	3.26	0.00
Sahodawa	Rich	Medium	3.49	2.56	0.36
		Poor	19.88(*)	2.56	0.00
	Medium	Rich	-3.49	2.56	0.36
		Poor	16.39(*)	2.48	0.00
	Poor	Rich	-19.88(*)	2.56	0.00
		Medium	-16.39(*)	2.48	0.00

** The mean difference is significant at the 0.05 level.*

Comparing C Stock of ToF between Two Villages

The t-test showed that, there were no differences in carbon stocks in ToF of rich to rich, medium to medium and poor to poor HHs of both villages at 5% level of significance. It may be due to nearly similar stage of plantation in both families, about to same number of plants ha^{-1} and generally same species.

Biodiversity Indices of ToF of Pipara and Sahodawa Villages

The result showed that, the values of Shannon-Weiner Biodiversity Index were high from 2.06 to 2.08 ToF of rich households in Pipara and Sahodawa respectively and they were low 1.66 to 1.82 in poor households in Pipara and Sahodawa correspondingly (Table 3). The reason behind the variation in biodiversity was their poor economic condition that limits them to pay for less choices of species selection for planting ToF but rich can afford to buy the plants of any types of species so the varieties of tree species were found in their orchards and consequences were high diversity.

The research done by Sapkota (2009) in *Shorea robusta* forest in hills showed that values of Shannon-Weinner index was 2.42 which are close to the present findings. Here, the value of Shannon-Weinner index was close to the values of ToF of rich families in both villages. However, no any research has done yet to assess the biodiversity in ToF in Nepal.

Table 3 : Values of biodiversity indices in ToF of different households

Biodiversity Indices	ToF of Pipara village owned by HH			ToF of Sahodawa belong to HH		
	Rich	Medium	Poor	Rich	Medium	Poor
Shannon-Weiner Biodiversity Index	2.06	1.86	1.66	2.08	2.04	1.82
Average species richness	7.57	8.07	6.77	7.75	7.56	6.70
Simpson's evenness (mean value)	0.80	0.59	0.59	0.71	0.64	0.60

Correlation between Carbon Stock and Species Richness

Relationship between carbon stock and species richness showed that there was positive but very weak relationship between carbon stock and species richness. The r^2 values were less than 0.5 in between carbon stock and species richness in ToF of both villages. (Table 4). Generally, the variation of carbon stock does not depend up on the species diversification. The research done by Karna (2012) also supported that there is positive but weak relationship between carbon stock and biodiversity (Wang et al, 2011) and the hump- shaped relationship exists between them (Guo, 2006) which means initial the biodiversity is increased in the beginning according to increasing trend of carbon stock but after that it decreased.

Table 4 : Relationship between carbon stock and species richness in ToFs

C-stock and HH	Correlation coefficient r	Coefficient of determination r^2	Equations	Remarks
Species richness and carbon stock in Pipara village				
ToF of Rich HH	0.63	0.4	0.538x+5.749	
ToF of Medium HH	0.49	0.24	0.1027x+4.9487	
ToF of Poor HH	0.49	0.24	0.0553x+5.5541	
Species richness and carbon stock in Sahodawa village				
ToF of Rich HH	0.49	0.24	0.1288x+3.5293	
ToF of Medium HH	0.48	0.23	0.1048x+4.2754	
ToF of Poor HH	0.67	0.45	0.0852x+4.667	

Correlation between Carbon Stock and Simpson's Evenness

It was found weak and negative and weak relationship between carbon stock of ToF and Simpson's evenness, the value of R^2 ranges from 0.15 to 0.35. (Table 5). This finding is supported by the study done by Heather et al (2010). Initially, the as the carbon stock increases the Simpson's evenness decreased but after that there is no more good correlation.

Table 5 : Relationship between carbon stock and simpson's evenness in ToFs

C-stock and HH	Correlation coefficient r	Coefficient of determination r^2	Equations	Remarks
Simpson's evenness and carbon stock in Pipara village				
ToF of Rich HH	0.59	0.35	-0.0046×+0.9543	
ToF of Medium HH	0.44	0.19	-0.0067x+0.79	
ToF of Poor HH	0.42	0.18	-0.0046x+0.697	
Simpson's evenness and carbon stock in Sahodawa village				
ToF of Rich HH	0.54	0.29	-0.014x+1.67	
ToF of Medium HH	0.39	0.15	-0.0078x+0.8862	
ToF of Poor HH	0.58	0.34	-0.0064x+0.7534	

Conclusion and Recommendation

The value of carbon stock and Shannon-Weiner Biodiversity Index was the highest in ToF of rich family while it was the lowest in ToF of poor family in both villages.

The significant difference in Shannon-Weiner Biodiversity Index was recorded in ToF owned by medium -medium households only but such difference was not found in case of carbon stock of ToF of any households types. This indicated that there is no any strong relationship between biodiversity and forest carbon stock, So, REDD+ needs to work emphasizing high priority for the biodiversity conservation.

Acknowledgement

We would like to heartily acknowledge farmers namely Tapeshwar Yadav and Ramprit Yadav of tree outside forests in Pipara and Sohodawa village for their support during data collection.

References

Barlow, J. Gardner, T. A. and Araujo I. S., 2007, *Quantifying the biodiversity value of tropical primary, secondary, and plantation forests*, Proceedings of the National Academic of Sciences of the United States of America 104 (47), 18555-18560.

Chabbra A., Palriya S. and Dadhwal V.K., 2002, *Soil Organic Carbon Pool in Indian Forest*, Forest Ecology and Management, 14, 87-101.

Chave J., Andalo C. , Brown S., Cairns M.A., Chambers J.Q., Earnus D., Folster H., Fromard F., Higuchi N., kira T., Lescure J.P., Nelson B.W., Ogawa H., Puig H., Riera B. and Yamakura T. 2005. *Tree Allometry and Improved Estimation of Carbon Stocks and balance in Tropical Forests*, Oecologia 145, 87-99.

Chapagain N., Banjade M.R., 2009, *Community Forestry and Local Development:Experiences from the Koshi Hills of Nepal*, Journal of Forest and Livelihood 8(2), 78 -92.

Corbera Esteve and Heike Schroeder, 2010, *Governing ad Implementing REDD*, Environmental Science and Policy. 10, 1-11.

Eggleston S., Buendia L., Kiyoko M., Nygra T., Kiyoto T. 2006, *IPCC, Guidelines for National Greenhouse Gas Inventories, National Greenhouse Gas Inventories Programme*, IGES, Japan.

FAO 2005 Tree outside forest; Food and Agricultural Organization of the United Nations, Rome.

FAO, 2010. *Global Forest Resources Assessment 2010.* FAO forestry paper 163,10-15.

FRA/DFRS. 2014. Terai Forests of Nepal (2010 – 2012). Babarmahal, Kathmandu: Forest Resource Assessment Nepal Project/Department of Forest Research and Survey.

FSI 2011 State of Forest Report, 2011; Forest Survey of India, Ministry of Environment and Forests, Government of India, Dehra Dun, India.

Gibbs H.K., Sandra B., Niles J. O. and Foley l J. A., *Monitoring and estimating tropical forest carbon stocks: making REDD a reality*, Environmental Research Letters, 2, 1-13.

Guo Q., 2006, *The diversity- biomass- productivity relationship in grassland management and restoration*, Basic and Applied Ecology 8 (2007), 199-208

Heather O. Vence- Chalcraft, Michael B. Willig, Stephen B. Cox, Ariel E. Lugo and Frederick N. Scatena. 2010. *Relationship between Aboveground Biomass and Multiple Measures of Biodiversity in Subtropical Forest of Puerto Rico*, Biotropica 42 (3) 290-299

Karna Y. K., 2012, *Mapping Above Ground Carbon Using World View Satellite Image and Lidar Data in Relationship with Tree Diversity and Forests*. M Sc Thesis, University of Twente., The Netherlands 60-62 pp

Leah L. Bremer, Kathleen A. F., 2010, *Does plantation forestry restore biodiversity or create green deserts? A synthesis of the effects of land-use transitions on plant species richness*. Biodiversity Conservation 10, 1-23

Longi A. J. and P.K. Ramchandran N., 1999, *Tree Outside Forests: Agro-, Community and Urban Forestry*. New Forests 17, 145-174.

MacDicken K.G. 1997, *A Guide to Monitoring Carbon Storage in Forestry and Agroforestry*

Projects, Winrock International Institute for Agricultural Development, Arlington VA (US), pp.112-118

Mandal R.A., Dutta I.C., Jha P.K., Haque S.M., 2013, *Potential Carbon Offset in Public Plantation: Offering Opportunity for REDD+ and Soil Fertility*, International Journal of Ecology and Development 25(2), 21-31.

Mandal R.A., Dutta I.C., Jha P.K., Karmacharya S.B., Yadav K.K., Yadav B.K.V., 2012, *Effects of Deforestation and Forest Degradation on Forest Carbon Stocks in Collaborative Forests, Nepal*, Conservation science 63(4), 325-338.

MFSC, 2000, *National Biodiversity Action Plan, Ministry of Forests and Soil Conservation , HMG of Nepal, Global Environment Forum* , UNDP, 2000.

Mini, E.R. and Rao, Y. S., 2011, *An Evaluation of Soil Carbon Sequestration in Teak and Ecalypt Plantations,* NeBIO. 2(3), 9-11.

Rocky J.1 and Mligo C. 2012, *Regeneration pattern and size-class distribution of indigenous woody species in exotic plantation in Pugu Forest Reserve, Tanzania*, International Journal of Biodiversity and Conservation 4(1),1-14.

Sapkota I.P., Tigabu M and Odén P.C., 2009. *Tree diversity and regeneration of community-managed Bhabar lowland and Hill Sal forests in central region of Nepal*. Swedish University of Agricultural Sciences Southern Swedish Forest Research Centre, PO Box 101 SE-230 53 Alnarp., Sweden.

Sedjo, R.A. 2001, *Forest carbon sequestration: Some issues for forest investments*, Resources for the future, 25, 1 - 26.

Singh S.P., Sah P. P., Tyagi V. and Jina B.S., 2005, *Species diversity contributes to productivity– Evidence from natural grassland communities of the Himalaya*, Current Science, 89, 548- 552

Singh P. and Lodhiyal L.S., 2009, *Biomass and Carbon Allocation in 8-year-old Poplar (Populus deltoids Marsh) Plantation in Tarai Agroforstry System of Central Himalaya, India*. New York Science Journal, 2(6), 49-53.

Singh K. and Chand P. , 2012, *Above-ground tree outside forest (TOF) phytomass and carbon estimation in the semi-arid region of southern Haryana: A synthesis approach of remote sensing and field data*, Journal Earth System Science 121 (6), 1469–1482.

Skutsch M. and Laake P. V. 2009, *REDD as Multi-level governance in Making*, Energy and Environment, 19(6), 831-844.

Tamrakar P.R., 2000, *Biomass and Volume Tables with Species Description for Community Forest Management*, Ministry of Forests and Soil Conservation, Kathmandu, Nepal,

Thompson I., Mackey B., McNulty S. and Mosseler A., 2009, *Forest Resilience, Biodiversity, and Climate Change. A synthesis of the biodiversity/resilience/ stability relationship in forest ecosystems. Secretariat of the Convention on Biological Diversity, Montreal*. Technical Series no. 43, 67-68.

Walkley A.E. and Black J.A. 1958, *An Examination of the Method for Determining Soil Organic Method, and Proposed Modification of the Chromic Acid Titration Method*, Soil Science 37, 29-38.

Wang W., Lei X., Ma Z., Daniel D. K. and Peng C. 2011, *Positive Relationship between Aboveground Carbon Stocks and Structural Diversity in Spruce- Dominated Forest Stands in Brunswick, Canada*. Forest Science 57(6), 506-515.

Quantification of Carbon stocks under Different Landuse System of Chitwan District, Nepal

Asmita Poudel[1]*, Him Lal Shrestha[2] , Roshan M. Bajracharya[3] and Bishal K. Sitaula[4]

Abstract

Carbon sequestration in terrestrial ecosystems is emerging as an important strategy to address climate change issues globally including Nepal. As the information on carbon stock under different land use systems with focus on both biomass and soil profile is lacking, this paper aims to quantify carbon stock in biomass and in soil profile under different land use, namely community forest, leasehold forest and agricultural land of Chitwan district. Carbon stock in biomass was calculated using standard allometric equations and dry combustion method was used to determine SOC as mentioned in the guidelines published by ICIMOD, ANSAB and NORAD. Carbon content in AGTB was found higher (81.25 t/ha) in community forest compared to leasehold forest which was (80.09 t/ha). Carbon stock in AGSP was calculated only for community forest which was (3.67 t/ha). Similarly LHG density was also higher in community forest (9.25 t/ha) in comparison to leasehold forest 6.45 t/ha. Further root carbon stock density was higher in community forest (16.25 t/ha) than the mean value of (16.02 t/ha) for leasehold forest. However, SOC density was highest in agricultural land (73.42 t/ha) followed by community forest (66.38 t/ha) and leasehold forest (52.62 t/ha). Therefore, in totality, carbon stock was observed to be highest in community forest (176.8 t/ha) followed by leasehold forest (155.18 t/ha) and agricultural land (73.42 t/ha).Thus well managed community forests are instrumental in enhancing carbon fluctuation in terrestrial ecosystems.

Keywords : Total Carbon Stock, Leasehold Forestry, Community Forestry, REDD, Climate change

[1] *Graduate Student, Kathmandu University*

[2] *PhD Scholar, School of Science, Kathmandu University*

[3] *Professors, School of Science, Kathmandu University*

[4] *Norwegian University of Life Sciences, Norway*

* *Corresponding Author: Email- poudel.asmita09@gmail.com*

Introduction

Global warming has become the most concerning issue these days to scientists and environmentalist. Recent estimate indicate that human activities are currently responsible for annual global carbon emission of about 10 Giga ton (Gt), of which 1.5 Giga ton is a result of land use change and rest from fossil fuel use and cement production (Canadell et al., 2007). Inter governmental Panel on climate change (IPCC, 2007) reveals that the rate of increase of CO_2 in atmosphere from 1995 to 2005 on average is 2 ppm compared to 1.25 ppm from 1960 to 1995. Every year atmospheric concentration increases by 2 ppm (IPCC, 2007) and now it has reached 397.34 ppm (NOAA at Mauna Loa, 2013).

Scientists and Environmentalists around the world started to respond the rise in temperature, joining an international treaty, the United Nation Framework of Convention on Climate Change in 1992. By 1995 countries recognized that commitments contained within the convention were inadequate and hence they adopted Kyoto Protocol.

Countries signing Kyoto Protocol commit themselves to develop, periodically update, publish and make available their national inventories of emission by source and removals by sink to the COP. However the protocol focuses only on increasing the capacity of forest as sink through reforestation and afforestation but excludes reduced emission from forest degradation (REDD). After COP 13 initiative on reducing emission from deforestation and forest degradation (REDD) in developing countries was taken.

REDD is primarily about reducing atmospheric CO_2 emission through avoided deforestation and provides financial incentive to the countries on the reduction of Carbon emission. Also the stern review on the economics of climate change noted that REDD could be cost effective measure to address climate change as cited in Acharya et al.,(2009).

Taking action on C sequestration under the Kyoto Protocol or any post-Kyoto treaty will not only helps to lower the concentration of GHGs but will help to improve soil properties and have positive impact on environment (FAO, 2001) as Carbon Sequestration is the process which prevents the buildup of CO_2 gas in the atmosphere through the transfer of atmospheric CO_2 into terrestrial systems, aquatic systems or mechanically injecting it underground.

Objectives

To quantify and compare the carbon stock under different land use system namely, Community managed forest, Leasehold forest and Agricultural land.

1. To determine the carbon stock in above ground biomass, leaf litter, herbs, grass (LHG) and Soil organic Carbon (SOC) for different land use of Shaktikhore VDC.

Rationale

Community forestry in Nepal officially started in late 1970 (Eckholm, 1976; World Bank, 1978) as cited in Carter et al., (2011), which is about 25% of forest area. Community forestry in Nepal is often considered as an international example of successful community based forest management. (Gilmour and Fisher, 1991; Gautam et al., 2002; Acharya et al., 2009,). Currently there are around 17800 community forests across Nepal (Community forest database). This may be advantageous in terms of REDD for Nepal.

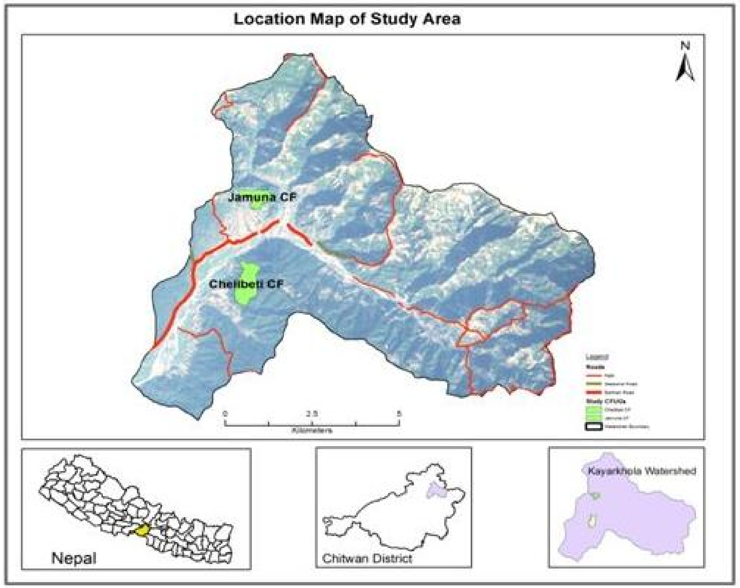
When concept of REDD plus emerged for developing countries like Nepal, much of focus diverted on community forest but focus need to be expanded on other types of locally managed forest like leasehold forest, religious forest, collaborative forestry and buffer zone forest.

Therefore the main objective of this study is to quantify carbon stock in biomass and in soil profile under different land use system of Kayerkhola watershed. Such studies are necessary to assess the effect of forestry management, cropping system option on carbon dynamics and to guide management decisions that deals with enhancing C sequestration potential of an ecosystem as highlighted by Wutzler et al., 2011)

Materials and Method

Study Area

The study was conducted in Shaktikhore VDC, ward no. 5, of Kayerkhola watershed, Chitwan district, Nepal as shown in Figure 1. The kayerkhola watershed represent tropical and subtropical region. For this study, sample was collected from two CFUGs, two LFUGs and agricultural soils of the Jamuna and Chelibeti forest user groups.



Fiture 1 : Location of Study Area

Study Methods

Study was conducted following the guidelines given in a report published by International Centre for Integrated Mountain Development(ICIMOD), Asia Network for Sustainable Agriculture and Bioresources (ANSAB) and Federation of Community Forest Users, Nepal (FECOFUN), 2010 called "Guidelines for measuring carbon stock in Community Managed Forest" under the financial support from Norwegian Agency for Development Cooperation (NORAD).

In order to quantify the C stock in two Forest user group, a total of 16 sampling plots were considered, 2 plots for community forest, 2 plots for leasehold forest and 4 plots for agricultural soils in Jamuna Group and Chelibeti Group respectively. Sampling plots were selected randomly within the sampling area. Then Above Ground Tree Biomass (AGTB), Above Ground Sapling Biomass and Regeneration (AGSB), Leaf litter, Herbs and Grass Biomass (LHG), were determined to quantify C Stocks.

Soil samples collected from depth of (0 -15, 15 – 30, 30 – 60, 60 – 100) cm was brought to laboratory for analysis. Properties such as pH, SOC, soil texture and bulk density was determined in Environmental science laboratory of Kathmandu

University. Similarly CEC, N, P, K was determined in Aquatic Ecology Center (AEC).

Data Analysis

Above Ground Tree Biomass (AGTB)

$AGTB = 0.0509*\rho*D^2*H$…………eq (i)

Where,

AGTB = above-ground tree biomass [kg];

ρ = wood specific gravity [g /cm^3];

D = tree diameter at breast height [cm]; and

H = tree height [m].

Above Ground Sapling Biomass (AGSB)

For determination of sapling (dbh> 5 cm) biomass following regression model equation was used:

$\text{Log (AGSB)} = a + b \log (D)$

Where,

Log = natural log [dimensionless];

AGSB = above-ground sapling biomass [kg];

a = intercept of allometric relationship for saplings [dimensionless];

b = slope allometric relationship for saplings [dimensionless]; and

D = over bark diameter at breast height (measured at 1.3 m above ground) [cm]

Leaf Litter and Herb/Grass (LHG) Biomass

Leaf litter, herbs and twigs from 1 m^2 plot was collected in plastic bag and following formula was used to determine LHG biomass of forest floor.

$$LHG = \frac{W_{field}}{A} * \frac{W_{subsample dry}}{W_{subsample wet}} * \frac{1}{10000}$$

Where,

LHG = biomass of leaf litter, herbs, and grass [t ha-1];

W_{field} = weight of the fresh field sample of leaf litter, herbs, and grass, destructively sampled within an area of size A [g];

A =size of the area in which leaf LHG were collected [ha];

$W_{sub\ sample\ dry}$ = weight of the oven-dry sub-sample of LHG taken to the laboratory to determine moisture content [g]; and

$W_{sub\ sample,\ wet}$ = weight of the fresh sub-sample of LHG taken to the laboratory to determine moisture content [g].

Root Biomass

It is recommended to use MacDicken (1997) root to shoot ratio value of 1: 5 that is to use 20% of above ground biomass as root or below ground biomass. So, 20% of above ground biomass was taken as root biomass.

Soil Organic Carbon (SOC)

SOC was determined by using the following formula as given by Pearson et al., 2007.

$SOC = \rho * D * C\%$

Where,

SOC = soil organic carbon stock per unit area [t ha^{-1}],

ρ = soil bulk density [g cm^{-3}],

D = the total depth at which the sample was taken [cm], and

%C = carbon concentration [%].

Total Carbon Stock

The biomass stock density was converted to carbon stock density by multiplying it with IPCC (2006) default value 0.47.

Total carbon stock was determined by summing all the carbon stock of individual carbon pool of a stratum using the following formula.

C (LU) = C (AGTB) + C(AGSB) + C(LHG) + C(BB) + C(DWS) + SOC

Where,

C (LU) = carbon stock density for a land-use category [Mg C ha-1],

C (AGTB) = carbon in above-ground tree biomass [Mg C ha-1],

C (AGSB) = carbon in above-ground sapling biomass [Mg C ha-1],

C (BB) = carbon in below-ground biomass [Mg C ha-1],

C (LHG) = carbon in litter, herb & grass [Mg C ha-1],

C (DWS) = carbon in dead wood and stumps [Mg C ha-1], and

SOC = soil organic carbon [Mg C ha-1]

Results and Discussion

Plant Species Diversity

During our survey we came across 18 different species in eight sampling plots. Sal (*Shorea robusta),* Botdhayero *(Lagerstroemia parviflora),* Sindure *Mallotos phillipinensis,* Rajbriksha *(Cassia fistula)* were the major species occurring in the community forest. Sal (*Shorea robusta)* and Bhalayo *(Rhus wallichi)i*, were also dominant in leasehold forest along with fodder species such as Khanyu (*Ficus semicordata)*,Siris *(Albizia juriblissin)*, Tiyari, and Thimke (*Quercus floribunda).* Plant species diversity in community forest and leasehold forest are shown in Figure 2 and Figure 3 respectively.

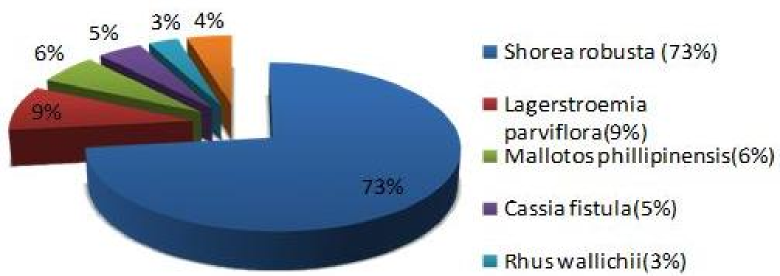


Figure 2 : Plant species density of community forest

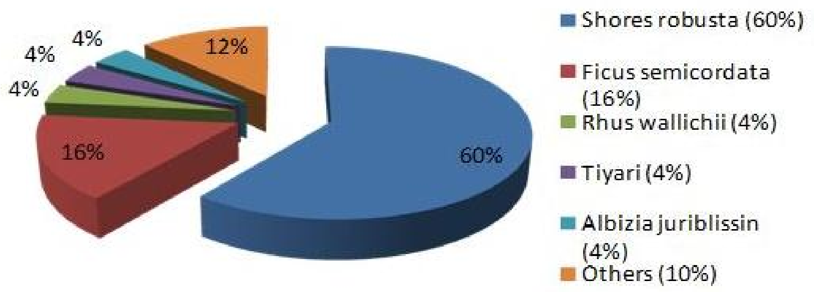


Figure 3 : Plant species density of seasehold forest

Above Ground Tree Biomass (AGTB) and Carbon Stock Density

The AGTB carbon density was greater in community forest (81.25 t C/ha) than in leasehold forest (80.095 t C/ha) as shown in Figure 4.

The carbon stock in AGTB as determined in this report is comparable with the values reported by Baral et al., (2009), Oli and Shrestha, (2009) and Shrestha and Singh, (2007) for Terai forest.

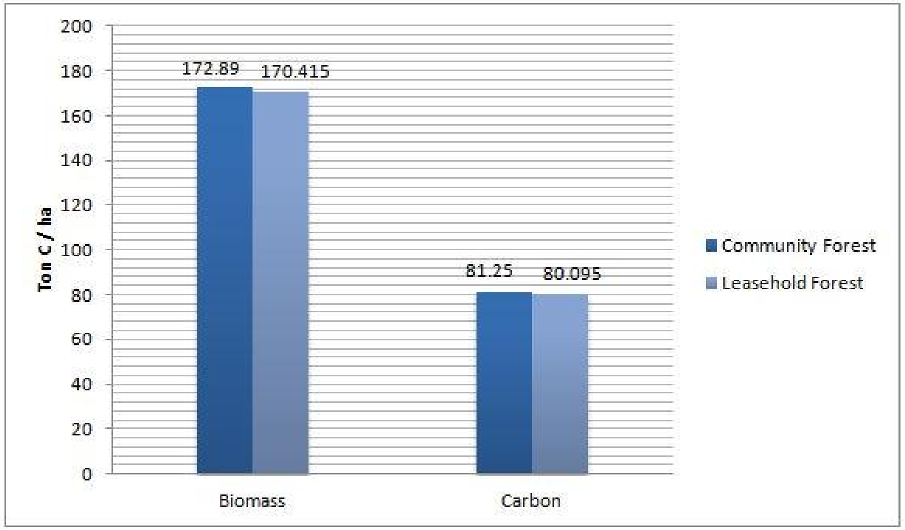


Figure 4 : Bar Graph showing biomass and carbon stock density in AGTB of dirrerent land use system

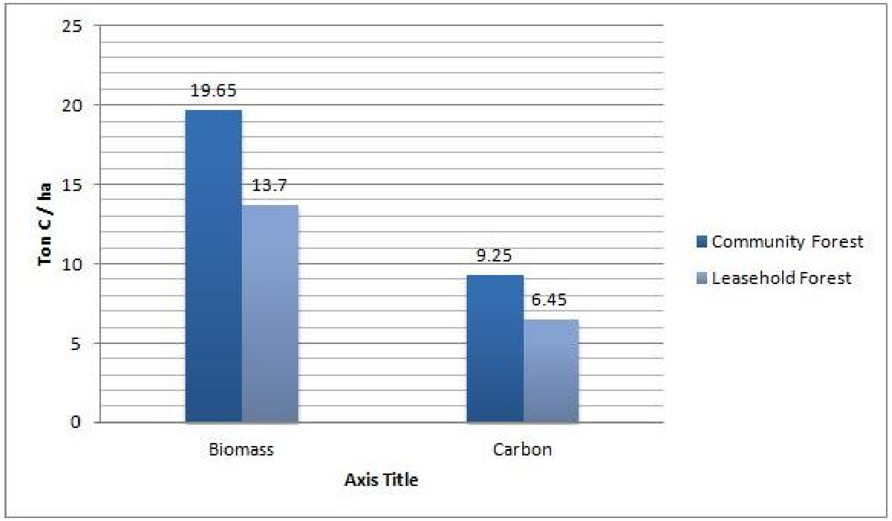


Figure 5 : Bar Graph showing biomass and carbon stock density in LHG under dirrerent land use system

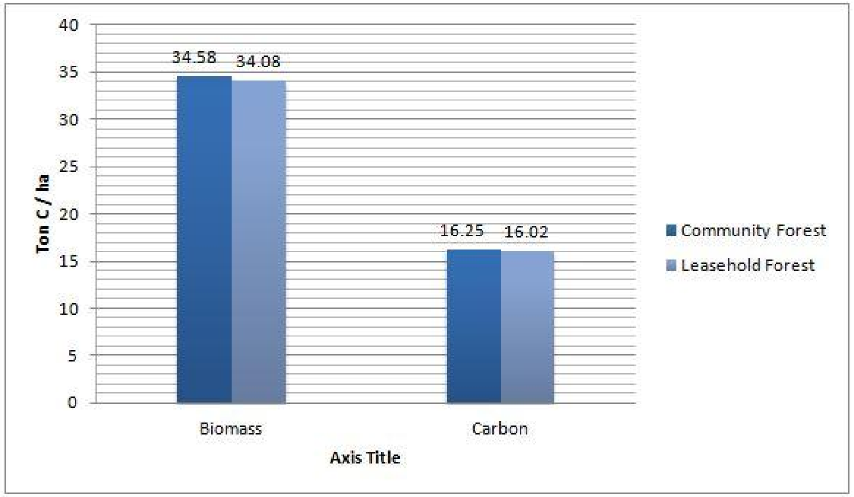


Figure 6 : Bar Graph showing biomass and carbon stock density in rood biomass under dirrerent land use system.

Leaf Litter, Herbs, Grasses (LHG) Biomass and Carbon Stock Density

Calculation of carbon content in leaf litter, grasses, and herbs including twigs in both community as well as leasehold forest as shown in Figure 5, showed that this carbon pool contributes significantly in the sequestration of atmospheric carbon. Comparing the carbon content in LHG (including twigs), between community forest and leasehold forest, LHG from community forest had higher biomass and thus carbon content.

Root Biomass and Carbon Stock Density

Root biomass and hence the carbon content was found higher in community forest than in leasehold forest as shown in Figure 6.

Soil Organic Carbon (SOC)

The result shows that SOC (t/ha) up to 30 cm depth was highest in agricultural land (73.42 t/ha) compared to community forest (66.38 t/ha) and leasehold forest (52.62 t/ha). Similarly, comparing the SOC level under two types of forest, community forest and leasehold forest, SOC level is higher in community forest as shown in Figure 7. Similar result was reported in study conducted by Shrestha and Singh, (2007).

Total Carbon Stock Density

Calculation of total carbon stock under different land use system depict that community forest sequester greater amount of atmospheric carbon than leasehold forest and agriculture as shown in Figure 8.

Further, comparing only SOC agricultural land stores higher amount of carbon than the forest.

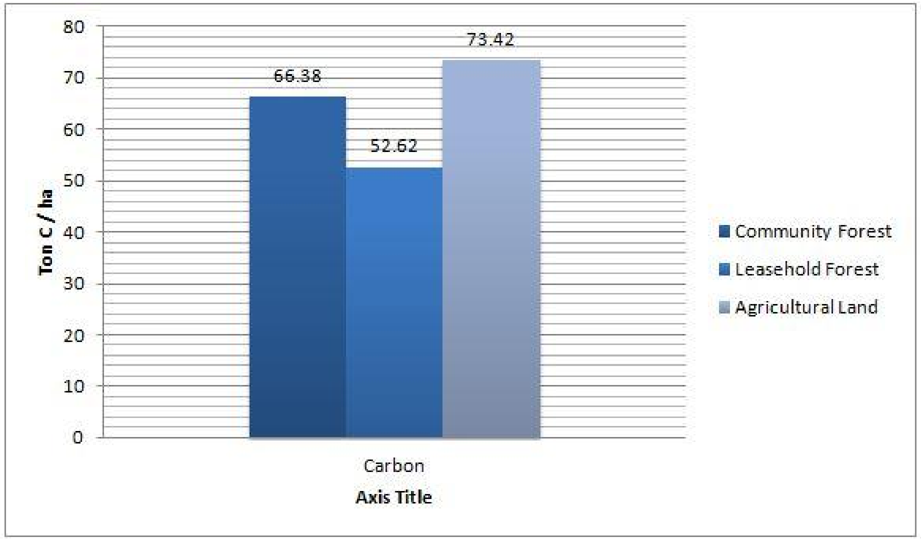


Figure 7 : Bar Graph showing carbon stock density in soil of different land use system

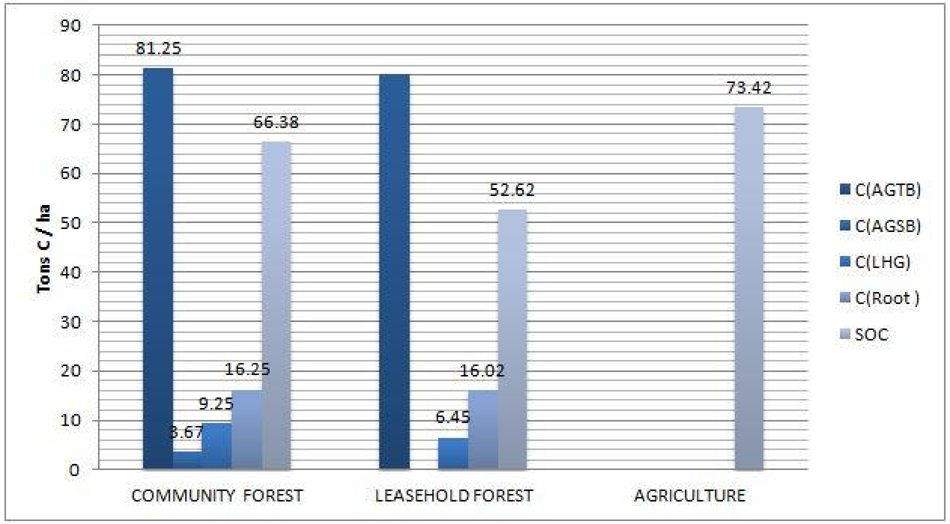


Figure 8 : Carbon stock density in dirrerent carbon pools of different land use system

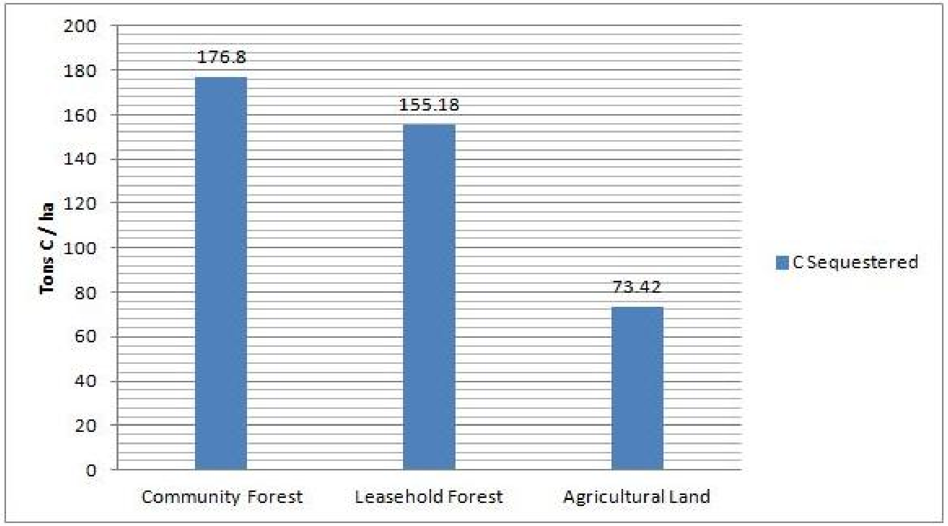


Figure 9 : Total carbon sequestered under different land use system

Conclusion and Recommendation

Conclusion

As expected, community forest exhibit higher carbon stock (176.8 t/ha) followed by leasehold forest (155.18 t/ha) and agriculture (73.42 t/ha) as shown in Figure 9. Likewise, above ground biomass of community forest stores (94.17 tons) carbon per hectare and leasehold forest (86.54 t C/ha). Similarly, SOC in community forest is 66.38 tons/hectare, 52.62 tons/ha in leasehold forest and 73.42 t/ha in agriculture. Root carbon is 16.25 t/ha in community forest and 16.02 t/ha in leasehold forest. The result show that carbon stored in forest biomass is 1.5 times higher than in forest soils (considering SOC up to 30 cm depth).This finding is in accordance with the fact stated by Lal, (2005) that carbon sequestration potential of forest is very high, about 0.4Pg C/year in forest soil and 1 – 3 Pg C/year in forest biomass.

Although the carbon stock in community forest was higher than that of leasehold forest, the latter showed good potential for enhancing carbon sequestration also. This indicates that if proper forest management techniques are applied by concerned group, then different classification of forest that we have will sequester notable amount of carbon.

Recommendation

1. As, SOC was observed to be highest in agricultural land, proper soil and crop management techniques should be employed for maintenance and increasing carbon level.

2. Leasehold forest can also sequester comparable amount of carbon to community forest if managed with proper forest management practices. This could be a more socially and economically viable option.

References

Acharya , K.P., Dangi, R.B., Tripathi, D.M., Bushley, B.R., Bhandary, R.R. and Bhattarai, B. (eds.). (2009).Ready for REDD? Taking stock of experience, opportunities and challenges in Nepal. Nepal Foresters' Association, Nepal.

ANSAB, ICIMOD AND NORAD. 2010. Forest Carbon Stock in Community Forests in three Watershed (Ludhikhola, Kayarkhola and Charnawati).

Baral.S.K., Malla.R. and Ranabhat. S.2009. Above-ground carbon stock assessment in different forest types of NepalBanko Janakari, Vol. 19, No. 2.

Authors exten the acknowledgement to the FORESC Project under which the study was accepted. We also acknowledge the contribution of fellow researchers and local people who supported during the field.

Blake, G.R. and Hartage, K.H. (1986). Bulk Density. In: A. Klute (Editor) Methods of Soil Analysis, Part I, Physical and Mineralogical Methods. Madison, Wisconsin, USA: American Society of Agronomy, Soil Science of America.

Canadell, J. G., Le Quéré, C., Raupach, M. R., Field, C. B., Buitenhuis, E.T., Ciais, P., Conway, T. J., Gillett, N. P., Houghton, R. A., and Marland, G.(2007). Contributions to accelerating atmospheric CO2 growth from economic activity, carbon intensity, and efficiency of natural sinks. Preceding of National Academy of Science of United States of America, 104,18866-18870.

Carter.J., Pokheral.B., Parajuli.R.R. (2010). Two decades of Community Forestry in Nepal: What have we learned? Nepal Swiss Community Forestry Project.

Dahal.N. and Bajracharya.R.M.2010. Prospects of Soil Organic Carbon Sequestration: Implications for Nepal's Mountain Agriculture. Journal of Forest and Livelihood 9(1) December, 2010.

Dangi, R.B. and Acharya, K.P.(2009). A quick review of potential benefits and costs of REDD in Nepal. In: Acharya , K.P., Dangi, R.B., Tripathi, D.M., Bushley, B.R., Bhandary, R.R. and Bhattarai, B. (eds.). Ready for REDD? Taking stock of experience, opportunities and challenges in Nepal, Mass Printing Press, pp 9 – 20.

FAO. 2009. Global Forest Resources Assessment 2010 - Nepal Country Report. Retrieved on 19 April 2013 in http://www.forestrynepal.org/publications/country-reports/4245

FAO. Org. 2010/ FAO resource page

FAO. 2012. State of World's Forest.

Gee, G.W. and Bauder, J.W. (1986) Particle Size Analysis. *In:* A. Klute (ed.) Methods of Soil Analysis, Part 1. Physical and MineralogicalMethods-Agronomy Monogram No. 9 (2nd Edition). American Society of Agronomy- Soil Science Society of America, Madison, WI, USA, p. 383-411.

IPCC(2007).ClimateChange 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Pachauri, R. K. and Reisinger, A. (Eds). IPCC: Geneva, Switzerland.

Lal.R. (2004). Soil carbon sequestration to mitigate climate change, Geoderma, pp 1- 22.

Lal.R. (2005). Forest soils and carbon sequestration, Forest Ecology and Management ,pp 242–258.

Acharya , K.P., Dangi, R.B., Tripathi, D.M., Bushley, B.R., Bhandary, R.R. and Bhattarai, B. (eds.). Ready for REDD? Taking stock of experience, opportunities and challenges in Nepal, Mass Printing Press, pp 1-8..

McLean, E.O. (1982) Soil pH and lime requirement. Methods of soil analysis. Chemical and microbiological properties. 2nd ed. American Society of Agronomy. Monograph No. 9. Madison (WI): ASA-SSSA, Inc., Madison, WI, USA, p. 199-224.

Nelson, D.W., and Sommers, L.E. 1982. Total Carbon, Organic Carbon and Organic Matter In: A. L. Page, R. M. Miller and D. R. Keeney, eds. Methods of Soil Analysis Part 2. Chemical and Microbiological Properties, 2nd Ed. American Soc. of Agron. Monograph No. 9, ASA-SSSA, Inc., Madison, WI, USA, p. 539-580.

Oli,B.N., Shrestha,K.,2009. Carbon Status in Forests of Nepal: An Overview. Forest and livelihood, 8 (1). ISSN 1684 – 0186.

Subedi, B.P., Pandey, S., Pandey, A., Rana, E.B., Bhattarai, S., Banskota, T., et al. (2010). Forest Carbon Stock Measurement: Guidelines for measuring carbon stocks in community managed forest. Kathmandu: ANSAB, FECOFUN, ICIMOD.

TFD review. 2010. Investing in REDD plus. Consensus Recommendations on Frameworks for the Financing and Implementation of REDD-plus.

Wutzler, T., Profft, I. & Mund, M. 2011. Quantifying tree biomass carbon stocks, their changes and uncertainties using routine stand taxation inventory data. Silva Fennica 45(3): 359–377.

Theme 5

Community Forestry/Agro-Forestry and Livelihood

Green Agriculture: Evaluation of Plant Extracts for Effectiveness Against Mealy Bug

S. N. Das*, Soumyesh Mandal

Abstract

To find out the efficacy of few plant extracts against mealy bug, laboratory evaluation was conducted by the use of seven methanolic extracts of different plants viz. Ramtulsi (Ocimum gratissimum Linn.) Japanese Mint (Mentha arvensis Linn.), Marigold (Tagetes ercta Linn.), Custard Apple (Anona squamosa Linn.), Neem (Azadirachta indica A. Juss), along with one bulb of Garlic (Allium sativum Linn.) and one soap nut of Ritha (Sapinodus mukorossi) extracts with two concentrations (1.0 & 1.5%) towards causing mortality of mealy bug F. virgata. The results reveal that few of the tested plant extracts caused mortality varied up to 99.99 % as compared to untreated control where no mortality was noticed. Among all the treatments, Japanese Mint at both concentrations resulted 99.99 % mortality after 96 hrs. and was significantly better than all other treatments. While Custard Apple extracts showed poor efficacy and its mortality reached up to 20 % at 1% and 40% at 1.5 % conc. after 120 hrs of treatment. Among the tested plant products assayed against mealy bug, Custard Apple showed lowest efficacy (20.56%), followed by Ramtulsi (33.12%), Marigold (48.78%), Neem (49.42%), Ritha (56.61%), Garlic (68.92%) and Japanese Mint (73.46%) in increasing order of overall efficacy. Botanical pesticides used in our findings can be recommended as an eco safe chemical in the management of agricultural pests as sustainable strategy. Because of their biodegradable nature with safety profile, it is expected that plant based pesticides play significant role in achieving evergreen revolution.

Introduction

The use of chemical pesticide and other agro chemicals are getting restricted / being banned globally because of their toxic effects on human beings and their livestocks, residual toxicity, environmental problems, pest outbreaks and drastic effects on beneficial insects. Green agriculture aims at minimizing the incidence of insect pests and controlling of diseases to such a degree that they do not seriously damage crops by upsetting nature's balance. The use of synthetic pesticides has undoubtedly resulted in achievement of green revolution in different countries through increased crop production. However, in recent years there has been considerable pressure on consumers and farmers to reduce or stop the use of synthetic pesticides in agriculture. Botanicals are the most promising source and are under extensive trials for their biological activity against various agricultural pests. Pesticidal compounds of plant origin are effective against pests with the symptoms such as growth retardation, feeding deterrent, anti ovipositional effect and reduction in fertility, mostly through diverse modes of action. Such allelo-chemicals need proper attention of plant biologists to exploit chemical ecology in integrated management of plant pests. Most of the essential oils of higher plant origin act in bio-rational mode of action interrupting the function of octapamine receptors found in insects but absent in mammalian system. Hence, their exploitation in pest management would be an ideal eco-chemical approach. Therefore, detailed documentation is needed for the vast wealth of plants, which are rich sources of bioactive compounds.

Ferrisia virgata is an important pest of Datura and infests severely under the surface of leaves producing characteristics damage symptoms of mealy bug i.e. yellowing and gradual withering of leaves and final defoliation. This pest is found almost throughout the year on different crops and apart from leaves it also appears on young twigs and leaf petioles. Since this causes noticeable damage on Datura and other crops, it was decided to undertake a laboratory experiment to evaluate some of the plant extracts capable of causing mortality of this pest. This paper embodies the results obtained in that experiment.

Objectives of the Paper

I. To develop a holistic system of tackling pests by making it more eco-friendly, economically viable and socially acceptable for the farmers.

II. To rediscover and develop strategies whose cost and ecological side effects are minimal.

III. To look for substitutes of synthetic insecticides in those based on naturally occurring substances.

Material and Methods

Preparation of Extracts -

Fresh leaves of ramtulsi (Ocimum gratissimum Linn.), Japanese mint (Mentha arvensis Linn.), marigold (Tagetes ercta Linn.), custard Apple (Anona squamosa Linn.), neem (Azadirachta indica A. Juss), along with small cut pieces of bulb of garlic (Allium sativum Linn.) and soap nut of ritha (Sapinodus mukorossi Gaertn) were taken and then oven dried by keeping the leaves and small pieces

Agricultural Training Centre/ State Agricultural Management and Extension Training Institute, West Bengal

** Corresponding Author : Email- sourenks@gmail.com*

of garlic and ritha for at least 15 min. within temperature range of 45-500 C. When the leaves, garlic and ritha becomes crispy, those were taken out and crushed in a grinder. The crushed powder was put in methanol and kept for 2 days allowing the methanol to extract the toxicants of the leaves, garlic and ritha. The conical flask containing methanol with powder leaves, garlic & ritha were shaken periodically for better extraction. After 48 hours, the extract was decanted out and was dried in a vacuum desiccator. The dried extract was scrapped out with the help of a sharp blade and weighed. About 1gm and 1.5 gm scrapped dried materials were dissolved in 100 ml of water each separately so as to get the desired concentration of extract of 1.0 % and 1.5% respectively.

Testing of Mortality-

For testing the mortality of pests, different plant extracts thus prepared was sprayed on leaf bits of Datura kept on wet cotton swab in a petridish with the help of micropipette syringe and on each of the leaf bits, 20 mealy bugs were released. A definite amount of spray fluid was topically applied by the said syringe and care was taken so that the leaf was uniformly sprayed. After application, the petridish containing the sprayed leaves was kept for taking observation towards mortality after different intervals like 24, 48, 72, 96 & 120 hours. Since the sprayed leaves were kept on wet cotton swab, the leaves remain fresh until the last observation was completed. In each dose three replications were maintained and there was also a controlled petridish where the leaf bits containing mealy bugs were sprayed with water only. To be sure of their mortality, the test insects were turned upside down with a needle and those which did not respond or were moribund, were considered as dead.

The percentage of mortality was calculated using the formula:

$$\frac{\text{Number of the dead insects}}{\text{Total number of insects treated}} \times 100$$

All the values were calculated using Abbott's formula (Abbott, 1925) as given below. The data recorded for percent mortality of different treatments were subjected to statistical analysis using SPSS-10 in Windows version.

$$\text{Percentage of corrected mortality} = \frac{P - P_0}{100 - P_0}$$

(P = Percentage mortality after treatment with plant extract &

Po = Percentage mortality in controlled treatment)

Results

A perusal to the experiment reveals that at both concentrations (1.0 % & 1.5 %), 24 hrs. after treatment Japanese mint had given the highest mortality i.e. 60.0 % & 53.3 % and reached 99.9% mortality after 96 hrs of treatment (from table -1). No mortality was recorded in custard apple in both concentrations after 24 h of treatment and its mortality reached up to 20.0 % at 1.0 % and 40.0% at 1.5 % concentration after 120 h of treatment. No mortality was recorded in case of controlled treatment.

After 24 hrs of treatment garlic, soapnut of ritha, marigold , neem & ramtulshi recorded 44.7%, 25.3%, 26.7%, 20.0% & 7.7% and 53.3%, 46.7%, 33.3%, 33.3% & 20.0% mortality at 1% and 1.5% concentrations, respectively. Japanese mint was significantly superior to all other treatments in both concentrations (1% & 1.5%) but same mortality (53.3%) was recorded in garlic at 1.5% concentration after 24 h of treatment.

Likewise garlic was also superior to soapnut of ritha, marigold, neem & ramtulsi in both 1.0 % & 1.5 % concentration. The rate of mortality increased with increase of different intervals up to 72 hours. At increasing of intervals of time, mortality also increased in the same fashion in different treatments of both concentrations. Among the tested plant products assayed against mealy bug, custard apple showed lowest efficacy (20.6%) followed by ramtulsi (33.1%), tagetes (48.8%), neem (49.4%), soap nut of ritha (56.6%), garlic (68.9%) and Japanese mint (73.5%) on increasing order of overall efficacy (from table-2) . It also showed that plant extracts in 1.5 % concentration are better than in 1% concentration and refer 54.5% and 45.6% overall efficiency against mealy bug among the plant parts products being tested (Table-3).

Table 1 : Effect of some plant extracts at two different concentrations (1.0 and 1.5%) on the mortality of mealy bug (*Ferisia virgata* Cock.) at different intervals of treatment

Plant Extracts	Conc. (%)	H-24	H-48	H-72	H-96	H-120	Mean
Garlic	1.0	44.66 (43.11)c	66.66 (54.76)c	86.66 (68.61)c	93.33 (75.00)c	99.99 (89.00)a	66.09
	1.5	53.33 (46.89)b	73.33 (58.89)b	93.33 (75.00) b	99.99 (89.00)a	99.99 (89.00)a	71.75
Ramtulsi	1.0	7.66 (16.00)g	13.33 (21.39)i	20.00 (26.57)i	40.00 (39.23)h	40.00 (39.23)f	28.48
	1.5	20.00 (26.57)f	25.33 (30.11)g	33.33 (35.24)g	46.66 (43.11)g	65.11 (53.76)e	37.75
Japanese Mint	1.0	60.00 (50.77)a	66.66 (54.76)a	86.66 (68.61)c	99.99 (89.00)a	99.99 (89.00)a	70.42
	1.5	53.33 (46.89)b	86.66 (68.61)c	99.99 (89.00)a	99.99 (89.00)a	99.99 (89.00)a	76.50
Marigold	1.0	26.66 (31.11)e	40.00 (39.23)f	46.66 (43.11)f	60.00 (50.77)f	86.66 (68.61)c	46.56
	1.5	33.33 (35.24)d	46.66 (43.11)e	53.33 (46.89)e	66.66 (54.76)e	93.33 (75.00)b	51.00
Custard Apple	1.0	0.00 (0)h	1.33 (6.66)j	5.33 (13.33)j	20.00 (26.57)j	20.00 (26.57)g	14.66
	1.5	0.00 (0)h	20.00 (26.57)h	26.66 (31.11)h	33.33 (35.24)i	40.00 (39.24)f	26.43
Neem	1.0	20.00 (26.57)f	26.66 (31.11)g	46.66 (43.11)f	46.66 (43.11)g	80.00 (63.43)d	41.46
	1.5	33.33 (35.24)d	40.00 (39.24)f	66.66 (54.76)d	86.66 (86.61)b	99.99 (89.00)a	57.36
Ritha	1.0	25.33 (30.11)e	46.66 (43.11)e	66.66 (54.76)d	66.66 (54.76)e	93.33 (75.00)b	51.54
	1.5	46.66 (43.11)c	53.33 (46.89)d	66.66 (54.76)d	86.66 (68.61)d	99.99 (89.00)a	60.47
Mean		30.83	40.32	50.34	59.06	69.64	
SE (m)		0.79	0.71	0.80	0.74	0.64	
CD at 5 %		2.28	2.05	2.32	2.14	1.84	

** Numbers in parenthesis represent percentage of corrected mortality*

Table 2 : Overall mean mortality percentage of mealy bug (*Ferisia virgata* Cock.) at both concentrations (1.0 % and 1.5 %) by seven plant extracts at different intervals of treatment

Plant extract	H-24	H-48	H-72	H-96	H-120	Overall (%)
Garlic	45.00	56.83	71.80	82.00	89.00	68.92
Ramtulsi	21.29	25.57	30.91	41.17	46.50	33.12
Japanese Mint	48.83	61.69	78.80	89.00	89.00	73.46
Marigold	33.18	41.17	45.00	52.77	71.81	48.78
Custard Apple	0.00	16.62	22.22	30.95	32.59	20.56
Neem	30.91	35.17	48.94	55.86	76.22	49.42
Ritha	36.61	45.00	54.76	61.69	82.00	56.61
Std. Error (m)	0.56	0.50	0.57	0.52	0.45	

Table 3 : Overall mean mortality percentage of mealy bug (*Ferisia virgata* Cock.) in two different concentrations (1% and 1.5%) by seven plant extracts at different intervals of treatment separately

Conc. (%)	H-24	H-48	H-72	H-96	H-120	Overall (%)
1.0	28.24	35.86	45.44	54.08	64.42	45.61
1.5	33.42	44.77	55.25	64.05	74.86	54.47
Std. Error (m)	0.30	0.27	0.30	0.28	0.24	

** H-24, H-48, H-72, H-96, H-120 represents mortality % after 24, 48, 72, 96 and 120 hours of treatments respectively in Table-1, Table -2 and Table-3.*

Discussion

The insecticidal properties of the extract of Mentha aquatica and Mentha longifolia were found against Sitophilus oryzae infesting store grain of wheat, rice and maize (Perrot, 1944). Also some extracts of Melia azadirach, Myrtus comnumis, Mentha longfolia, Pegnum larmala and Cymbapogan citrates acted as insecticides causing various degree of mortality as well as repellency (Saljoqi et al. 2000)

In the present study the extracts of Mentha arvensis both at 1.0 % & 1.5 % conc. registered highest mortality among all the treatments. In a laboratory evaluation Japanese mint (Mentha arvensis Linn.) gave 100% mortality 96 hrs after treatment at 1.5 % conc. and 120 hrs. of treatment at 1.0% conc. and it was significantly better among five treatments for mealy bug (Ferrisia virgata) (Gupta et al. 2007).

The extracts of Ocimum gratissimum and Mentha aquatica also proved having insecticidal property against DBM (Plutella xylostella) and Formica ruffa in Democratic Republic of Congo (MashiMango et al.1990). The aerial parts of

Japanese mint are also known to eradicate external parasites like lice, pleas, bugs and flies and 100% mortality was recorded by using extracts of Mentha longifolia against Sitophilus oryzae in wheat after 48 hours of treatment (Melkani et al. 2009). As per the present experiment, the mortality observed with the use of extracts of garlic was 44.66 to 99.99 % at 1.0 % conc. and 53.33 to 99.99% at 1.5 % concentration. The extracts of Alium sativum (garlic) at 2 % concentration agreed nymphal cotton mealy bug (Phenacoccus solenopsis) on shoe flower plant (Hibiscus rosa sisnensis) gave 72 % mortality after 24 hours of treatment (Bhattarai, 1991). This confirms the findings of the present experiment.

In the present study mortality of Mealy bug (Ferrisia virgata) by soap nut of ritha extracts was recorded 93.3 % and 99.9%, 120 hours after application of 1.0 % & 1.5 % concentrations, respectively. Therefore, the observations of the present study have similarity with the earlier workers.

It was reported that a saponin fruit extract from Saponidus emarginatus showed toxicity against adults of the greenhouse whitefly Triaburodes vaporium (Hemiptera, Aleyroridae) (Porras & Lopez–Avila, 2009) and complete methanolic extracts from fruits have shown larvicidal and morphological alternations effects on mosquito Acdes aegypti (Diptera, Culicidae) (Ferreira Barreto et al. 2006). Another ethanolic fruit extracts from Sapindus mukorossi also showed anti coleopteran activity against pest of store grains (Sitophilus oryzae) (Coleopteran : Curculionidae) and also against Pediculus humanus (Phthiraptera : Padiculidae) (Rahman et al. 2007).

Several parts of plants viz. neem, pongamia, Indian privet, adathoda, chrysanthemum , turmeric, onion, garlic, ocimum, custard apple, ginger and some other plants acted as insecticidal plants which can be used in insecticide preparation (Singh and Saratchandra, 2005). Most plant species used for plant protection exhibit insect deterrent properties rather than insecticidal effect. It indicates that in some way those compounds inhibit normal development in insects. It acts as deterrent in the form of insect growth regulators (IGR), feeding deterrents, repellent and confuse ants. Antifeedent and repellent activity have been evaluated for some of the plants. A true antifeedent gives insect the opportunity to feed on the plants, but food intake is reduced until the insect die from starvation (Saxena, 1987). The growth regulators cause abnormality in metamorphosis and the insects suffering from malformations may become sterile or even die.

The present findings may be compared with the earlier study conducted in different parts of India and abroad with extract of other four tested plants like marigold, neem, ramtulshi & custard apple against Ferrisia virgata. However, it was quite more or less apparent from present study that most of the plant

extracts tested herein had shown good insecticidal properties and caused mortality, varying from 1.3 % to 99.9%.

Future Approaches

Large scale control of agricultural and stored grain pests depends mainly on chemical pesticides even today. New technologies are needed to be developed with minimal usage of pesticides. Bio-technology based approaches can be tried using available research data. Small scale farm trials can be done for long period to ensure the bio safety satisfactorily. Thus there is a vast wealth of plants with rich sources of bioactive compounds both explored and unexplored so far. However, further information is required before concentrating upon the plant materials seriously. Standardized laboratory tests are needed to be undertaken, examining the residual effects of these materials over 6-12 months duration against key insect species like mealy bug.

Conclusions

In the context of agricultural pest management, botanical pesticides are well suited for use in organic food production and may play a great role in the production and protection of food in developing countries. The current trend of modern society towards green consumerism desiring fewer synthetic ingredients in food may favour plant based products (viz. Japanese mint, garlic, soap nut of ritha, tagetes, neem, ramtulshi, custard apple) which are generally recognized as safe (GRAS) in eco-friendly management of plant pests as botanical pesticides.

In this paper, it has been suggested that botanical pesticides should prove most beneficial towards affluent consumers and also for farmers in developing countries. Apart from economic considerations and potential health benefits, another important focus driving botanicals into their disparate markets is the regulatory environment.

References

Abbott,W.S.1925. A method of computing the effectiveness of an insecticide. *Journal of Economic Entomology.* 18: 265-267

Bhattarai, J.R. 1991. *A critical review of the techniques for testing insecticides*. Commonwealth Agricultural Bureau, England, 267 p.

Ferreira Barreto, C., G. M. Cavasin., H. H. Garcia da Silva, and I .Garcia da Silva. 2006. Study of the morphohistological modifications in larvae of Aedes aegypti (Diptera,Culicidae) submitted to the pure ethanolic extract of *Sapindus saponaria* Lin. (Sapindaceae). *Revista de Patologia Tropical.* 35 (1): 37-57

Gupta, S. K., S.N. Das and H. Biswas. 2007. Laboratory evaluation of some plant extracts towards causing mortality of Mealy bug, *Ferrisia virgata* Cockrell (Insecta: Homoptera: Pseudococcidae) infesting *Datura metal* L (Solanaceae). *Journal of Natural History.* 3 (2) 43-49.

MasshiMango, B., B, Sanvura and K. Chifundera. 1990. Insecticidal activity of *Ocimum gratissimum, Mentha aquatica and Haumaniastrum galeopsifolium* (Lamiaceae), plants from Kivu Province (Democratic Republic of Congo). *Annales De Lus,* 1:72-76.

Melkani, A.B., G.C. Shah and R.R. Parihar, 2009. Mentha longifolia subssp. Himalalensis: a few species as a sources of aroma chemicals. P.177-180 in Proc. of 11th Cong on *Essential oils, Fragrances and flavours.* Delhi, India during 12-16 November, 2008

Perrot, E.1944.*Matières premières* usuelles *du règne végétal*. Tomes II. Ed. Masson et cie. pp 1-797

Porras, M. F. and A. Lopez-Avila. 2009. Effect of extracts from *Sapindus saponaria* on the glasshouse whitefly *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae). *Revista Colombiana De Entomologia.* 35 (1): 7-11

Rahman, S. S., M. M Rahman., S. A. Begum., M. M. R. Khan and M. M. H. Bhuiyan. 2007. Investigation of *Sapindus mukorossi* extracts for repellency, insecticidal activity and plant growth regulatory effect. *Journal of Applied Sciences Research.* 1(2): 95-101

Saljoqi, A.U.R., M.K. Afridi, A.K. Shah, and Rehman, S. 2000. Effects of six plant extracts on rice weevil *Sitophilus oryzae* L. in the stored wheat grain. *Journal of Agricultural and Biological science.* 1(4): 1-5.

Saxena, R.C.1987.Antifeedents in tropical pest management .*Insect Sci. Applic.* 8, 731-736.

Singh, R.N. and B. Saratchandra. 2005. The Development of Botanical Products with Special reference to Seri Eco system. *Caspian J. Env. Sci.* 3(1): 1-8.

Soil Properties under Different Land Use Practices in the Mid-Hills of Nepal

I. Bhattarai[1*], K. Kafle[1], H.L. Shrestha[2], R. M. Bajracharya[3], R. Shakya[4] and Bishal K. Sitaula[5]

Abstract

Soil chemical and physical properties play a vital role in vegetation growth and crop production. Degradation of soil leads to a decrease in productivity and crop yields. In order to manage soil for sustainable use, it is important to monitor and optimize its physical and chemical properties. This study was carried out to determine and compare the physical and chemical parameters of soil under different land-use types, namely, leasehold forest, shifting cultivation and upland agricultural, at two different sites, i.e., Panchkhal in Kavre district and Ambukhaireni in Tnahun district, Nepal. Replicate soil samples from each of the land use types was done during March-April 2013 and analysis was of different parameters done at Kathmandu University. Soil bulk density was found to be higher in Panchkhal sites than in Ambukhaireni. Shifting cultivation of Ambhukhaireni had the highest total nitrogen (2464±635.54 mg kg^{-1}), available phosphorus (38.25±12.49 mg kg^{-1}), exchangeable potassium (245.35±56.28 mg kg^{-1}) contents and cation exchange capacity value (43.67±9.98 cmolc/100g). The overall pH values of all the sites were noted to be slightly acidic.

Keywords : Soil properties, Leasehold forest, Shifting cultivation, Agricultural land, Soil bulk density.

Introduction

Nepal is an agro based country where still 66% of people are dependent on agriculture. According to ministry of Agriculture and Development, agriculture along has contributed 36% of National GDP. Out of 75 districts of Nepal, 26

[1] *Graduate student, Kathmandu University*

[2] *PhD Scholar, Kathmandu University*

[3] *Professor, Kathmandu University*

[4] *Department of Forestry Research and Survey*

[5] *Norwegian University of Life Sciences, Norway*

* *Corresponding Author : Email- indubhatr@gmail.com*

districts of hilly region is not being able to meet the demand of local food production (MDD, 2000). Middle mountain region (mid-hills) of Nepal has only 30% of total land suitable for agriculture purpose (Maskey, 2001). The scarcity of crop land has serious implication for food security and rural development. Decrease in productivity of the soil also affects the rural livelihood. Since, most of the people in Nepal depend on agriculture to survive, the decline in agriculture has a direct inpact on their livelihood. Thirtle et.al's (2001) finding suggests that every 1% increase in productivity decreases 0.62% to 1.3% of the population under the poverty line. Similarly, declines in the soil fertility also cause adverse impact on forest vegetations. Hence, management of soil is necessary for both, people and forest to survive.

The primary grounds of food deficit or decrease in productivity could be declining soil fertility. Fertile soil is essential for vegetative growth. Not all soil types support plant growth with equal ease. If all soils can mechanically support plant life equally, then the productivity would have been same throughout the country. But the scenario is different. There is difference in production ratio in different areas because of available plant nutrient in soil. For a soil to be fertile and productive, wide varieties of ions in correct proportion must be available to plant root system. There are many essential mineral nutrients which come from the soil and is taken up by a plant's root. Among them Nitrogen (N), Phosphorous (P) and Potassium (K) are the primary macro nutrient. N, P and K are the limiting nutrients, which is used mostly by the plant for their growth and survival. Plant's growth ability also depends on the physical nature of the soil. Soil texture, moisture content, acidity (pH) and Cation Exchange Capacity determines the extent to which nutrient is available to plants. Mobility of soil nutrient within the soil depends on physical properties of the soil such as soil texture, porosity, moisture content, etc. Hence, determination of chemical and physical properties of the soil will help to provide information regarding essential nutrient present in the soil and to evaluate what other essential nutrient are needed to enhance the productivity of the soil.

The main objective of this study was to determine the physical and chemical parameters of three different land use (leasehold forest, shifting cultivation and agricultural land) to ascertain the character of the land, and to compare the parameters between three different sites.

Material and Methods

Study Area

The proposed project was conducted in two different area of Nepal's mid hill; Ambukhaireni VDC of Tanahun district and Panchkhal municipality of

Kavrepalanchowk district. Tanahun is located in Gandaki zone of Central Nepal, with an area of 1546 km2. It lies at elevation range from 340 m to 2134 m. Temperature in this district ranges from 50 C in winter to 350 C in summer. Tropical and subtropical climate is found in this area. Whereas, Kavrepalanchowk district lies in Bagmati zone of Central Nepal with the total area of 1396 km2. It has an elevation range from 318 m to 3018 m above sea level. Climate varies from subtropical to cool temperate in this district. Temperature in this region ranges from minimum 30 C in winter to maximum 400 C in summer.

Two land use sites were selected form each study area. In Ambukhaireni VDC, Gaidatar leasehold forest and Shifting cultivation were selected. Gaidatar leasehold forest was established in 2062 B.S. and the land is leased to six household for a period of forty years. On the other hand in Panchkhal municipality, Sirishghari leasehold forest and agricultural land were selected. Shirishghari Leasehold forest was established in 2051 B.S. and is leased for the period of forty years. There were total 26 household engaged in this leasehold forest group.

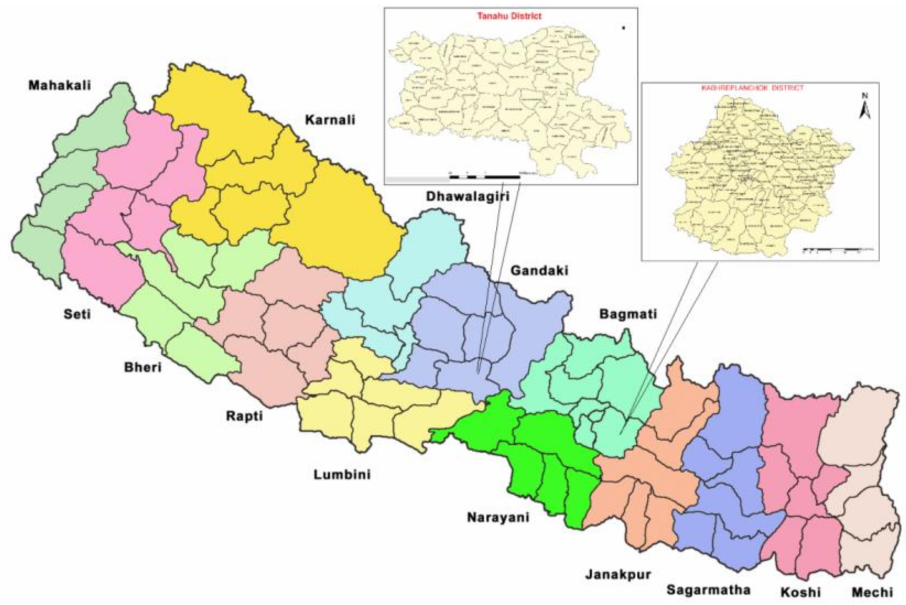


Figure 1 : Map of Nepal showing Kavrepalanchok district and Tanahun District

Figure 2 : Arial view of Ambukhaireni Site (source: Google Map)

Figure 3 : Arial View of Panchkhal site (Source: Google Map)

Soil Analysis

Four replicate sites from two depths (0-15 and 15-30 cm) were chosen from each land use type: leasehold forest and shifting cultivation at the Ambhukhaireni site and leasehold forest and upland agricultural in Panchkhal. Hence a total of 16 samples were taken from the two study areas. Eight sample plots (four samples from Gaidatar leasehold forest and four from shifting cultivation) were taken in Ambukhaireni site, whereas, another eight sample plots (four each from Shirishghari leasehold forest and upland agricultue) were taken at Panchkhal site.

Laboratory Analysis

Air dried soil samples were passed in 2mm sieve for physio-chemical analysis. Table 1 shows the list of physical parameters and their standard method where as Table 2 include list of chemical parameters and their standard method used in the laboratory for soil sample analysis.

Table 1 : Physical parameters and their standard methods used during laboratory analysis

Physical Parameters	Methods used
Soil moisture	Oven dry method
Soil Bulk Density	Soil Corer method Corer of diameter 4.7cm and length 6cm Dry bulk density, $\rho_{bd= Ms/Vt}$
Soil pH	1:1 soil water ratio using a pH probe method
Soil Texture	Hydrometer Method % Clay = 2* hydrometer reading %Sand = (wt of sand retained on sieve/wt of sand taken initially)* 100 % Silt = 100-% clay-% sand

Table 2 : Chemical parameters and their standard methods used during laboratory analysis

Chemical Parameters	Methods used
Total Soil Nitrogen	Kjeldahl Method (Bremner and Mulvaney, 1982). 1ml 0.1 N HCl = 1.402mg N-NH_4 %TN in soil = (ml HCl *1.402 mg N*100)/ 5000mg soil (5gm) = ml HCl * 0.02804
Soil Available Phosphorus	Modified Olsen's Method (Olsen and Sommers, 1982). (ppm) P in soil = ppm in test solution * 100/5 * 50/10 = ppm P in test solution *100
Cation Exchange Capacity and Potassium	Ammonium Acetate Method (Rhoades 1982) CEC is expressed in $cmol_c$/kg soil. m.e. of N in NH_4^+ form = (S-B)*N Where, S= volume of H_2SO_4 used in sample B= volume of H_2SO_4 used in blank N= normality of H_2SO_4 W= weight of sample in gm Therefore, CEC = ((S-B)*N*100/W) = ((S-B)*0.1*100/10gm) = (S-B)

Data Analysis

Data were analysed using excel and SPSS software. Soil texture was analysed using USDA Soil Textural Triangle.

Result and Discussion

Texture Class According to Land Use

The texture of the soil was observed following the USDA system. In Sirishghari Leasehold Forest, sand was found to be the highest while Gaidatar leasehold Forest was dominated by silt. Hence, Sirishghari Leasehold Forest soil had a textural class of Sandy Clay Loam and Gaidatar Leasehold Forest had textural class of Silt Loam.

Shifting Cultivation of Ambukhaireni and Agricultural land in Panchkhal had loam and clay loam soil texture with silt dominating in Shifting cultivation and sand dominating in agricultural land.

Table 3 : Soil texture of different sites

S.N	Plot site	Sand %	Silt %	Clay%	Texture class
1	Sirisghari leasehold forest (PLH)	54	21	25	Sandy Clay Loam
2	Gaidatar leasehold Forest (GLH)	19	60	21	Silt Loam
3	Shifting cultivation (SC)	29	49	22	Loam
4	Agriculture Land (AL)	41	26	33	Clay loam

Soil Bulk Density Soil Under Different Land Uses

Soil bulk density varied considerably between two sites i.e. Ambukhaireni and Panchkhal. Bulk density was higher in Panchkhal than Ambukhaireni site. Shirishghari leasehold forest and agricultural land of Panchkhal have highest bulk density, this might be due to the higher percentage of sand (Table 3) on these sites. Bulk density will be relatively higher in sandy soil because total pore space in sand will be less than that of silt or clay soil.

Similarly, bulk density is found higher in 15-30cm soil layer than on 0-15cm soil layer of leasehold forests and shifting cultivation. While agricultural land have higher bulk density in 0-15cm layer than other land use sites, this might be because of cultivation on agricultural land. Cultivation results in compaction on the soil layer with increase bulk density.

Table 4 : Bulk density of the soil within the depth of 0-15 cm and 15-30 cm in different plots of leasehold forests, shifting cultivation and agricultural land.

Depth(cm) / Site Name	0-15	15-30
Sirishghari leasehold Forest (PLH)	1.38±0.10 g/cm^3	1.47±0.0.06 g/cm^3
Gaidatar leasehold forest(GLH)	1.03±0.17 g/cm^3	1.13±0.25 g/cm^3
Agricultural land(AL)	1.44±0.09 g/cm^3	1.40±0.10 g/cm^3
Shifting cultivation(SC)	1.31±0.13 g/cm^3	1.39±0.02 g/cm^3

Total Nitrogen

Ambukhaireni had higher total nitrogen (TN) amounts than in the Panchkhal site while shifting cultivation recorded highest mean TN value (2464±635.54 ppm) and agricultural land of Panchkhal recorded low TN levels (791±242.14 ppm).The use of nitrogenous fertilizers may be the cause of high TN value in Ambukhaireni's shifting cultivation. However at the Panchkhal site, the agricultural land was fallow at the time of sampling as well as use of fertilizers may have been less. In general red soil tends to be highly weathered and less fertile than other soil type, i.e, lower amount of nitrogen and other nutrients.

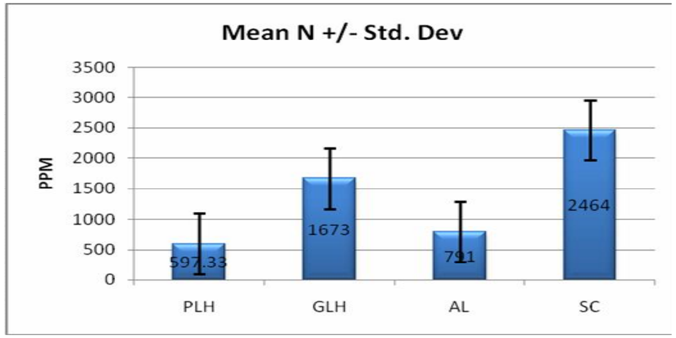


Figure 4 : Mean nitrogen value in different landuse type with their standard deviation.

Note : PLH (Sirishghari Leasehold forest); GLH (Gaidatar leasehold forest); AL(Agricultural land); SC(Shifting Cultivation)

Phosphorus Available

The available phosphorous (AP) was found to be high in Ambukhaireni while Panchkhal recorded lower AP values. Shifting cultivation had the highest AP amounts among the different land uses while there was less available phosphorous in agricultural land of Panchkhal. The reason could be that more phosphorous based fertilizers were used in Ambukhaireni's Shifting Cultivation. The phosphorous levels seen at the different sites lightly reflect the different management practices, such as retention of organic residues and application of fertilizers.

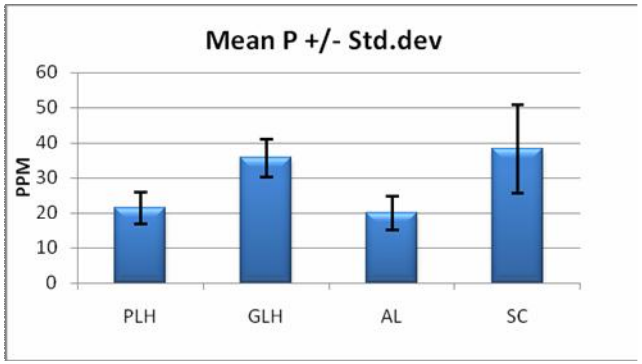


Figure 5 : Mean phosphorous value and their standard deviation

Note : PLH (Sirishghari Leasehold forest); GLH (Gaidatar leasehold forest); AL(Agricultural Land); SC (Shifting Cultivation)

Exchangeable Potassium

Site-wise and land use wise, the potassium values varied considerably. Ambukhaireni showed a higher value of Potassium than that of Panchkhal. Shifting cultivation has highest potassium while Shirisghari leasehold forest recorded less potassium value. The availability of soil potassium depends primarily on the types and amounts of rocks and minerals present. Unavailable potassium found in rocks and primary minerals becomes available only after these minerals begin to decompose (Soil Science Extension, North Carolina State University, 2006), (Brady & Buckman, 2002).This suggests that the mineral decomposition of Ambukhaireni's land (leasehold forest & shifting cultivation) could be higher than in Panchkhal. The exchangeable K values likely reflect the rock types and degree of mineral weathering at different locations.

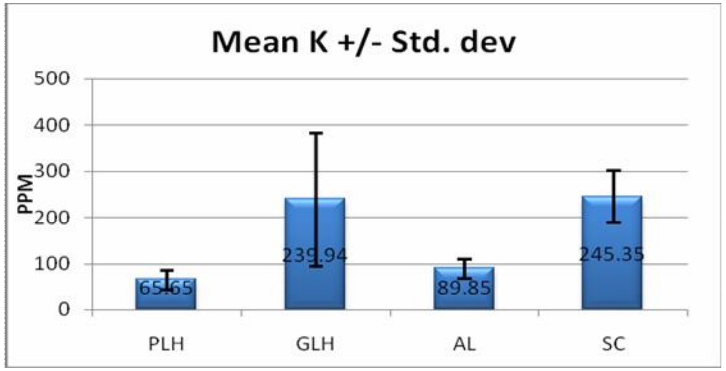


Figure 6 : Mean potassium value of different sites and their standard deviation. Note: PLH (Sirishghari Leasehold forest); GLH (Gaidatar leasehold forest); AL(Agricultural Land); SC (Shifting Cultivation)

CEC (Cation Exchange Capacity)

Like all the N, P and K values, CEC varied significantly site wise and land use wise. Ambukhaireni had the highest CEC value while Panchkhal recorded the lowest CEC value. Shifting cultivation of Ambukhaireni had high CEC and Sirishghari Leasehold Forest had low CEC value. This means shifting cultivation had more exchange sites compared to other land uses thus making it capable to hold more nutrients and avoid rapid changes in soil solution. It might be due to nature of parent material or the clay present in the soil.

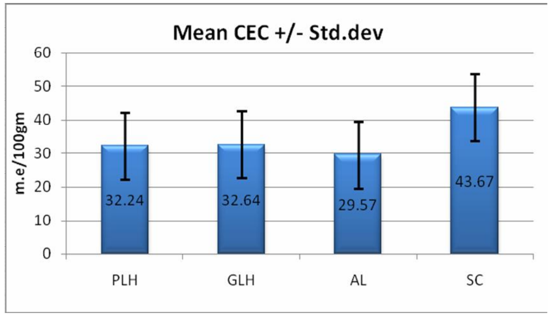
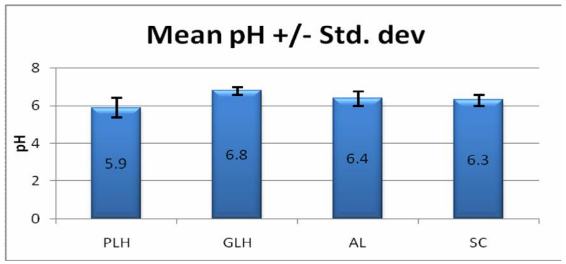


Figure 7 : Mean CEC value of different sites and their standard deviation. Note: PLH (Sirishghari Leasehold forest); GLH (Gaidatar leasehold forest); AL(Agricultural Land); SC (Shifting Cultivation)

Among all the nutrients, Nitrogen was to be the highest in all the sites. This is because it is the nutrients needed by plants in the greatest amounts and is supplied primarily by organic matter and residues in the soil, and to a lesser extent by atmospheric discharge and symbiotic nitrogen fixation by plant-associated and free-living microorganisms in the soil.

Soil pH

The overall pH of all the sites was slightly acidic to near neutral. The pH of Gaidatar leasehold forest was observed to be the highest (6.8) among the four sites and the pH of Sirishghari leasehold forest was the least (5.9) which is in fact less than the pH of Agricultural land, as well as, shifting cultivation. None the less, the soil pH of all sites, which was in the narrow range of less than 1 pH unit can be regarded not much different among the sites and is suitable for crops and plant growth.



.

Figure 9 : pH of different plot sites and their standard deviation.

Note : PLH (Sirishghari Leasehold forest); GLH (Gaidatar leasehold forest); AL(Agricultural Land); SC (Shifting Cultivation)

Conclusions

The study indicates that shifting cultivation in Ambukhaireni has higher plant nutrients than the other land use. The red soil in agricultural land of panchkhal has resulted in less cation exchange capacity due to which the availability of the plant nutrients is observed lesser in amount. With the optimal pH of all the soil of different land use is between 5.5-7.5, the soil is suitable for the plant growth in the area. The over all quality of the soil for agriculture is satisfactory while for the leasehold forest, the soil quality has supported the local plant growth with the good results in both the sites.

Acknowledgement

This research work was financially supported by FORESC Project between Kathmandu University and Norwegian University of Life Sciences and Aquatic Ecology Centre (AEC) family are gratefully acknowledged for their support and encouragement.

Reference

Bremer, J.M., C.S. Mulvaneyy, 1982. Method of Soil Analysis Part II, Chemical and Microbiological Properties, 2nd edition, American Society of Agronomy, SSSA Inc., Madison, WI, USA, p 595-624.

Maskey, R. 2001. Option for Sustainable Land Management in the Mid-Hills of Nepal: Experience of Testing and Demonstration of Contour Hedgegrow Intercropping Technology . Mountain Agriculture in the Hindu Kush Himalayan Region , p. 79. Kathmandu.

MDD, 2000. Special Issue Market Information Bulletin, Kathmandu: Market Development Division, Department of Agriculture

Olsen, S.R., Sommers L.E., 1982. Methods of Soil Analysis Part II; Chemical and Microbiological Properties, 2nd edition, American Society of Agronomy, SSSA Inc., Madison, WI, USA, p 403 - 430

Rhoades, J.D., 1982. Methods of Soil Analysis part II: Chemical and Microbiological Properties, 2nd edition, American Society of Agronomy, SSSA Inc., Madison, WI, USA . P. 149-158

Thirtle, C., Irz, X., Lin, Lin, Mckenzie-hill, V., & Wiggins, Steve. 2001. Relationship between changes in agricultural productivity and the incidence of poverty in developing countries (Report No. 7946). London: Department for International Development.

Integrated Farming System – The Answer to Livelihood Security?

A. Baishya[*], J. Hazarika, B. Gogoi, M. Borah, A.S. Bora, A. Rajbongshi, D.Bordoloi and J.P. Hazarika

Abstract

A model has been developed on Integrated Farming System (IFS) with crop – Cattle-Fishery- Apiary in 1.0 ha area. Recycling of cowshed waste were done by converting it to liquid manure as well as Biogas; besides this cowdung along with crop residue converted to vermin-compost and all these were used for crop production with less use of chemical fertilizer. The economic analysis of IFS model under rainfed situation during the year 2012-13 revealed a net return of Rs.145,284 or $2410 and with a benefit:cost ratio of 1.94 and an employment generation of 434 mandays/ha/year. Besides this it produced bio-fuel, food for family members and feed for cattle. By, recycling the bio-waste, pollution to the environment reduced and also improves the input generation within the system itself. From a mixture of 120 kg cowdung and 180 kg crop residue (including Water Hyacinth) the vermin-compost recovery was 136 kg and nutrient content of vermin-compost were 2.04% nitrogen, 1.22% phosphorous and 2.58% potash. For bio-fuel production, 2000Kg cowdung initially and 50-55 Kg cowdung per day were used and bio-fuel produced were sufficient to use in a single burner or even more. Cowshed waste were collected in a three chambered tank and after the process of sedimentation liquid manure were collected in the fourth chamber and 40 litres of liquid manure were collected after every 3 days. This liquid manure contains 0.66% Nitrogen, 0.32% Phosphorous and 0.50% Potash. Fish ponds, besides producing good amount of fishes, it also serves the purpose as water harvesting structure and rain water deposited there during the rainy season were utilized in the rabi crops at the time of harvesting of fishes (1st/2nd week of January). De-siltation of fish ponds were carried out after every two years. Sincer this silt contains 0.5% organic carbon, 0.029% N, 0.025% P and 0.018% K, as it was used in different fruit crops. The rice bran produced during processing of paddy as byproduct and the oilcake produced as byproduct during processing of Toria were used as a cattle as well as fish feed and thereby minimizing the requirement of purchased inputs.

Keywords : Bio-waste, Recycling, Bio-fuel, B:C Ratio, Employment generation.

Integrated Farming System, Assam Agricultural University, Jorhat, Assam-785 013 (India)

[*] *Corresponding author: Email:* baishya.ajit@gmail.com

Introduction

Assam is a North-Eastern state of India, which is situated between 24º to 28º 18′ N latitude and 89º4′ to 96º E longitude sharing international borders with Bhutan and Bangladesh. The climate of Assam is sub-tropical humid. The mean annual precipitation is 1900 mm, 70% of which received during June to August. A small quantity of rainfall also received during April-May and September-October. The maximum temperature ranges between 36º to 38ºC during summer and minimum temperature falls down to 7ºC during winter.Its relative humidity during summer season remains around 80 percent; however, it may reach as low as 60 percent during winter. Due to cloudy weather sunshine hours are very less (on an average 4 hours per day) in summer. The average sunshine hour is higher in winter months (6 hours/day). Soils are mostly acidic (pH 4.2-5.8) in all the zones except Hill Zone where it ranges from acidic to neutral (4.5-7.1). The N, P and K status is generally low to medium.

A high dependence of agriculture for livelihood, widespread practice of traditional farming technique, low usage of modern farm inputs, inadequate agricultural infrastructure, thus lower levels of productivity and incomes in the sector and so on. About 75% of the state's population is directly or indirectly dependent on agriculture, while about 69% workforce in the state is actually engaged in agricultural activities.

Review of Literature

Jayanthi et.al. (2009) in Tamil Nadu, India demonstrate that besides facilitating cash income, Integrated Farming System generates additional employment for family labour and minimizes the risk associated with conventional cropping system. It also sustains soil productivity through the recycling of organic nutrient resources from the enterprises involved.

Ugwumba et.al. (2010) in Nigeria revealed that highest net farm income of $7462.77 was recorded with Crop – Livestock – Fish partial integration which is close to the full integration of Crop – Livestock – Fish – Processing – Biogas.

Gupta et.al. (2012) in Jammu, India explained that in an Integrated System, Crops and Livestock interact to create a synergy with recycling allowing the maximum use of available resources. Crop residues can be used for animal feed, while livestock and livestock byproduct production and processing can enhance agricultural productivity by intensifying nutrients that improves soil fertility, reducing use of chemical fertilizers.

Walia and Kaur (2013) in Punjab, India mentioned that Sustainable development must include Integrated Farming System(IFS) with efficient soil, water, crop and pest management practices which are environmentally friendly and cost effective.

Need for Research

With an average land holding of 1.15 ha, Integrated Farming System (IFS) seems to be an answer to solve the problem of increase in food production, increasing income, improving nutrition of the small and marginal farmers of Assam. With only crop component byproduct may go waste or even create pollution; but in integrated farming system, these byproducts may be utilized in livestock or fishing enterprises. Hence, integration of different agricultural allied enterprises with crop activity as base, will provide ways to recycle produces/waste materials of one component as input of other linked component and to reduce the cost of production of economic produce of component enhance the net income of the system, reduces pollution from bio-waste, improve soil fertility and reduces resource degradation.

More than 80% farmers are within the category of marginal and small farmers, hence integrated farming system may be a suitable action to improve their livelihood, resource conservation as well as minimizing environmental pollution. It can be an answer for mitigating global warming.

Assuming a family having 5 members (Man-1, Woman-1, Boy-2, Girl-1) the annual food requirement was calculated for the family and the model was developed to meet up the requirement along with the cattle and fishery as far as possible. The annual food requirement as per Indian Council of Medical Research standard were calculated and mentioned in Table-1.

Based on above discussion an Integrated Farming System Model has been developed by the team of Scientist working under the leadership of Chief Agronomist, All India Co-ordinated Research Project on Integrated Farming System, Assam Agricultural University, Jorhat with the financial assistance of Indian Council of Agricultural Research through the Project Directorate of Farming System Research, Modipuram, Meerut, U.P., India.

IFS model develop: Crop (Field+Horticultural crop) - Cattle – Fishery - Apiary

Operational area 1.0 ha

Methods

Land were distributed in different activities to meet up the family needs as far as possible and based on this the land used pattern is presented in Table 2.

Cropping Sequences

5 different cropping sequences which were carried out to meet up the different requirements of farm family are presented in Table 3.

Table 1 : Annual food requirement of a family having 5 members (Man-1;Woman-1;Boy-2 and Girl-1)

Food groups	***g/ portion/ meal	Per year (kg.)	Food requirement as per nature of work (Kg)				**Total (kg.)**
			Heavy		Sedentary		
			Man	Woman**	Boys**	Girl**	
Cereals	30.00	10.95	10.95 × 23 = 251.85	10.95 × 16 = 175.20	10.95 × 14 × 2 = 306.60	10.95 × 10 = 109.50	843.00
*Pulses	28.50	10.40	10.40 × 3 = 31.20	10.40 × 3 = 31.20	10.40 ×2 × 2 = 41.60	10.40 × 2 = 20.80	125.00
Fish	31.50	11.50	11.50 × 1 = 11.50	11.50 × 1 = 11.50	11.50 × 2 = 23.00	11.50 × 1 = 11.50	58.00
Roots & Tubers	20.00	7.30	7.30 × 3 = 21.90	7.30 × 3 = 21.90	7.30 × 2 = 14.60	7.30 × 1 = 7.30	66.00
Green leafy vegetables	50.00	18.25	18.25 × 1 = 18.25	18.25 × 1 = 18.25	18.25 × 1 = 18.25	18.25 × 1 = 18.25	73.00
Other vegetables	100.00	36.50	36.50 × 1 = 36.50	36.50 × 1 = 36.50	36.50 × 1 = 36.50	36.50 × 1 = 36.50	146.00
Milk	100.00	36.50 lit.	36.50 × 3 = 109.50 lit	36.50 × 3 = 109.50 lit	36.50 × 3 = 109.50 lit	36.50 × 3 = 09.50 lit	53.00
Fruits	100.00	36.50	36.50 × 1 = 36.50	36.50 × 1 = 36.50	36.50 × 1 = 36.50	36.50 × 1 = 36.50	49.00
Sugar	5.00	1.83	1.83 × 11 = 20.13	1.83 × 9 = 16.47	1.83 × 5 = 9.15	1.83 × 4 = 7.32	53.00
Fats/ Oils	5.00	1.83	1.83 × 11 = 20.13	1.83 × 8 = 14.64	1.83 × 4 = 7.32	1.83 × 4 = 7.32	49.00

*One pulse portion will be substituted by fish or other non-vegetarian item for non- vegetarian people.

**3 Woman = 2 Man; Hence, 1 Woman = 2/3 Man = 0.67 or 0.70 Man

2 Children = 1 Man; Hence, 1 Children = ½ Man = 0.50 Man

****Based on Indian Council of Medical Research Dietary Guidelines for Indians.*

Table 2 : Land use pattern.

Land distribution under different activities	Area (Sq. m)
1. Land allotted to animal shed, store house, Apiary, Vermicompost unit, Threshing floor and common uses	1050
2. Area under cereals, pulse, oilseed and fodder to meet household food, feed and fodder demand .	3846
3. Rice+ Vegetable	1450
4. Fruit and Fodder crops	950
5. Fishery also water harvesting structure	500
6. Water body with less water depth (Fishery as well as water harvesting structure)	420
7. Raised and Sunken bed system	1200
8. Seed bed/ Nursery	500
9. Passage, Drain etc.	84
Total	**10,000**

Table 3 : Area under different cropping sequences

Cropping system	Area (Sq.m)
Rice (w)-Toria-Cowpea(F)	2187
Rice (w)-Toria-Green gram	789
Rice (w)-Oat(F)- Black gram	920
Rice (w)-Potato-Lady's finger	700
Rice (w)-Cabbage- Cowpea(V)	700
Total	**5296**

Crops Grown

Suitable and recommended varieties of crops were grown in different cropping sequences and proper package of practices were followed. The varieties cultivated and seed rate taken were presented in Table 4.

Table 4 : Varieties and seed rate of different crops

Sl. No.	Crop	Varieties	Seed rate
1.	Winter rice	Rajendra Suwasini	45 kg/ha
2.	Cabbage	Golden acre	800 g/ha
3.	Potato	Kufri Jyoti	22.5 Q/ha
4.	Toria	TS-46	10 kg/ha
5.	Oat	Kent	100 kg/ha
6.	Green gram	Pratap	18 kg/ha
7.	Black gram	PU-31	25 kg/ha
8.	Lady's finger	Parbhani Kranti	21 kg/ha
9.	Cowpea (Fodder)	EC 4216	50 kg/ha
10.	Cowpea (Vegetable)	Green long	20 kg/ha

Fertilizer Application

Different levels of fertilizers were applied to different crops and those are presented in Table- 5.

Table 5 : Levels of fertilizers applied to different crops during different seasons.

Kharif	Rabi	Summer
Winter rice @ 80-40-40 NPK Kg/ha	Cabbage @ 120-60-60 NPK Kg/ha and Borax 10 Kg/ha	Black gram @ 10-35-10 NPK Kg/ha (with Rhizobium culture)
	Potato @ 60-50-50 NPK Kg/ha and Vermi-compost application @ 15 Q/ha	Green gram @ 10-35-10 NPK Kg/ha (with Rhizobium culture)
	Toria @ 60-40-40 NPK Kg/ha and Borax 10 Kg/ha	Cowpea (F) @ 10-35-10 NPK Kg/ha
	Oats @ 40-20-20 NPK Kg/ha	Cowpea (V) @ 15-35-10 NPK Kg/ha
		Lady's finger @ 50-50-50 NPK Kg/ha

Raised and Sunken Bed Module

1200 sq.m. marshy land were converted to 20 numbers Raised bed and 20 numbers Sunken bed during the winter season of 2010 to make it more productive. Informations relating to Raised and Sunken bed are mentioned in Table 6. Recommended package of practices were carried out for different crops.

Table 6 : Number, areas, varieties and fertilizer levels in raised and Sunken bed.

Raised bed	Sunken bed
Number of Raised bed = 20	Number of Sunken bed = 20
Size of each bed = 30 sq.m.	Size of each bed = 30 sq.m.
Total area = 600 sq.m.	Total area = 600 sq.m.
Cropping sequence: Cabbage/ Potato/ Pea/ French bean- Black gram/ Cow pea (F)	Cropping sequence: Winter rice-summer rice
Varieties: Cabbage–Golden acre; Potato–Kufri Jyoti; Pea– Azad; French bean–Anupam; Black gram–PU 31; Cowpea (F) – EC 4216	Varieties: Winter rice – Ranjit Summer rice – Joymoti
Fertilizer application: Cabbage @ 120-60-60 NPK Kg/ha and Borax 10 Kg/ha; Potato @ 60-50-50 NPK Kg/ha and Vermi-compost application @ 15 Q/h; Pea @ 20-46-10 NPK Kg/ha (without Rhizobium culture); French bean @ 30-40-20 NPK Kg/ha.	Fertilizer application: Winter rice @ 40-20-20 NPK Kg/ha; Summer rice @ 60-30-30 NPK Kg/ha.
Seed rate: Cabbage: 800 g/ha; Potato: 22.5 Q/ha; Pea: 50 Kg/ha; French bean: 50 Kg/ha; Black gram: 25 Kg/ha; Cowpea(V): 20 Kg/ha	Seed rate: Winter rice: 45 Kg/ha; Summer rice: 45 Kg/ha;

Details of Other Activities:

Horticultural crops viz. Banana (Dwarf Cavendish - 27 nos.; Tall Cavendish - 7 nos.), Assam lemon - 32 nos., Papaya (hybrid) - 7 nos., Guava (Allahabad Safeda) - 4 nos. and Pineapple (Kew) - 244 nos. were grown in the bank of the pond to supplement farm with cash income and also provide nutrition to the farm family.

Vermi-compost was prepared in 2.26 cu.m. Vermi-compost unit from different vegetables and fruit waste viz. discarded cabbage leaf, pea plants after harvest of pea, semi dry banana leaves etc., along with well decomposed rice straw and cow dung. Liquid manure production from cow-shed waste was carried out in 3 chambered sedimentation tanks (total area = 2.34 sq.m.) and finally liquid manure was collected in a 0.18 sq.m. tank; Liquid manure was used in fruit crops other than banana. Fodder crops like Setaria (Setaria sphaccilta cv. Kazungula) was planted which besides checking soil erosion also produce green fodder; Hybrid Napier was planted in 30 sq.m. area in the northern border of the IFS model.

A 2 cubic metre Bio-gas plant was established and run with the Cow dung available from the IFS Cattle Component. Two fish ponds of 500 sq.m. and 420 sq.m. were utilized for water harvesting as well as for fishery within the IFS model.

Management of the Fishery

Before rearing of fishes, Urea @ 2.55 g/ sq.m. and SSP @ 2.10 g/ sq.m. were applied. Cowdung was applied before and after rearing of fishes @ 201.0 g/sq.m. and 7.5 g/ sq.m., respectively till the water becomes light green in colour. To reduce the turbidity of water, Toximer was used @ 12.5 g/sq.m.

Fishes were reared @ 1 fingerling/ sq.m. in the ratio of 40:30:30 for Surface feeder: Column feeder: Bottom feeder. Catla was reared as surface feeder, Rohu and Java Puthi as column feeder whereas Kurhi, Mali and Mrigal were reared as bottom feeder. Feed for fish was used @ 2% of the body weight, out of which 1% was Rice bran and 1% was Mustard Oil Cake. Before rearing of fishes 35.0 g/ sq.m. lime ($CaCO_3$) was applied (this amount is 1/3rd of the total lime requirement). After rearing of fish, 2/3rd of the amount i.e. 70 g lime/ sq.m. were applied in 10 splits @ 7.0 g/ sq.m. in one split. Before harvesting of fishes water were pump out to irrigate the rabi crop. De-siltation were carried out after every two years to maintain depth, besides silt were very fertile which contain 0.495% organic carbon, 0.0293% N, 0.025% P and 0.0175% K. Altogether 146.4 tonnes silt were removed and were utilized in different fruit crops;

Livestock Unit

Two cross breed milch cow along with a Heifer of 12 months old were reared. Approximate weight of milch cow was 350 Kg. The different breed of cattle in the IFS model is presented in Table-7.

Table 7 : Different breeds of cattle and their number in the IFS model.

Year	Breed		Number
2012-13	Milch Cow	Holstein Fresian	1
		Jersey	1
	Calf	Jersey	1

Feeding of Cattle

Different feeds were provided to the cattle for overall improvement of its metabolic functions such as growth and development, increasing body weight, resistance to diseases and reducing dry period etc.

Feeding of Milk Cow

Fodders, concentrate, Paddy straw and mineral mixture were provided to milch cow. The different feeds along with quantity fed to milch cow are presented in

Table-8 and feed provided to calf in Table-9. The different ingredients of the concentrate are presented in Table-10.

Table 8 : Quantity of different feeds provided to milk cow.

Total requirement of two milch cows (Kg/ day)	Quantity (Kg/ milch cow/ day)	Feed
44	22	Green fodder
8	4	Paddy straw
8	4	Concentrate
0.10	0.05	Mineral mixture

Table 9 : Feed provided to the calf.

Quantity (Kg/ calf/ day)	Feed
10	Green fodder
1	Concentrate
0.02	Mineral mixture

Table 10 : Constitution of concentrate

Quantity (Kg)	Constitution
0.40	Maize or Rice grinded material
0.37	Mustard oil cake
0.20	Wheat bran/ Rice bran/ Husk
0.03	Dry fish + Salt + Bone meal etc.

Apiary Management

As per recommendation, 5 bee hives are recommended per hectare where honey bee species was Apis cerena (Indian Honey bee). Shady areas, as far as possible, near the Horticultural/ plantation crop were selected to maintain optimum temperature requires for the bees. Besides, holes were made in the boxes to allow air to pass through it and kept the honey bee active. During Rabi (winter) and summer season when flowering occurs in plants, workers become active. Fragrance and pollen grain attract honey bees and reproduction occurs during that time. During rainy season a sugar solution was prepared by dissolving 750 g sugar in one litre of water, after that cotton was shocked in the solution and place in a petri dish which was placed inside the apiary. On the other hand, during winter season Apiary was transferred to an sunny area to maintain optimum temperature. To stop the movements of ants, platform of the bee hives were filled up with water.

Vermicompost Unit

Area allocated for Vermi-compost production was 2.26 cu.m. Incorporation of 753 nos. of earthworms (Eisenia foetida) were carried out [1 Kg contains 1000 nos. (approx)], which was expected to multiply up to 3,000 nos. in the cycle; so in the second cycle along with vermi-compost say 2000 nos. of earthworm was sold which also follow in 3rd and 4th cycle. Therefore, all together 6000 nos. of earthworms could sold along with vermicompost which gave added returns of Rs. 15,000 (cost of each earthworm was Rs. 2.50). From 120 kg cow dung and 180 kg crop residue (bio-waste) of the IFS model itself 136 kg vermi-compost produced (i.e. recovery was around 45%). Vermi-compost produced from this substrate contains 2.04%N, 1.22%P and 2.58%K. Total 180kg Crop residue/ bio waste were used which contained dried water hyacinth (65 kg), cabbage leaf (50 kg), straw (30 kg) and waste obtained at the time of winnowing of rice (35 kg).

Bio-gas Plant

Size of the bio-gas plant was 2 cu.m, where 2000 kg cowdung was used initially as fuel. This required 45 days for fermentation and for the evolution of gases. For the production of bio-gas, 55kg dung per day was used which produced 1.4 cu.m. bio-gas/ day.

Liquid manure Production

Output of cow dung and urine mixture was channelized to a 4 chambered tank. Through the process of sedimentation in the three chambers finally complete liquid manure was collected in the 4th chamber @40 litres/ three day. It was used in case of horticultural crops particularly fruits crop other than banana,(anticipating probable earthworm infestation in case of banana). Sediment solid portion were also utilized in field as well as in horticultural crops. Chemical analysis of liquid manure revealed 0.66%N, 0.32%P and 0.50%K as constituents.

Soil Analysis

Comparison of soil analysis data after liquid manure application with that of initial value are presented in Table-11.

Table 11 : Soil analysis data before and after use.

Available Nutrients (Kg/ha)			Organic Carbon (%)	pH	Horticultural Species
K2O	P2O5	N			
125.00	14.50	260.12	1.14	4.65	Areca nut
228.48	56.04	396.07	1.61	5.45	Lemon
115.80	17.00	254.00	0.72	4.90	Banana
188.16	23.90	302.31	0.90	4.55	Citrus
190.00	24.75	304.82	0.96	4.80	Guava
134.75	17.70	258.00	0.77	4.70	Pine apple
168.70	51.68	407.32	1.54	5.40	Papaya
264.48	18.00	287.00	0.67	5.50	Initial value

Analysis of Economy of IFS Model and Employment Generation

Economic analysis of the IFS model was done using different concept to assess the productivity and profitability of the farm. Actual utilization of labour for production of different enterprises during the period of study was taken as employment. It was expressed in terms of man days/ ha. However, it was calculated considering specific area under a particular enterprise i.e. not on per hectare basis.

Results

Various sizes of the lands were allotted to different cropping sequences. Fruit and Fodder crops were planted in the bank of the pond. The yields of different crops of different cropping sequences are presented in Table-12, Prices in Table-13. Fruit and Fodder crops (other than sequences) in Table-14, cost and return in Table-15 and cost and return of Raised and Sunken bed for the year 2012-13 are presented in Table 16.

Table 12 : Yield of individual crops in the cropping sequences.

Grain yield (kg/ plot)			Cropping sequence	Plot size (m2)	Plot No.
Summer	Rabi	Kharif			
2083	48	298	Winter rice - Toria – Cowpea(F)	960	1
13	15	77	Winter rice - Toria – Green gram	220	2
42	34	211	Winter rice - Toria – Green gram	556	3
30	2414	166	Winter rice – Oat(F) – Black gram	460	4
23	4348	138	Winter rice – Oat(F) – Black gram	460	5
619	25	98	Winter rice - Toria – Cowpea(F)	326	6
354	8	42	Winter rice - Toria – Cowpea(F)	161	7
750	12	110	Winter rice - Toria – Cowpea(F)	370	8
800	10	120	Winter rice - Toria – Cowpea(F)	370	9
56	1204	200	Winter rice - Potato – Lady's finger	700	10
210	620	206	Winter rice - Cabbage –Cowpea(V)	700	11
		1666	Total rice		

Table 13 : Prices (Rs./kg) considered.

Price	Crop	Price	Crop	Price	Crop
30.00	Toria	45.00	Black gram	11.00	Winter rice (Grain)
45.00	Green gram	7.00	Potato	0.20	Winter rice (Straw)
15.00	Lady's finger	8.00	Cabbage	1.00	Cowpea (F)
15.00	Cowpea (V)	1.00	Oat		

Table 14 : Yield and Price of Fruit and Fodder crops (other than sequences)

Price (Rs./Kg/no.)	Rate (Rs./no./ Kg)	Yield	Crops
5720.00	20/ no.	286 nos	Pineapple
240.00	20/ kg.	12 kg	Guava
274.00	2/ no.	137 nos	Assam lemon
1700.00	25/ kg.	68 kg	Papaya
405.00	1.5/ no.	270 nos	Banana
3000.00	1/ kg.	3000 kg	Setaria (Fodder crop)
600.00	1/ kg.	600 kg	Napier (Fodder crop)

Table 15 : Cost and return of cropping sequences and fruit & fodder crops (2012-13).

B:C ratio	Net return (Rs.)	Variable cost (Rs.)	Gross return (Rs.)	Area (sq.m.)	Cropping sequences, fruit & fodder crops
					A. Crop Component
1.93	3655	3943	7598	960	1. Winter rice - Toria – Cowpea(F)
1.91	1016	1119	2135	220	2. Winter rice - Toria – Green gram
1.99	2839	2863	5702	556	3. Winter rice - Toria – Green gram
1.44	1078	2436	3514	460	4. Winter rice – Oat(F) – Black gram
1.55	1335	2436	3771	460	5. Winter rice – Oat(F) – Black gram
1.56	942	1678	2620	326	6. Winter rice - Toria – Cowpea(F)
1.57	469	829	1298	161	7. Winter rice - Toria – Cowpea(F)
1.57	1094	1905	2999	370	8. Winter rice - Toria – Cowpea(F)
1.65	1244	1905	3149	370	9. Winter rice - Toria – Cowpea(F)
1.57	2875	5015	7890	700	10. Winter rice - Potato – Lady's finger
1.40	9037	3759	12796	700	11. Winter rice - Cabbage – Cowpea(V)
2.65	7431	4508	11939	950	12. Fruit and Fodder crops
2.02	**33015**	**32396**	**65411**	**6233**	**Total**

Green Fodder Production to Meet up Cattle Requirement

Total fodder demand for two milch cow requirement per year was 16060 kg (@22 kg/ day/ milch cow) and for the calf it was 3650kg/ year (@10 kg/ day/ calf). Total fodder requirement for the cattle per year = (16060 + 3650) kg. = 19710 kg. Paddy straw requirement per milch cow = 4 kg./ day. Total requirement of straw for 2 milch cow per year = 4 × 2 × 365 = 2920 kg.

Table 16 : Cost and return of Raised and Sunken bed during 2012-13

B:C ratio	Net return (Rs.)	Gross return (Rs.)	Production (Kg.)	Variable Cost (Rs.)	Area (sq.m.)	Different beds and crops grown there
Raised bed						
	93	272	34	179	60	Cabbage
	264	555	37	291	120	Pea
	130	480	32	350	180	French bean
	545	1666	238	1121	240	Potato
1.53	1033	2973		1940	600	Total
Sunken bed						
	1708	4410	490	1370	600	Winter Rice
	1461	2975	350	1514	600	Summer Rce
2.56	4501	7385	840	2884	1200	Total
2.15	5534	10358		4824	1200	Grand Total

Green fodder like Setaria, oat, cowpea and Napier were cultivated in 2214.5 sq.m. from where 10885 kg. green fodder were obtained but fodder requirement were 19710 kg so the less amount i.e. 8825 kg were obtained from the green grasses available throughout the year from 354 sq.m. bund area (Table-17).

Table 17 : Green fodder area and production in IFS area.

Production (kg.)	Area (sq.m.)	Green fodder
2523	1227	Cowpea
4762	920	Oat
3000	37.50	Setaria
600	30	Napier
8825	354	Locally available green grasses
19710	**2568.50**	**Total**

Total rice production in the IFS area was 2506 kg (1666kg + 840kg) and total straw production was 3500 kg. As because total production of straw were 3500 kg. in the IFS area and total requirement were 2920 kg. So, around 580 kg. straw was surplus, some of which were used for vermi-compost production.

Contribution of Dairy Enterprise:

Milk production of dairy was recorded on monthly basis and milk was sold @ Rs. 28.00/ lit. Total milk production for the year 2012-13 was 3574.30 litre and gross return was Rs. 1,00, 080.00 where as variable cost was Rs. 71,102.00 and the B:C ratio was 1.41 (Table-18). The large production of milk from the cattle was the result of proper feeding management of the cattle which were fed with green fodder, naturally available green grasses, paddy straw and formulated feeds like concentrate and mineral mixture along with proper health maintenance.

Table 18 : Economics of the dairy component for the year 2012-13.

Amount (Rs.)	**Rate (Rs.)**	**Quantity**	**Particulars**
0*	1	44	Green fodder (Kg./day)
32120	11	8	Concentrate (Kg./ha)
0*	0.2	4	Paddy straw (Kg./ha)
8760	100	0.24	Mineral mixture (g/day)
0*	1	10	Green fodder (Kg./day)
4015	11	1	Concentrate (Kg./ha)
2190	100	0.06	Mineral mixture (g/day)
47085			Total feed cost
23790	130	4 cycle	Labour (man days) 183 md
70875			Total variable cost
-	28/ lit.	3574.30 lit.	Sale of milk
1,00,080	-	-	Gross return
29,205	-	-	Net return
1.41	-	-	B: C ratio

*available within the system

Contribution of Fishery Enterprise

Production of fish increased considerably in the IFS system. Different species of fishes were stocked in the fishery based on the feeding habit at different layers. Month-wise measurement of length and weight of fishes indicated a satisfactory increase in its length and weight every month. This proper growth and development may be attributed to the balance feeding of the fish and because of the highly fertilized fishery bottom on account of the production of zoo and phytoplankton which is utilized fully by the fish. Among the different species Catla recorded the highest length (52.50 cm) and body weight (2300 g) at the time of harvesting in December.

The total harvest from all species i.e. Catla, Rohu, Java Puthi, Kurhi, Mali and Mrigal were 245 kg and it was sold @ Rs. 100.00 per Kg. providing gross return of Rs. 24,500.00. The economics of the fishery components were analysed and are presented in Table-19 and Table-20.

Table 19 : Economics of fishery component for the year 2012-13

Amount (Rs.)	Rate (Rs.)	Quantity	Particulars
2500	5	500 nos.	Fingerlings
200	10	20 Kg	Lime
0*	0.5	500 Kg	Cow dung
125	10	12.5 Kg	Urea
115	10	11.5 Kg	SSP
440	-	-	Cost of lime, fertilizers
4776	12	550 Kg (152kg. produced in IFS; Total reqd. 398kg.)	Mustard oil cake
0*	10	550 Kg (534kg. rice bran produced in IFS, so almost covers the required amount)	Rice bran
4776	-	-	Feed cost
4160	130	32 mandays	Labour
75	15 / 20 g	100 g	Other cost (KMnO4)
11951	-	-	Total cost
24500	100	245 Kg	Production
12549	-	-	Net return
2.05	-	-	B:C ratio

**produced within the system.*

Table 20 : Economic analysis of water body with less depth (within fishery component) for the year 2012-13

Amount (Rs.)	Rate (Rs.)	Quantity	Particulars
2100	5	420 nos.	Fingerlings
168	10	16.8 Kg.	Lime
0*	0.5	420 Kg.	Cow dung
105	10	10.5 Kg.	Urea
96.7	10	9.67 Kg.	SSP
369.7	-	-	Cost of lime, fertilizers
4800	12	400 Kg.	Mustard oil cake
4000	10	400 Kg.	Rice bran
8800	-	-	Feed cost
3900	130	30 mandays	Labour
60	15/20 g	80 g	Other cost (KMnO4)
15230	-	-	Total cost
20500	100	205 Kg.	Production
5270	-	-	Net return
1.35	-	-	B:C ratio

**produced within the IFS.*

Contribution from Apiary Unit

In the bank of the pond, 5 bee hives were placed because 5 bee hives are recommended for 1.0ha of land. Production was on an average 12.0 kg per bee hive and altogether 60 kg from 5 bee hives.Honey bee was sold @Rs.200.00 per Kg. Economics of Apiary component are mentioned in Table-21.

Table 21 : Economic analysis of apiary component during the year 2012-13.

B:C ratio	Net Return (Rs.)	Total Cost (Rs.)	Operational cost (Labour cost + Artificial food cost) for 5 bee hive (Rs.)	Cost for 5 bee hives	Income per year from 5 bee hives (Rs.)	No. of bee hives
2.00	6,000.00	6,000.00	2,000.00	4,000.00	12,000.00	5

Additional Return from Processing

Apart from yield advantages of main produce from the crops, it had also other advantages and helped in increasing the efficiency of the system as crop component, processing also gave an additional return of Rs. 30,712.00. A total of 2506 kg rice and 152kg toria were obtained. After processing 1554 kg grain and

802 kg Rice bran, 46 litre Mustard oil and 91 kg Mustard oil cake were obtained. Economic comparison of processing and without processing of farm produce are presented in Table 22.

Table 22 : Economics of with processing and without processing of farm produce of IFS model.

Amount (Rs.)	Rate (Rs./kg)	Quantity (kg / no.)	Unit	Particulars
				Milling charge
2506.00	1	2506	Rs./kg	Paddy
1520.00	10	152	Rs./kg	Toria
520.00	130	4	Man days	Labour charge
4546.00	-	-	Rs.	Total processing cost
				Conversion factor
46620.00	30	1554	Kg	Head yield of rice (62%)
8020.00	10	802	Kg	Rice bran (32%)
4600.00	100	46	Litre	Mustard oil (30%)
1092.00	12	91	Kg	Mustard oil cake (60%)
60332.00	-	-	Rs.	A. Total return from processing
				B. Return from farm produce without processing
25060.00	10	2506	Kg	1. Paddy
4560.00	30	152	Kg	2. Toria
29620.00				Total
30,712.00				Total

**After processing, additional profit of Rs. 30,712.00 was obtained from the crop component and accordingly net return was calculated.*

Recycling of Manure in the IFS System

The cow dung excreta per day was 20 kg per cow and per year it was 21,900 kg. The per day per cow urine excreta was recorded as 13 litres/cow/day and therefore from the cattle component per year (from 3 cattle) it was 14235 litres. Those quantity of cow dung and urine were recycled during the year 2012-13 and liquid manure was prepared and used in different horticultural crops other than banana (Table-23).

Table 23 : Quantity of recyclable manurial resources

Uses manurial resources	Quantity produced/ year (kg)	Quantity produced/ day (kg)	Recyclable manurial resources	Component
Use in vermicompost production (120 kg), in paddy field (2050 kg), in bio gas production (2000 kg) and in horticultural crops (650 kg).	21900	20kg/cow/ day	Cow dung excreta	Cattle
Use in production of liquid manure.	14235	13 lit./ cow/ day	Urine excreta	

Liquid Manure Application in the Horticultural Crops

Liquid manure prepared from cattle shed was applied in the horticultural crops except banana. One litre of liquid manure contains 6.6 kg Nitrogen, 3.2 kg Phosphorus and 5.0 kg Potassium. Total number of application per annum was 24 and total quantity applied per plant per annum was 222 litres. In terms of nutrients, liquid manure supplies a total of 1465 g Nitrogen, 710 g Phosphorus and 110 g Potassium per annum and in terms of Urea, SSP and MOP a total of 3179 g, 4440 g and 1854 g respectively was supplied by liquid manure. On the contrary to this, in case of application of chemical fertilizers, total NPK supplied per annum was 872 g, 922 g and 872 g respectively which in terms of Urea, SSP and MOP will be 1892 g, 5762 g and 1456 g respectively per annum. The NPK content of chemical fertilizers and liquid manure applied in horticultural crops are mentioned in Table-24.

The cost of 6 man days @ Rs. 130.00/ man day was considered as cost involved in the use of liquid manure.

Return from Vermicompost Production Unit

Vermicompost was produced in an unit of 2.26 m3. A very high B:C ratio of 7.86 was obtained because raw materials were available from IFS unit itself and also sold out extra earthworm. Economic analysis of vermicompost is presented in Table-25.

Table 24 : Composition of NPK content of chemical fertilizer and liquid manure (g/plant) applied in horticultural crops.

Total	Guava	Papaya	Pineapple	Assam lemon	Particulars
					NPK content/litre of liquid fertilizer (g) N (6.6%) P (3.2%) K (5.0%)
37	16	16	1	4	Quantity of liquid manure applied/ plant (litre)
24	6	6	6	6	Number of application/ annum
222	96	96	6	24	Total quantity applied/plant/ annum (litre)
					In terms of nutrients (g)
1465	634	634	40	158	N
710	307	307	19	77	P
1110	480	480	30	120	K
					In terms of fertilizers (g*)
3179	1375	1375	86	344	Urea
4440	1920	1920	120	480	SSP
1854	802	802	50	200	MOP
					Chemical nutrient requirement/ plant (g)
872	260	500	12	100	N
922	320	500	2	100	P
872	260	500	12	100	K
					In terms of chemical fertilizers (g)
1892	564	1085	26	217	Urea
5763	2000	3125	13	625	SSP
1456	434	835	20	167	MOP

**Liquid manure in terms of Urea, SSP and MOP per plant was multiplied with total number of plants.*

Table 25 : Economic analysis of vermicompost production.

Amount (Rs.)	Rate (Rs./Unit)	Quantity/ Cycle	Unit	Particulars
			2.26 m3	Size of the unit
			4 cycle	Number of production cycle/ annum
			-	Initial cost
			-	Cost of tank
20,000	2500	8.00	Kg	Earthworm
				Raw materials/ cycle
0*		120.00	Kg	Cow dung
0*		180.00	Kg	Crop residue
2,600	130	5 (× 4)	Man days	Labour
2,600			-	Total variable cost
5,440**	10	136 (× 4)	Kg	Production
15,000	2500	6	Kg	Sale of earthworm
20,440			Rs.	Gross return
17,840			Rs.	Net return
7.86				B:C ratio

**By-product of IFS unit*

***Rs. 1360.00 in one cycle and total were 4 cycles so it amounts to Rs. 5440.00*

Contribution of Bio-gas Plant to IFS Model

The size of the plant was 2 m3. The total variable cost of the system was Rs. 6110.00. Per day 1.4 m3 and annually 511 m3 of Bio-gas was produced; the annual production of LPG from Bio-gas was 219.73 kg. A B:C ratio of 2.27 was recorded from Bio-gas plant. The economics of Bio-gas plant is presented in Table-26.

Besides cow dung and cow urine were used for production of liquid manure. Bio-gas plant and vermi-composting which recycle crop residues was also benefits the IFS unit. The cattle can maintain with paddy straw and crop residues with reduced concentration feeding. Apart from feeding of cattle, straw was also used for production of vermicompost. 180 kg crop residue was used in Vermicompost production in one cycle.

System Profitability

The system profitability of IFS model with 1.0 ha area are presented in Table-27, which reveal a B:C ratio of 1.94 from the system.

Table 26 : Economic analysis of bio-gas plant

Amount (Rs.)	Rate (Rs./unit)	Quantity	Unit	Particulars
			2 m3	Size of the plant
34,000**			Rs.	Initial cost
			Rs.	Variable cost
		2000*	Kg.	Dung as fuel (initially)
		55*	Kg./ day	Dung as fuel
6110	130	47	Man days	Labour
6110				Total variable cost
		1.4	m3	Bio-gas production/ day
		511	m3	Annual
				1m3 bio-gas = 0.43 kg LPG
13860	924	15	No.	Number of cylinder (1 cylinder contains 14.5 kg LPG)
7750				Net return
2.27				B:C ratio

**By product of the system, hence cost is not considered.*

***Fixed cost is not considered for calculation of cost and return of Bio-gas plant.*

Table 27 : Economic analysis of IFS model:

Cost (Rs)	Return (Rs.)	Component/Activities
37,220.00	75,769.00	Crop component including horticultural and fodder crops
70,875.00	1,00,080.00	Dairy (cattle component)
27,181.00	45,000.00	Fishery
6,000.00	12,000.00	Apiary
2,600.00	20, 440.00	Vermicompost unit (with sale of earthworm)
6,110.00	13,860.00	Bio-gas plant unit
4,546.00	30,712.00	Additional return from processing
780.00	2,734.00	Return from liquid manure use
1,55,311.00	3,00, 595.00	Total
1,45, 284.00		Net return
1.94		B:C ratio

Employment Generation

Four hundred and thirty four mandays was generated as employment in the IFS model with 1.0 ha area (Table-28). The highest employment of 183 mandays was recorded from cattle component.

Table 28 : Employment generation from 1.0 ha area of IFS model during the year 2012-13

Employment (Man days)	Component/Activities
105	Crop production and processing
13	Horticultural crops
183	Dairy
58	Fishery
2	Apiary
20	Vermicompost unit
47	Biogas plant
6	Liquid manure use
434	Total

The high employment generation from cattle component was because of the fact that cattle rearing is not a seasonal or short duration rearing, it takes more than a year to complete its life cycle unlike other enterprises. Moreover, daily feeding and proper maintenance of cattle is very important. These labourers have to be engaged throughout the life cycle of the cattle.

Application of Bio-pesticides/ Botanicals

Kamdhenu (mixture of cow urine and neem leaf extract) was applied @ 1:250 litre of water/ha against the major insect pest of rice viz. caseworm, leaf folder, rice bug and stem borer. Reduction in pest population after application in comparison to pre-treatment count was observed; however, lowest pest population after application was recorded in case of plant hopper (1.04) followed by stem borer (dead heart 1.76) (Table-29); it was tried in seven rice plot.

Table 29 : Percent reduction of pest population after using Kamdhenu along with pre-treatment count.

Mean pest population						Pre-treatment
Stem borer		Rice borer	Plant hopper	Leaf folder	Case worm	
WEH	DH					
1.81	1.76	1.80	1.04	1.85	3.34	7.65

Pumello fruit (after making pieces) was applied @ 30 kg/ha in remaining rice plots which prevent the crop from insect pest. Pest controlling activity of Pumello fruit may be attributed to the presence of essential oil in particular and other secondary metabolites in abundance. Quantitative analysis of Pumello fruit is presented in Table-30.

Table 30 : Quantitative analysis of pumello fruit

Essential oil	Terpenoid	Steroids	Flavonoid	Alkaloid	Fruit part
Present	Present	Nil	Present	Nil	Outer skin
Present	Nil	Nil	Present	Nil	Inner peel (pink)
Present	Nil	Nil	Present	Nil	Fruit (pink)

Conclusions and Recommendations

Results clearly reveal that Integrated Farming System plays a vital role in securing sustainable production of high quality food and other production fulfilling the basic need of household like food (cereal, pulse, oil seed, milk, honey, fish etc.), feed, fodder etc; this system helps in sustaining farm income by reducing the cost of production. As agricultural waste (bio-waste) are efficiently recycled in the system so it helps in eliminating environmental degradation, maintain soil fertility and agricultural sustainability. Bio-pesticide/Botanicals also help to reduce environmental pollution. Considering the economic return, vermicompost gives better benefit:cost ratio and cattle component gives the highest net return. Through efficient recycling and processing money involved in the purchase inputs can be reduced which ultimately improves the economic viability of the system and improves natural resources. Integrated Farming System also generates lots of employment.

Under rainfed condition the Integrated Farming System with crop (Field+Horticultural) -Cattle – Fishery - Apiary along with supplementary and complementary activities like Liquid Manure, Bio-gas, Vermi-compost production and processing with a net return of 1,45,284.00 or $2409.75 and B:C ratio of 1.94 may be recommended for marginal and small farmers with need based changes based on the available resources in the Farmer's Household. The model not only provide productive, economically viable and sustainable agriculture system, but also contribute to bio-safety by reutilizing waste material or by product of different enterprises which may otherwise cause environmental pollution and pest harbouring site in the form of heap of debris.

Acknowledgements

We are very much thankful to the Indian Council of Agricultural Research, New Delhi who provide the fund through Project Directorate of Farming System Research, Modipuram, Meerut; we are also thankful to Dr. B. Gangwar, Project Director for his valuable advice time to time. We thankfully acknowledge the technical advice, help and co-operation received from Dr. K. M. Bujarbaruah, Honourable Vice Chancellor, Assam Agricultural University, Jorhat. Thanks are also due to staff and workers of AICRP on Integrated Farming System, Assam Agricultural University, Jorhat, Assam (India) for the help and co-operation.

References

Gupta, V., Rai, P.K. and K.S. Risam. 2012. Integrated crop-livestock farming system: A strategy for resource conservation and environmental sustainability. India Research Journal of Extension Education, Special Issue (2):49-54.

Jayanthi, C., Vannila, C. Nalini, K. and B. Chandrasekaran. 2009. Sustainable integrated management of crop with allied enterprises- ensuring livelihood security of small and marginal farmers. Tech Monitor, Special Feature (Jan.-Feb.) :21-27.

Swamy, K.K. 2007. Dietary guidelines for Indian- A manual. National Institute of Nutrition, Hyderabad. Pp.74.

Ugwumba, C.O.A., Okoh, R.N., Ike, P.C., Nnabuife, E.L.C. and E.C. Orji. 2010. Integrated farming System and its effect on farm cash income in Awka South Agricultural Zone of Anambra state, Nigeria. American Eurasian Journal of Agricultural and Environmental Sciences, 8(1): 1-6.

Walia, S.S. and N. Kaur. 2013. Integrated Farming System- An ecofriendly for sustainable agricultural environment- A review. Greener Journal of Agronomy, Forestry and Horticulture, 1(1):1-11.

Theme 6

Watershed and water management

Effect of Weed Management on Productivity of Transplanted Rice

Sumana Ghosh*, G.C.Malik, Mahua Banerjee

Abstract

Rice, the most important staple food crop of India is cultivated under various ecosystems. In transplanted rice, weed infestations reduce the grain yield and quality. Though many pre-emergence herbicides are available for controlling weeds, the need for post-emergence herbicide is often realized to combat the weeds emerged during later stages of crop growth specially under scarcity of labour. Keeping this in view a field experiment was conducted during *kharif* 2013 at Chella, Kamarpara, Birbhum district of West Bengal. The experiment was laid out in randomized complete block design replicated three times. The twelve weed management treatments were: **T_1**- pendimethalin @0.75 kg/ha;**T_2**- pendimethalin @0.75 kg/ha + hand weeding at 50 DAT (Days after transplanting); **T_3**-bispyribac sodium @ 25 g /ha at 30 DAT; **T_4**- pendimethalin @0.75 kg/ha + bispyribac sodium @ 25 g /ha at 30 DAT; **T_5** - bispyribac sodium @ 50 g /ha at 30 DAT; **T_6**-pendimethalin @0.75 kg/ha + bispyribac sodium @ 50 g /ha at 30 DAT; **T_7**-orthosulfamuron 50%WG @80g/ha at 12 DAT; **T_8**-pendimethalin @0.75 kg/ha + orthosulfamuron 50%WG@ 80g/ha at 12DAT; **T_9**- orthosulfamuron 50%WG @150g/ha at 12 DAT; **T_{10}**- pendimethalin @0.75 kg/ha + orthosulfamuron 50%WG@150g/ha at 12DAT; **T_{11}**- weed free and **T_{12}**-weedy check. The recommended dose of fertilizers (N:P:K-80:40:40) was used for the experiment. The seedlings of variety MTU-7029 (*Swarna*) were transplanted at 20cm x 15cm spacing.

The weed controlling effect of bispyribac sodium applied plot was higher than all pre-emergence application of pendimethalin and post-emergence application of orthosulfamuron applied plot as evidenced from the total weed density and dry weight. Among the weed control treatments, post-emergence application of Bispyribac sodium @ 25 g /ha at 30 DAT recorded highest weed control efficiency and minimum weed index%. Among various weed management practices higher yield was recorded from bispyribac sodium applied plots. Weed free plot recorded highest grain and straw yield which was at par with bispyribac sodium @ 25 g /ha at 30 DAT, pendimethalin @0.75 kg/ha + bispyribac sodium @ 25 g /ha at 30 DAT and pendimethalin @0.75 kg/ha + bispyribac sodium @ 50 g /ha at 30 DAT. The higher grain yield in Bispyribac sodium applied plot may be attributed to lesser weed population and weed dry weight which might have caused lesser weed competition which was reflected in higher grain yield. Thus, the application of bispyribac sodium @ 25 g /ha at 30 DAT recorded highest grain yield (6.9 t/ha) than other weed management practices. So, it may be concluded that bispyribac sodium can be used for weed management in transplanted rice under lateritic belt of West Bengal.

Keywords: Bispyribac sodium, Transplanted rice, weed management, yield

* *Institute of Agriculture, Visva-Bharati, Sriniketan, Birbhum, West Bengal*

Corresponding author's e-mail: sumana.agro@gmail.com

Introduction

Rice, the most important staple food crop of India is cultivated under various ecosystems. Weeds cause 28-45% yield losses in transplanted rice(Singh *et al*. 2003,Kumar *et al*. 2008,Yadav *et al*. 2009). Though many pre-emergence herbicides are available for controlling weeds, the need for post-emergence herbicide is often realized to combat the weeds emerged during later stages of crop growth specially under scarcity of labour. Keeping this in view, an experiment was carried out to study the effect of weed management on weed growth in transplanted rice and productivity of transplanted rice.

Methodology

A field experiment was conducted during *kharif* 2012 at Chella, Kamarpara, Birbhum district of West Bengal. The experiment was laid out in randomized complete block design replicated three times. The twelve weed management treatments were: **T_1**- pendimethalin @0.75 kg/ha;**T_2**- pendimethalin @0.75 kg/ha + hand weeding at 50 DAT (Days after transplanting); **T_3**-bispyribac sodium @ 25 g /ha at 30 DAT; **T_4**- pendimethalin @0.75 kg/ha + bispyribac sodium @ 25 g /ha at 30 DAT; **T_5** - bispyribac sodium @ 50 g /ha at 30 DAT; **T_6**-pendimethalin @0.75 kg/ha + bispyribac sodium @ 50 g /ha at 30 DAT; **T_7**-orthosulfamuron 50%WG @80g/ha at 12 DAT; **T_8**- pendimethalin @0.75 kg/ha + orthosulfamuron 50%WG@ 80g/ha at 12DAT; **T_9**- orthosulfamuron 50%WG @150g/ha at 12 DAT; **T_{10}**- pendimethalin @0.75 kg/ha + orthosulfamuron 50%WG@150g/ha at 12DAT; **T_{11}**- weed free and **T_{12}**-weedy check. The recommended dose of fertilizers (N:P:K-80:40:40) was used for the experiment. The seedlings of variety MTU-7029 (*Swarna*) were transplanted at 20cm x 15cm spacing.

Results

All the weed management practices significantly reduced total weed density and dry weight compared to weedy check. The weed controlling effect of bispyribac sodium applied plot was higher than all pre-emergence application of pendimethalin and post-emergence application of orthosulfamuron applied plot as evidence from the total weed density and dry weight. Among the weed control treatments, post-emergence application of Bispyribac sodium @ 25 g /ha at 30 DAT recorded highest weed control efficiency and minimum weed index%. Among various weed management practices higher yield was recorded from bispyribac sodium applied plots. Weed free plot recorded highest grain and straw yield which was at par with bispyribac sodium @ 25 g /ha at 30 DAT, pendimethalin @0.75 kg/ha + bispyribac sodium @ 25 g /ha at 30 DAT and pendimethalin @0.75 kg/ha + bispyribac sodium @ 50 g /ha at 30 DAT. Similar results of Yadav *et al*.(2009) and Veeraputhiran *et al*.(2013) on effective weed control along with higher grain yield by Bispyribac sodium against mixed weed flora in transplanted rice were in confirmative with the present investigation. The higher grain yield in Bispyribac sodium applied plot was attributed to lesser weed population and weed dry weight which might have caused lesser weed competition which was reflected in higher grain yield. In case of harvest Index% ,there was no significant difference observed among weed management practices, but highest harvest Index% was recorded with pendimethalin @0.75 kg/ha + bispyribac sodium @ 25 g /ha at 30 DAT.

Conclusion

Thus, the application of bispyribac sodium @ 25 g /ha at 30 DAT recorded highest grain yield (6.9 t/ha) than other weed management practices. So, it may be concluded that bispyribac sodium can be used for weed management in transplanted rice under lateritic belt of West Bengal.

Table : Effect of weed management treatments on weed growth and grain yield in transplanted rice

Treatments	Total weed density at 45 DAT(no./m^2)	Total weed dry weight (g/m^2)	Weed control efficiency %	Weed index %	Grain yield (t/ha)
T_1- Pendimethalin @0.75 kg/ha	16.67	19.66	28.89	10.31	6.37
T_2- Pendimethalin @0.75 kg/ha +hand weeding at 50 DAT	12.33	14.49	47.76	7.45	6.57
T_3- Bispyribac @ 25 g /ha at 30 DAT	10.67	7.71	54.94	2.81	6.90
T_4 -Pendimethalin @0.75 kg/ha + bispyribac @ 25 g /ha at 30 DAT	12.67	8.77	46.54	3.30	6.87
T_5 - Bispyribac @ 50 g /ha at 30 DAT	13	8.63	44.63	6.50	6.60
T_6- Pendimethalin @0.75 kg/ha + bispyribac @ 50 g /ha at 30 DAT	11.67	9.23	50.66	3.75	6.83
T_7-Orthosulfamuron 50%WG @80g/ha at 12 DAT	16	10.29	32.22	10.32	6.37
T_8 -Pendimethalin @0.75 kg/ha + orthosulfamuron 50%WG@ 80g/ha at 12DAT	18.33	14.50	21.75	6.55	6.63
T_9- Orthosulfamuron 50%WG @150g/ha at 12 DAT	13.33	11.06	43.45	8.44	6.50
T_{10}- Pendimethalin @0.75 kg/ha + orthosulfamuron 50%WG@150g/ha at 12DAT	16.33	9.26	30.41	7.93	6.53
T_{11} - Weed free	0.00	0.00	100.00	-	7.10
T_{12} -Weedy check	23.67	40.97	-	30.55	4.93
C.D. at 5%	3.47	1.57	-	**-**	**0.37**

References

Kumar S, Angiras NN, Rana SS and Sharma N. 2008.Efficacy of new herbicides to manage weeds in transplanted rice. *Himachal Journal of Agricultural Research* **34**(1): 18-21.

Singh G, Singh VP, Singh M and Singh SP. 2003.Effect of anilophos and triclopyr on grassy and non grassy weeds in transplanted rice. *Indian Journal of Weed Science* **35**:30-32.

Veeraputhiran R,Balasubramanian R.2013.Evaluation of bispyribac-sodium in transplanted rice. *Indian Journal of Weed Science* **45(**1):12-15.

Yadav DB,Ashok Yadav and Punia SS.2009.Evaluation of bispyribac-sodium for weed control in transplanted rice. *Indian Journal of Weed Science* **41**(1&2): 23-27.

Fresh Water Cyanophyceae from Godavari River in Nashik District

Shivaji B. Andhale*

Abstract

Godavari River shows variety of rich algal forms of various taxonomic groups. Biodiversity studies of the algal flora found at the onset of winter season at the Godavari River reveals abundance of member of Cyanophyceae. A preliminary survey of algae of the Godavari River was undertaken at four locations during the years 2012-2014. Algae play an important role in maintaining aquatic ecosystem and form base of food web as well as harmful to aquatic ecosystem. It was noted that several planktonic algae were present in the river. A large number of taxa of fresh water algae have been recorded from different localities of Godavari River *Nostoc, Oscillatoria, Lyngbya, Microcystis, Aphanocapsa, Gloeocapsa, Chroococcus, Arthrospira* and *Spirulina* are found to be dominant genus at certain locations of the river during winter.

Keywords: algae, taxonomy, food web, equatic ecosystem.

Introduction

Godavari is one of the prominent river in Maharashtra. This region of water body is biologically active, having large number of flora and fauna. Several angiospermic plants and large number of algae are observed in this area, which have not been explored so far. Therefore, the study of vegetation of the river was undertaken during years 2012-2014.

During the study, a large number of phytoplanktons like Nostoc, Oscillatoria, Lyngbya, Microcystis, Aphanocapsa, Gloeocapsa, Chroococcus, Arthrospira and Spirulina were observed. The present paper describes 14 species of Oscillatoria, 12 species of Lyngbya, 03 species of Microcystis, 01 species of Aphanocapsa, 02 species of Gloeocapsa, 01 species of Arthrospira and 04 species of Spirulina and its varieties, observed during present investigation. Indetification them by referring to the standard literature of algae Sarode and Kamat (1979, 1980 and 1983) and Ashtekar (1980). However, the cyanophyaceae has not been studied so far, and this is the first report.

Head Department of Botany M.V.P.'samaj, K.P.G., Arts, Commerce and Science College, Nashik.

** Corresponding Author : Email- shivaji andhale@ gmail.com*

Methods

For the present study, 4 locations of the Godavari river water viz. Shomeshwar, K.T.H.M.college and Ramkund were selected. The water samples from each locality were collected once in a month in the morning between 8.00 a.m. to 10.00 a.m. The collections were made for 3 consecutive years during 2012-2014, during the months of November to March. For phytoplankton analysis, water samples were collected by plankton net, as per the method adopted by Narkhede (2006). 20 liters of surface water was collected by dipping a jug and filtered though the plankton net and was collected in 1 lit. wide mouth bottle. 20 ml of water sample was preserved in 4% formalin. The morphological studies of specimens were done by using Olympus Research Microscope and Labomed Microscope (Model no. T250L250) and the photographs were taken using Kodak EazyShare cx 7330 camera. Identification of taxa was done using Fritsch (1935), Patel and George (1977), Philipose (1967), Prescott (1951), Rath and Adhikari (2005) and other relevant literature.

Order : Chroococcales

Family : Chroococcaceae

Genus : Microcystis Kuetzing

1) Microcystis flos-aquae (Wittr.) Kirchner. (Pl.1, Fig.1)

Desikachary, 1959, p 94, pl 17, f 11& pl 18, f 11

Colonies free-swimming, blue-green, roughly spherical or often squarish in optical section, not clathrate, with in distinct hyaline and homogenous colonial mucilage; cells 4.9 µ in diameter, spherical, air spaces not present.

2) M. pseudofilamentosa Crow (Pl.1, Fig.2)

Desikachary, 1959, p 94, pl 18, f 9 & pl 20, f 1

Colonies planktonic, blue-green, very long and narrowing, consisting of a series of parietal colonies and constricted at intervals, reticulate; margins of colonial mucilage indistinct; colonies varying greatly in size, frequently 250 µ in length, 29.3 µ in width; parietal colonies being about equal in length and width; cells 3.8 µ diameter, spherical.

3) M. robusta (Clark) Nygaard. (Pl.1, Fig.3)

Desikachary, 1959, p 85, pl 17, f 7-10

Colonies planktonic, blue-green, at first round, later irregularly elongate and clathrate; sheath distinct, cells 6.6 µ diameter, without gas-vacuoles.

Genus : Chroococcus Nag.

4) Chroococcus giganteus West, W. (Pl.1, Fig. 4)

Desikachary, 1959, p 101, pl 26, f 1

Cells mostly three, seldom 2-4 bright blue-green, without sheath 5.3 µ broad, with sheath 64µ broad, lamellated, colorless, colonies 13.9 µ in diameter.

5) C. indicus Zeller (Pl.1, Fig. 5)

Desikachary, 1959, p 109, pl 26, f 10

Thallus gelatinous, thin, a pale brownish; cells single, spherical, 19 µ diameter, greenish; sheath hyaline, conspicuous, contents granular.

6) C. macrococcus (Kuetz.) Rabenh. (Pl.1, Fig. 6)

Desikachary, 1959, p 101, pl 27, f 3,9,10

Thallus mucilaginous, somewhat broad, yellowish brown, cells spherical, single, 25µ diameter, with sheath 31 µ diameter, sheath thick, colorless, lamellated.

7) C. minutus (Kuetz.) Nag. (Pl.1, Fig. 7)

Desikachary, 1959, p 103-105, pl 24, f 4 and pl 26, f 4, 15

Cells spherical or oblong, single or in groups of 2-4, light blue-green, with sheath 12.8 µ diameter, sheath not lamellated, colorless, colony 27.1 µ diameter.

8) C. montanus Hensgirg (Pl.1, Fig. 8)

Desikachary, 1959, p 108, pl 26, f 12

Thallus slimy, gelatinous, brownish, cell 5.6µ diameter, in groups of 2, colonial sheath lamellated, colony 19.2µ in diameter.

9) C. tenax (Kirchn.) Hieron (Pl.2, Fig. 9)

Desikachary, 1959, p 103, pl 26, f 7, 16

Cells mostly in groups of two, blue-green colored, without sheath 19 µ, with sheath 33.4 µ in diameter; sheath colorless, very thick, very distinctly lamellated, 3 lamellae.

Genus : Gloeocapsa Kuetzing

10) Gloeocapsa calcarea Tilden (Pl.1, Fig.10)

Desikachary, 1959, p 115, pl 24, f 6

Thallus with calcium incrustation; free floating, cells with individual sheath, 7.7 µ diameter, blue green; sheath colorless, often thin; colonies with 3 cells, colonies 52 µ in diameter

11) G. kuetzingiana Nag. (Pl.1, Fig.11)

Desikachary, 1959, p 118-119, pl 23, f 4 & pl 24, f 12

Thallus thin, soft, free floating, brownish or blackish; cells densely aggregated in colonies, cells without sheath 4µ in diameter, with sheath 4.6 µ diameter; blue green; sheath yellow, not lamellated, colonies 13.4 µ in diameter .

Genus : Aphanocapsa Naeg.

12) Aphanocapsa biformis A.Br. (Pl.1, Fig.12)

Desikachary, 1959, p 134, pl 21, f 3,4

Thallus planktonic, olive green, gelatinous, often expanding;cells 6.1 µ diameter, spherical or oval, mostly with a special envelope, loosely arranged, 2-4 cells together in common mucilaginous envelope.

Order : Nostocales

Family : Oscillatoriaceae

Genus : Arthrospira Stizenberger

13) Arthrospira platensis (Nordst) Gomont. v. non-constricta (Banerji) Desikachary (Pl.2, Fig.1)

Desikachary, 1959, p 190-191, pl 36, f 1, 2

Thallus blue-green, free-floating, trichomes without sheath, slightly constricted at the cross-walls, not attenuated at the ends. Less regularly spiraley coiled; ends cells broadly rounded. Trichomes 6.5 µ broad, unconstricted, cells 3.5µ long, spirals 37.6 µ broad and 52.4 µ distant.

Genus : Spirulina Turpin em. Gardner

14) Spirulina gigantea Schmidle (Pl.2, Fig.2)

Desikachary, 1959, p 197, pl 36, f 12, 14-17

Trichome without sheath, free-floating, 3.9 µ broad, deep blue-green, regularly spirally coiled, at the end conical attenuated, spirals 7.2 µ broad.

15) S. major Kuetz. ex Gomont (Pl.2, Fig.3)

Desikachary, 1959, p 196, pl 36, f 13

Trichome without sheath, free-floating, 3.8 µ broad, regularly spirally coiled, blue-green, spirals, 3.3 µ broad and 4.2 µ distant.

16) S. meneghiniana Zanard. ex Gomont (Pl.2, Fig.4)

Desikachary, 1959, p 195, pl 36, f 8

Trichome without sheath, free-floating, 3.2 µ broad, flexible, irregularly spirally coiled, bright blue-green, forming a thick blue-green thallus; spirals 5 µ broad and 3.4 µ distant from each other.

17) S. princeps W. et G.S. West (Pl.2, Fig.5)

Desikachary, 1959, p 197, pl 36, f 7

Trichomes without sheath, 4.3 µ broad, short, blue-green, regularly spirally coiled, straight spirals 6.4 µ broad and 9.4 µ distant, mixed with other algae.

Genus : Oscillatoria Vaucher

18) Oscillatoria amphibia Ag. ex. Gomont (Pl.2, Fig.6)

Desikachary, 1959, p 229, pl 37, f 6

Thallus deep blue-green; planktonic, trichome straight or coiled, apices not attenuated, not capitate, not tapering towards the apex, not constricted at the cross-walls, 4.3 µ broad, cells 2-3 times longer than broad, 8.2 µ long, end cell not capitate, rounded, calyptra absent.

19) O. annae van. Goor (Pl.2, Fig.7)

Desikachary, 1959, p 203, pl 38, f 13

Trichome straight, dull blue-green, constricted at the cross-wall, 11.8µ broad, mostly attenuated at the ends, and bent; cells 1/3-15 as long as broad, 3.9µ long, not granulated at the cross-walls; end-cell rounded, calyptra absent.

20) O. biswasii Kamat (Pl.2, Fig.8)

Kamat, 1963, p 282, pl 14, f 80

Plant mass blue-green; trichomes straight or bent, tapering towards the apices, constricted at the cross-walls; cells shorter than broad, 8.7 µ in diameter, 8.9 µ long; end cell conical without cap or calyptra.

21) O. chlorina Kuetz. ex Gomont (Pl.2, Fig.9)

Desikachary, 1959, p 215, pl 40, f 4

Thallus very thin, yellowish-green; trichome straight or curved, unconstricted at the cross-walls; 6-12 µ broad, gas-vacuoles absent; cells somewhat shorter than broad, 5.2 µ long, cross-walls not granulated, calyptra absent; end cells convex.

22) O. cortiana Meneghini ex Gomont v. minor Kamat (Pl.2, Fig.10)

Kamat, 1963, p 284, pl 16, f 90

Plant mass blue-green; trichomes tapering towards the apices, slightly bent at apices, constricted at the cross-walls; cells longer than broad, 6µ in diameter, 7.2µ long, end cell conical, without calyptra or cap.

23) O. foreaui Fremy (Pl.2, Fig.11)

Desikachary, 1959, p 219, pl 40, f 18

Trichomes sparse, elongate, bent, apex gently curved, distinctly constricted at the cross-wall, and 5.2µ broad, apex not attenuated not capitate; cells ½ as long as broad, apical cell rounded, calyptra absent.

24) O. irrigua (Kutez.) Gomont (Pl.2, Fig.12)

Desikachary, 1959, p 224, pl 42, f 7, 9

Thallus blackish blue-green, straight, flexuous, not torulose, 6.2 µ broad, apex, slightly attenuated, subcapitate, straight; cells about ½ as long as broad, 3.4µ long, septa ordinarily not granulated; apical cell convex, with an evident thickened outer wall, calyptra present.

25) O. limosa Ag. ex. Gomont (Pl.2, Fig.13)

Desikachary, 1959, p 206, pl 42, f 11

Thallus dark blue-green to brown; trichome more or less straight, not constricted at the cross-walls, or only slightly constricted, 10.7 µ broad; cells 1/3-1/6 as long as broad, 3.3 µ long, cross-walls frequently granulated; end-cell flatly rounded with slightly thickened membrane.

26) O. margaritifera (Kuetz.) Gomont (Pl.2, Fig.14)

Desikachary, 1959, p 202, pl 42, f 8

Trichome olive-green, forming blackish thallus, 15.1µ broad, fragile, straight, constricted at the cross-walls, apices slightly bent, slightly attenuated; cells 1/3-1/7 as long as broad, 6.4 µ long, cross-walls granulated, end cell capitate with slightly convex calyptra.

27) O. ornata Kuetz. ex Gomont (Pl.2, Fig.15)

Desikachary, 1959, p 206, pl 40, f 3

Thallus dark blue-green, slightly bent at apices, constricted at the cross-walls, 7.8 µ broad, dull blue-green, cells 1/2-1/6 as long as broad, 3.3 µ long, cross-walls granulated; apices slightly attenuated; end-cells convex, not capitate, without thickened membrane.

28) O. ornata v. crassa Rao, C.B. (Pl.2, Fig.16)

Desikachary, 1959, p 206, pl 39, f 11 and pl 41, f 12

Thallus dark blue-green; trichome straight of uniform thickness, 8.1 µ broad, constricted at the cross-walls, cross-walls granulated; cells shorter than broad, 5.2 µ long; end-cell convex without calyptra, not captitate.

29) O. princeps Vaucher (Pl.2, Fig.17)

Prescott, 1951, p 489, pl 110, f 1

Trichomes solitary or loosely entangled to form small floating plant masses, which are black-green, brownish, or violet in color; trichomes very slightly and briefly tapering at the apex. Apical cell usually not capitate, sometimes very slightly so, the outer membrane broadly convex and smooth. Cells 24 µ in diameter 5.7 µ long; not constricted at the cross walls, which are not granular; cell contents densely granular.

30) O. rubescens D.C. ex Gomont v. curvata Kamat (Pl.3, Fig.1)

Kamat, 1963, p 289, pl 16, f 94

Plant mass blue-green, sometimes forming a purple red, free swimming bundles, trichome straight, slightly curved at the apex, ends gradually attenuated, 6.9 µ broad, not constricted at the cross-walls, cells 1/2-1/3 as long as broad, 2.7 µ long, often granulated at the septa, end cell capitate with convex calyptra.

31) O. rubescens D.C. ex Gomont v. kolhapurensis Kamat (Pl.3, Fig.2)

Kamat, 1963, p 289, pl 16, f 95

Plant mass blue-green, trichomes long, usually straight, tapering towards the apices, not constricted, at cross-walls, cells shorter than broad, 7.1 µ in diameter, 2.8 µ long; end cell capitate with calyptra. The trichomes are broader than the type specimen.

32) O. sancta (Kuetz.) Gomont (Pl.3, Fig.3)

Desikachary, 1959, p 203, pl 42, f 10

Trichomes aggregated to form a dark gray-green plant mass, usually on submerged vegetation; straight, not tapering towards the apex, distinctly constricted. Apical cell slightly capitate, with a calyptra, and with a thickened outer membrane. Cells 8.7 µ in diameter, 3.4 µ long; slightly constricted at the cross-walls, granular.

33) O. subbrevis Schmidle (Pl.3, Fig.4)

Prasad and Khanna, 1987, p 256, f 1

Thallus pale gray-green. Trichomes single, 10.2µ broad, nearly straight, not tapering towards the apices, not attenuated at the apices; cell contents granular, cell 2.3 µ long, not constricted at the cross wall; end cell rounded, calyptra absent.

Genus : Lyngbya Ag.

34) Lyngbya antartica Gain v. maior Kamat (Pl.3, Fig.5)

Kamat, 1963, p 294, pl 17, f 99

Filaments usually solitary, blue-green; 15.3 µ diameter; sheath thin, yellow brown; trichomes attenuated at the apices, not constricted at the cross-walls, cells shorter than broad, 11 µ in diameter, 1.8 µ long; end cell capitate without calyptra.

35) L. birgei Smith (Pl.3, Fig.6)

Desikachary, 1959, p 296, pl 50, f 7, 8

Filaments straight, seldom coiled, free-floating, 24 µ; sheath firm, colourless, mostly unlamellated, trichome constricted at the cross-walls, 22 µ broad, ends rounded, not attenuatd, not capitate; cells shorter than broad, 2.6 µ long.

36) L. confervoides C.Ag. ex. Gomont (Pl.3, Fig.7)

Desikachary, 1959, p 314, pl 49, f 9 & pl 52, f 13

Thallus blue-green, filament straight; sheath colourless, not constricted at the cross walls, not attenuated at the apices 8.1 µ broad; cells 1/3-1/8 times as long as broad, 2.6 µ long; end cell round, calyptra absent.

37) L. connectens Bruhl et Biswas (Pl.3, Fig.8)

Desikachary, 1959, p 308, pl 51, f 5,6,11

Stratum extensive, lying parallel to each other; filaments straight, sheath firm, brownish, dark green; trichomes 7.1 µ broad, not constricted at the cross wall, cells about 1/6 as long as broad, 1.3 µ long.

38) L. hieronymusii Lemm. (Pl.3, Fig.9)

Desikachary, 1959, p 297, pl 48, f 4

Filament single, free-floating, straight, 13.6µ broad; sheath firm, homogenous, colourless, cells 12.4µ broad, 3.5µ long, not constricted at the cross-walls, granulated, end cell broadly rounded.

39) L. latissima Prescott. (Pl.3, Fig.10)

Prescott, 1951, p 501, pl 112, f 9

Plant solitary, planktonic, entangled among other floating algae; trichomes straight, not tapering towards the apices; not constricted at the cross wall, cells disc-like, with contents finely and evenly granular, 22 µ diameter, 3.5 µ long; sheath thick, lamellated, ends cell rounded, calyptra present. The diameter of the observed specimen is smaller than the type species.

40) L. maharashtrensis Kamat (Pl.3, Fig.11)

Kamat, 1963, p 299, pl 17, f 103

Plant-mass blue-green; filament 12 µ broad, usually straight, sheath thin, unstratified, hyaline to yellow-brown; trichomes not tapering towards the apices, not constricted at the cross-walls; cells much shorter than broad, 1/4-1/3 times as long as broad, 14.1 µ diameter, 2.6 µ long; end cell rounded without calyptra.

41) L. major Meneghini (Pl.3, Fig.12)

Prescott, 1951, p 502, pl 112, f 10

Plant mass dark green; entangled with other algae, filament straight or slightly curved, somewhat gregarious, sheath thick, stratified, yellow brown; trichomes not constricted and not granulated at the cross-walls, not attenuated at the ends; cells much shorter than broad, 23.8 µ in diameter, 2.6 µ long; end cell rounded without calyptra.

42) L. majuscula Harvey ex Gomont (Pl.3, Fig.13)

Desikachary, 1959, p 313, pl 48, f 7, pl 49, f 12, & pl 52, f 10

Thallus expanded, dull blue-green, filament very long, sheath colourless, lamellated up to 11 µ thick, not constricted at the cross-walls, not attenuated at the ends, 25 µ broad, cells very short 1/5-1/4 times as long as broad, 4 µ long, end cells rounded, calyptra absent.

43) L. martensiana Menegh. ex Gomont (Pl.3, Fig.14)

Desikachary, 1959, p 318, pl 52, f 6

Thallus caespitose, blue-green, filament long, sheath colourless, thick trichome 11.6 µ broad, not constricted at the cross-walls, apices not attenuated, cells 10.2 µ broad, 2.8 µ length; end cell rounded, without calyptra.

44) L. rubida Fremy (Pl.3, Fig.15)

Desikachary, 1959, p 298, pl 53, f 10

Thallus floccose, less expanded, brownish purple; sheath reddish, filament straight, not constricted at the cross-walls, 5.7 µ broad, ends not attenuated, not capitate; 4.9 µ long; end cells rounded, calyptra absent.

45) L. stagina Kuetz. f. non-granulata Kamat (Pl.3, Fig.16)

Kamat, 1963, p 301, pl 17, f 102.

Filament long, curved, entangled, 16.2 µ broad; sheath thick, stratified, yellow-brown; trichomes not tapering towards the apices, not constricted and not granulated at the cross-walls; cells much shorter than broad, 13.1 µ in diameter, 3.2 µ long; end cell rounded without calyptra.

Discussion

Thirty seven taxa, represented with 45 genera have been reported from this area. Genus Nostoc, Oscillatoria, Lyngbya, Microcystis, Aphanocapsa, Gloeocapsa, Chroococcus, Arthrospira and Spirulina occur dominantly in various locations. All these taxa are being reported for the first time from this area.

References

Ashtekar, P.V. (1980) Studies on the freshwater algae of Aurangabad district. Ph.D. thesis, Marathwada University, Aurangabad.

Kamat, N.D. (1963-a) The algae of Kolhapur, India. Hydrobiologia 22 (3-4): 209-305.

Kamat, N.D. (1963-b) The algae of Mahabaleshwar. J. Uni. of Bombay 31 (3 & 5): 28-41.

Patel, R.J. and I. George (1977) Chlorococcales of Gujarat, India- Pediastrum Meyen, Sorastrum Kuetzing and Hydrodictyon Roth. J. Indian bot. Soc. 56: 172-178.

Philipose, M.T. (1967) Chlorococcales, Indian Council of Agricultural Research, New Delhi.

Rath, J. and S.P. Adhikary, (2005) Algal flora of Chilika Lake, Daya Publishing House, Delhi.

Narkhede, P.N. (2006) Genus Nitzschia and Surirella from Hatnur dam, Jalgaon district, Maharashtra. J. Aqua. Biol. 21 (2): 19-22.

Seasonal Variation of Water Chemistry of Panch Pokhari: A Case Study of an AlpineL Series in the Central Himalaya

*Rosha Raut, Subodh Sharma and Roshan Man Bajracharya

Abstract

Panch Pokhari is a well known alpine lake series which includes five lakes situated at an elevation of 4160 masl in Sindhupalchowk district of Central Nepal. The lake series has vital socio-cultural, religious and environmental significance and provides habitats for highly sensitive aquatic biodiversity. As these lakes are considered holy, every year, during the event of *Janai purnima* (full moon festival in August), hundreds of Hindus and Buddhists pilgrims visit the place to perform rituals. Pilgrims put vermilion, metallic items including coins and other things in to the water bodies as offerings as well as dispose wastes in and around the lakes. Consequently, the increased number of lake visitors in recent years may have a negative impact on lake-water because of haphazard waste disposal and improper management. Detailed study of the lake series is still lacking. Therefore, the present research was carried out with the aim of assessing detailed water characteristics and its implications for the lake environment. Water samples were collected during the pre- and post-monsoon seasons from the inlet, outlet, human influence site, littoral zone, middle (central) and deepest point of the main lake. However, from other associated lakes, samples were collected only from the inlet and outlet. Physico-chemical parameters such as pH, conductivity, TDS, cations (Ca^{++}, Mg^{++}, Na^+ & K^+), anions (Cl^-, SO_4^{--} & HCO_3^-), nutrients (TN & TP) and trace metals (Fe, Mn, Cd, Pb, Cr, Cu, Zn, Ni, Co, As & Al) were analyzed. Panch Pokhari lakes series is characterized by low concentration of nutrient and presence of negligible amounts of trace metals indicating oligotrophic state. However, low value of pH and detection of lead indicates, lakes seem to be affected either by natural or anthropogenic influences. The major cations and anions were found to be in the ordered of Mg^{++} >, Na^+> and K^+> Ca^{++} & SO_4^{--} >HCO_3^{--} >Cl^- and Mg^{++} > K^+> Na^+> Ca^{++} & SO_4^{--} > Cl^-> HCO_3^- in all the lakes, respectively.

Key words: Glacial lake, major ions, nutrients, water quality, traces metals

Aquatic Ecology centre AEC), School of Science (SOS),Kathmandu University, Dhulikhel, Kavre, Nepal.

* *Corresponding author:* rautrosha@yahoo.com

Introduction

In Nepal, water bodies cover 5.06% of total land area (FDD 1992) and 3.2% is occupied by lakes, ponds and reservoirs out of an estimated coverage of 720,000 ha of water bodies (Bhuju et al., 2012). A total of 5358 lakes have been reported in varied ecological conditions from subtropical low land Terai to alpine high altitude of Himalayan range, of which 42 percentage are situated in high land, i.e., above 3000 masl (Bhuju et al., 2010). Among these, the Panch Pokhari (Five lakes) of Sindhupalchowk district of Nepal is a permanent alpine fresh water lake series and is a unique natural wetland in high Himalaya Paleoartic biogeographical region; it has major cultural and socio-economic value. Every year during the month of August Hindus and Buddhist pilgrims gathered there on the occasion of famous cultural festivals i.e. *Janai purnima* (full moon festival). Thus, the lake is associated with Hindus religion as like that of Gosainkunda Lake and also situated almost at a similar range of elevation. The areas is rich in biodiversity (Pradhan et.al., 2009) as well but annually controls the healthy growth of the vegetation's in this part due to heavy snow fall which exist almost for six months.

The Himalaya regions has many lakes and wetland of different shapes, sizes and are located in the different landscapes which makes a unique ecosystem in the nature. Nowadays, these are becoming very important in the global context as they are highly potential research areas to investigate climate change impacts. Located in remote areas with less human intervention these hotspots are ideal for environmental studies. Thus, the present study site is of importance from research point of view as well, especially, comparative and long range transport of air borne pollutants impacts. Very little work on water chemistry or biodiversity of aquatic organisms, e.g., diatoms has been conducted on the lake series. Therefore, the present study was carried out with the aim of assessing detailed water characteristics and its implications for the lake environment.

Materials and Methods

Study Area

The present study area Panch Pokhari (five ponds) lies in the central Himalayan region of Nepal in between the latitude of 28°2.41'- 28°2.54' E and longitude of 85°42.96'-85°43.25' N at an elevation of 4160 m. asl. It is about 100 km North-East of Kathmandu and located to the Bhotang VDC of Sindhupalchowk district of central Nepal. The area belongs to the Langtang National Park; one of the most intensively studied regions in the Himalaya (Beug and Miehe 1998, Barnard et al.,

2006). There is heavy rainfall between the month of May and September. The mean annual temperature is 2^{0}C recorded from the nearest meteorological station, i.e., in Kyanjin Gompa (Barnard et al. 2006), lake is generally frozen until the end of April. Heavy snow fall typically occurs here almost for six months and melting of winter snow generally starts from the month of May in the summer draining as cold water into the Panch Pokhari Lakes.

Location Map

Figure 1 : Google image of Panch Pokhari showing five different sampling points

Source: Google Earth, accessed in June 19, 2013 (Modified from Google Maps)

Sampling Sites

In the Panch Pokhari lake series, one is considerably larger than the rest, and was given the code Lake 1. Lake 2 is located near the rest house and very shallow. Therefore, lake 1 was studied thoroughly and water samples were collected from five different locations, i.e., the inlet, outlet, littoral zone, middle (centre) and deepest point of the lake. For Lake 2, littoral and human influence area have also been considered. From the other four lakes, samples were collected from inlet and outlet sites at least, but littoral zone as well where accessible. An inflatable boat was used for sample collection.

Sample Collection and Preservation

For the analysis of chemical parameters like nitrate, nitrite, ammonia, total nitrogen and phosphate analysis, samples were collected in a pre-washed (500 ml) clean plastic container and added concentrated H_2SO_4 as preservative. The same volume of water samples were also collected in unpreserved conditioned for other chemical parameters such as sodium, potassium, chloride, sulphate, total silica, etc. However, for the trace metals like Fe, Mn, Cu, Zn, Cd, Cr, Ni, Co, Pb, As and Al the samples were collected in pre-acid washed plastic containers and preserved with concentrated HNO_3. All water samples were transported in an ice-box to the Soil and Water Analysis Laboratory at the Aquatic Ecology Centre of Kathmandu University for further analysis.

Sample Analysis

Physico-chemical parameters like pH, temperature, electrical conductivity, and dissolved oxygen were measured by using a multiparameter probe (Orion Star Series Multimeter set) *in situ*. Bicarbonate alkalinity was analyzed immediately after the collection of sample by titrimetric method. Chloride and total hardness also analyzed by titrimetric method. Other chemical parameters like nitrate, nitrite, ammonia, organic nitrogen, total nitrogen and total phosphate were analyzed by UV-visible spectrophotometric method. Major cations such as Ca^{++}, Mg^{++}, Na^{++} and K^{++} were analyzed by flame photometer (AAS without lamp). Total silica and sulphate were also analyzed by spectrophotometer. And all the trace metals, namely, Fe, Mn, Cu, Zn, Cd, Cr, Ni, Co, Pb and As were analyzed by Atomic Absorption Spectrometer (AAS), whereas, Al was analyzed by spectrophotometer.

In the laboratory, fresh standard solutions were prepared from stock standards during analysis of each and every parameter with at least 4 different concentrations of standards with a blank for calibration and quality control mechanism. All the sample collection techniques, quality control mechanisms and analytical methods were followed according to the *Standard Methods for the Examination of Water and Wastewater* **(APHA, AWWA & WEF, 1998).** The

analyzed physico-chemical parameters, units and their test methods are mentioned in Table 1.

Table 1 : The analyzed physico- chemical parameters, unit and their brief test methods

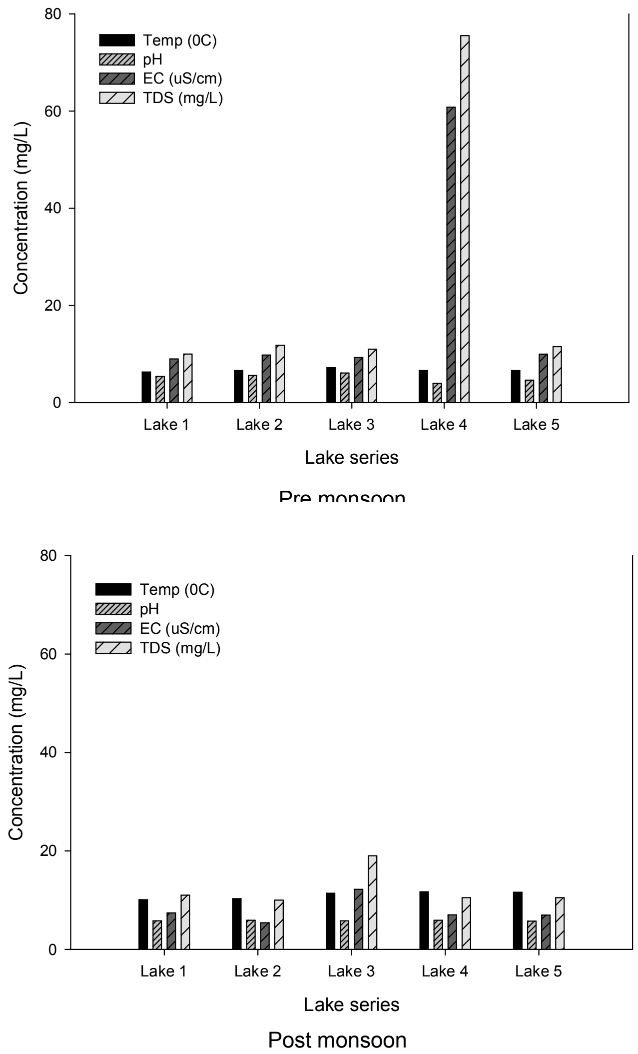
S. No.	Parameters	Units	Test method/Instrument used
	Physico chemical parameters:		
1	Water Temperature	^0C	Thermometer
2	pH	-	Multi Parameter Probe
3	Electrical Conductivity	µS/cm	Multi Parameter Probe
4	Total Dissolved Solids (TDS)	mgL^{-1}	Multi Parameter Probe
	Major cations and anions:		
5	Bicarbonate Alkalinity (HCO_3^-)	mgL^{-1}	Titrimetric (H_2SO_4)
6	Chloride (Cl^-)	mgL^{-1}	Argentrometric
7	Total Hardness as $CaCO_3$	mgL^{-1}	EDTA Titration
8	Calcium (Ca^{++})	mgL^{-1}	Direct Air Acetylene Flame/AAS
9	Magnesium (Mg^{++})	mgL^{-1}	Direct Air Acetylene Flame/AAS
10	Sodium (Na^+)	mgL^{-1}	Direct Air Acetylene Flame/AAS
11	Potassium (K^+)	mgL^{-1}	Direct Air Acetylene Flame/AAS
12	Sulphate (SO_4^{--})	mgL^{-1}	Spectrophotometric
13	Orthophosphorus	mgL^{-1}	Ammonium molybdate ascorbic acid red.^{n}
14	Total Phosphate	mgL^{-1}	Potassium Persulphate digt^n followed by Ammonium molybdate ascorbic acid reduction.
15	Organic Nitrogen	mgL^{-1}	Kjeldhal digestion
16	Total Nitrogen	mgL^{-1}	$N\text{-}NO_3+N\text{-}NO_2$+Organic nitrogen
	Trace metals:		
17	Iron (Fe)	mgL^{-1}	Extraction/Air Acetylene Flame/AAS
18	Manganese (Mn)	mgL^{-1}	Extraction/Air Acetylene Flame/AAS
19	Zinc (Zn)	mgL^{-1}	Extraction/Air Acetylene Flame/AAS
20	Copper (Cu)	mgL^{-1}	Extraction/Air Acetylene Flame/AAS
21	Cadmium (Cd)	mgL^{-1}	Extraction/Air Acetylene Flame/AAS
22	Chromium (Cr)	mgL^{-1}	Extraction/Air Acetylene Flame/AAS
23	Nickel (Ni)	mgL^{-1}	Extraction/Air Acetylene Flame/AAS
24	Cobalt (Co)	mgL^{-1}	Extraction/Air Acetylene Flame/AAS
25	Lead (Pb)	mgL^{-1}	Extraction/Air Acetylene Flame/AAS
26	Arsenic (As)	mgL^{-1}	Extraction/Air Acetylene Flame/AAS ((Hydride Generation - vapor)
27	Aluminum (Al)	mgL^{-1}	Spectrophotometric (Erichrome Cyanine)

Results and Discussion

The detailed results of mean, minimum and maximum values of analyzed parameters of Panch Pokhari lake series in pre monsoon and post monsoon season and Pearson correlation coefficient matrix were shown in graphs and table, respectively. Most of the parameters were observed to be in a similar range in Panch Pokhari lake series, however, a few notable parameters exhibited considerable variability and lower values were recorded in post monsoon as compared to pre monsoon season.

Physical Parameters

The physical parameters like temperature, pH, EC and TDS trend could be regarded as normal as generally found in other high altitude lentic water bodies (Lacol and Freedman, 2005). The pH value of the water varied from a lower 3.47 to 6.20 in pre monsoon while 5.53 to 5.98 in post monsoon season that mainly due to the dilution effect of monsoon rain. EC and TDS values seems to be almost in the similar range in lake series, especially lowest value of EC was found in the Langtang area of High Himal and similar trend was also recorded in Gosainkunda Lake (Raut et al, 2012) and also the same in five different location of Lake 1 of Panch Pokhari as well (Raut et al., 2013). However, TDS was found to be quite high in Lake 4 in premonsoon and but in both lake 3 and 4 in post monsoon as compared to other lakes. Lake 4 is located at approximately the middle part of the basin and seems to be the outlet of others lakes, hence might be the cause of deposition of ions.

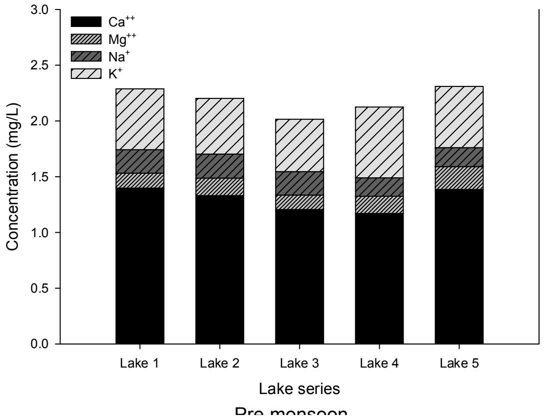


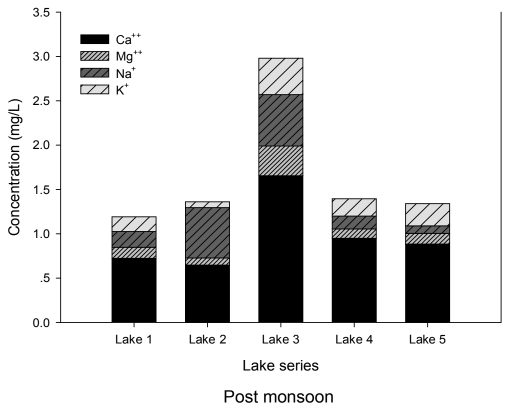
Premonsoon **Post monsoon**

Figure 2 : Physical parameters (Temp, pH, EC & TDS) in five different lakes (Panch Pokhari)

Major Cations and Anions

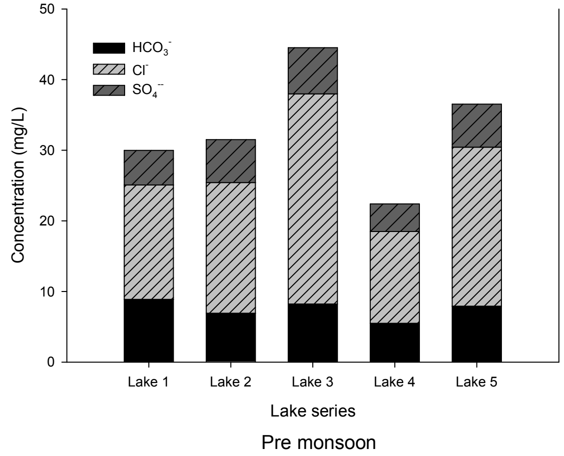
Parameters such as calcium (Ca^{++}), magnesium (Mg^{++}), sodium (Na^{+}), potassium (K^{+}) and chloride (Cl^{-}), bicarbonate alkalinity (HCO_3^{-}), sulphate (SO_4^{--}) were considered as the major cations and anions, respectively. The high concentration of Ca^{++} in Panch Pokhari was thought to be mainly due to weathering of calcareous rocks (Wetzel, 2000) from surrounding catchment and similar trend was also recorded in the high altitude lakes, Gosainkunda and Gokyo (Raut et.al., 2012; Gurung et.al., 2011). The Ca^{++} and Cl^{-} are the major dominant cation and anion respectively in pre monsoon whereas Ca^{++} and HCO_3^{-}, cation and anion respectively in the post monsoon.

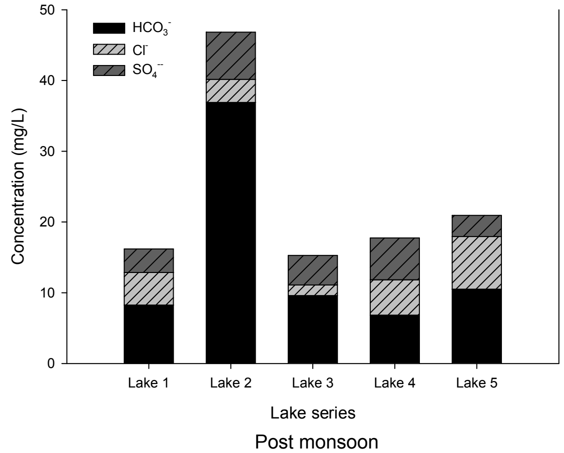




Premonsoon **Post monsoon**

Figure 3 : Major cations (Ca, Mg, Na & K) proportion in five different lakes (Panch Pokhari)

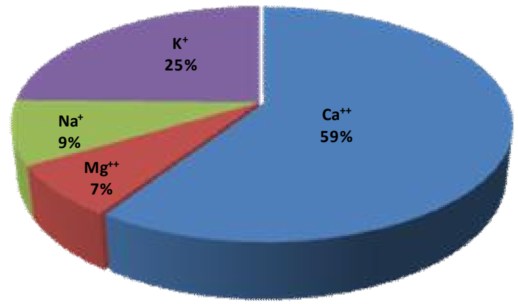




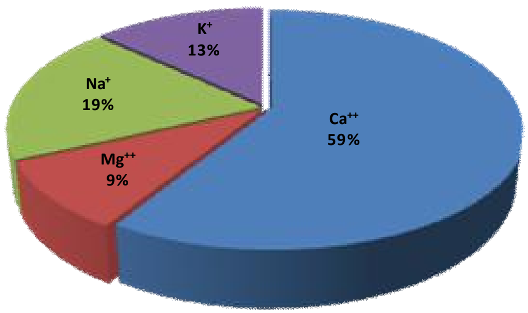
Pre-monsoon **Post monsoon**

Figure 4 : Major anion (HCO_3, Cl & SO_4) proportion in five different lakes (Panch Pokhari)

In Panch Pokhari lake series, the cations and anions composition seems to be in ordered of Mg^{++} >, Na^{+}>, K^{+}> Ca^{++} & SO_4^{--} >HCO_3^{-} >Cl^{-} respectively in pre monsoon season. Where as in cations and anions compositions were found to be in ordered of Mg^{++}>K^{+}>Na^{+}>Ca^{++} & Cl^{-}>SO_4^{--}>HCO_3^{-} respectively in post monsoon season in all the lakes (Figure 5).



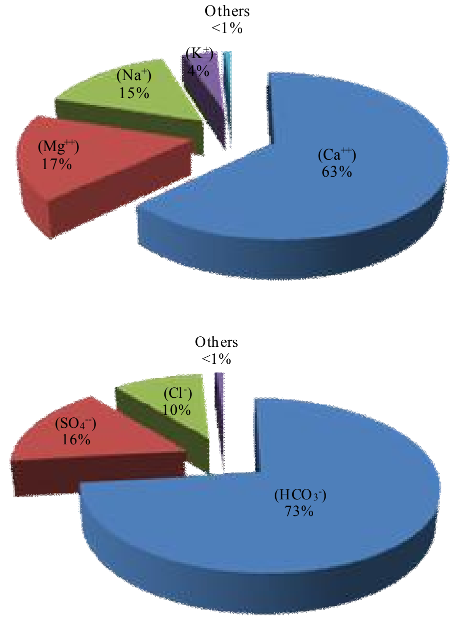
Pre monsoon



Post monsoon

Figure 5 : Ion composition in pre monsoon and post monsoon (Panch Pokhari lake series)

In a typical freshwater lake has an ion balance of sum of the positive ions equal to the negative ions such as four major cations (calcium (63%), magnesium (17%) sodium (15%), potassium (4%) and three major anions (bicarbonate (73%), sulphate (16%), chloride (10%) and other ions are <1% *(www: water on the web/understanding/Lake Ecology/chemical)* shown in (Figure 6). Ions balance is in the ordered of $K^+ > Na^+ > Mg^{++} > Ca^{++}$ and $Cl^- > SO_4^{--} > HCO_3^-$ respectively. Thus, a similar trend as reported elsewhere was observed in the Panch Pokhari lake series however, there appears to be some seasonal variability in the ions concentration that might be due to the monsoon rainfall.



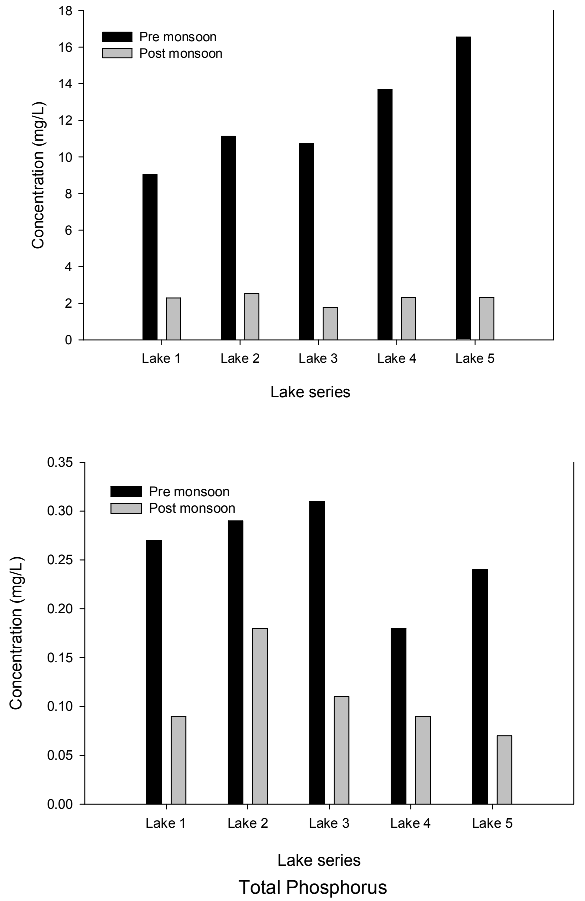
Cations Anions

Figure 6 : Major Ion balance in typical freshwater

(www: water on the web/understanding/Lake Ecology/chemical)

Nutrients

The major nutrients nitrogen and phosphorus are the limiting factors for all kind of freshwater bodies. The concentration of nitrogen ranges from 5.0mg/L to 21.1mg/L and where as 1.63mg/L to 3.45mg/L in the pre monsoon and post monsoon respectively in all the lakes of Panch Pokhari. In the case of phosphorus concentration, it was ranges from 0.15mg/L to 0.06mg/L to 0.41mg/L in the pre monsoon and post monsoon respectively. The recorded values of TP were seems to be lower that of TN and suggested that the Lakes are still oligotrophic. Phosphate concentration <10, 10-20, >20 are oligotrophic, mesotrophic and eutrophic, respectively (Saxena 1998). A similar trend was also reported in the other high altitude lakes of Nepal (Lacol and freedman 2005; Raut, et al., 2012).



Pre-monsoon **Post monsoon**

Figure 7 : Major nutrient concentration in five different Lakes (Panch Pokhari)

Trace Metals

Most of the analyzed trace metals except aluminum, iron and lead were found to be below the detection limit from (extraction/air acetylene flame/AAS). The mean value of Pb^{2+} ranged from 0.008mg/L to 0.03mg/L in the pre-monsoon, while the value seemed to be quite low during the post-monsoon in the Panch Pokhari lake series. Detection of Pb^{2+} in high altitude lakes indicates either some atmospheric impact of long range of air bore pollution or anthropogenic source. Fe^{2+} as also detected in the pre-monsoon in all the lakes except Lake 1, but

concentrations were reverse during the post-monsoon season, i.e., only lake 1 was observed to be contaminated with Fe^{2+} and the value was high as well, which might be caused by solubilization and leaching from the iron rocks by heavy rain. Within the Panch Pokhari lake series, the concentration of Al^{3+} was found to be ranges from 1.92mg/L to 3.56mg/l and 0.03mg/L to 0.17mg/L in the pre monsoon and post monsoon respectively. Aluminum can be toxic to organisms and is soluble in water at low pH as well as leached from the watershed catchment by acidic deposition. However, Al^{3+} concentrations were found to be higher than (NDWQS, 2063) for drinking purpose in the pre- monsoon season but lies within the range for Nepal Water Quality Guidelines for the Protection of Aquatic Ecosystem (DoI, 2065) in all the lakes.

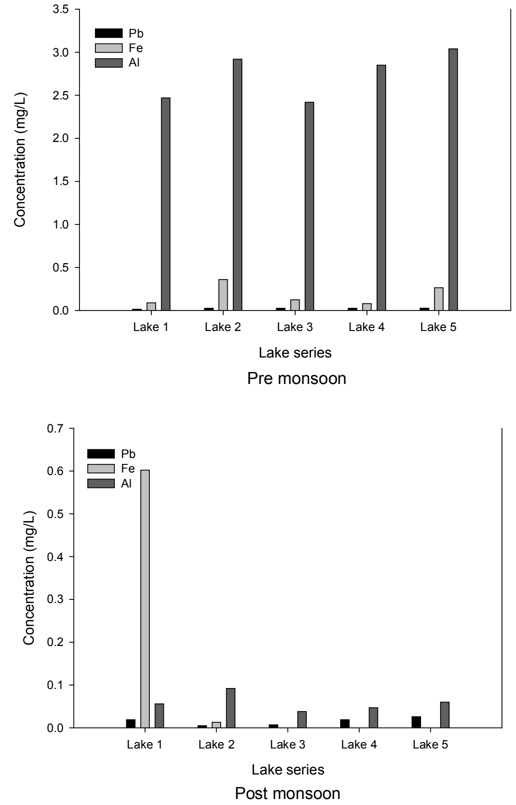


Figure 8 : Trace metals (Pb and Al) concentration in five different lakes (Panch Pokhari)

Pearson's Correlation Coefficient

Pearson's correlation coefficient analysis was applied to the various measured water quality parameters during the pre-monsoon and post-monsoon seasons (Tables 2 and 3) using SPSS software in order to determine the significance of correlation between parameters at P<0.05 and P<0.01 levels. TDS and EC were found strongly correlated with each other in both seasons. EC of a solution is a measure of its ability to carry an electric current and sum of all ionized solutes are the TDS. Hence, there is an expectant relationship in these parameters of water chemistry having a common origin. Similarly, cations like Na^{+} and K^{+} were significantly correlated with pH and EC, TDS and anions SO_4^{2-} with Cl^{-}, respectively, which was mainly due to the low pH and weathering of bed rocks. TN had a strong positive correlation with Mg^{2+}, while TP had good correlation with SO_4^{2-} and Na^{+}. Aluminum also was well correlated with Mg^{2+} and Pb^{2+} which was clearly found in pre monsoon and post monsoon season. Al has also good correlation with HCO_3^{-} and SO_4^{2-} because Al^{3+} is soluble at low pH levels and is highly sensitive to changes in the pH of water.

Table 2 : Pearson correlation coefficient matrix in pre monsoon (Panch Pokhari) lake series

	Temp	pH	EC	TDS	HCO_3^{--}	Cl^{-}	SO_4^{--}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	TN	TP	SiO_2	Al	Fe	Pb
Temp	1.00																
pH	0.45	1.00															
EC	-0.10	-0.77	1.00														
TDS	-0.10	-0.77	**1.000****	1.00													
HCO_3^{--}	0.02	0.65	-0.85	-0.86	1.00												
Cl^{-}	**0.82**	0.66	-0.60	-0.60	0.53	1.00											
SO_4^{--}	0.56	0.72	-0.82	-0.82	0.53	**0.87**	1.00										
Ca^{++}	-0.61	0.15	-0.69	-0.70	0.64	-0.06	0.28	1.00									
Mg^{++}	-0.20	-0.58	0.05	0.05	-0.24	-0.06	0.12	0.31	1.00								
Na^{+}	0.13	**.892***	-0.61	-0.61	0.45	0.26	0.44	0.19	-0.68	1.00							
K^{+}	-0.54	**-.938***	**0.85**	**0.84**	-0.62	-0.80	**-.913***	-0.22	0.28	-0.75	1.00						
TN	0.02	-0.69	0.29	0.29	-0.38	0.00	0.00	-0.01	**.930***	-0.86	0.40	1.00					
TP	0.35	**.972****	**-.884***	**-.880***	0.70	0.66	**0.81**	0.34	-0.40	**0.87**	**-.967****	-0.58	1.00				
Al	-0.30	-0.63	0.24	0.24	-0.55	-0.33	-0.05	0.17	**.898***	-0.55	0.37	**0.80**	-0.46	0.60	1.00		
Fe	-0.03	0.19	-0.47	-0.46	-0.04	0.16	0.60	0.43	0.54	0.22	-0.43	0.28	0.37	-0.22	0.65	1.00	
Pb	-0.25	-0.67	0.42	0.43	-0.74	-0.42	-0.18	-0.04	0.78	-0.53	0.45	0.73	-0.55	0.65	**.968****	0.56	1.00

*. Correlation is significant at the 0.05 level (2-tailed).

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

Table 3 : Pearson correlation coefficient matrix in post monsoon (Panch Pokhari) lake series

	Temp	pH	EC	TDS	HCO_3^{--}	Cl^{-}	SO_4^{--}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	TN	TP	SiO_2	Al	Fe	Pb
Temp	1.00																
pH	-0.22	1.00															
EC	0.46	-0.15	1.00														
TDS	0.47	-0.14	**1.000****	1.00													
HCO_3^{--}	-0.50	0.36	-0.45	-0.44	1.00												
Cl^{-}	-0.50	0.28	-0.66	-0.67	-0.15	1.00											
SO_4^{--}	-0.08	0.20	-0.45	-0.44	**0.88**	-0.32	1.00										
Ca^{++}	0.63	0.02	.955*	**.960****	-0.39	-0.70	-0.30	1.00									
Mg^{++}	0.47	-0.11	**.989****	**.991****	-0.33	-0.75	-0.32	**.965****	1.00								
Na^{+}	-0.17	0.34	0.38	0.39	0.65	-0.66	0.49	0.41	0.49	1.00							
K^{+}	0.73	-0.26	**.936***	**.938***	-0.62	-0.64	-0.47	**.940***	**.913***	0.13	1.00						
TN	-0.50	0.16	**-.998****	**-.998****	0.51	0.63	0.49	**-.955***	**-.980****	-0.32	**-.952***	1.00					
TP	-0.52	0.50	-0.25	-0.24	**.960****	-0.21	0.76	-0.19	-0.13	**0.80**	-0.48	0.31	1.00				
Al	-0.59	0.12	-0.78	-0.78	**0.87**	0.17	**0.80**	-0.76	-0.70	0.22	-0.87	**0.82**	0.72	-0.60	1.00		
Fe	-0.66	-0.41	-0.10	-0.12	-0.22	0.45	-0.54	-0.38	-0.19	-0.30	-0.24	0.09	-0.22	-0.16	0.02	1.00	
Pb	0.39	-0.55	-0.33	-0.34	-0.58	0.37	-0.28	-0.33	-0.41	**-.927***	-0.02	0.28	-0.78	-0.60	-0.16	0.13	1.00

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

*. Correlation is significant at the 0.05 level (2-tailed).

Conclusions

In the Panch Pokhari lake series, water chemistry did not vary greatly with seasons. However, the concentration of measured parameters were found to be generally lower during the post-monsoon as compared to pre-monsoon season. Most of the parameters were observed to lie within the range for Nepal Water Quality Guidelines for the Protection of Aquatic Ecosystem in all the lakes, with the exception of a few parameters like pH, lead and aluminum. Most of the others were within the range for drinking water quality standard as well. Low values of pH, Pb^{2+} detection, and the excessive values of Al^{3+} indicated that there could be some influence from long range transport of atmospheric pollutant or some mineral sources. There are chances of dissolution and leaching of aluminum from the catchment through acidic deposition due to the low pH as aluminum is soluble in water. Nonetheless, anthropogenic impact may also be a contributing factor. As the lakes are located in a remote area far from human settlement, the impact seems to be only by seasonal and during the festival time. Further research is needed and the application of sensitive biological indicators, such as diatoms, could help elucidate the main cause of impacts to the Panch Pokhari lake series.

Acknowledgements

The authors gratefully acknowledge WWF Nepal for providing partial financial support to conduct this research. We are also thankful to Aquatic Ecology Centre, Kathmandu University for crucial logistic and laboratory support to carry out all the analytical works. Also acknowledged for assisting with field work are Mr. Hariram Upadhyaya, Dr. Smriti Gurung, Ayush Gyawali, Rupesh Subedi, Bimal KC, Nisha Gautam and Asmita Paudel.

References

APHA, AWWA & WEF. (1998); Standard Methods for the Examination of Water and Wastewater. American Association of Public Health, American Water Works Association and the Water Pollution Control Federation, American Public health Association, 20th Edition, Washington. D.C. 1268pp.

Barnard P.L., Owen L.A., Finkel R.C. & Katsuhiko A. (2006). Landscape response to deglaciation in a high relief, monsoon influenced alpine environment, Langtang Himal, Nepal. *Quaternary Science Reviews* 25: 2162–2176.

Beug H.J. & Miehe G. (1998); Vegetationsgeschichtliche Untersuchungen in Hochasien. 1. Anthropogene Vegetationsveränderungen in Langtang-Tal, Himalaya, Nepal. *Petermanns Geographische Mitteilungen 142: 141–148*.

Bhuju et al., (2012); Scientific Discourse of Lakes in Nepal, *Nepal Journal of Science and Technology Vol. 13, No. 2 (2012) 147-158.*

Bhuju, et al., (2010). A map based inventory of lakes in Nepal, *Nepal Journal of Science and Technology 11: 173-180*.

DOI (2065); Nepal Water Quality Guidelines for the Protection of Aquatic Ecosystem, Department of Irrigation, Ground water project (Nepal Gazette Number 10, BS, 2065-03-02).

Fisheries Development Division FFD (1992). National fisheries development plan 1992/93, Department of Agriculture Development, Kathmandu, Nepal.

Gurung et al., (2011); Physico –Chemical Parameters of Gokyo Lakes: High Altitude Himalayan Freshwater Lakes, Natural Resources Management: In Reviews and Research in the Himalayan Watersheds II, (special publication of NUFU HUMUNET Project, Vol. II), Eds. Balla, M. and Sing, Abadhesh.

Lacoul P, B. Freedman (2005). Physical and Chemical Limnology of 34 water bodies along a Tropical to Alpine Altitudinal Gradient in Nepal. *Internat. Rev. Hydrobiol., 90(3): 254-276*.

NDWQS (2063); Nepal Drinking Water Quality Standard, Ministry of Physical Planning, (Nepal Gazette, Number 10, BS, 2065-03-02).

Pradhan et al, (2009): An Assessment of Biodiversity in Panch Pokhari of Sindhupalchowk District of Central Nepal Emphasizing Conservation Needs, A Project Report (Final) Submitted to Rufford Small Grants Foundation, The United Kingdom.

Raut et al, (2013); Preliminary Water Quality Assessment of High Altitude Fresh water Lake System(Panch Pokhari) in the Central Himalaya of Nepal, Proceeding, International Conference Forest, People & Climate: Changing Paradigm, organized by Government of Nepal (MFSC/DFRN), Institute of Forestry, Pokhara, Nepal & University of Copenhagen, Denmark, *28 – 30th August 2013*, Pokhara Nepal.

Raut et al., (2012): Physico-chemical Characterization of Gosainkunda Lake. *Nepal Journal of Science and Technology Vol. 13, No. 1 (2012) 107-114*.

Saxena, A. (1998). Primary productivity studies in a sewage polluted lake with special reference to phytoplankton. Ph.D. Thesis, Barkatullah University, Bhopal, INDIA

Wetzel (2000); Limnological analyses, *Springer Verlag*, New York.

River Water Quality Monitoring Using Benthic Macro Invertebrates in Budhi and Singhiya River of Eastern Nepal

K. Poudel, S. Dahal, B. M. Dahal*, S. Gurung

Abstract

Budhi Khola of Ithahari and Singhiya Khola of Biratnagar are the main rivers flowing through these two big municipalities. These municipalities are chosen due to the increasing concern of water quality deterioration increasing urban area and solid and liquid waste. Both municipalities have experienced a rapid urban development in the Terai region and in order to assess the present condition and possible future scenarios of the rivers flowing through these municipalities, the study has been assessing the water quality status by applying different methods.

The major objective of the study is to assess the ecological impacts on river water quality in Eastern Terai Region. Physico-chemical analysis were conducted to indicate the status of water quality, oxygen relationship in water, atmospheric reaeration in water, P_H, Temperature and conductivity of water and behavior of Phosphate, Nitrate and Ammonia in water. Biological assessment of the rivers was conducted to evaluate the ecological impacts of pollution from various points and non- point sources using NEPBIOS score method. The study showed that these rivers are heavily affected by human activities. The growing number of settlements and increasing amount of solid waste and waste water are found to be the main causes of water pollution. The physicochemical analysis of the water showed that the rivers are within acceptable range. However, the higher values are recorded around the pollution discharge and industrial effluents areas.

Introduction

Anthropogenic induced river water deterioration is becoming an increasing concern in many parts of the world (UNESCO, 2010) with urbanization being recognized as one of the major contributing factors (Cuffney et al., 2008; Roy et al., 2009). It results in the "alteration of landscape from natural to residential, commercial and industrial uses, through construction" (Wheeler et al., 2005). An investigation in Hindu Kush-Himalayan countries also highlights four major deteriorating factors for river water: waste, land use, damming/impoundment and climate change (Korte, 2009).

In Nepal also, the trend of urbanization is increasing (CBS, 2011) resulting in water and environmental degradation in the major cities of Nepal (Ghimire, 1985; Scholz, 2001; Kannel, 2007). Consequently many river sections have lost their ability of providing ecological services for the human society, e.g. self purification capacity, recreational benefits and many others (Shrestha *et* al, 2009). Therefore regular assessment and monitoring of rivers are essential. Since an integrated approach using biological along with traditional physical and chemical evaluations are considered the best (Reynoldson et al., 1989), such techniques are frequently used to monitor river water quality. Among the different biological indicators, macroinvertebrates are often use as they have been found to integrate and respond to the cumulative impacts of both physical and chemical disturbances (Sharma et al., 2005). This paper attempts to study the impacts of urbanization using macroinvertebrates as biological indicators in Budhi Khola and Singhya Khola of Biratnagar and Itahari in Eastern Nepal. Biratnagar and Itahari are two municipalities in the Eastern Development Region, Nepal. These two municipalities have experienced a rapid urban development in the Terai region over the years due to which there is an increasing concern of water quality deterioration. Moreover people living along the banks of these rivers are heavily dependent on the river water for various activities. Therefore the monitoring of the water quality of these rivers becomes imperative.

Material and Methods

Study Area

Two rivers were studied during the study period, which were Singhya Khola of Biratnagar and Budhi Khola of Itahari municipality of Eastern Development Region, Nepal (Figure 1). Five sites (site 1 – site 5) from each river were identified for the study considering different effects. Site 1 is considered as reference or the condition of river water entering the municipality territory.

Budhi Khola starts from mid hills, east of Dharan, and flows through the industrial areas of Itahari. After urban area of Itahari it flows though the industrial area of Khanar, Sonapur and Duhabi, and it is also border of Hattimuda and Duhabi VDC. Singhya Khola borders the Biratnagar Municipality from the eastern side.

Department of Environmental Science and Engineering, Kathmandu University, Dhulikhel, Nepal

* *Corresponding Address: bedmani@gmail.com, bedmani@ku.edu.np*

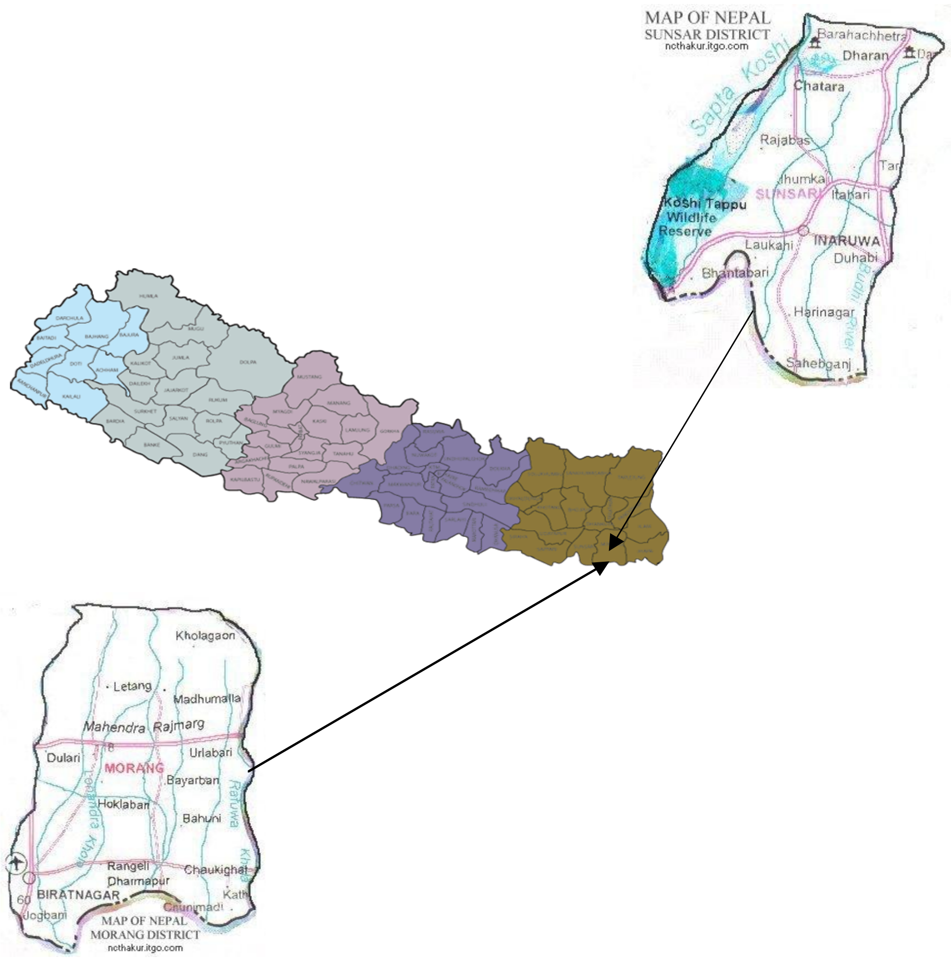


Figure 1 : Map of the Study Area

Identification of Point Sources of Pollution

To identify the pollution source, each river was visited and visual assessment was conducted by walking along the banks of the rivers.

Physico - Chemical Analysis

Selected physico-chemical parameters such as the temperature, conductivity, pH and Dissolved Oxygen were measured in the site itself using multi parameter kits. 500 ml of water samples were collected for estimation of Biological Oxygen Demand (BOD), Nitrate, Phosphate and Ammonia. Biological Oxygen Demand

(BOD) was analyzed by Azide Modification at Water Lab, Biratnagar and Nitrate by Brucine method, Phosphate by Ammonium Molybdate method, and Ammonia by Nesslers Reagent method at NCDC water analysis lab following titration methods.

Biological Assessment Method

Qualitative sampling of macroinvertebrates was done following Barbour et al. (1999). Macroinvertebrates were collected using hand-net with mesh size 250 µm. A one hundred meter river stretch was sampled in each site. The substrate was disturbed by kicking action in front of the net to collect the organisms. Macroinvertebrates were allowed to be drifted towards the net. Artificial substrates such as woods and other detritus were also inspected for macroinvertebrates. Stones were also turned and observed and some macroinvertebrates were handpicked as well. The collected specimens were sorted in a white tray and some were identified in field itself and then samples were preserved in 70 % Ethanol and brought to the laboratory for further identification.

NEPBIOS is used to classify the river water quality which consists of five classes and color codes. Macroinvertebrates were identified up to family level using relevant identification keys and literature (Merrit and Cummins, 1996; Wolfman et al. 2006 and Hartmann, 2007). An ecological assessment tool Nepalese Biotic Score/Average Score Per Taxon (NEPBIOS/ASPT) (Sharma, 1996) was applied to obtain the Water Quality Class (WQC) of the sampling sites. In this method, 82 macroinvertebrate families are assigned a numeric value (1 to 10) based on their pollution tolerance and WQC is determined by adding the total score of the animals divided by the total numbers of the groups of the animals present in the site. WQC is determined with reference to the transformation table for the NEPBIOS/ASPT values obtained.

Results and Discussion

Point Sources of Pollution at the Rivers

The main sources of pollution in both the rivers are non point sources arising from agriculture, improper sanitation, bathing and washing. S4 at Buddhi Khola was observed to be the most polluted site with multiple stressors. This site receives the highway drainage which is the main point source of sewage. The site also had a cremation site, solid waste dumping particularly at the sides of the bridge. The other stressors included sand and gravel extraction. The major points and area receiving different forms of pollution in both rivers are shown in Table 1.

Table 1 : Major pollution sources and their magnitude

Site Code	Pollution Sources
B5	Highway Drainage
B3	Sand extraction activity
S2	Cremation site
S4	Solid waste disposal at the side of the bridge, on the rivers and river banks
S3	Match factory drainage
B5	Household sewage drainage
S3	Open sewage
B5	Domestic activity like bathing, washing, cattle washing, etc

Physico- Chemical Parameters

The temperature of all rivers ranged from 19 to 25°C which is normal for the low land rivers of Nepal. The temperature fluctuates very much with time and weather condition and is not considered as a major parameter for water quality assessment. In this study, all sites were with higher pH (more than 7) value which might be due to natural source (lime stone rocks) through which the water is flowing. The higher pH might also be due to anthropogenic activities like sewage discharge, mainly detergents and crimination activities (ash) also help in higher Ph. The conductivity levels of the studied river samples are between 423 to 511 µS/cm, which shows that the mineral and salt content in the river water is low when compared with the WHO guidelines The BOD values for Budhi Khola is found low (less than 3 mg/L) which shows that the water is still with less external pollution. Comparatively, Singiya Khola recorded higher BOD values at site S1, S2 and S5 (higher than 10 mg/L) which are mainly due to point source pollution (see pollution and pollution source points in river section). In terms of Nitrate, Phosphate and Ammonia in studied rivers, the levels are within the guideline values. However, the disturbed and municipal discharge sites show the higher values indicating that the rivers are in threat due to human activities. These three values are found to be increasing along with the downstream river flow in all rivers which might be due to the cumulative effect of the pollution Results of the physico- chemical parameters are given in the Table 2.

Table 2 : Result of physico-chemical analysis of Budhi and Singhya Khola.

Parameters	Budhi Khola			Singhya Khola		
Temperature	Sites	B1	23.4	Sites	S1	19.2
		B2	21		S2	22
		B3	21.2		S3	21
		B4	22.2		S4	22.2
		B5	23.2		S5	21.7
		Mean (±SD)	**22.2±1.1**		**Mean (±SD)**	**21.2±1.2**
pH	Sites	B1	8.2	Sites	S1	9.6
		B2	9		S2	10.5
		B3	9.2		S3	10.9
		B4	9.3		S4	12.1
		B5	11		S5	11.4
		Mean (±SD)	**9.34±1**		**Mean (±SD)**	**10.9±0.9**
Conductivity (µS/cm)	Sites	B1	511	Sites	S1	429
		B2	440		S2	440
		B3	441		S3	456
		B4	442		S4	457
		B5	443		S5	423
		Mean (±SD)	**455.4±31.1**		**Mean (±SD)**	**441±15.4**
DO (mg/L)	Sites	B1	6.67	Sites	S1	9.69
		B2	10		S2	8.29
		B3	9.85		S3	10.8
		B4	10.6		S4	10.67
		B5	9.5		S5	10.3
		Mean (±SD)	**9.93±0.8**		**Mean (±SD)**	**10.95±1**
BOD (mg/L)	Sites	B1	2.78	Sites	S1	15.89
		B2	2.94		S2	14.6
		B3	2.5		S3	8.8
		B4	2.54		S4	8.07
		B5	4.44		S5	12.99
		Mean (±SD)	**3.04±0.8**		**Mean (±SD)**	**12.07±3.4**
Nitrate (mg/L)	Sites	B1	0.18	Sites	S1	0
		B2	0.47		S2	0.29
		B3	0.35		S3	0.41
		B4	0		S4	0.18
		B5	0.24		S5	0.12
		Mean (±SD)	**0.24±0.17**		**Mean (±SD)**	**0.2±0.15**
Phosphate (mg/L)	Sites	B1	0.01	Sites	S1	0.16
		B2	0.06		S2	0.18
		B3	0.17		S3	0.23
		B4	0.23		S4	0.19
		B5	0.2		S5	0.22
		Mean (±SD)	**0.13±0.09**		**Mean (±SD)**	**0.19±0.02**
Ammonia (mg/L)	Sites	B1	0.31	Sites	S1	0.13
		B2	0.13		S2	0.06
		B3	0.38		S3	0.06
		B4	0.69		S4	0.56
		B5	0.38		S5	0.69
		Mean (±SD)	**0.37±0.2**		**Mean (±SD)**	**0.3±0.3**

Macroinvertebrate Assemblages

A total of 22 families of macroinvertebrates belonging to 2 Phyla 9 Orders and were observed at the sampling sites. 17 families were observed in Budhi Khola and 14 families were observed in Singhya Khola (Figure 2). The sites with highest diversity was B1 (11 families) followed by B5 and S4 (9 families each) and B3 and S1 (8 families each) whereas the least number of families were observed at B2 (4 families) (Figures 3a and 3b).

The insect fauna composed of Order Ephemeroptera represented by four families (Baetidae, Caenidae, Ephemerellidae and Ephemeridae); Diptera with four families (Chironomidae red and not red, Culicidae, Tabanidae); Odonota with three families (Aeshnidae, Gomphidae, Libellulidae); Hemiptera with two families (Corixidae, Nepidae); Trichoptera with one family (Hydropsychidae) and Heteroptera with one family (Gerridae); Crustaceans composed of Order Decapoda with two families (Palaeomonidae, Potamidae) whereas the phylum Mollusca was represented by five families (Corbiculidae, Physidae, Pleuroceridae, Thiaridae Viviparidae).

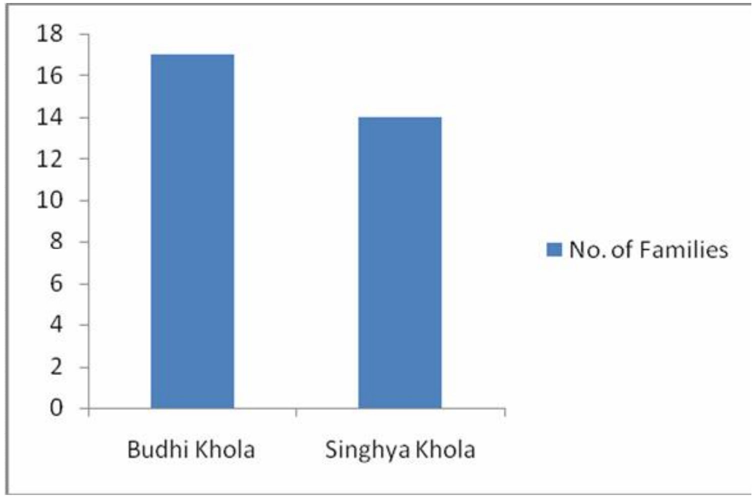


Figure 2 : Total number of macroinvertebrate families in Budhi Khola and Singhya Khola.

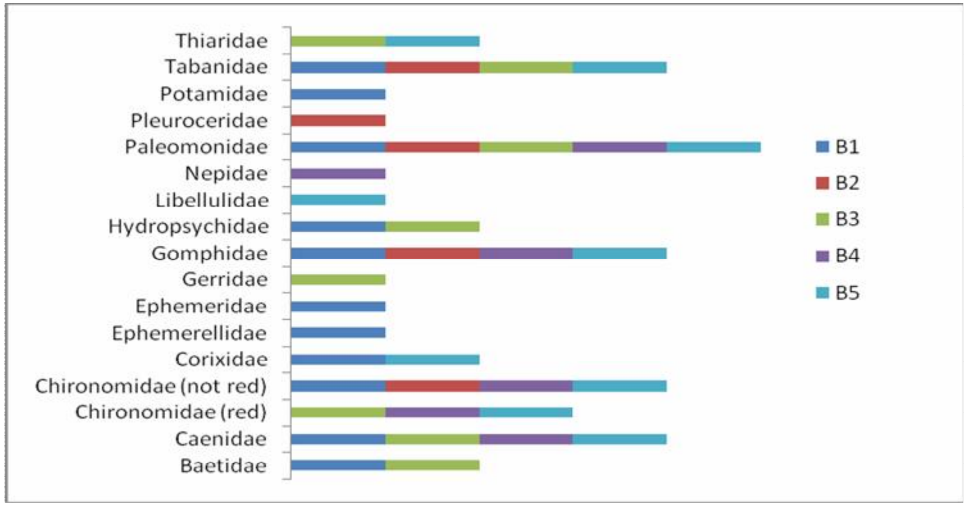


Figure 3a : Total number of macroinvertebrate families irrespective of sites in Budhi Khola.

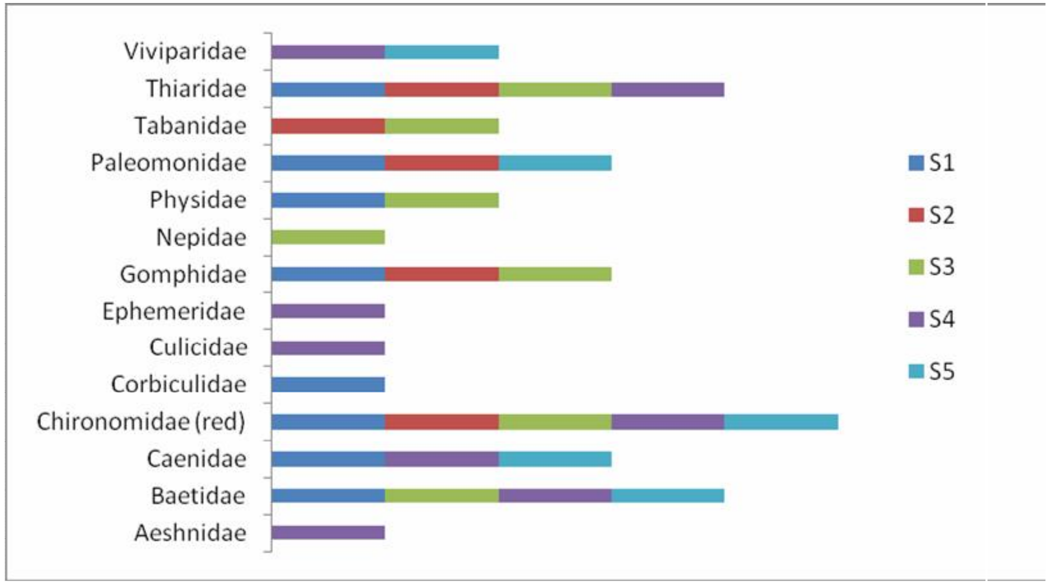


Figure 3b : Total number of macroinvertebrate families irrespective of sites in Singhya Khola.

Table 3 : Results of NEPBIOS/ASPT based WQC.

Municipality	River	Sites	Dry Season	Wet Season
Itahari	Budhi Khola	B1	I-II	II
		B2	III	II
		B3	III	II-III
		B4	II	II-III
		B5	III	II-III
Biratnagar	Singiya Khola	S1	II	II-III
		S2	II	III-IV
		S3	II-III	III
		S4	I-II	II
		S5	I-II	II-III

A distinct seasonal variation in macroinvertebrate families was observed in the sampling sites. Application of NEPBIOS/ASPT showed seasonal variation in WQC (Table 3). The WQC were observed to be degraded in the wet season than in the dry season which could be attributed to the pollutants and contaminants from the upstream areas. Site B1 was observed to have WQC I-II. This site was also shown to have the highest number of macroinvertebrate families of 11. All the four families of order Ephemeroptera was found in B1. In general, Ephemeroptera are considered to be pollution sensitive taxon and are indicators of clean water (Alam et al., 2008). Most of the sites fall in WQC II-III which shows that the river water is critically polluted. This indicates high anthropogenic activities on the river. Plecoptera was not observed in any sites as Plecoptera is found in only cold water and also Plecoptera are considered to be highly sensitive to organic pollution (De Walt et al., 2005). Only one family of Trichoptera was observed. Five families of Mollusc were observed.

Conclusions and Recommendations

Physicochemical parameters are within the acceptable range as per WHO result. The rivers were moderately to heavily polluted based on biological monitoring. Both the rivers showed higher species diversity during the wet season. Singhiya Khola of Biratnagar is more polluted than the Budhi Khola of Itahari. A holistic approach for water quality assessment and monitoring should be adopted for conservation of the rivers.

Acknowledgment

Fund Provided by Namsaling Community Development Center (NCDC) enabling the work is greatly acknowledged.

References

APHA. 1998. Standard methods for the experiment of water and waste water, American Association of Public Health, American Water works Association and the Water Pollution and Control Federation. American Public Health Association, 20th edition, Washington D.C. 1268 pp.

Barbour, M.T., Gerritsen, J., Snyder, B. D., Stribling, J.B. (1999) *Rapid Bioassessment Protocols for Use in Streams and Waseable Rivers: Periphyton, Benthic Macroinvertebrates and Fish*. Second Edition: EPA/841-B-99-002, U.S. EPA, Office of Water, Washington, D.C.

CBS. (2011). Nepal Census 2011, Vol 1. Central Bureau of Statistics, Nepal.

Ghimire, G. (1985). *Water pollution- A major crisis in Nepal*. Environmentalist.

Kannel, P., S, L., YS, L., Kanel, and S, K. (2007). *Application of water quality indices and dissolved oxygen as indicators for river water classification and urban impact assessment*. Environmental Monitoring Assessment 132, 93-110.

Korte,T. (2009). River Assessment using Benthic Macroinvertebrat in the Hindu Kush-Himalaya Region.

MERRIT, R.W. AND K.W. CUMMINS (EDS.). 1996. *An introduction to the aquatic insects of North America*, 2nd edition Kendall/hunt Publishing Corporation Durbuque.

Reynoldson, T.B., R. H. Norris, V. H. Resh, K. E. Day & D. M. Rosenberg, 1997. The reference condition: a comparison of multimetric and multivariate approaches to assess water- quality impairment using benthic macroinvertebrates. Journal of the North American Benthological Society 16(4): 833-852.

Dewalt, R.E., Favret, C. and Webb, D.W. (2005) Just How Imperiled Are Aquatic Insects? A Case Study of Stoneflies (Plecoptera) in Illinois. Illinois Natural History Survey, Center for Biodiversity, 607E. Peabody Drive, Champaign, IL 61820.

Roy, A.H., Purcell, A.H., and Walsh, C.J. (2009*). Urbanization and Stream Ecology: Five Years Later*. Journal of North American Benthol Society, 908-910.

Scholz, c. (2001). *Organic Pollution of Seti River in Pokhara Region*, Nepal.

Sharma, S. (1996) *Biological assessment of water quality in the rivers of Nepal*. PhD Dissertation, University of Agricultural Sciences, Vienna, Austria.

Sharma, S., Allen, M., Courage, A., Hall, H., Koirala, S., Oliver, S. and Zimmerman, B (2005) *Assessing water quality for ecosystem health of the Babai river in Royal Bardia National Park*, Nepal, Kathmnadu University, Journal of Science, Engineering and Technology: vol. I, no. 1.

Shrestha, M., Pradhan, B., Tachamo, Shah, R.D., and Sharma. (2009). *Water Quality Assessment and Associated Stressing Factors of Seti River Basin*. Pokhara. Journal of Hydrology and Meterology, 49-57.

UNESCO. (2007). State of World Population. United Nationals Population Fund.

Wheeler AP; Angermeier PL.; Rosenberger AE (2005). Impacts of New Highways and Subsequent Urbanization on Stream Habitat and Biota. Reviews in Fisheries Science, 13, 141-164.

WHO. 1984. Guidelines for Water Quality. Health and other supporting information, World Health Organisation, Geneva.

Theme 7

Atmospheric and Climate Change

Climate change adaptation and water induced disaster management in Nepal (A case of Terai and Mountain district of Nepal)

Krishna Raj Tiwari*, Suresh K Shrestha* and Santosh Rayamajhi*

Abstract

Nepal is one of the most disaster-prone countries in the world. In recent decade climate change impact and water induced disasters have further threatened livelihood of the people in the mountain and terai regions of Nepal. Some GOs and NGOs have initiated actions for minimizing climate change impact and water induced disasters. A study was conducted to assess the water induced disaster and adaptation management practices to minimize the vulnerability from water induced disasters in mountain (Tahanu), siwalik (Nawalparashi) and terai districts (Chitawan, Kapilbasthu, Kailali and, Bardia) of Western Nepal. Documents review, field visit, line agencies meetings (GOs/NGOs personals), community group meetings and key informant interviews were used for collection of data needed for the research.

Result showed that too much water and too little water is the major problem in the mountain and terai regions. Long dry season in the winter resulted in decreased water sources for drinking and irrigation for farming whereas, too much water during rainy season resulted in erosion and land slide in the mountain and flooding in the terai regions. Climate change adaptation such as water resource conservation and management practices for drinking and irrigation during dry seasons in the mountain area were effective and increased the farm production. Disaster management particularly flood management activities were very effective and institutionalized in DDC and VDC level plans and programs in the terai regions. Establishment of early warning system and water induced disaster management activities from community to district to national level have significantly reduced human casualties from the flood. It is reported that government mechanism to response for disaster victims was very weak. Poor and vulnerable communities were cultivating vegetables and producing water melon in the flood affected (sand deposit) land and improved their livelihood. Integrated water management practices, early warning system, immediate response mechanisms and adoptive cropping practices could be the better options to reduce the vulnerability of the local community.

Key words : Livelihood, disaster management, early warning system and water management

* *Institute of Forestry, TribhuvanUniversity, Pokhara Nepal. Email: krishna.iof@gmail.com*

Background

There is plethora of evidence of anthropogenic climatic change and of its effects on natural and human systems in various regions of the world (IPCC, 2013). Recent decade has witnessed a numbers of catastrophic natural hazards (OECD, 2013) in the developing and developed countries. For example, the 2004 Indian Ocean intercontinental tsunami, the 2005 Hurricane Katrina in the USA, the 2010 floods in Pakistan, the 2011 tsunami in Japan and the 2013 Himalayan tsunami in India. Natural hazards have caused more damage to life and property than many major wars. During the last two decades, over 2 billion people were affected by climate-related disasters in developing countries (EM-DAI, 2013).

According to the Global Climate Risk Index (GCRI), Nepal is one of highly vulnerable countriesto hydrological hazards, many of these have been there for years but newer threats, which have come up in the recent decades, are more sever and frequent. The country is prone to a variety of recurring natural disasters such as floods, landslides, snow avalanches, glacial lake outburst floods (GLOF), hailstorms, thunderstorms, cold waves, hot waves, drought, epidemics and earthquake. Out of the 75 districts in the country, 49 are prone to floods and/or landslides, 23 to wildfires, and one to windstorms(NAPA, 2010). According to MOHA (2009), a total of 64 out of 75 districts are prone to climatic disasters of some type. People in most of terai region are affected by floods every year.These recurring floods not only destroy their property and livelihood support system but also cost many humanlives.

The steep and flood-prone terrain, low levels of awareness, high illiteracy, poverty, rapid and unplanned urbanization, the adverse effects of climate change and the lack of institutional and legal frameworks for disaster risk management all make Nepalese peoples' property and the country's infrastructure vulnerable to natural hazards. Floods and landslides are the natural disasters that occur most often and cause the most damage. During the monsoon season flood disrupts the lives of tens of thousands of people and ruins large tracts of agricultural land. Landslides and floods are a recurrent threat to hill communities and lowland terai communities. Climate change is exacerbating these threats leading to increase in frequency and intensity of disasters such as floods, drought and landslide.

The Natural Calamity Relief Act 2039 (1982), as amended to 1992, is the main legal instrument specifically directed towards disaster management in Nepal. Its focus is on response and reconstruction (MOHA, 2013). The Government has recently (2010) approved National Strategy for Disaster Risk Management in Nepal (NSDRM) for implementation of national Disaster Risk Reduction (DRR) strategies. In 2009, the Nepal Risk Reduction Consortium was formed to support the Government of Nepal in developing a long term Disaster Risk Reduction Action Plan building on the NSDRM. It also has a legally mandated system of devolved decision-making and local governance system at District Development Committee (DDC), which is central to DRR implementation. In line with the government policy and priorities, different GOs/NGOs have initiated *Climate Change Adaptation and Disaster Risk Reduction (CCA&DRR) programs and activities*through different institutional arrangements. The goal of these programs are helpingthe poor living in plains and hills of Nepal by making them better able to cope with risksfrom flooding, landslides, drought and other impacts of climate change. Therefore, the study was conducted to assess the effectiveness of different climate change adaptation and disaster risk reduction programs in terai and mountain regions of Nepal.

Objective of the study: The main aim of the study was to assess the effectiveness of different climate change adaptation and disaster reduction activities in plains and mountain of Nepal.

Methodology

Study area: The study was conducted in selected VDCs of mountain, siwalik and terai regions. These included Bhanu VDC of Tanahu districtfrom mountain region, Hupsakot VDC of Nawalparashi District from siwalik region and Saurah, Singhokhor, and Kajarhawa VDCs of Kapilbasthu district, Thapapur VDC of Kailali district and Rajapur VDC of Bardia district.

Research Methods

The research employed both quantitative and qualitative methods of data collection but more focused on qualitative information. The researchers have had thorough and in-depth interactions and discussions with the concerned beneficiaries and vulnerable groups at various levels ranging from VDC to Community level DRR management committees, DDC personals, District Administration Officers, local implementers, field level staffs, school teachers and other stakeholders as required. It also included review of DRR documents.

Findings and Discussions

Major Climate and Water Induced Risks and Hazards in the Study Area.

Major Hazards

Landslides, riverbank erosion, flood and drought are the common and main climate induced disasters reported in the area (Table 1). Geographically, disaster such as landslides is dominant in the Mountain, and Siwalik.Establishment of settlements and farmlands in steep slopes are the major cause of damage in these areas. In the foothills and floodplains of the river valleys, floods often deposit coarse sediment over the adjoining floodplain damaging standing crops and converting the land into an infertile land mass.

River banks in such areas are subjected to severe bank erosion and loss of soil, which in turn provide more sediment for the river to deposit downstream. Additionally, unpredictable rainfall and longer drought periods coupled with haphazard construction of rural road in mountain and Siwalik regions have intensified landslides and floods resultingin decrease in water flow in the streams, and drying of natural spring. The phenomena iscreating semi-desert like conditions in the foothills and -terai region.

Floods, landslides and droughts are likely to become more common and more intense as regional and seasonal precipitation patterns change, and rainfall becomes more concentrated into heavy events (with longer and hotter dry periods in between). In general, floods and landslides during the monsoon are a natural phenomenon in Nepal. The country's more than 6,000 rivers and rivulets, with a total of 45,000 km in length, support irrigated agriculture and other livelihoods, but also wreak havoc in valleys and in the terai when they overflow (Dixit, 2010).

Table 1 : Major climate risk/ hazard in the study sites

	Region		
Climate hazard	**Mid- mountain**	**Siwalik**	**Terai**
Riverbank erosion	√	√	√
Landslide	√	√	
Flood/sedimentation	√	√	√
Drought	√	√	√
Drying of springs	√	√	
Hailstone	√		

Impact from Water Induced Disasters

The review of the documents and field data collected through local consultations indicated that the scale of vulnerability from water induced disasters has increased in recent years. The increasingly long drought periods have affected rainfed farmers and rural women. The scale of landslide and drought has increased due to climatic variability and anthropogenic activities such as rural road construction in mountain and forest degradation in the siwaliks and mountain region.

Similarly, frequency of flood and scale of damage has also increased in the terai and inner terai regions of Nepal. Long term data recorded from MOHA reported that thousands of people are being affected by flood every year (Table 2) in Nepal during the monsoon season. It is reported that in 2012, four people died and 200 HHs were affected in the Bardia district, and twopeople died and 75 HHs were affected in Kailali district from the flood (MOHA, 2013). The MOHA report also claimed that flood and landslides have caused more numbers of human casualties since 2000. According to MOHA (2011), about 5000 families in the mountain and terai area are badly affected by drought each year. Additionally, during recent monsoon (2014) season many areas of the countries reported human casualties, loss of properties and household (Table 3).

There are indications that the poor and women are being affected more by climate-induced disasters than other sections of the society. For example, loss or decrease of nearby sources of drinking water adds extra burden on rural women. Additionally, it is observed that poor and vulnerable communities are more exposed to such disasters. For example, the poor and vulnerable people who reside nearby flood prone areas are more badly affected from the flood and the poor and vulnerable people who reside by marginal dry lands are more affected from failed crops.

The findings also indicated that a significant increase in heavy rainfall events in future will result in an increased flood risk to society, physical infrastructure, and water quality (Singh et al, 2011). Increase in the frequency and severity of landslides, floods and droughts are projected to have an adverse effect on sustainable development. Shrestha et al. (2003) suggest that the number of flood days and consecutive days of flood events have been increasing in Nepal. Increases in glacial melting and likely increases in runoff will also heighten the risk of glacial lake outburst floods. Table 2 and 3 displays the type and frequency of disaster and their impacts on people in Nepal.

Table 2 : Water induced disaster and their impact in Nepal (1971- 2012)

S.N.	Type of disaster	No of events	No of Death	Affected family	Affected HH
1	Landslide	2942	4511	555705	32187
2	Flood	3685	4079	365608	181961

(Source : MOHA, 2013).

Table 3 : Monsoon season loss in 2014 from water induced disaster in Nepal

SNo	Area	Unit	Total
1	Human death	no	256
2	Missing	no	255
3	Injured	no	155
4	HH fully damaged	no	8000
5	HH partially damage	no	22000
6	Family displacement	no	16000
7	Total estimated properties loss	NRs	More than 4 billion NRs only in Surkhet District

Source: (MOHA, 2014, Kantipur Sept 25, 2014)

Local Adaptation Practices

Climate change is the crosscutting issues and its impactsare more evident on rural farmer particularly upland farmers and rural women who are more dependent on natural resource for their livelihood. The negative impact of climate change to the rural communities opens the space for opportunities to implement the integrated conservation and development program and activities. Management of too much water and too little water in the region provide opportunities to minimize water induced disasterssuch as landslides, flooding, and drought through decreasing run-off, channeling water courses, and harvesting rain water for dry season.These will ultimately helpimproving crop production, and stability of infrastructures, and improvementof livelihood of the people, especially the rural communities.

Water deficit is the major problems for production of field crops in the Siwalik region of Nepal particularly during winter and summer. An integrated water resource management project was initiated in 2011 in the Bhandare village of Hupsakot VDC in Nawalparashi Districtas a climate change adaptation. The project activities included development of irrigation facilities, training locals for vegetable farming and supporting vegetable seeds.Every household (HH)is now involved in cultivating vegetable crops and supporting their livelihood. The project demonstrated that providing reliable irrigation facilities and developing skills for cultivation of draught resistant cash crops such as vegetable, as well as traditional crops like potato and wheat might be an appropriate adaptation practices for dry area and upland farms for improving food security where many HH have foods available only for 5-6 months. The project not only increased the vegetable production but also saved money spent on buying vegetables from market which on average comes around NRs 2,000 to 12,000 per HH per month and contributed to improve food security. Furthermore, it also improved the intake of nutrition in their food items. Women were especially happy with these outcomes because of easy availabilityof kitchen items right in their farmland during scarce periods.

Similarly, in the flood prone area of Terai region, farmers are now practicing vegetable farming during the winter season. They have constructed new houses in higher lands , improved drainage system in the village, and started storing the seed grain in the top floor of the house. Furthermore, strong community houses are being constructed in safer area in each village as a shelter during the high flooding time.

DRR Program and Activities at the Study Area

Establishment of Emergency Relief Matching Funds at VDC Levels

To fulfill the needs of climate induced disaster affected people during the time of emergency, some VDCs of Kapilbastudistricts has created an emergency fund at the community level so that they could provide emergency relief to loss and damage caused by the disasters.For example, in Kailali and Kapilbastu district. These funds have to be used inrelief support and distributing grains during flooding time. Two thousand HHs are participating and benefitting from this program. It is reported that Singhokhor and Dhankauli VDCs had established such kind of emergency funds comprising Rs. 200,000 and Rs. 16,000 respectively.

Establishment of Grain Bank

Interestingly, people were found developing innovative ideas to struggle with climatic disasters. Collection and storage of food grain from each HH at community level was being practiced in one area. Each HHs voluntarilycontributed food grains during the rice crop harvesting time. The grains collected weresold in the market and the money wasdeposited in a bank to create relief fund. The purpose of this fund is to provide relief to those HHs who are affected from the climatic disasters or during famine at least for a week. The support is provided either directly distributing the grains or cash or other supports by selling food grain in the market This practice seemed more helpful to the most vulnerable groups like children, pregnant and lactating women, ageing and disables to be safe from the adverse situation of disaster. Two communities (Singhokhor and Dhankauli) had already established the grain banks and two other communities (Akabarpur and Kajarhawa)were collecting the grains for the same purpose. In long run these local initiatives of the grain bank could be very positive initiation for the sustainability of the disaster management programs.

Strengthening Institutions/Networks in Targeted VDCs

One of the major progressesmade by the DRR activities were the strengthening of the local institutions and network of the project sites. In all sites, local partners are playing leading role to implement the DRR program and establish a network from local to national level. It is found that project has developed good rapport with all stakeholders at district level government offices and sensitized them to institutionalize the DRR program. It is a positive indicator for sustainabilityof the program. However, the research team noticed that with poor resources and weak institutional capacity prevalent at the district and local level, it is difficult to address the DRR program effectively unless these things are improved.

Early Warning System

Early warning system (EWS) was found to be an effective intervention in the study sites for reducing disaster risks, particularly in targeted communities in flood prone areas of the Chitawan, Banke and Bardia districts. The EWS project has strengthened the capacity of vulnerable flood prone communities and district authorities and stakeholders to respond to and mitigate the effects of flood. The activities included advocacy and public awareness, infrastructure support, development of information flow mechanisms system (Figure 1) and establishment of mitigation measures such as installation of EWS equipment and capacity building of vulnerable communities to strengthen their resilience to respond to risk. The direct beneficiaries are people living alongside the east Rapti and Narayani rivers of Chitawan District, west Rapti river in Banke district and Karnali river in BardiaDistrict. Altogether 31 VDCsof Chitwan, 5 VDCs of Banke and 8 VDCs of Karnali river are benefitting from this project. The Department of Hydrology and Meteorology (DH&M) has provided technical support to establish community level flood gauge stations.

EWS hasbeen successfully institutionalized and implemented as DRR activities at the district level through coordination among the stakeholders. It has implemented community based flood EWS by developing linkages of upstream DH&M gauging station with downstream communities (Figure 1). Combination of simple information flow channel, hand operated siren and involvement of communities and local stakeholders to disseminate the upstream water level information and possible flood risk to the downstream vulnerable communities proved very effective.

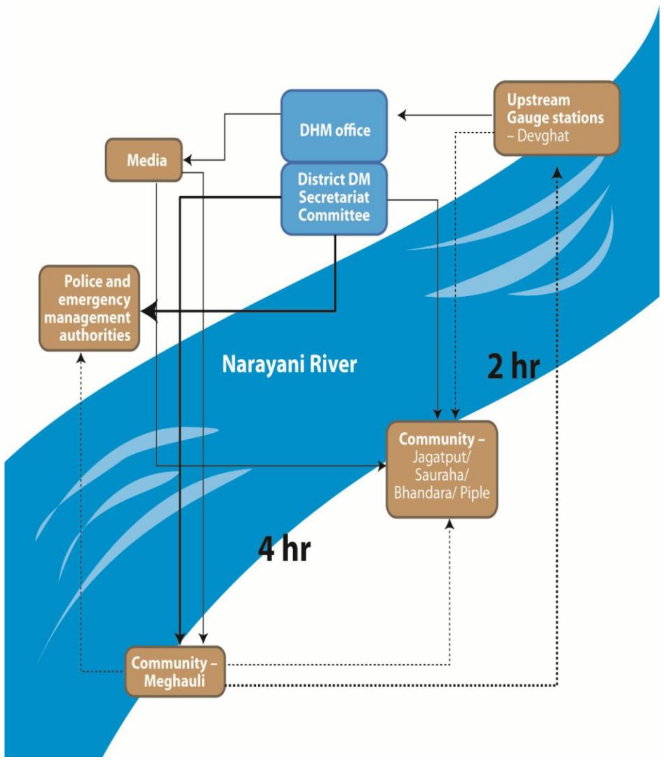


Figure 1 : Mechanisms of the early warning system

Additionally, small scale mitigation activities and low cost, replicable infrastructures were promoted to assist community level Disaster Risk Reduction (DRR). For example, community house equipped with the rescue equipmentand first aid items are constructed at the ward level to shelter during the flood time, Community Based Disaster Management (CBDM) plan in target communities, DDR Plan at VDC level and District Disaster Management Plan (DDMP) at district level have been prepared for Chitawan and Bake District. Sharing of lessons learned from the project has helped government and non-government organizations in up-scaling EWS approach in other areas. It is reported that improvement in flood risk monitoring and early warning system at community and institutional level has significantly reduced the human loss almost to nil in Chitawan, Banke and Bardia Districts in recent years (Tiwari, KR. 2012).

Regarding the landslide incidences in the mountain areas, it was found that there were no any mechanisms available to aware people early about the landslide like

the flood EWS in the terai. It was however learned that in the mountains, landslide problem is not regular case as flood problem in the plain. In case of plain area, disaster from flood is more regular phenomena along the river bankcommunities. Therefore, communities and local institutions more actively participated and institutionalized the program within a relatively short period of time.

Institutional Arrangements on DRR from National, District to Local level

This study found that DRR has been now institutionalized in the national, district and VDC level plans, and budget is allocatedparticularly for flood prone area ofthe districts. At the district level District Disaster Reduction Management Committee has been formed in the Banke, Bardia, Chitawan,and Nawalparashi districts with the chairpersonship of the District Administration Officer by involving all stakeholders. Additionally,District Early Disaster Response Plan, and Disaster Response Team has been formed. Similarly, VDC and community level committees havebeen also formed in these districts.

With regards to organizational arrangements, key national government agencies involved in hazard and vulnerability assessments for floods have been identified and their roles are clarified. MoHA is responsible for all aspects of disaster management, while DHM (under the Ministry of Science Technology and Environment) is responsible for all forecasting with regards to floods; hazard and vulnerability assessment, a strategy for mapping and bringing all vulnerable areas under an EWS is in the pipeline.

Early Warning and DRR have been recognized by the state, a disaster management strategy is legalized and an EW strategy is in the pipeline, as an immediate and long term national priority. Further, natural and human-induced disaster management has been identified as the core need of sustainable and broad-based economic growth beginning from the Tenth Plan (2003-2008) (NPC, 2011).

At present, district administrations in affected areas have also come on board on developing systems and committees have been put in place in the districts where the programsare running. District administrations are creating funds to supplement the DHM funding and this is beginning to show some desirable results. Examples and benefits of early warning have been communicated with senior government officials and political leaders by publishing case studies from the program areas including a self assessment of EWS against previous floods.However, it was noticed that local institutions had no any capacity to rescue the disaster affected communities immediately.

Conclusions and Recommendations

It is learned that disasterreduction program and climate change adaptation activities are the multi -disciplinary program. Poor and marginalized communities are vulnerable from the disaster and climate change impact. Study found that DRR activities such as early warning system, communication mechanisms during flood period, community relief fund, establishment of seed bank, water source protection and management and livelihood support program are to be effective to minimize the vulnerability of the climate change and disaster at the local communities. It is noticed thatlocal institutionsare not capable to address the disaster management, they need to be more equipped and empowered to respond immediately for disaster affected communities. Furthermore, it has been found that DRR activities were well suited to target the flood affected area in the terai/plain but not found effective in the land slide affected mountain areas. It is suggested that these program need better coordination and equipped for resource mobilization to all the GOs and local communities to minimize the impact particularly, during flooding period.

Acknowledgements

We would like to acknowledge the support of Practical Action Nepal and Danida Church Aid-Nepal forfield visit program and documents through Social Welfare Council, Nepal. Similarly, to COMFORM Project, and SUNREM/ NORHED-IOF Pokhara for providing partial support to present the paper.

References

Dixit, A. 2010. Climate change in Nepal: Impacts and adaptive strategies. Institute for Social and Environmental Transition, Kathmandu, Nepal.

EM-DAT 2013: The International Disasters Database. Availablefrom:http://www.emdat.be/natural-disasters-trends(accessed 04.03.13).

IPCC, 2013. Working Group I Contribution to the IPCC Fifth Assessment Report: Climate Change 2013: The Physical Science Basis, Summary for Policymakers.

OECD. 2003. Emerging risks in the 21st century: an agenda for action. OECD Publications Service, Paris.

MOE/NAPA, 2010. National Report. Ministry of Environment, National Adaptation Program of Action

to Climate Change. Kathmandu, Nepal.

MOHA, 2009. Nepal Disaster Report 2009. Ministry of Home Affiars, GON, Kathmandu, Nepal.

MOHA, 2014. Preliminary Report,Nepal Disaster Report, 2013. Ministry of Home Affairs (MOHA) and Disaster Preparedness Network Nepal, Government of Nepal

MOHA, 2013. Nepal Disaster Report, 2013. Ministry of Home Affairs (MOHA) and Disaster Preparedness Network Nepal, Government of Nepal.

MOHA, 2011. Nepal Disaster Report, 2011. Ministry of Home Affairs (MOHA) and Disaster Preparedness Network Nepal, Government of Nepal.

NPC 2011. Nepal Status Paper – United Nations Conference on Sustainable Development 2012 (Rio+20) Synopsis. Kathmandu, Nepal: National Planning Commission

Singh, SP., Bassignana-Khadka, I, Karky, BS., Sharma, E. 2011. Climate change in the Hindu Kush-Himalayas: The state of current knowledge. Kathmandu: ICIMOD

Shrestha, KL., Shrestha, ML, Shakya, NM, Ghimire, ML, Sapkota, BK, 2003. 'Climate change and water resources of Nepal.'In Muhammed, A; Hansen, FJ (eds), Climate Change and Water Resources in South Asia: Proceedings of year end workshop, Kathmandu, Nepal, 7–9 January 2003, Kathmandu, Nepal. Islamabad, Pakistan : Asianics Agro Dev International.

Tiwari, KR., 2012. Climate change Adaptation and Disaster Management Project, Midterm Evaluation Report, Practical Action Nepal. Assigned by Social Welfare Council, Kathmandu, Nepal.

Prolonged Climate Variation Influences on Agricultural and Water Resources of Tamil Nadu, India Using Spatial Analysis

M. Aarthi*, M. Arunpandiyan, K. Balamurugan,
M. Prashanthi Devi

Abstract

The fast urbanization and related anthropogenic activities has been devouring the adjacent natural resources leading to a greater decline of the complex ecosystem. This in turn leads to the loss of habitat and decline in species associated with this ecosystem. The resulting loss is not only a burden on the environment but also acts as an economic and social burden among the public whose lives are directly dependant on the natural resources. Therefore regular monitoring of the depletion of natural resources is a forefront task. The study area Tiruchirapalli, Thanjavur, and Tiruvarur district are located in the Cauvery delta region, with fertile soil and is endowed with rich water resources. Agriculture is the chief occupation of these areas. The depletion of water resources affects the irrigation which in turn reduces the agricultural productivity. Thereby the cost of agricultural production is increased and also alleviating the economic burden on the poor. The inflation of costs of natural food resources and water is a result of such environmental damage. The present study aims at assessing the depletion of natural resources such as water resources and vegetation in the delta region i.e., Tiruchirapalli, Thanjavur, and Tiruvarur of Tamil nadu, India using spatial technology tools like remote sensing and GIS. The Survey of India toposheet of the year 1972 at the scale of 1:50000 for the study area were geo registered and projected using Universal Transverse Mercator projection. The administration boundaries of Tiruchirapalli, Thanjavur, and Tiruvarur were digitized including the vegetative area and water bodies. The recent satellite images (IRS, LISS III) of the study were extracted from ISRO Bhuvan (2009). The images were classified using supervised classification (maximum likelihood) in to four classes' i.e., urban settlements, drainages, vegetation and water body. Change detection analysis was performed to detect the rates of depletion among water and vegetative resources. A comparison of the areas estimated for urban, water bodies and vegetation was done to identify the land increase and decrease over a period of 37 years. The results show that the urban areas increased by 421.61 km^2 and the water bodies had drastically decreased by 107.844 km^2, and the land under vegetation had drastically decreased by 6075.78 km^2. This pattern was accounted as a total sum for the entire three districts. From the present study, it is revealed that natural resources are greatly declined over the period of 37 years due to the urbanization activities. This value exceeds the naturally estimated decline for the same region. Hence conservation measures have to be adopted for the optimal utilization of these resources without compromising the economic benefits and sustainability of these resources.

Keywords: Climate Change, Agriculture, Urbanization, Supervised Classification, Change Detection.

Department of Environmental Management, Bharathidasan University, Tiruchirappalli – 24

* *Corresponding Author : Email- aarthimariappan10@gmail.com*

Introduction

Anthropogenic activities are a major force in impacting the hydrological cycle as well as the climate. Assessing the impacts of human activities on hydrological environments is becoming a wide-focused topic. Accelerated groundwater exploitation over the past few decades has resulted in great social and economic benefits by providing low-cost, drought-reliable and high quality water supplies for urban areas, rural populations and crop irrigation. The rapidly increasing large cities in semiarid and semi-humid regions raise many problems in water resources management

The Cauvery Delta region viz., Thanjavur, Tiruchirappalli and Thiruvarur districts have recorded deficit rainfall from -3 to -61% and an overall deficit is around -16.8% over the past four years. Though this deficit has recently occurred due to fast urbanization, other reasons such as climate change, failure in monsoons and global warming are also pointed out. Out of these urbanization plays a very important role in the depletion of water resources.

The last 50 years of its growth have witnessed large scale destruction of this physical heritage of study area. Large scale encroachments have lead to filling up of lakebeds and conversion to built up area by both the government and private agencies over the last few decades. Land clearing, primarily for agriculture in earlier days, but recently due to urbanization is perhaps the single most important cause of environmental degradation, loss of species, and depletion of ecological communities. Forest loss and degradation are particular problems for conservation biology because forests are some of the most species-rich environments on the planet (Civco, D.L., Hurd, J.D., 2002), particularly for birds (Alcamo, J., 2008) and invertebrates (Meyer J.R. (2000). The United Nations Food and Agriculture Organization reviewed global forest clearance, and found that between 1990 and 2000, the average rate of forest loss was 16.1 million hectares per year (Briscoe. J 2005). The causes of desertification and vegetation destruction are usually grouped into natural and human causes. Desertification has been blamed on long-term climatic changes, cyclic fluctuations in climate, and periodic droughts and destructive consequences of human activities.

Agriculture is one of the most climate-sensitive industries, with outdoor production processes that depend on particular levels of temperature and precipitation. Although only a small part of the world economy, it has always played a large role in estimates of overall economic impacts of climate change. In monetary terms, agriculture represents less than 2 percent of GDP in high-income countries, and 2.9 percent for the world as a whole. It is more important for low-income countries, amounting to almost one-fourth of GDP in the least developed countries. And its product is an absolute necessity of life, with virtually no substitutes (fisheries, another food-producing sector, will also be heavily impacted by climate change) (A. Stanton, 2013).

According to the Intergovernmental Panel on Climate Change (IPCC, 2011), increasing average global temperatures will result in a number of impacts to the hydrological cycle, including changes in precipitation. Precipitation will be directly impacted by changes in atmospheric circulation and increases in water vapor and evaporation associated with warmer temperatures. This will result in an overall increase in precipitation, though the magnitude of this increase is uncertain. Changes in rain and snowfall can result in a number of impacts for water resource managers that depend on snowpack for water supply, including increases in flooding, decreases in summer water supply, and changes to both groundwater and surface water quality. These impacts may require water resource managers to develop alternative sources of water supply and water treatment and invest in new flood infrastructure.

The studies of UNEP (United Nations Environmental Programme, 2000) indicated that past 20 years, the problem of land degradation had continued to worsen. The impacts indicate that over-cultivation, overgrazing, deforestation and poor irrigation practices are degrading dry land in every continent. The major factors for this are population (human and livestock) pressures, inappropriate land use and agricultural practices, social conflicts and drought. There was also growing recognition of the part played by human activities and climate change such as prolonged or frequent droughts aggravating land degradation.

In an arid environment, the main limiting factor for plant production is the amount of water in the soil available to the vegetation. Droughts are common in arid regions. It occurs when a region has insufficient moisture to meet the demands of plants, people, livestock or wildlife. The absence or shortage of rain and the temporary character of the problem are the most visible elements. Drought may be a meteorological drought when rains fail to reach a certain level over a particular period of time in a given area; agricultural drought when the combined effects of amounts and distribution of rainfall, soil water reserves, and evaporation bring about a drastic reduction of agricultural yields and livestock leading to food scarcity and other associated problems; or hydrological drought due to changes that reduce the absorption and storage of moisture in the soil. The net change in crop yields is determined by the balance between these negative and positive direct effects on plant growth and development, and by indirect effects that can affect production. These indirect effects have been largely ignored in the assessment of climate change effects. Indirect effects may arise from

changes in the incidence and distribution of pests and pathogens (Sutherst et al. 1995), increased rates of soil erosion and degradation, and increased troposphere ozone levels due to rising temperatures (Adams 1986). The objective approached in the present study is to analyze the extent at which urbanization has affected the small water resources in the study area and to provide appropriate and affordable strategies for conserving the water resource quality in this community.

Study Area Description

The study area selected for the present work are Tiruchirapalli, Thanjavur and Tiruvarur regions of Tamil Nadu (Table 1) with a geographical extension that lies between 10 to 11.30′ N lat and 77-45′ to 78-50′ E, 9.50′ to 11.25′ N and 78.45′ to 79.25′ E, 10.20′ to 11.07′ N and 79.15′ to 79.45′ E. The total geographic study area covers about 10177.4 km^2. The districts Tiruchirapalli consists of 9 taluks, Thanjavur-8 taluks and Thiruvarur-7 taluks. The districts are surrounded by Pudukottai, Karur, Namakkal, Perambalur, Ariyalur, Nagapattinam district as per clock wise directions and the Bay of Bengal on the south east.

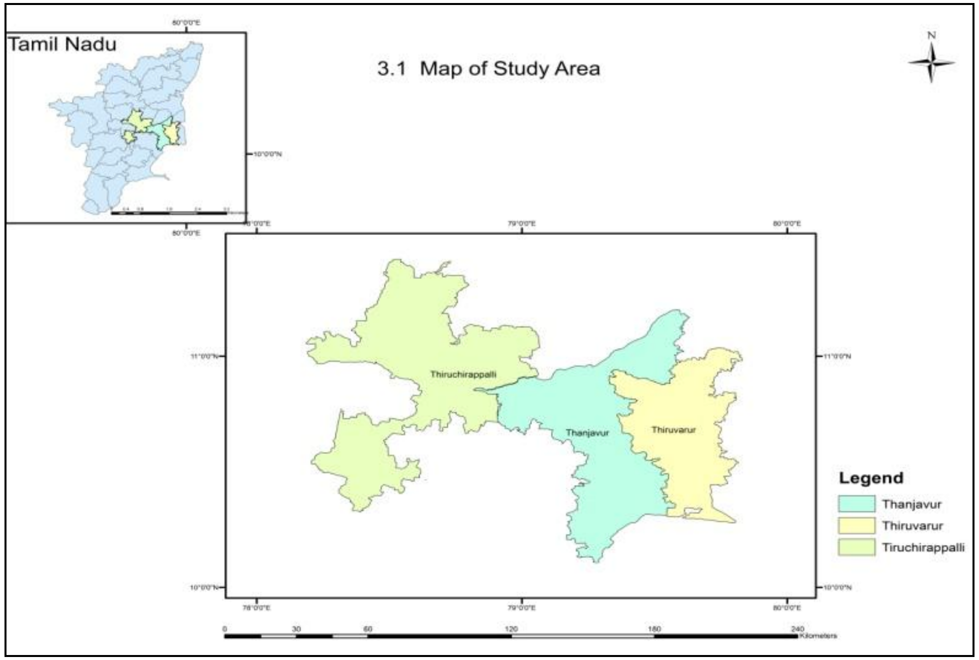


Figure 1 : Map of study area.

Data Used and Methodology

The data used for the present study are Survey of India toposheets of the year 1972 at the scale 1:50,000 which included 34 maps to cover the entire study area. The IRS LISS III images for the study area were downloaded through the portal ISRO Bhuvan and used for further processing. The near infrared red and green bands were layer stacked to obtain a false color composite. The images were classified using supervised classification (maximum likelihood) in to four classes' i.e., urban settlements, drainages, vegetation and water body. Change detection analysis was performed to detect the rates of depletion among water and vegetative resources.

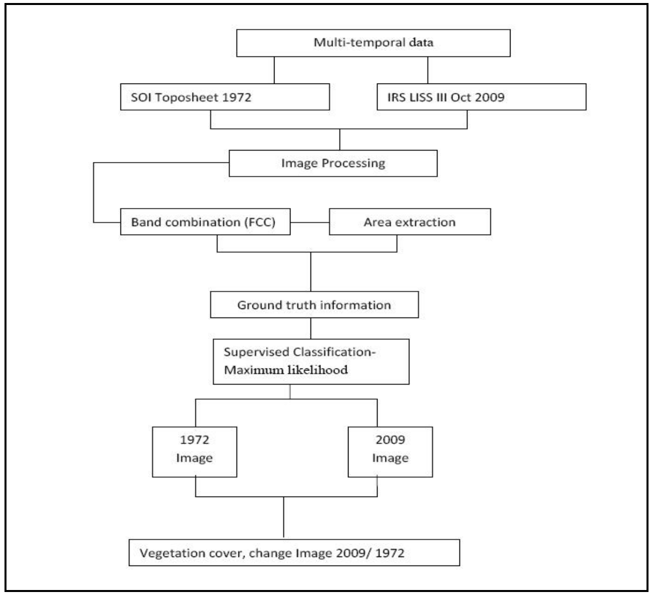


Figure 2 : Flow diagram of the study approach.

Results

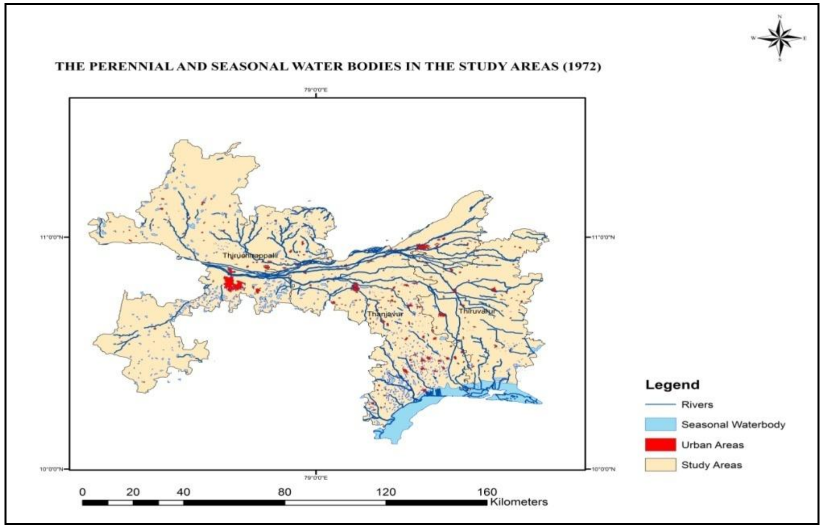


Figure 3 : Percennial and seasonal water lodies in the study area (1972).

The surface of the land as an important resource which human activities are continually modifying. Rapid population expansion has placed great demands for living space leading to increasing urbanization and exploitation of marginal lands. The latter has led to problems such as deforestation, land degradation and desertification, flooding and other associated problems in many tropical and subtropical areas. Urbanization leads to changes in the hydrology, geomorphology, water quality and riparian vegetation of rivers, leading to degraded sites and reduced biodiversity. On comparison of the multi temporal GIS data depletion of water bodies in the study area was enumerated over a period of 37years. From the results, the estimation of the water bodies is 175.94 km2. Similarly the urban area or area under construction was observed to be 226.9 km^2.

The IRS LISS III image for the year 2009 was subjected to supervised classification using visual interpretation method. The land use classes such as vegetation, urban areas and water bodies were extracted from the supervised classes and the area in km^2 was estimated for each class. From the results, it was observed that the water body was covered an area of 68.09 km2. The urban area was covered an area of 648.51 km^2.

Table 1 : Areas and change in the different land use classes.

LULC Class	Year 1972 Area in km2	Year 2009 Area in km2	Changes in Area (km2)
Urban	226.9	648.51	421.61 (+)
Water bodies	175.943	68.0982	107.844 (-)
Vegetation	9492.25	3418.47	6075.78 (-)

A comparison of the areas estimated for urban and water body was done to identify the land under increase and decrease over a period of 37 years. The tabulated results shows that the urban areas have increased by 421.61 km2 and the water bodies had drastically decreased by 107.844 km2. the land under vegetation hard decreased by 6075.78 km2.

To study the depletion of vegetation cover, the same procedure was adopted. It was estimated that the area under vegetation cover is 9492.25 km2 during 1972 and the urban area or area under construction was observed to be 226.9 km2.

For the year 2009, it was observed that the vegetation cover was had an area of 3418.47 km2 and the urban area covered 648.51 km2.

Comments

i. better to give Table numbers and Figure numbers and mention that in the text for clarity to the readers.

ii. All km2 in the above text/paragraphs has to be changed to km^2

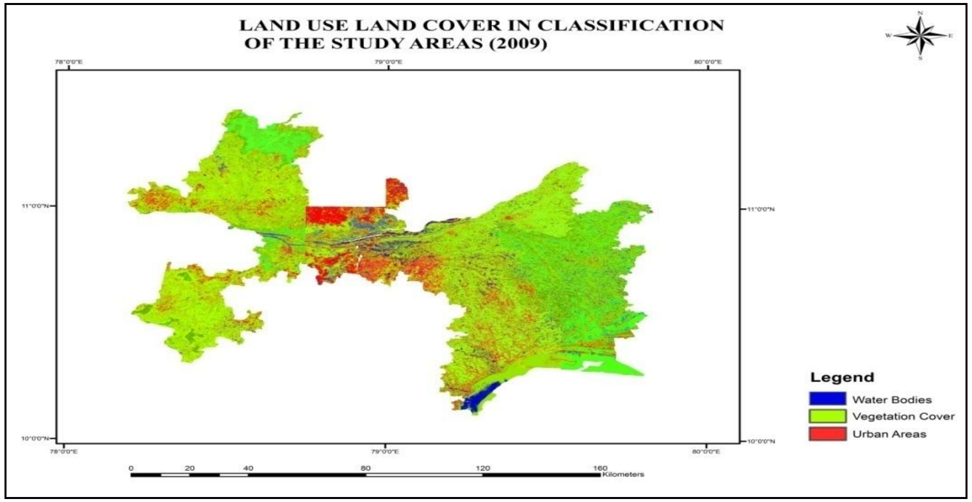


Figure 4 : Land use and land cover classification (2009)

Conclusion

From the present study, it is revealed that the natural resource has greatly declined over the period of 37 years due to the urbanization activities. This value exceeds the naturally estimated decline for the same region. Hence conservation measures have to be adopted for the optimal utilization of these resources without compromising the economic benefits and sustainability of these resources.

Global warming is now causing unprecedentedly rapid changes in the climate conditions that affect agriculture – much faster than crops can evolve on their own, and probably too fast for the traditional processes of trial-and-error adaptation by farmers. At the same time, the world's population will continue to grow through mid-century or later, increasing the demand for food just as climate change begins to depress yields. To adapt to the inescapable early states of climate change, it is essential to apply the rapidly developing resources of plant genetics and biotechnology to the creation of new heat-resistant, and perhaps drought-resistant, crops and cultivars.

Adaptation to climate change is necessary but not sufficient. If warming continues unabated, it will, in a matter of decades, reach levels at which adaptation is no longer possible. Any long-run solution must involve rapid reduction of emissions, to limit the future extent of climate change. The use of digital data, spatial information and computer networks have become the key factors in modern technology, and as the flood of raw data moves into the digital frameworks, it becomes critical to make use of what is now available. This will not only gather the data, but, more importantly, it will also manage, index and interoperate this wealth of information, which is of different scale and time span, for the user community, governmental decision making and environmental management. This study demonstrates the application of remotely sensed satellite data to dynamical monitor the process of the loss of water bodies and vegetation due to urbanization. Integrated technologies of remote sensing and the geographic information system (GIS) were used to analyse the urbanization process of the study area with its impact on regional environmental changes. Spatial information was acquired from remotely sensed data, while factors responsible for urban expansion were analysed using socio-economic data.

Remote sensing satellites in particular, are very beneficial for observations related to climate change parameters, impacts and mitigation actions, as well as adaptation to climate change. However, there are still limitations in the use of remote sensing satellite.

References

Briscoe, J, (2005), India's Water Economy. Bracing for a Turbulent Future. ReportNo. 34750- IN, viii–xi (World Bank,).

Civco, D. L., Hurd, J. D., Wilson, E. H., Song, M. and Zhang, Z. (2002), A Comparison of land use and land cover change detection methods. ASPRS–ACSM Annual Conference and FIG XX11 Congress, Washington, DC, USA; 22–26.

Alcamo, J., C. J. Vörösmarty, R. J. Naiman, D. Lettenmaier, and C. Pahl-Wostl (2008), A grand challenge for freshwater research: Understanding the global water system, Environ. Res. Lett., 3,

Meyer J. R. (2000). The Role of Industrial and Post Industrial Cities in Economic Organization

Adams RM (1986) Agriculture, forestry and related benefits of air pollution control. Am J Agric Econ 68:885–894

Sutherst RW, Maywald GF, Skarrate DB (1995) Predicting insect distributions in a changed climate. In: Harrington R, Stork NE (eds) Insects in a changing environment. Acade- mic Press, London, p 59–71

NCC Research Report May 2011 "Impact of Climate Change on Land Degradation over India"

Frank Sckerman and Elizabeth A.Stanton 2013, Global Development and Environmental Institute Working Paper No.13-01 Climate Impacts on Agriculture: A Challenge to Complacency.

Impact of Climate change on Environment and Tibal Halth in Nilgiri Dstrict of TamilNadu, India

Brindha B[1*] Vidyalakshmi R[1] Rajakumar S[1] and Prashanthi Devi M[2]

Abstract

Climate change is one of the biggest threats & its impact on human health is a matter of serious concern among public health. Among the factors that influence the health of the tribal population, climatic factors relevant to geographical boundaries are of great importance. The rising temperatures, changing precipitation patterns, humidity are causing major threat amongst the locations where the Indigenous populations thrive because these people live in close harmony with the environment. Their characteristic subsistence of lifestyle and prevalence in realm of marginalization and cultural disparities increase their disease burden. As the climatic parameters vary seasonally, there occurs an increased demand for oxygen supply in higher altitude regions. These conditions affect the health of tribal people causing decreased blood oxygen levels and modify gene expressions due to hypoxic condition on high altitude regions. As a result the red blood cells undergo a bizarre transformation resulting in rapid destruction which causes profound anemia. Therefore, both genetic and prolonged climatic changes may cause the variability in sickle cell disease among these tribes in different geographic areas in Nilgiri district of Tamilnadu.

The study is attempted to evaluate if any relationship exists between the change in meteorological parameters and sickle cell disease. Climatologicall data (long-term monthly average temperature precipitation and humidity amount) were obtained from the various sources for the period 1997 to 2012. The screened Sickle cell patients' data were collected from NGO's like ASHWINI, NAWA and CTRD. The statistical analysis was conducted using STATAGRAPHICS 16.2 based on 95% confidence interval. Monthly predicted cases were estimated through regression on multiple independent variables that include sickle cell disease cases, monthly average temperature, monthly cumulative rainfall, trend and epidemic cycles. Derived possible lag time of serial correlation through data analysis using Autocorrelation Function (ACF), Partial Autocorrelation Function (PACF). Average annual rainfall of the district is 1920.8 mm. As this district is situated at an elevation of 900 to 2636 m above MSL, the average temperature ranges from a maximum of 25 °C to a minimum of 10°C. During the winter, the temperature drops to 2°C. Our findings showed that sickle cell disease cases with 22 weeks serial relationship best fitted the selected model. The Moving Average (MA) at 0.93 of our model suggests that rainfall and sickle cell disease cases explained the variance of monthly sickle cell disease distribution. The increase in rainfall and decrease in temperature reduce the concentration of oxygen isotope. Therefore due to prolonged variation in oxygen isotopes may affect the tribes residing at high altitude for long periods which alter the gene expression and induce hypoxic mutations in genes. Thus mutation reduces the oxygen carrying capacity to the red blood cell resulting in sickling of RBC and hence causes sickle cell anemia among these tribes living in mountainous regions of Nilgiri district. The importance of environmental influences and their mechanisms hold great potential for increasing the understanding and further amelioration of sickle cell disease. Changes in temperature and precipitation therefore are a key variable in determining the oxygen level in higher altitude therefore influence the physiological and behavioural responses of sickle cell disease.

Keywords: Climate Change, Oxygen Isotope, Sickle cell disease, Tribes, Statistical analysis

[1] *Department of Environmental Management, Bharathidasan University, Tiruchirapalli, Tamil Nadu, India,*

[2] *Department of Marine Biotechnology Bharathidasan University, Tiruchirapalli, Tamil Nadu, India,*

* *Corresponding Author : Email- brindha. yash@gmail.com*

Introduction

Sickle cell disease is a rapidly rising genetic disease that is endemic in tropical and subtropical countries in Africa, Sub Saharan and the Asia regions. Globally, 300,000 children were born throughout the world with hemoglobin disorder every year. According to WHO, about 5% of the world's population carries genes responsible for haemoglobinopathies. India caters nearly 20 million people with sickle cell anemia (Sahu et.al, 2003).The Hbs gene first occurred in the central and southern India. Moreover the trait has been found among the Veddoid people (Todas,Badagas and Irulas) of the Nilgiri region in Southern India where a frequency of 30% is reported for one tribe (Lehman and Cutbush, 1952). Sickle cell disease (SCD) is caused by a point mutation at sixth position in beta globin chain, valine substituting glutamic acid due to which, in the deoxygenated state, the shape of erythrocytes change to sickle shape and also the fragility of cell membrane increases (Ingram, 1956). In several areas in Asia the ßs gene has arisen independently as a new mutation. Recognised by differences in the ß globin gene cluster, that is inheritance of two ßs genes leads to homozygous SCD or sickle cell anaemia (HbSS). As a result of mutations that result in decreased synthesis of ß globin genes give rise to SCD with varying severity depending on the number and type of gene deletions (Kinney and Ware, 1994). This mutation is caused by various environmental factors. As a general rule environmental factors influence the health status of the inhabitants. Sickle cell disease is influenced by a complex interplay of factors that include socio-economic status, hygienic, sanitary conditions, dietary habits and climate. The environmental conditions including the altitude and climatic parameters such as rainfall, temperature and relative humidity may also play some role in modifying the clinical presentation of the sickle cell disease. Both very cold and very hot weather may precipitate the gene.

There are six tribal communities such as Toda, Kota, Irula, Kurumba, Paniya and Kattunaikan in Nilgiri district of Tamilnadu living in different altitudes. The Toda and Kota exist at higher altitude (2200 m), just below the middle range (1680 m) Kurumba and Irulas inhabit, whereas at foot hills the Paniya and Kattunayakans (840 m) are found. Their life and livelihood are linked to the biological and physical environment in the region. They are mainly the forest dwellers greatly dependent on the forest for their daily needs, including food, shelter, instruments and medicine. The change in climate alter the living environment is now considered as one of the most serious problem. The rising temperatures, changing precipitation patterns, humidity are causing major threat amongst the locations where the indigenous populations thrive because of the close harmony with the environment. Their characteristic subsistence of lifestyle

and prevalence in realm of marginalization and cultural disparities increase the health problem in Nilgiri district.

Climate change is recognized as the most crucial environmental problem that the world is experiencing today (Pachauri and Reisinger, 2007; Solomon et al 2007; Parry et al 2007). These climatic impacts have the potential to adversely affect the biodiversity and function of ecosystems, availability and quality of natural resources, human health and societal infrastructure of vulnerable tribal communities. In recent decades pattern change in temperature rainfall and humidity have been widely studied for their potential as early warning tools to fend off climate-sensitive infectious diseases (Kuhn et al; 2005, Thomson et al; 2005, Degallier et al; 2009, Wang et al ; 2011). In this study we have attempted to analyse the influence of severe climatic factors that may trigger genetic disorders in tribes of Nilgiris. This allows to prove that environmental conditions like climate change can cause hereditary change that protects a population by only allowing the individuals with the strongest genetic makeup to reproduce. The latter results in deoxygenating while the former is a factor leading to sickling.

It is well known that oxygen becomes increasingly depleted in precipitation with increasing altitude (Dansgaard, 1964; Siegenthaler and Oeschger, 1980). Air masses in the tropic forest loose water to condensation and precipitation with a temperature dependent isotopic fractionation. This ''rainout'' leads to a progressive depletion of the heavy isotopes in vapor and subsequent precipitation events, leading to a general tendency for precipitation isotope ratios to decrease along trajectories of atmospheric vapor transport, with decreasing temperature, and with increasing altitude. At high altitude, the concentration of oxygen in air remains constant however, barometric pressure decreases, thereby decreasing partial pressure of oxygen; leading to a condition as hypoxia. Inadequate oxygen (hypoxia) triggers multiple cellular responses that play important role in normal physiology and many human diseases. As a result high altitude presents an environment of hypoxia due to low ambient air pressure and reduced oxygen availability due to change in climatic factors (Kellogg, 1968;Honigman et al., 1993). In addition to high altitude, the climatic parameters such as temperature, rainfall and humidity play a crucial role in depletion of oxygen. Exposure to the oxygen depleted environment triggers the onset of a range of physiological and biochemical reactions. Subsequently, the supply the oxygen in the blood will decrease, this decreased oxygen of the blood of persons residing at high altitude was related to an increased concentration of 2, 3 diphodphoglycerate (DGP) within their red blood cells. At molecular level, there is an expression of an array of genes redirecting the metabolic and other cellular mechanisms to mutate cell under hypoxic environment. A more comprehensive weather-based forecasting tool is hence required to obtain precise information on the correlation between risk of sickle cell disease epidemic and weather conditions favourable for genetic mutation, so that sickle cell disease control efforts among the tribes in Nilgiri district can be made more effective steps to avoid sickle cell disease in the future generation .

Objectives

In our study, we have developed an approach to identify the relationship between the climatic parameters and to the development of mutations leading to sickle cell disease. Using this climate-based sickle cell disease forecasting model a link to excess rainfall and mutation trigger is attempted.

Material and Methods

Geography of Study Area

The study area is located in the Western Ghats of Tamilnadu. It is elongated in the east - west direction and bounded by 11°30′ and 11°15′ North latitude and 76°45′ and 77° 00′ East longitudes (Figure 1). The Nilgiris is an ancient land mass thrust upwards at the junction of the two major mountain ranges near the southern end of India some 70 million years ago. 57% of the surface of the Nilgiri hills rises over 1000 m above the Mean Sea Level (MSL) and 47% of that towers over 1800 m with the pinnacle formed by the big mountain at 2670 m. The total areal extent of the district is around 2551 km^2 and is one of the smallest districts in the state. Nilgiris is mostly hilly district located on the fragile environment of Western Ghats with an elevation ranging from 300 m in the Moyar Gorge to 2634 m above MSL at Doddabetta peak. Average annual rainfall of the district is 1920.8 mm. As this district is situated at an elevation of 900 to 2636 m above MSL, the average temperature ranges from a maximum of 25 °C to a minimum of 10°C. During the winter, the temperature drops to 2°C. Irula and Kurumba are hunters and honey collectors whereas, Panniyas and Kattunaikans are forest dwellers and boned laborers, they are interrelated in terms of exchange of their produce for their livelihood. The highest incidence of Sickle cell disease was recorded in Irulas (1097), Panniyas (326), kurumba (263) and Kattunaikans (62).

Data Collection

Monthly sickle cell cases from 1997 to 2012 were obtained from Non – Government Organisation's such as Association of Health Welfare in Nilgiri District (ASHWINI), Nilgiri Adivasi Welfare Association (NAWA) and Centre for Tribal Research Development (CTRD) in Nilgiri district. Monthly rainfall,

temperature and relative humidity was obtained at the nearest meteorological station (meteorological rain gauge station: 12) for the years 1990 to 2012.

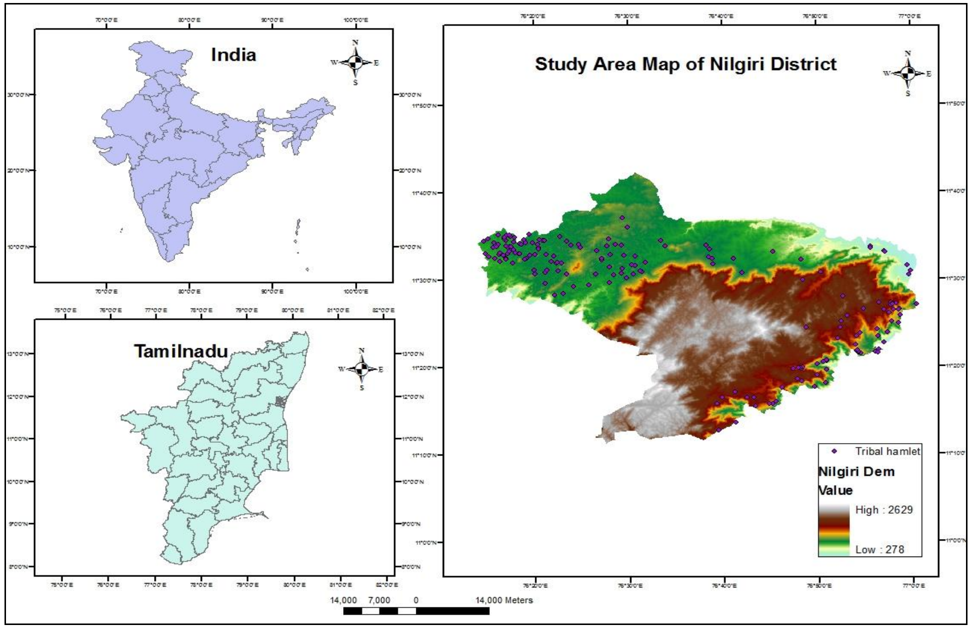


Figure 1 : Map showing the study area of Nilgiri district in Tamilnadu

Statistical Methods

A sickle cell disease forecasting model was developed using time series Poisson multivariate regression that allowed over-dispersion of data. Monthly predicted cases were estimated through regression on multiple independent variables that include sickle cell disease cases, monthly average temperature, monthly cumulative rainfall, trend and epidemic cycles. The forecasting model was developed using three processes: 1) model construction and training using data from 1990–2012; 2) model validation by forecasting cases in 1990–2012; and 3) sensitivity tests on outbreak diagnoses. Our statistical analysis was conducted using STATAGRAPHICS 16.2 (Stat point technologies) based on 95% confidence interval.

Model Construction

Sickle cell disease distribution patterns were analysed using retrospective data and then extrapolated for several months ahead. Sickle cell disease forecasting models was developed based on assumption that the past sickle cell disease distribution patterns will, to a large extent, continue in the future through a pattern of hierarchical diffusion (Gould et al 1991). Bivariate equation (Dx) for each independent variable was first formulated using Poisson regression and subsequently combined to form a multivariate model that takes multiple factors into consideration.

Let us Denote Dx ~ Poisson (µt),

where Dx represents monthly total number of predicted sickle cell disease cases as a function of independent variable x.

Serial Correlation of Sickle Cell Disease Cases

One characteristic of genetic disease is the influence of past cases on the number of current cases. Therefore, autoregression was included in the model to account for the serial relationship between past and current cases. We derived possible lag time of serial correlation through data analysis using Autocorrelation Function (ACF), Partial Autocorrelation Function (PACF), and prior knowledge on sickle cell disease transmission from one generation to other. ACF analysis on sickle cell disease data showed gradual increasing spikes that indicated strong autocorrelation between past and current cases; whereas, PACF cut off after the 3rd spike suggesting a lag time of 3 months. However, it must be noted that genetic disorder mutations are triggered before or during conception of the off spring and not after the birth. Hence, a lag period ranging from 11 -15 months are required to observe the mutations in the human offspring. Thus, we have used a lag time of 11 months and selected the optimal lag order using model selection and validation.

We denote DAR as the auto regression of sickle cell disease cases k months before forecast in month t. The effects of auto regression on dengue cases are computed as:

$$DAR = ø0 \sum_{K=1}^{v} Ø_{t-k}\, AR_{t-k} \qquad (1)$$

where AR_{t-k} = sickle cell disease cases at lag month k,

ø0= the constant number of sickle cell disease cases,

$ø_{t-k}$= parameter of autoregression at lag month k.

Lag Term and Meteorological Data Cycle

We examined the time gap between exposure to weather conditions and subsequent occurrence of sickle cell disease cases using cross correlation function. Correlation between rainfall and sickle cell disease showed sine wave oscillating at about 11. While correlation between rainfall and sickle cell disease revealed similar time cycles with a relationship from 125 month because previous cases were not recorded. It is possible for sickle cell disease transmission to occur several months after favorable weather conditions as mutations developed due to severe climatic conditions prevailing during the period. We identified the optimal lag term and weather time cycle for forecasting by testing lag terms from 120 months. We observed a highest rainfall peak at 188th month and a relative peak of highest number of sickle cell cases at 220th month with various data cycle periods of weather variables. Forward stepwise regression was used to consider a non-linear relationship between weather and sickle cell disease cases. Thus, we partitioned weather data into 4 equally spaced percentiles with knots at 25th, 50th, and 75th percentiles using spline function.

Let DRain denotes number of sickle cell disease cases as a function of monthly cumulative rainfall:

$$DRain = ß0 + \sum_{g=t-(L+m)}^{t-L} ßgq\ Raingq \qquad (2)$$

where ß0 is the baseline number of sickle cell disease cases; ßgq = parameter of rain at lag term g in q range of monthly cumulative rain; g= t - (L+m); t= month; L = lag term in month; m = data cycle period of monthly cumulative rainfall; q= rain11 to rain14 derived from piecewise spline function.

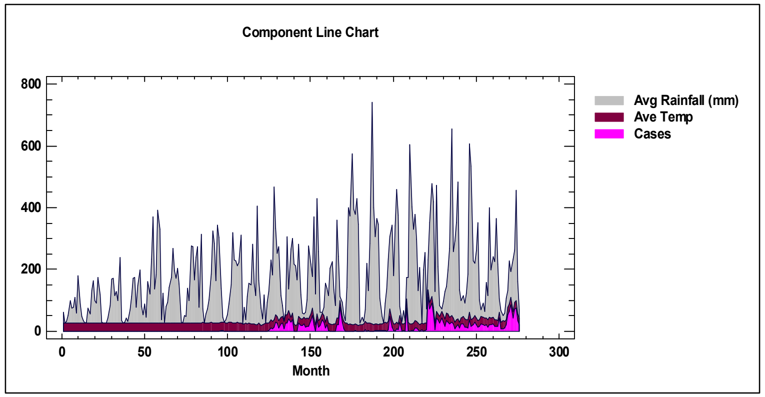


Figure 2 : Graph of average rainfall and temperature.

Results

During the study period, the heaviest rainfall occurred in July 2005 (max = 717.29 mm, std dev= 131.15 mm); whereas the lowest temperature was recorded in June 2001 (max= 18.3 °C, std dev= 2.51 °C). The lowest humidity was recorded in May 1999 occurred (max = 64.75 %, std dev =14.5 %).In caseof Sickle cell cases the highest cases was observed during May 2008 (max= 110) and lowest cases during 1998, 1999 and 2005 years. As shown in figure 2, the average monthly temperature fluctuation was similar approximately throughout the years, whereas rainfall, which had less distinctive pattern generally a more fluctuation pattern with the highest amount of rainfall during the month of July. Our findings showed that sickle cell disease cases with 11 month relationship best fitted the selected model.

Figure 2. Graph showing cumulative rainfall, temperature and sickle cell disease cases from 1990 to 2012

The cross correlation between rainfall and sickle cell disease cases showed a symmetrical sine wave oscillating about the zero line at a time frame of about 10 months per cycle. The symmetrical pattern suggested a consistent and stable relationship between rainfall and sickle cell disease incidence; indicating that rainfall could be a strong predictor for sickle cell disease forecast. Simultaneously, cross correlation between monthly cumulative rainfall and sickle cell disease revealed amore symmetrical oscillation at a consistent a time cycles.

The Moving Average (MA) at 0.93 of our model suggests that rainfall and sickle cell disease cases explained the variance of monthly sickle cell disease distribution. The time series of fitted cases against actual reported cases as shown in figure 3 and figure 4 exhibited a good fit of the model. The model was able to predict the peaks of the outbreaks that occurred in years for the months up to 310

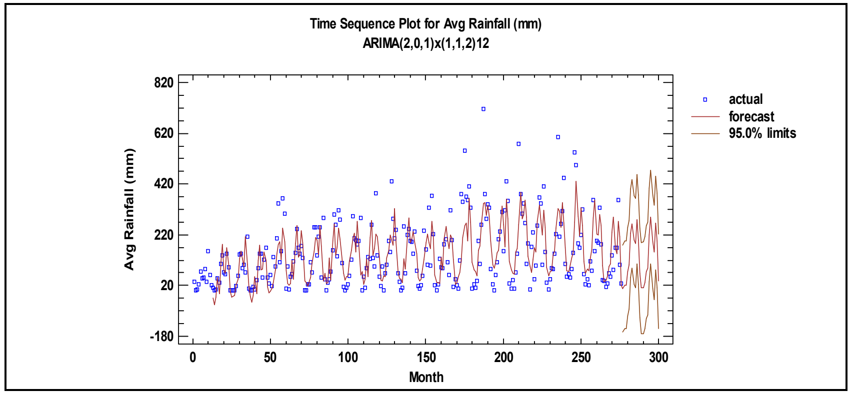


Figure 3 : Graph showing time sequence plot for average rainfall

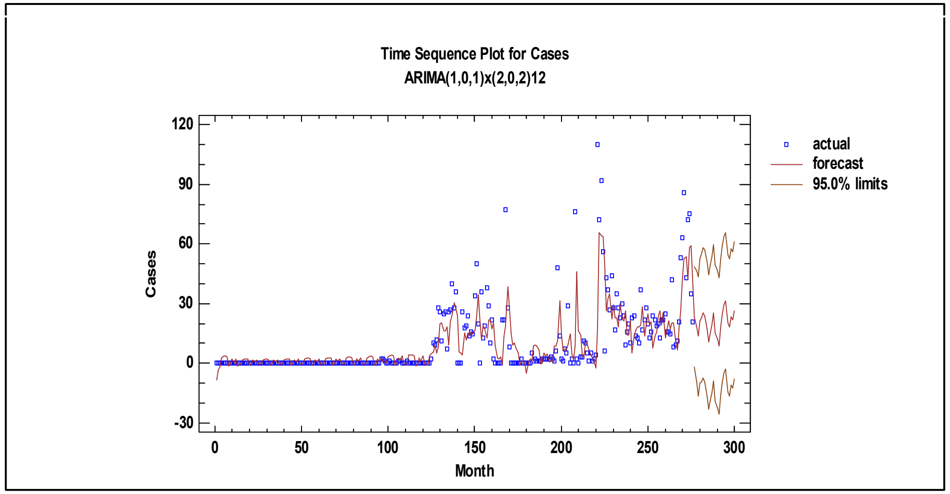


Figure 4 : Graph showing time sequence plot for average cases automatic forecasting - cases

Data variable: Cases

Number of observations = 276

Time indices: Month

Length of seasonality = 12

Table 1 : Summary of selected model fitting historical data

Validation Period	Estimation Period	Statistic	Variables
	84.3893	RMSE	Rainfall
	60.4166	MAE	
		MAPE	
	2.01928	ME	
		MPE	
	12.4478	RMSE	Cases
	6.66669	MAE	
		MAPE	
	0.651195	ME	
		MPE	

Table 2 : ARIMA model summery

P-value	t	Stnd. Error	Estimate	Parameter	Variables
0.000000	16.5717	0.0675587	1.11956	AR(1)	Rainfall
0.000000	35.7709	0.0261476	0.935321	MA(1)	
0.000000	-23.2212	0.0399343	-0.927325	SAR(1)	
0.000000	18.4747	0.0460677	0.851085	AR(1)	Cases
0.000019	4.35423	0.0817532	0.355972	MA(1)	
0.000000	7.53444	0.148125	1.11604	SAR(1)	

Rainfall

Back forecasting: yes

Estimated white noise variance = 7431.55 with 258 degrees of freedom

Estimated white noise standard deviation = 86.2064

Number of iterations: 15

Cases

Back forecasting: yes

Estimated white noise variance = 162.965 with 270 degrees of freedom

Estimated white noise standard deviation = 12.7658

Number of iterations: 16

Discussion

In recent years, the ability to predict local and regional weather in terms of accuracy and lead times has rapidly been improved due to advances in technology. This had allowed a better understanding of the interaction between climate and the temporal-spatial distribution of sickle cell disease as well as stimulating research interest on epidemic prediction modelling (WHO, 2004). We developed the weather-based sickle cell disease model based on scientific evidence that rainfall and temperature has significant influence on genes of tribes. However, further validation in terms of reducing oxygen levels and their impact on the development of red blood cell is to be done. The lag time between weather and sickle cell disease cases could be partly accounted for by the impact of weather conditions on the biological development of human foetus and related mutation developed to exposure to severe climatic conditions.

Conclusion

Evidence has grown that climate change already contributed to the global burden of many diseases. They play an important role in the spatial and temporal distribution many infectious and non-infectious diseases. This study demonstrates that climate variables could be important factors for the development of a simple, precise, and low cost functional sickle cell disease early warning. Since, sickle cell disease SCD, in its various forms, is a serious debilitating disease affecting tribal people in Nilgiri district .A climate -based sickle cell disease early warning system could benefit local vector surveillance and control in several ways. First, an early warning system enhances efforts of sickle cell disease control to reduce the size of an outbreak which in turn decreases disease transmission from one generation to another. Second, the use of publicly available climate variables removes the necessity for financial investment in climate -based predictive methods and further allows to focus their operations on high risk period; thus, maximizing alert measures to control the tribal people exposed to severe climate change.

References

Sahu T ,N.C Sahani.,S.Das.,S.K Sahu.Sickle cell anemia in tribal children of Gajapati district in South Orissa, Indian Journal of Community Medicine,2003;Vol. XXVII,No.4.

Lehman H,Cutbush M.Sickle cell trait in Southern India, British Medical Journal,1952,Vol.I,404-5.

Ingram VM. A specific chemical difference between the globins of normal human and sickle cell anaemia haemoglobin. Nature 1956; 178:792.

Kinney TR, Ware RE. Compound heterozygous states. In: Embury H, Hebbel RP, Mohandas N, Steinberg MH (eds). Sickle cell disease: basicprinciples and practice. New York: Raven Press, 1994:437-51.

Solomon, S., D. Qin, M. Manning, R.B. Alley, T. Berntsen, N.L. Bindoff, Z. Chen, A. Chidthaisong, J.M. Gregory, G.C. Hegerl, M. Heimann, B. Hewitson, B.J. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, T. Matsuno, M. Molina, N. Nicholls, J.Overpeck, G. Raga, V. Ramaswamy, J. Ren, M. Rusticucci, R. Somerville, T.F. Stocker, P. Whetton, R.A. Wood and D. Wratt, 2007: Technical Summary. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Parry M.L, Canziani O.F, Palutikof J.P, van der Linden P.J. and Hanson C.E. 2007.Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Eds.Cambridge University Press, Cambridge, UK, 976 pp.

Kuhn K, Campbell-Lendrum D, Haines A, Cox J (2005) Using climate to predict infectious disease epidemics. Geneva: World Health Organization.

Thomson MC, Mason SJ, Phindela T, Connor SJ (2005) Use of rainfall and sea surface temperature monitoring for malaria early warning in Botswana. Am J Trop Med Hyg 73: 214–221.

Degallier N, Favier C, Menkes C, Lengaigne M, Ramalho WM, et al. (2009) Toward an early warning system for dengue prevention: modeling climate impact on dengue transmission. Climate Change.

Wang J, Ogden NH, Zhu H (2011) The impact of weather conditions on Culex pipiens and Culex restuans(Diptera: Culicidae) abundance: A case study in Peelregion. Journal of Medical Entomology 48: 468–475.

Dansgaard, W., 1964. Stable isotopes in precipitation. Tellus 16, 438–468.

Siegenthaler, U. And Schotterer, U. Hydrological applications of isotope measurements in Switzerland Gas Wass. Abwass. 57, 501−506 (1977)

IPCC (2007) Climate Change 2007: Synthesis Report. In: R. K. Pachauri and A. Reisinger, Eds., Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge.

IPCC (2007) Climate Change 2007: The Physical Science Basis. In: S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H. L. Miller, Eds., Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge.

IPCC (2007) Climate Change 2007: Impacts, Adaptation and Vulnerability. In: M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson, Eds., Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge.

Joeri, R., William, H., Jason, H.L., van Vuuren, D.P., Keywan, R., Mathews, B.M., Tatsuya, H., Kejun, J. and Malte, M. (2011) Emission Pathways Consistent with a 2˚C Global Temperature Limit. Nature Climate Change, 1, 413-418. http://dx.doi.org/10.1038/nclimate1258

Spencer, R.W. (2008). The Discovery of Global Warming. American Institute of Physics, Harvard University Press, Cambridge. http://www.aip.org/history/climate/co2.htm

Johnson, K.R., Ingram, B.L., 2004. Spatial and temporal variability in the stable isotope systematic of modern precipitation in China; implications for paleoclimate reconstructions. Earth Planet. Sci. Lett. 220, 365–377.

Vuille, M., Werner, M., Bradley, R.S., Keimig, F., 2005. Stable isotopes in precipitation intheAsianmonsoonregion.J.Geophys.Res.Atmos.110.doi:10.1029/2005JD006022

Cobb, K.M., Adkins, J.F., Partin, J.W., Clark, B., 2007. Regional-scale climate influences on emporal variation of rainwater and cave dripwater oxygen isotopes in northernBorneo. Earth Planet. Sci. Lett. 263, 207–220.

WHO (2004) Using climate to predict infectious disease outbreaks: A review. Geneva: World Health Organization.

Cock-A-Doodle-Do; A Climate Change Alarm

Vijaya Tamla Rai*

Abstract

This paper exhibits constructive worldview approach on conducting a social research in the field of climate change, a burning environmental issue, in a rural setting. This paper drifts the concerns of climate change towards lived experiences of Rai people from Champe. Moreover, this paper aims to induce multiple realities that are subjective in nature from the research participants. Diverse perceptions and experiences were bestowed by the participants with the help of environmental entities such as rivers and forests in order to develop a relative understanding and experience sharing. In so doing, Habarmas' practical interest (Flynn, 2004) and anthropogenic global warming theory (Bast, 2010) at theoretical grounds, and hermeneutical phenomenology (Kafle, 2011) and narrative inquiry (Webster & Mertova, 2007) at methodological levels were coupled. Contextual findings have arisen that explore and experience plural avenues of lived experiences climate variability, composition changes in environment and other indicators of climate change by being a Rai of Champe.

Keywords: Climate change, Rai people, lived experiences, precipitation, belief system

Melting of polar ice caps, islands like Tavula in southern pacific threatened by sea level rise, heat waves in Europe, devastating floods in Asia and prolonged droughts in Africa are some of the imageries that come to our mind while talking about climate change. The reports published by Intergovernmental Panel on Climate Change, environmental ministries of many countries, Conference of Parties (COP) meetings and other climate science journals are evident about climate change discussion in global scale. However, how is climate change perceived by indigenous people? This paper deals with how Rai people of Champe, a village in eastern Nepal perceive various climatic changes through their lived experiences. Endeavours to explore the entire agendas webbed with climate change would be like touching the sun. Therefore, I designed following research question to share my own experiences of climate variability and

School of Education, Kathmandu University, Hattiban, Lalitpur, Nepal

* *Corrresponding Author : Email tamla@khsoed.cdu.np*

perception of Rai people regarding climate change: What sort of lived experiences about climate change do Rai people have?

Coupling Practical Interest and Climate Change Theory

Interpretivism driven by Habermas' theory of practical interest and anthropogenic global warming theory are blended together in order to provide theoretical lens to synthesize understandings of Rai people's thoughts, beliefs, values and experiences (Taylor, Settlemaier, & Luitel, 2012) regarding climate change.

In the words of Grundy (1987), the practical interest is a fundamental interest in understanding the environment through interaction based upon a consensual interpretation of meaning (as cited in Butler, 1997). Smyth (2006) says that tentative conceptualizations inform the research design and data gathering processes with successive analysis informing the conceptualizations as a researcher interprets the data and makes meaning from it. He further argues that to establish confirmability and remain consistent with the practical interest, instead of acting in isolation with preconceived expectation a researcher regards the data as the source of the study's findings. Thus, practical interest was a prerequisite for my research as it guides the interaction between my research participants as researched and me as researcher to form a foundation of understanding and knowledge.

The next theory that I chose was anthropogenic global warming theory. It is the most widely known climate change theory (Bast, 2010) that claims greenhouse gases, primarily Carbon Dioxide, Methane, and Nitrous Oxide emitted due to human activities as the dominant causes of global warming in last five decades. Although, there are many climate change theories based on solar variability, ocean currents, bio-thermostat, planetary motion (Bast, 2010) and cosmoclimatology (Vardiman, 2008) which denounce anthropogenic global warming theory, however, it would be futile to increase emission of greenhouse gases, claiming the gases not being responsible for dramatic rise in temperature. Cannot we become accountable towards consequences of anthropogenic activities on environment, and attempt to decouple economic growth and environmental degradation?

Anthropogenic global warming theory makes us accountable for our own misdeeds. This theory suggests that artificial greenhouse gases are responsible for floods, droughts, severe weather, crop failures, species' extinction, spreading of diseases, ocean coral bleaching, famines, and other hundreds of calamities (Bast, 2010). Al Gore in An Inconvenient Truth and scientists associated to IPCC advocate this theory. Moreover, Al Gore regards 'anthropogenic global warming' not just a theory but fact (Guggenheim, 2006). The reason I choose this theory is; its way of being critical towards anthropogenic actions and ourselves; *Homo sapiens sapiens*!

Methodological Review

My interests were better fulfilled by interpretive research paradigm than nomothetic paradigm of positivism. That is how I came across various perspectives; 'life worlds' of Flick, Kardorff, and Steinke (2004) where 'day to day actions' of research participants as members of a society under different physical and cultural circumstances are studied, 'self-reflective nature' of qualitative research (Creswell, 2007), understanding 'phenomena' through different lenses (Cohen, Manion, & Morrison, 2007), and 'storytelling to create compelling framework of writing' as discussed by Bryman (2008).

Philosophical Consideration

My research was based on interpretive paradigm of qualitative research design. As an interpretive researcher I embrace an open-ended research design process that allows emergent research questions, emergent modes of inquiry and emergent reporting structure (Taylor, Settlemaier, & Luitel, 2009). To discover the subjective meaning through interpretation of communicative actions of my participants (Cohen, Manion, & Morrison, 2007), I had framed my ontological, epistemological and axiological assumptions.

Willis (2007) regards ontology as the 'nature of reality or existence or being' that is not 'out there' but exists relatively in the form of multiple mental constructions based on socio-ecology of individuals who hold the 'truths'. Therefore, an ontological question for my research was 'How do Rai people perceive climate change?' Similarly, what climate change means to them is other facet of inquiry. My ontological assumption was guided by Heideggerain Hermeneutic Phenomenology (Laverty, 2003) that raises existential questions of experiencing and understanding climate change such as; what does it mean to become a Rai of Champe and witness the climatic changes within one's life world?

Epistemology is metaphysical backbone of qualitative research which is one of the ways of 'knowing'. For Creswell (2007) epistemology is about 'how a researcher knows about what s/he knows'. Similarly, Willis (2007) regards epistemology as 'what we can know about reality and how we can know it'. For me, it is a way of constructing my own values, meaning and understanding through multiple interpretations of lived experiences of Rai people along with

reflection of my own life world. Based on constructive epistemological assumptions which are internally constructed, I aimed for collection of subjective knowledge that varied from one participant to another.

Creswell (2007) regards 'axiology' as the role of values in research. The answers of 'How did *fupa*[8] shape values in me and construct my ways of understanding climatic variability?' guided my axiology. Similarly, Rais have their own traditional values and belief systems. What roles do those values play in their livelihood and traditional knowledge systems? Are there threats to their value system due to climate change? These questions are my subjects of inquiry so that I am able to acknowledge the research as value laden. On the basis of my research insights, I discuss the explicit values that shape my interpretation conjugated with that of my participants.

Methodology

Primarily I use hermeneutic phenomenological research methodology for intervening in my study by focusing on subjective experiences of Rai people in Champe (Kafle, 2011). However, for analysis, interpretation and generation of meaning from my insights I use narrative inquiry as my research method because for me stories create meaningful ways (Elliot, 2005) of understanding interaction of Rai people with ongoing climate change. Nevertheless, narrative inquiry had a potential drawback of collecting excessive data in the form of stories as it attempts to gather 'whole story'. In order to minimize chances of continuously burrowing data, at times I intervene narrative inquiry with hermeneutical phenomenology because the later communicates understandings of particular 'phenomenon' at certain points. Similarly, hermeneutic cycle targets to uncover better understanding of the phenomenon (Kafle, 2011).

Study Area

My study area is Champe Village Development Committee (VDC), one of the 63 VDCs of Bhojpur district. It is 1,596 m above sea level. It lies in North Eastern part of Bhojpur district. The area of Champe VDC is 16.26 square km. Champe has a high school and four primary schools. When I asked an employee at Champe VDC about the VDC's demography he said that according to the population census 2011 there are 116 households of Rai people out of 590 households in the VDC. The total population of the VDC is 3,518 out of which 683 are Rai people. 19.41% of the people of Champe are Rai. Champe has been a trade

[8] *Fupa or also called kopa means grandfather in Dungmali language, one of the Rai dialects*

centre for *Lekh* and *Besi*. Since last 90 years farmers sell their products, buy necessary products in *hatiya* (i.e., carnival) which is held fortnightly at Pokharitar of Champe (Shrestha, 2010).The major occupation of Champe people is agriculture. They are subsistence farmers. Rice is their major subsistence crop followed by maize, wheat, mustard and soybean. Cardamom is the major cash crop of this VDC. About 500-600 tons of cardamom is annually grown (Shrestha, 2010).

How did I end up being my own research participant?

All Rai people of Champe VDC were my potential participants. Ward number two, three and nine have majority of Rai residents. Therefore, these three wards were my primary areas for participant selection. I selected thirteen local Rai peoples including myself as my participants through purposive stratified sampling. I chose my participants purposively based on my convenience and my perception of study demand. The sampling process was primarily non probability stratified purposive sampling. The grounds of stratified sampling (Flick, Kardorff, & Steinke, 2004) are profession, age, gender and place of origin.

Interpretation of data is a step ahead than descriptive production of data. Using first person narrative as mode of address I could step on shoes of my participants and gather emic perspectives. Had my role been only of a researcher, I would have been able to gather etic perspectives but not emic ones. To make my research trustworthy I became my own researched so that as a participant I could refer my own experiences. Thus, my interpretation with others is more justifiable when I recognised myself as one of the participants. It also helped me minimize the gap between a researcher and a researched. Moreover, it gave me freedom to express my personal reflections on climate variability experiences by standing on shoes of both researcher and researched. As hermeneutic phenomenological researcher, I could embed reflections of my own lived experiences, relate my understandings and historical memories of climatic conditions of Champe with that of other participants (Laverty, 2003) and construct a collage of climatic experiences to expose the broader portions of a big picture.

Not a Mare's nest; Climate Change in Champe

It is often believed that scientific and technological advancement overshadow religion and faith with reasoning and evidences whereas Rai community still is attached towards Kirant , *Mundum* (i.e., oral tradition of performing rituals) and ancient ways of living. Most of the villagers participate in *hom,* a ritual performed for prosperity or evade a crisis. After *hom*, priest forecasts tentative days of rainfall. Superstitious! One might say. But it rains on that day! Miracle! So, at

times, I become skeptic about my own experiences, understanding and 'truths' I grew up with. So, at times I even fail to locate my start point and end point (Herising, 2005) and run out of words. Nevertheless, I console to myself; even though I fail to find 'proper' terminologies to express, learning does not stop happening even in emptiness! Learning passes through me like a transverse wave does through vacuum. It is a filling in itself despite of the emptiness. That is how I move on during ambiguity and crises.

Whimpering Rivers: A Response to Climate Change

I have considered local rivers like Lale Khola and Bhude Khola, and Rai people of my village as my pointers to organize evidences of climate change. People born and people die. People migrate in and out of the village. But, these rivers are the perennial witnesses of climate change. I have spent good deal of time with some of these rivers. Rivers do not converse like human beings do. But, I have overheard the cries and woes of these rivers. I have stood on the bosom of Lale Khola and felt its weakening heartbeat. The rivers represent the life worlds where Rai people of Champe dwell along. It is my practice of Heidegger's hermeneutic phenomenological approach of 'Dasein' or 'the situatedness of human in the world' (Laverty, 2003). The situatedness of Rai people along the surrounding of various rivers helps to form their consciousness guided by their own historically lived experiences.

I have felt as if these rivers not only have their own painful voices but they also carry on joys, laughter, sorrows and woes of generations of Rai dwellers. Rai people directly depend upon these rivers for drinking water, water for household purpose, water for cattle, poultry, irrigation, and recreation like swimming and fishing. So, together with the painful voices of rivers I consider the experiences of Rai people as well. Hence, by conversing with my research participants, by observing their day to day activities and by involving myself in some of those activities I observe different facets of climate change like that of a 'crystal'. Les Pereira (2007) refers to Valerie Janesick's (2000) argument of crystallization for extensive inclusion of multi-perspectival approach to understanding. Similarly, hereby I am opting for crystallization of my phenomenon; 'climate change experiences and perceptions' of Rai people to develop perspectival understanding in me (Pereira, 2007) so that my understanding of the phenomenon would not be a mare's nest!

Mitawe and Lekhawe; The Environmental Politics

Today is 7th April, 2012. I went to see *Gaumukhi Dhara* after having my lunch. The *Dhara* reminded me of Suddhi *depa*. His full name is Suddhi Bahadur Rai. He is 63 years old and permanent resident of ward number 9, Champe. He runs a small shop for his living. When I went to meet him, he was sitting in his shop listening to his old fashioned classic radio by holding it with both hands close to his right ear. As he saw me approaching towards his shop, he put down the radio on his table and held his spectacles that were resting on his chest hung by thread. They were anchored by a black thread around his neck. He squeezed his face, twisted his head towards left that nearly dropped his *Dhaka topi*[9] and focused at my face with wrinkles around his eyes.

He was full of surprises. First, he listened to me as if he had heard about climate change for the first time. Second, he began speaking, "Oh Climate Change! I have also heard about it in the radio; Ozone layer depletion, Green House Gases, Rio De Generio in Brazil during Girija's (i.e., late former prime minister Girija Prasad Koirala) regime. Rio + 20, is going to happen right? Environment has become a matter of politics!"

When I enquired about his personal experiences of environmental changes, he said, "Isn't timely rainfall one of the indicators of climate change? Well, three-four years down the line, there has been untimely rainfall. Instead of *Ashad* (i.e., June/July), it rains during *Mangsir* (i.e, November/December). We face heavy rainfall after prolonged drought. During drought, forest fires occur time and again. Last year, in *Tin Taley forest*[10], there was disastrous forest fire. Not only the woods were in blaze but many wild animals and young birds in nests burnt into ash. Similarly, the availability of water used to decrease only in *Jestha* (i.e., May/June) in the past whereas now, by *Falgun* (i.e., February/March), four months ahead, the water sources start drying."

"Metawe? – Haa!

Likhawe? – Naa!"

"I heard this proverb when I was in Terai, *'Mitawe? Haa! Likhawe? Naa!'*" Suddhi *depa* said after taking a long break.

I did not get what he meant. But as he elaborated, he was indicating deforestation. The proverb has metaphors '*mitawe*' and '*lekhawe*'. '*Mitawe*' symbolizes deforestation. People say 'yes' for deforestation whereas they say 'no' to '*lekhawe*', i.e., afforestation; planting of trees.

---

[9] *Dhaka topi is traditional and national Nepali cap*

[10] *Tin Taley forest is one of the community forests literally meaning 'Three Storied Forest'*

Picture 2 : Office of community forest user group in champe that was established in 2065 B.S. (i.e., 2008)

Picture 3 : *Kalika Devi* community Forestry user group's office that was established in 2052 B.S. (i.e. 1995)

"A decade back, there was a whim of 'Plant trees, save forest for environmental conservation'. People planted trees on bare hills. Currently there are four community forests in Champe. They have formed Consumers' Committee. But, I don't see that functioning well. The financial transactions are not transparent. Where do they spend the budget? No one knows.

They do not think about selling Oxygen to developed countries and earning dollars. They are merely concerned about firewood, timber, swattar[11] only. People here quarrel for 'a doko of swattar'. Isn't this time of using better technology? There is not one biogas plant in Champe! We are comfortable to burning firewood. I have told your dema[12] to use LPG (Liquefied Petroleum Gas) cylinder. But, my wife does not agree. She says that the cylinder might burst. Well, I cannot convince my own wife, whom else could I convince about improved technology?"

---

[11] *Swattar is collection of dry leaves in forest, used for making manure*

[12] *Dema means aunt who is wife of depa*

Conventional VS Climate Technology[13] : Gap In-between Theory and Practice

At that moment, I realized that 'to know something and to implement what one knows' are two different aspects. I too had a hard time convincing *muma*[14] to purchase solar panels for electricity. It was not because we could not afford. It was because, *muma* regarded it would be dangerous to use. Once when she was in Kathmandu, she had seen a house ablaze due to short circuiting of an invertor. "What if same happened, and this house would burn into ashes?" she always said and found *tuki* safer. But, finally when the whole villagers used solar *tuki*, *muma* agreed to purchase one. It was tough for me to communicate and intervene into the normative beliefs (Flynn, 2004) of my *muma*, because at times my communicative actions not only seemed 'less motivating' but were over ruled by *muma*'s communicative power.

Listening to Suddhi *depa*, I imagined how he might be feeling; as I was feeling pathetic for failing to convince my *kaka* to build a bio gas plant or use LPG gas. The reasons he denied were that it might be expensive to build the plant, and if dung was used for biogas, how could manure for field be prepared? Food cooked on biogas could be unhealthy, we already have solar panel so there is no need of bio gas to light bulbs, there are enough trees in the forest to provide us with firewood fuel, and LPG gas is expensive, unreliable and difficult to be supplied during monsoon due to poor condition of road. Well, he had few points which I could not deny. Although the road way was good during summer and winter seasons, during monsoon, no vehicles would run. The road turns into swamp during monsoon. So the supply of LPG might not be possible throughout the year. Another factor is distance of our house from the road. Although the road way has touched almost every ward, it passes through the upper region of our ward. From the road, it takes twenty minutes of downhill; uphill would take longer. In addition, *muma* is comfortable with firewood and maize's *khoya* (i.e., solid inner part of maize; remnant after harvesting the seeds).

"You can see the agricultural road has touched our V.D.C. (i.e., Village Development Committee). The road came, that is good but, along with the road, it became easier to wipe the forest. '*Mitawe? –haa*!' is happening. Road has become a boon for bad guys to smuggle the timber," Suddhi *depa* had said.

---

[13] *Climate technology refers to any technology that does not emit Carbon or any Greenhouse gases to induce global warming and climate change*

[14] *Muma also called koma means grandmother in Dugmali language, one of the Rai dialects*

I was surprised to see on my way home, agricultural road had been extended to every village. Even at places where there was very less human settlement. Is building road everywhere development? Is this how the local government spending their annual budget? Or is it the central government that was directing to construct roads that looked haphazard and unplanned. The tragic part was; deforestation to construct those roads. On the way, I saw people rocking saws on the stems of trees, huge trucks loaded with logs being driven towards the city, and the area being deforested. Who would stop those people?

They are better when they fall

"Chopping down trees; bad bad BAD;
Our teachers in school; teach teach TEACH
But, they also chop trees; down down DOWN
For firewood for timber and for sale sale SALE
Unemployed I was. But, no more I am!
I have a job, job and JOB
Pays me well; I earn breads for all, all and ALL
About these trees, who cares? I DON'T
They are better when they fall, fall and FALL
That way, we get money, money and MONEY"

-A boy from my village

I saw a boy from our village; he was one of the woodcutters. I stopped by and conversed with him for a while. He was a school dropped out. Few weeks back he got a job of a woodcutter. He was small but could rock the saw as hard and quick as an adult. When I asked him about climate change, he answered, "Why are you asking me? You must know it. If you really do not know, visit Poudyal sir in School. He will answer you."

Extinction of Aboriginal Species and Invasion of Uttis (*Alnus nepalensis*)

Another resident of ward number 9 of Champe, who depends upon the water brought from *Chintaloong* is Bam Bahadur Rai, 55. He is a businessman by profession. I had asked him to share his understanding and experiences of climate change.

He said, "Due to the excessive use of fossil fuels and primitive use of alternative energy resources like solar, there has been drastic change in climatic conditions resulting natural disasters like *Anabristi* (i.e., less precipitation), *Atibristi* (i.e., heavy precipitation), drought, flood, landslide, extreme heat, et cetera is climate change."

There used to be abundant trees of *Dhalne* (*Castanopsis indica*) and *Chilaune* (*Schima wallichii chois*) species. Those trees used to be healthy. Their timber used to be of good quality and free from *mau* or *dhamira*. Since last two decades, those species of trees are infected by *dhamira* and *mau*. I had never noticed *Uttis* (*Alnus nepalensis*) two decades back. But, now, *Uttis* has spread all over the forest. *Uttis* grows faster and the region where it grows other species of trees is not found.

Birds like *kalo chime,* sparrow, and *jureli* (i.e., bulbul) are not seen or heard much. Large animals like tiger, fox, and *salak* (i.e., a type of reptile) have extinct. Due to disappearance of tiger, deer population has increased. With the increase in deer population, hunting and poaching of deer has increased. Due to disappearance of fox, number of mice has increased. Mice destroy house and field. *Salak* has been illegally traded for its skin.

Since last eight to ten years, there has been lesser precipitation, drying of water springs and lesser availability of water during regular irrigation time. The perennial sources of water dry by *Kartik* (i.e., October/November). So it has directly affected agricultural system. For example, in the past, maize used to be sown by *Falgun* (i.e., February/March), but it has shifted to mid or late *Chaitra* (i.e., March/April). Rice used to be cultivated during *Ashad* (i.e., June/July), but now depending upon the precipitation, it may shift to *Jestha* (i.e., May/June). Since, most of us depend upon agriculture; change in crop cultivation and harvest pattern has brought many changes in our lifestyle. Due to the shifting of agricultural pattern, the production of crops has decreased. In the past, we used to grow hundred *muri*[15] rice in the paddy field, now in the same field it is difficult to harvest twenty *muri* rice."

Synthesis of Climate Change Facts

Precipitation pattern is one of the key indicators of climate change. All of my participants have experienced alteration in precipitation cycle in Champe, though their way of understanding the causes are different. Since hydrological cycle is sensitive to climate change, along with it other components like water runoff in

[15] *Muri is local system of measurement; one muri is approximately 57 kg*

rivers (Cruz, et al., 2007) and water availability in springs are adversely affected. Due to sensitivity of hydrologic cycle, spring-fed perennial rivers have turned into seasonal. This could be due to lack of timely water recharge in earth.

My participants have also experienced rise in temperature. Sherey *fupa,* one of my participants regards the dramatic loss of glaciers due to rise in temperature as an indicator of climate change. The glaciers used to be seen in past throughout the year every morning on peaks. Similarly, his perspectives align to anthropogenic climate change theory. Other participants like Suresh, and Suddhi *depa* also stand on similar ground to Sherey *fupa*. However, *muma* and *Jay Bahadur* have their own theories of climate change. These theories are constructed by their socio-cultural setup. Ghimire (2010) said that changes in precipitation and temperature patterns affect the availability of fuel wood, fodder, grasses and drinking water. People are likely to face longer distances to collect such supplies, which might become scarce gradually. These factors increase workload of people, and indirectly affect their physical and emotional health. In case of Champe, various community forest user groups are formed in order to minimize the hazards regarding firewood, fodder and grasses that Ghimire (2010) shared. Likewise, Rai people in Champe have built water tank near natural springs and turned stone spout taps into modern ones which can be opened and closed. Otherwise, they were facing complete water scarcity in dry seasons. Apart from precipitation and temperature, my participants have experienced changes in floral and faunal diversity. Many floral and faunal species are extinct or are in the verge of being so.

Thus, these experiences of changing precipitation pattern, rise in temperature, decrease water runoff in rivers; especially during summer seasons, drying of springs, lack of drinking water availability, extinction of biodiversity and spreading of particular species like *Uttis* shared by my respondents clearly indicate that climate change is happening in one way or the other. However, their perspectives about the factors causing 'climate change' are diversified. For them, climate change facts are constructed by their socio-cultural background. Participants like Sherey *fupa*, Suresh and Suddhi *depa* regard theories of natural science to cause global warming and climate change. They are more aligned to anthropogenic global warming theory because they regard human activities like deforestation, excessive use of chemical fertilizers and pesticides, burning of fossil fuels to run machines and means of transportation, hunting and poaching of rare animals and birds and other anthropogenic activities to be inducing current dramatic increment in local and global temperature and causing climate change. However, participants like Tulsi Kumari Rai regard climate change as a natural phenomenon that cannot be altered by human interest. She is aligned to non-anthropogenic climate change theories (Bast, 2010). Moreover, elderly generation like *muma* regard rise in evil nature in human beings inducing natural catastrophes, diseases, insects in crops, scarcity of resources and crises situation as punishment by mother earth. So for her climate change is a consequence of human beings abandoning ethics, humanity, values, norms and respect towards nature. She sounds like an eco-feminist to me. Her construction of climate change facts are based on intangible human behaviors. Thus, her perspectives draw a new boundary amongst theories of climate change i.e., anthropogenic climate change theory based on eco-feminism and intangible culture of paying tribute to natural resources, biodiversity and ecology.

Conclusion and Future Insights

I was very surprised at the fact that people used to worry about if someone would sneak to their house in order to drop the surplus paddy harvest. Now, the time has reversed. Rai people have been experiencing the effects of climate change; drying of water resources, untimely rainfall, decrement in rice yields and other serials, et cetera. However, these country people have diverse perceptions on climate change. Aged people like my *muma* take it as the omnipotent God's curse to corrupted mankind or business of divine Rain God whereas literate ones like the school teachers and Suddhi *depa*, perceive climate change as a human driven phenomenon. Similarly, some of the villagers took climate change as an inevitable phenomenon because they perceived it to be driven by nature. As I spent my time with some of the rivers like *Lale*, *Bhude*, and *Chintaloong* I not only became nostalgic about my childhood and *fupa* but, became more aware about the dramatic changes going on. The incident of precipitation after forecast by a priest at the end of *hom* made me question at myself about spirituality and science. At a place where meteorological station has not been functioning since last one decade, these perhaps *hom* is meteorology and our priests forecast weather very calculatedly that the forecasts do not fail.

Although there are many community forest user groups in Champe, they are mostly limited in fodder and firewood collection. It is time the community forestry user groups be aware about benefits of REDD (i.e., Reducing Emissions from Deforestation and Forest Degradation), REDD+, REDD++, carbon trading and other ecosystem services (e.g. wild plant species with medicinal values, timber, wild fruits, aesthetic values, habitats for birds and animals, et cetera) of forests for developing new strategies to conserve forests.

Reference

Bast, J. L. (2010). *Seven theories of climate change*. Chicago: The Heartland Institute.

Bryman, A. (2008). *Social research methods*. London, England: Oxford University Press. Retrieved from http://www.oxfordtextbooks.co.uk/orc/brymansrm3e/.

Butler, S. L. (1997). *Habermas' cognitive interests: Teacher and student interests and their relationship in an adult education setting*. Washington, DC: Auburn University.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education*. Oxon, NY: Routledge.

Creswell, J. W. (2007). *Qualitative inquiry and research design*. California, CA: Sage.

Cruz, R. V., Harasawa, H., Lal, M., Wu, S., Anokhin, Y., Punsalmaa, B., & Ninh, N. H. (2007). Asia climate change 2007: Impacts, adaptation and vulnerability. Contribution of working group II. In *Fourth assessment report of the Intergovernmental Panel on Climate Change* (pp. 469-506). Cambridge, England: Cambridge University Press.

Dibike, Y. B., & Coulibaly, P. (2005). Hydrologic impact of climatechange in the Saguenay watershed: Comparison of downscaling methods and hydrologic models. *Journal of Hydrology*, *307*(1-4), 145-163.

Elliot, J. (2005). *Using narrative in social research*. London, England: Sage.

Flick, U., Kardorff, E. V., & Steinke, I. (2004). *A companion to qualitative research*. London, England: Sage.

Flynn, J. (2004). Communicative power in Habermas' theory of democracy. *European Journal of Political Theory*, *3*(4), 433-454.

Ghimire, P. (2010). *Summary of strategic program for climate resilience*. Kathmandu, Nepal: Ministry of Environment.

Guggenheim, D. (Director). (2006). *An inconvenient truth* [Motion Picture]. USA.

Herising, F. (2005). Interrupting positions: Critical thresholds and queer pro/positions. In L. Brown, & S. Strega, *Research as resistance: Critical, indigenous, and anti-oppressive approaches* (pp. 127-151). Toronto: Canadian Scholars' Press/Women's Press.

Hyotylainen, R. (2005). Practical interests in theoretical consideration: Constructive methods in the study of the implementation of information systems. Finland: VTT Technical Research Centre of Finland.

Kafle, N. P. (2011). Hermeneutic phenomenological research method simplified. Bodhi: An Interdisciplinary Journal, 5, 181-200. doi:http://dx.doi.org/10.3126/bodhi.v5i1.8053

Laverty, S. M. (2003). Hermeneutic phenomenology and phenomenology: A comparison of historical and methodological considerations. *International Journal of Qualitative Methods, 2*(3). Retrieved from http://www.ualberta.ca/~iiqm/backissues/2_3final/pdf/laverty.pdf

Magga, O. H. (2005). *Indigenous knowledge systems: The true roots of humanism*. Oslo, Norway: World Library and Information Congress.

Pereira, L. (2007). Developing perspectival understanding. *Contemporary Quality Research*, 33, 189-203.

Shrestha, C. (2010). Champe V.D.C. In D. R. Dhakal, *Bhojpur Directory* (pp. 62-68). Kathmandu, Nepal: Kishor Press.

Smyth, R. (2006). Exploring congruence between Habermasian philosophy, mixed-method research, and managing data using NVivo. *International Journal of Qualitative Methods, 5*(2), 131-145.

Taylor, P. C., Settlemaier, E., & Luitel, B. C. (2012). Multi-paradigmatic transformative research as/for teacher education: An integral perspective. *International Handbook of Science Education*, 24, 373-387.

Vardiman, L. (2008). A new theory of climate change. *Acts & Facts*, *37*(11), 10.

Webster, L., & Mertova, P. (2007). *Using narrative inquiry as a research method*. New York, NY: Routledge.

Willis, J. W. (2007). *Foundations of qualitative research*. Thousand Oaks, CA: Sage.

Theme 8

Miscellaneous

Effect of Cattle Urine and Manure (FYM) on Plant Nutrient Status and Organic Matter Addition to the Soil in Mid Hills of Nepal

Sunil Pandey[1*], Krishna Bahadur Thapa[2] and Indra Bahadur Oli[1]

Abstract

Cattle urine and manure applied to the field not only have great role on maintaining soil fertility status but also reduce carbon emission to the atmosphere as organic carbon is stored in the soil in the form of soil organic matter. Increasing urbanization causes decrease in number of cattle rearing in the urban area due to which, production of farmyard manure also is in decreasing trends. The fertility status of soil is also decreasing due to lack of addition of enough cattle dung and urine in the soil. A study was conducted by providing four treatments concerning to application of farmyard manure and cattle urine to cauliflower and replicated three times by following randomized complete block design. The study revealed that the organic matter added to the soil showed positive result. The application of urine and farmyard manure showed significant effect on the crop yield. The correlation of the organic matter with nitrogen and potassium was also significant.

Introduction

The balanced fertilization of the agriculture land must be done with a judicious application of chemical fertilizers and organic manures to add the plant nutrients and organic matter. But the availability of the chemical fertilizer is not according to the demand of the farmers in the Nepalese markets. Also the chemicals cause the physical, chemical and biological degradation of the soil. Reduction in soil organic matter, decline in biomass carbon and decrease in activity and diversity of soil fauna are some indicators of biological degradation. Chemical degradation is also caused by the buildup of some toxic chemicals and an elemental imbalance that is injurious to plant growth (Karki, 2006). Nepal does not produce any chemical fertilizer and is fully dependent on imports. The share of foreign grants and loans in total imports has declined sharply over time (Agricultural Projects Services Centre and John Mellor Associates, 1995). The use of inorganic fertilizers has drastically declined following the energy crisis, which has immensely affected most of the developing countries (Hauck, 1982).

[1] *Regional Soil Testing Laboratory, Pokhara*

[*] *Corresponding Author: Email: soil_pandey@yahoo.com*

[2] *Coffee Research Programme, Gulmi*

Although the agriculture development plans emphasis on the increase use of the chemical fertilizer the consumption is inadequate due to unavailability in the market. Therefore the Nepalese farmers have to depend more on organic manure than on the chemical fertilizer for the production of the crops. Therefore, there is a great need for the Nepalese to prepare the organic fertilizer by using locally available materials such as plants and animal wastages.

In Nepal the farmers are using the cattle manure (Farm Yard Manure) since ancient time for the production of crops. But the use of cattle urine for the crop production has just been started in the country. Use of well prepared FYM is very effective to increase the crop production. But if we also collect the cattle urine and use it along with the compost, it will be more effective to improve the crop yield. The used compost and the urine also add the plants nutrients to the soil and maintain the fertility status of the soil.

Objective of the Study

A study was carried out in farmers' field to fulfill the following objectives.

- To study the effects of cattle manure and urine in the crop production
- To compare the effects of cattle urine and compost in crop production
- To study the effects of FYM and cattle urine on nutrients content of the soil

Material and Methods

Location: Armala V.D.C., Ward No. 2, Jumleti, Kaski, Nepal

Treatments and Experimental Design: A field experiment was conducted by providing four treatments of cattle urine and farmyard manure/compost in the soil. Factorial RCBD (2X2) was followed and replicated three times. The size of the each individual plot was 2X3 m^2. The indicator crop grown was cauliflower. Following treatments were provided in the soil.

Treatment 1: control.

Treatment 2: urine.

The urine was mixed with the water with the dilution ratio of 1:8. This urine was used in the plant (seedlings of cauliflower) starting from one month after the plantation of seedlings. In this treatment, half a liter of diluted urine was applied once a week per seedling. The application was stopped after the initiation of curd formation.

Treatment 3: FYM applied @ 30 t ha-1 in the soil

Treatment 4: Both the urine and FYM was applied (treatment 2 + treatment 3)

The nutrient content and pH of the FYM and the cattle urine is given in table 1.

Table 1 : Chemical properties of urine and FYM used in the soil

Organic Manure	pH	N (%)	P (%)	K (%)
Urine	8.5	0.15	0.01	1.3
FYM	8.2	1.52	0.42	1.3

Table 2 : Soil properties before cropping

Soil Properties	pH	OM(%)	N(%)	P_2O_5 (Kg ha^{-1})	K_2O (Kg ha^{-1})
Average	5.54	3.51	0.17	208	144

Planting of the crop: Cauliflower (Var. Snowmystic) was selected as an indicator crop and planted at the spacing of 50 cm X 60 cm. Irrigation was supplied regularly to maintain the moisture in the soil. The first weeding was done one month after the plantation and the second during one month after first weeding. Two foliar applications of micro-nutrients were accomplished at the fortnightly interval that started one month after transplantation. The plant was ready to harvest at 100 DAT.

Data recording: The data for curd diameter and yield was collected during the cropping season. The curd diameter was measured by using the measuring tape, while the curd yield was measured by using the weighing machine.

Soil properties: The soil sampling and analysis was done two times, once before the start of the experiment and second after the crop harvest. The collected soil samples was analyzed in Regional Soil Testing Laboratory, Pokhara for soil pH, organic matter content, total nitrogen, available phosphorus and available potassium before the transplantation and after the harvest of the curd.

Data Analysis: The generated data was analyzed by using MSTAT-C computer software. The significance of the treatments was analyzed with the help of the ANOVA table and the calculated means (tabulated).

Results and Discussion

Interaction Effects of Treatments on Soil Organic Matter

The data on organic matter content in the soil after the harvest observed to be lower (4.37 %) in the urine applied plots while, it was the higher (4.93%) in the urine cum FYM applied plots. The organic matter content in the control plots is higher than in urine treated plots due to the higher initial organic matter content. The soil organic matter was increased in all the treatments (Table 3).

Table 3 : Interaction effects of urine and compost on nutrients content of the soil (after the crop harvest)

Treatment	OM (%)	pH	N (%)	P_2O_5 (Kg ha^{-1})	K_2O (Kg ha^{-1})
Control	4.53	4.97	0.23	243	616
Urine	4.37	4.80	0.22	252	688
FYM	4.63	5.07	0.23	251	608
Urine + FYM	4.93	5.23	0.25	261	608
F- Test	NS	NS	NS	NS	NS
LSD	NS	NS	NS	NS	NS
C.V. (%)	5.8	1.5	5.4	2.8	14.0
Mean	4.62	5.01	0.23	252	630

The results was similar to the result explained by DOA (2011) according to which the addition of 20 t ha-1 of organic matter increase the organic matter content of the soil by 1%.

Interaction Effects of the Treatments on the Soil pH

The final pH was also lower (4.80) in the urine treated plots and higher (5.23) in combination of urine and compost. In this case there was not any significant change of soil pH from the treatment. The use of chemical fertilizer causes the soil to be acidic so the soil pH drops after several rotation of crop cultivation. But with the use of the organic fertilizer, the soil pH remained constant and was very much similar to the control (Masti, 2012).

Interaction Effects of Treatments in Nutrient Availability in the Soil

The effects of urine and compost were not significant to nitrogen, phosphorus and potassium content of the soil. The record on available nitrogen content was the higher (0.25 %) in urine cum compost treated plots, while it was the lower (0.22 %) in urine treated plots (Table 3). Similarly, the available phosphorus content of the soil was the higher (261 kg ha-1) in urine cum FYM treated plot while, it was the lower (243 kg ha-1) in control plot (Table 3). On the other hand, the data on the potassium content was higher (688 kg ha-1) in urine treated plot but lower (608 kg ha-1) in compost and urine cum compost treated plots (Table 3). The nutrient supplied to the soil by means of chemical fertilizer was very easily lost from the soil. Once they are applied to the soil they must be readily used by the plants, otherwise, these nutrients would be lost from the soil. But the nutrients added to the soil by the organic manure release very slowly and remain in the soil for a long time after they are applied in the soil. The above result is accordance with Khanal et al. (2011).

Table 4 : Interaction effects of urine and compost on yield and yield parameters

Treatment	Curd diameter (cm)	Curd weight (kg)	Yield (t ha^{-1})
Control	13.93	0.449	7.030
Urine	13.40	0.783	12.250
FYM	16.67	0.656	10.260
Urine + FYM	21.67	1.100	17.222
F- Test	NS	NS	NS
LSD	NS	NS	NS
C.V. (%)	7.7	4.1	4.2
Mean	16.42	0.747	11.688

Interaction Effects of Urine and FYM in Curd Diameter, Curd Weight and Yield of Cauliflower

There was no significant effect of the interaction of the urine and the FYM on curd diameter (Table 4). But the value was lower (13.40 cm) with urine and higher (21.67 cm) with urine cum compost application. The interaction effect of urine and FYM was not significant. But there was increased curd weight with the interaction effect of the urine and FYM (Table 4). It was lower (0.449 kg) in control and higher (1.100 kg) with urine cum compost treated plots. The interaction effect of urine and FYM was not significant. But the value increased from lower (7.030 t ha-1) in control to higher (17.222 t ha-1) in urine cum compost treated plots (Table 4). The effect of this organic manure to the plant yield parameters are very much similar to the results given by Poon et al. (2008).

Table 5 : Effects of urine and compost on nutrients content of the soil

Treatment	OM (%)	pH	N (%)	P_2O_5 (Kg ha^{-1})	K_2O (Kg ha^{-1})
Control	4.58	5.01	0.23	247	612
Urine	4.65	5.01	0.23	257	648
F- Test	NS	NS	NS	NS	NS
LSD	NS	NS	NS	NS	NS
Control	4.45	4.88	0.22	247	652
Compost	4.78	5.15	0.21	256	608
F- Test	NS	NS	NS	NS	NS
LSD	NS	NS	NS	NS	NS
C.V. (%)	5.8	1.5	5.4	2.8	14.0
Mean	4.62	5.01	0.23	252	630

Effects of Urine and Compost on Nutrients Content of the Soil

The mean values on OM (%), pH, N (%), P_2O_5 (Kg ha^{-1}) and K_2O (Kg ha^{-1}) of the soil after the crop harvest is sown in Table 5. The effects of urine and compost to organic matter content of the soil observed to be non significant but in both the cases the increase is positive. With urine the value increased from 4.58% to 4.65% while the value increased from 4.45% to 4.78% in case of compost application. The case was similar for pH, nitrogen, phosphorus and potassium. There is an increment increase in soil pH only in the case of compost i.e. from 4.88 to 5.15. There is no change in nitrogen content in the case of urine and in the case of compost. The nitrogen content is decreased slightly from 0.22% to 0.21%. The phosphorus content is increased positively in the cases, urine (247kg ha-1 to 257 kg ha-1) and compost (247 kg-ha-1 to 256 kg ha-1) treatment. The application of urine increased (612 kg/ha to 648 kg/ha) the potassium content of the soil but with the application of compost the potassium content is decreased (652 kg ha-1 to 608 kg ha-1). The decrease in the nutrients content of the soil is due to the heavy consumption by the crop for increased yield.

Table 6 : Effects of urine and compost on yield and yield parameters

Treatment	Curd diameter (cm)	Curd weight (kg)	Yield (t ha^{-1})
Control	15.30	0.553	8.644
Urine	17.53	0.941	14.731
F- Test	NS	**	*
LSD	NS	0.309	4.84
Control	13.67	0.616	9.638
Compost	19.71	0.878	13.737
F- Test	**	NS	NS
LSD	3.52	NS	NS
C.V. (%)	7.7	4.1	4.2
Mean	16.42	0.747	11.688

*Statistically significant (P>0.05) *   statistically significant (P>0.01) ***

Effects of Urine and Compost on Yield and Yield Parameters

There is no significant increase of urine in curd diameter but the effect of compost is highly significant. The increase in compost is from 13.67 cm to 19.71 cm. The effects of urine to curd weight is highly significant but the effect of compost is non significant. The increase with urine is from 0.553 kg to 0.941 kg. There is significant increase of crop yield due to urine but the increase of crop yield due to compost is non significant. The increase with urine is from 8.644 t ha-1 to 14.731 t ha-1.

Correlations of Organic Matter Content with Different Soil Parameters

The correlation of organic matter with available nitrogen was highly significant. There was a non significant and negative correlation of organic matter with phosphorus. The correlation of organic matter with available potassium was significant. There was positive and non significant correlation between organic matter and pH (Table 7).

Table 7 : Correlation coefficients of organic matter content with different soil parameters

Parameters	Correlation coefficients
OM vs Nitrogen	0.728**
OM vs Phosphorus	-0.457
OM vs potassium	0.583*
OM vs PH	0.430

*Statistically significant (P>0.05) *   statistically significant (P>0.01) ***

Conclusions

Although the treatments had no significant effects on the organic matter status, pH and nutrient status of the soil, the nutrients added are of positive value in most of the plots and the nutrients status was positive as compared to the control. The non significance is due to the fact that the experiment was a short term one and there was only a single rotation of the crop with the treatments. But the growth and the yield parameters of the crops were significant. The correlations of the organic matter with nitrogen and potassium were highly significant and significant respectively. But the correlations of organic matter with phosphorus and pH were not significant.

Thus, the effects of the cattle urine and FYM were proved to be effective in increasing the yield of the cauliflower and improving the chemical and biological properties of the soil.

References

Agricultural Projects Services Centre and John Mellor Associates. 1995. Nepal agricultural perspective plan (final draft), prepared for National Planning Commission of Nepal and the Asian Development Bank (Kathmandu).

DOA. 2011. Training manual for combating citrus decline problem in Nepal, Department of Agriculture, ministry of agriculture and cooperatives, Government of Nepal. p 28

Hauck H.W.1982. Organic recycling to improve soil productivity. Organic materials and soil productivity. FAO. Soil Bulletin. No. 45. FAO. Rome.

Karki K.B. 2006. Soil degredation in Nepal and some measures to rehabilitate. In: The J. Agr. and Env., Pp 38-42.

Khanal A., S.M. Shakya, S.C. Shah, and M.D. Sharma. 2011. Utilization of urine waste to produce quality cauliflower. J. Agr. and Env., 12:91-96.

Matsi T. 2012. Liquid cattle manure application to soil and its effect on crop growth, yield, composition, and on soil properties, soil fertility improvement and integrated nutrient management.

Poon T.B., O.B. Oli, and A.B. Pun. 2008. Effect of organic nutrients on cauliflower production in Dailekh. In: Proceedings of third SAS-N (Society of Agriculture Scientist, Nepal) convention. 27-29 August, 2008. Kathmandu, Nepal. Pp 154-157.

Corresponding Author: Sunil Pandey, Soil Scientist, Regional Soil Testing Laboratory, Pokhara; Email: soil_pandey@yahoo.com

Seasonal Variations in the Zooplankton Diversity of River Godawari

R. N. Bhavare[1] and S. B. Andhale[2]

Abstract

Zooplanktons are heterotrophic planktonic animals floating in water. They serve as good indicators of changes in water quality. The present study was undertaken to observe the seasonal fluctuations in diversity of zooplanktons of Godawari river, a significant freshwater body in Nashik. Both qualitative and quantitative analysis of were conducted from July 2012 to June 2013, by taking samples from 3 segments of the river. Zooplankton community of Godavari river comprised of 18 species belonging to Cladocera (08 sps), Copepoda (4sps) and Rotifera (6sps). Cladocerans showed dominance both in number and diversity, followed by Copepods and Rotifers. This study also reveals that different groups of zooplanktons have their own peak periods of density, which is affected by local environmental conditions prevailing at that time.

Keywords: Zooplanktons, seasonal variation, diversity, Godawari river

Introduction

Zooplanktons are minute aquatic animals that are non motile or are very weak swimmers. They contribute significantly to biological productivity of freshwater ecosystem. They serve as good indicator of changes in water quality, because it is strongly affected by the environmental conditions and it is quickly responded to changes in environmental quality. They are not only useful as bioindicators, but also helpful for ameliorating polluted waters. Zooplankton species are cosmopolitan in nature. They consist of fresh water, brackish and marine water forms. The freshwater zooplankton comprises Protozoans, Rotifers, Cladocerans, Copepods and Ostracods.

[1] *Principal and Head Department of Zoology, K.P.G. Arts, Commerce and Science College Email:prindrnb@rediffmail.com*

[2] *Head Department of Botany, K.P.G. Arts, Commerce and Science College,*

Igatpuri, Tal. Igatpuri-422403, Dist. Nashik (M.H), India Email : shivaji.andhale@gmail.com

Planktonic protozoans are group of unicellular ciliated or flagellated organisms. They feed on either picoplankton or nanoflagellates and small nanophytoplanktons according to their size. Heterotrophic nanoflagellates are more abundant than ciliates in freshwater body. Heterotrophic nanoflagellates are more abundant than ciliates in freshwater body. Rotifers, the tiny wheel animalcules are considered nature's water purifier. They are prominent group among the zooplankton of a water body irrespective of its trophic status. This may be due to the less specialized feeding, parthenogenetic reproduction and high fecundity. They are high in stable environmental conditions and disappear as pollution level increases (Das et al, 1996). So the present study was carried out to understand the diversity and seasonal variation of zooplanktons in Godawari river, in Nashik, Maharashtra.

Materials and Methods

Monthly samples were collected from these study sites during July 2012 to June 2013 and the data were incorporated into seasonal data considering January, March as summer; April, May, June as pre monsoon; July, August and September as monsoon; October, November and December as post monsoon. Qualitative sampling of zooplankton was done with the aid of plankton net of mesh size 60-75μ. Quantitative samples were collected by filtering 200 L water. The collected specimens were carefully transferred to a wide mouth bottle and preserved with 4% formalin and these were taken to the laboratory. Taxonomic identification was done with the help of Olympus Stereoscopic Dissection Microscope and using relevant literatures (Petersen, 2010; Yule and Sen, 2004).

Results and Discussion

Zooplankton community of Godawari river comprised of 18 species belonging to Cladocera (08sps), Copepoda (04sps) and Rotifera (06sps) (Table. 1).

The relative abundance of zooplankton population in this river depicted in Fig. 1 shows during summer, rotifers were dominated (40%) followed by copepods (30%) and cladocera (50%). The cladocerans marked higher abundance during pre monsoon.

Cladocera

The Cladoceran population identified from Godawari river during the present study were represented by 08 species belonging to 6 genera and 6 families; Bosminidae, Moinidae, Chydoridae, Aloninae, Daphnidae and Macrotricidae. Quantitative analysis during the period of study showed that the family

Bosminidae exhibit maximum diversity of species. It is represented by 2 species; Bosmina longirostris and B. exuvia. Moina spp. belongs to the family Moinidae, found to be predominant species. From all other families only a single species were recorded.

Copepoda

The Copepod population identified from Godawari river during the present study were represented by 4 species belonging to 3 genera and 3 families.

Copepoda exhibit highest peak at during post monsoon. It can be explained as the result of settling of rainwater and return of favorable condition. The minimum number was found in monsoon season. This decrease in the density of copepod may be due to environmental variation. So there exists seasonal fluctuation in the density of copepod population of Godawari river.

Rotifera

The Rotifer population identified from Godawari river during the present study were represented by 6 species belonging to 1 genera and 1 families; namely Branchionidae,. Quantitative analysis during the period of study showed that the family Branchionidae exhibit maximum diversity of species. This group exhibit highest peak during summer. Arora and Mehra (2003) while analysing seasonal dynamics of rotifers in relation to physico chemical conditions of lotic water body made similar observations in increased densities in summer and reduced densities in winter. In summer, the absence of inflow of water brings stability to the water body. The availability of food is more due to production of organic matter and decomposition. These factors contribute for high species density. In most of the aquatic ecosystem different zooplankton groups acts as one of the major primary consumer as a result, their diversity, abundance and seasonality affects the other biotic

Sr. No.	Class	Genus and Species
1	Cladocera	Bosmina longirostris
		B. exuvia
		Moina spp.
		Macrothrix sp
		Chydorous sp.
		Alona rectangula
		Ceriodaphnia sp.
		Moina sp.
2	Copepoda	Cyclopoid naupli
		Calanoida naupli
		Cyclop
		Calanoida
3	Rotifera	Brachionous quadridentatus
		B. species
		B. urceolaris
		B. calyciflorus
		B. fulcatus
		B. forficula

Discussion

Zooplankton plays a crucial role not only converting plant food to animal food but also themselves as source of food for higher organisms especially in the freshwater ecosystem. The availability and adaptations depends on the surrounding environmental factors. Zooplankton density of the present pond mainly depends upon the temperature, light and pH. It reveals that zooplankton community fluctuated according to the various physicochemical conditions of the pond. The present study confirms that how abiotic and biotic factors are limiting factors for abundance of zooplankton.

References

Das, P. K., Michael, R .G. and Gupta A, Tropical Ecology, [37 (2) (1996) 257-263].

Petersen, F, An illustrated key to the Philippine Freshwater Zooplankton. 2010.

Yule, C. M. and Sen, Y. H, Freshwater invertebrates of the Malaysian Region. Academy of Sciences, Malaysia, 2004, pp. 379-851.

ISBN: 978-9937-2-9137-8