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Short Communication

Carbon stock in the grassland of Koshi Tappu Wildlife Reserve, Eastern Nepal

Sabitri Shrestha
Department of Biology, Central Campus of Technology, Dharan, T.U., Nepal
sabli123123@yahoo.co.in

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Abstract

Carbon stock of soil and biomass were evaluated in the grassland of Koshi Tappu Wildlife Reserves (KTWR), Eastern Nepal. This was with a view to provide information on grassland serving as carbon sink and to assess their contribution to carbon stock. For the study, three 50m x 50 m core areas or sampling areas were established. Soil samples were randomly collected from each sampling areas at a depth of 15 cm, then it was air-dried, oven dried at 100°C and then analyzed the carbon stock in the soil. The above ground and below ground biomasses were harvested by randomly placing ten 50cm x 50cm quadrates in each sampling areas. The harvested plants were oven dried at 70°C to a constant weight, weighed, and analyzed carbon stock in biomass. The soil carbon stocks was found to be 25.12, 20.96, 18.50 t/ha to a depth of 15cm on short grass area, medium grass area and tall grass area respectively. The carbon stock in biomass was found to be 6.58, 11.30, 16.44 t/ha on short grass area, medium grass area and tall grass area respectively. The soil of short grass area stored the highest soil organic carbon and on the other hand biomass of the tall grass area stored the maximum organic carbon. The results concluded short grass area that has been mostly grazed contained more carbon stock.

Keywords: Soil organic carbon, short grass area, medium grass area, tall grass area, ground biomass, below ground biomass.

Introduction

Approximately 51% of the terrestrial surface of the earth is occupied by grasslands[1,2] and are important resource of the atmospheric carbon dioxide sequestration. About 1.75 million ha or nearly 12% of Nepal total land area is estimated to be covered by grassland areas[3]. These days global warming and climate change are perhaps the most pressing global issues. There is a growing concern about the accumulation of green house gas in the earth's atmosphere as witnessed in recent years, which is significantly raising the global temperature. Nepal's contribution to the global annual GHG emission is 0.025%[4,5]. The temperature in Nepal has been increasing at the rate of 0.06°C per year over the last 25 years[6,7].

KTWR is a protected area situated between 86º91' - 87º08'E and 26º72' - 26º56'N in Sunsari, Saptari and Udaypur. districts. It comprises extensive mudflats, reed beds, and freshwater marshes in the floodplain of the Sapta Koshi River, and ranges in altitude from 75 to 81 m. It was established in 1976 and designated as a Ramsar site in December 1987[6,8]. The climate is sub-tropical. The soils in the reserve are sandy, loamy sand, sandy loam, loam and sandy clay loam[6]. The aquatic habitats occupies 12.9% and terrestrial habitats occupies 87.1% of total available habitat of the reserve[9,10]. Based on aerial photos of (1991/1992) terrestrial habitats include 67.7% grassland, 2.6% savannah and 4.2% forest land[10]. The reserve is rich in biodiversity with, 670 species of vascular plants[11], 21 of mammals[12], 23 species of herpetofauna[13], 77 species of butterflies[14], 494 species of birds[15] and is habitat for a large number of globally and nationally threatened species[16]. The major species of grassland are *Saccharum spontaneum, Phragmites kharka, Imperata cylindrica, Typha angustifolia, Cymbopogon pendulus, Vetiveria zizannoides, Erianthus ravenna, Digitaria adscendens, Fimbristylis squomosa, Persicaria lapathifolia, Echinochloa crusgalli, Echinochloa colona, Paspalum distichnum, Cyperus compressus*, *Cyanodon dactylon, Alternanthera sessilis*[6,10].

Due to the change in river course most of the grassland of KTWR habitats have been observed to be replaced by new ones. Untimely, unscientific and haphazard use of grassland by local people has resulted in resources degradation and depletion. There was a significant changes in its ecosystems over last 34 years[17]. The changes are manifested by human pressure[17], climate change[18,19] land use and land cover change[17,20,21] with loss of habitat for many aquatic and terrestrial species[17]. Interestingly soil loss from different land cover classes[21] and higher vulnerability[22] are bringing numerous challenges to the reserve and basin. Some of the major challenges are on water availability, ecosystem vulnerability and poor adaptive capacity of the people living in buffer zone of the reserve and basin[19]. Thus, the natural and human activities are bringing various management challenges in the reserve as also reported by others[17,23].

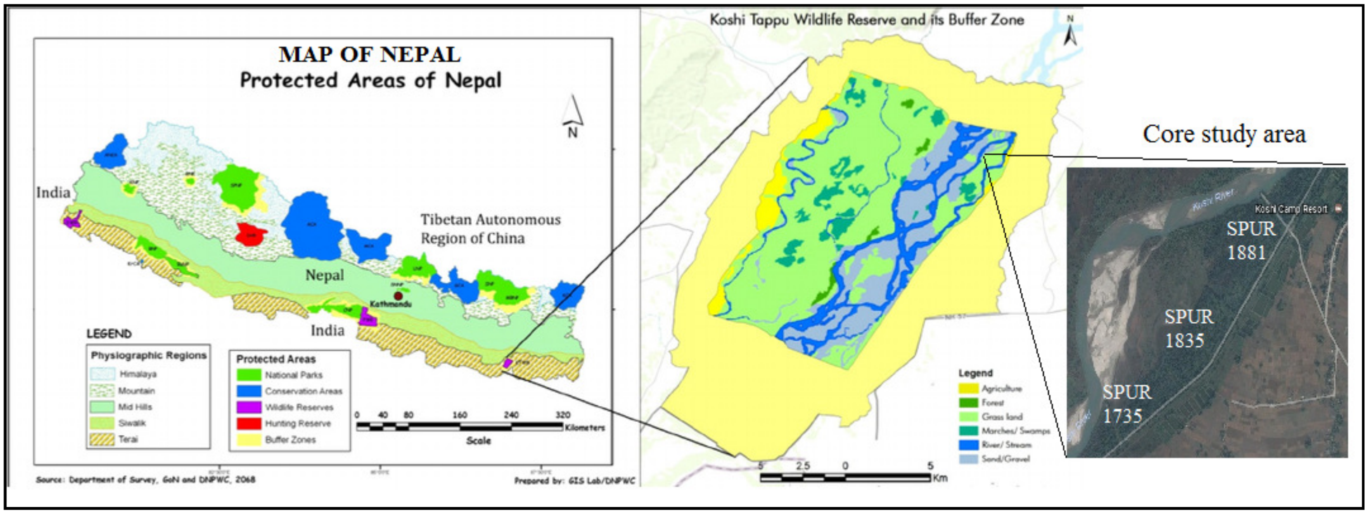

Figure-1: Map of the study area, KTWR[24].

Methodology

Survey of KTWR was carried on in the month of August, 2016. The sampling was carried in the eastern side of the main stream which included the spur no.1735, spur no.1835, spur no.1881. There the three core areas viz. short grass area, medium grass area and tall grass area for sampling was allocated. The core areas were approximately 50m by 50m. The core areas were identified on the basis of the height of grasses and grazing frequency. Short grass area have been frequently grazed and comprised very short annual grasses of height less than 20cm. The dominant grasses were *Paspalum distichum, Cyanodon dactylon, Cyperus compressus, Digitaria adscendens,* and short sprouts of thatch grasses. Medium grass area were moderately grazed with few short grasses and medium sized grasses of height less than 50cm. The dominant grasses were *Saccharum spontaneum, Imperata cylindrica, Typha anguistifolia, Vetiveria zizannoides and Phragmites kharka*. Tall grass area was rarely grazed and mostly comprised tall perennial grasses of more than 1m in height. The dominant grass was *Erianthus ravenna* which was commonly called elephant grass.

Soil sampling: From each core areas, five each soil sample was collected with the help of steel corer having 4cm diameter and 15cm length. Soil sample were separated into three sections viz. top layer (0-5cm), middle layer (5-10cm) and bottom layer (10-15cm) with 5cm length of each slice. Each layer of the soil was packed in separate zipped polythene bag and brought to laboratory. Each soil samples were oven dried at 100°C till constant weight. It was crumbled with thumbs and sieved through 2mm sieve. The remained particle was weighted and sieved particle was stored for further analysis.

Biomass sampling: Ten quadrates of size 50cm x 50cm were thrown in each selected core areas. The entire above ground biomass of the quadrate was harvested and was made sun-dry then oven dried at 70°C till constant weight. Similarly, below ground biomass was collected by excavating 15cm depth of the quadrate and entire soil was collected. The below ground biomass was isolated by removing soil particles with water jet through 2mm sieve. The washed root was made sun-dried then oven dried at 70°C till constant weight. Dried biomass was converted to t/ha.

Sample Analysis: Bulk density of sampled soil was determined by a standard method. Soil organic carbon was analyzed from stored sample by the Walkley-Black Chromic Acid Wet Oxidation Method[25]. Similarly, the dried weight values of the plant biomass were then multiplied by a factor of 0.5 to obtain the amount of carbon present. This factor is based on the principle that the plant matter of any ecosystem contains 50% carbon in its biomass once the water has been removed[26].

Statistical Analysis: For statistical analysis SPSS 20 software was used. To test whether there was significant difference of soil organic carbon (SOC), biomass carbon of different sites ANOVA (Analysis of Variance) was used. The significant means were separated using LSD (Least significant difference) Post hoc analysis ($P<0.05$).

Results and discussion

Soil carbon stock: SOC was found to be 25.12, 20.96, 18.50 t/ha as shown in the Table-1 and Figure-2 on short grass area, medium grass area and tall grass area respectively. The SOC of three different sites were significantly ($P<0.05$) different. However, there was no sharp difference in carbon stock. The carbon stock in frequently grazed area i.e short grass area were high compared to rarely grazed area i.e tall grass area. Further on performing LSD post-hoc analysis, soil organic carbon were significantly ($p<0.05$) different in short grass area - medium grass area and short grass area - tall grass area whereas the soil organic carbon were not significantly ($p>0.05$) different in medium grass area - tall grass area. The SOC level gradually decreased from top to bottom layer of soil as shown in Table-1 and Figure-2. Similarly, in the study "Soil carbon and nutrient status of rangeland in upper Mustang" carried on by Maharjan, the amount of the soil carbon decreased with increasing depth of soil[27]. The maximum carbon stock was in the soil layer of 0-5cm in all the three sampling areas. This is in agreement with the result found in carbon storage of the areas Gorujure and Milke in the himalaya rangeland of Milke-Jaljale area, eastern Nepal which showed that SOC level gradually decreased from top layer to bottom layer of soil[28].

Biomass carbon stock: The carbon stock in biomass was found to be 6.58, 11.30, 16.42t/ha on short grass area, medium grass area and tall grass area respectively as shown in Table-1. It is clearly seen in Figure-3, that there was an increasing trend in above ground biomass and below ground biomass with increasing the height. There was a significant difference in above ground and below ground biomass between short grass area and medium grass area, short grass area and tall grass area i.e. ($P<0.05$) whereas there were no significant difference in biomass between medium grass area and tall grass area i.e. ($P>0.05$).

Table-1: Carbon stock (t/ha) in the grassland of KTWR.

Study area	Soil carbon stock	Biomass carbon stock
Short Grass Area	25.12	6.58
Medium Grass Area	20.96	11.30
Tall Grass Area	18.50	16.42

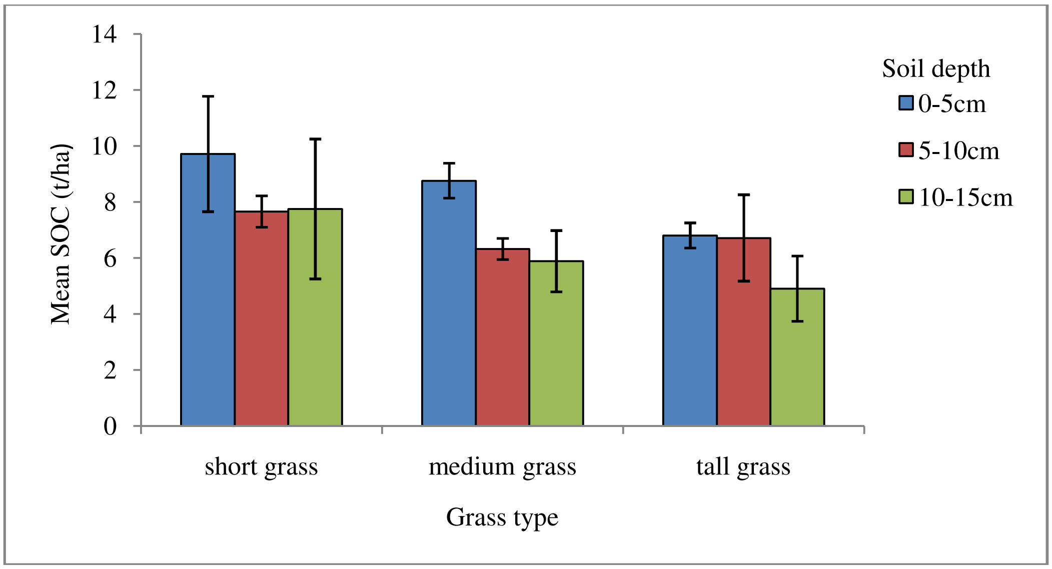

Figure-2: Soil organic carbon in the grassland of KTWR (error bars represents standard deviations of 5 soil samples).

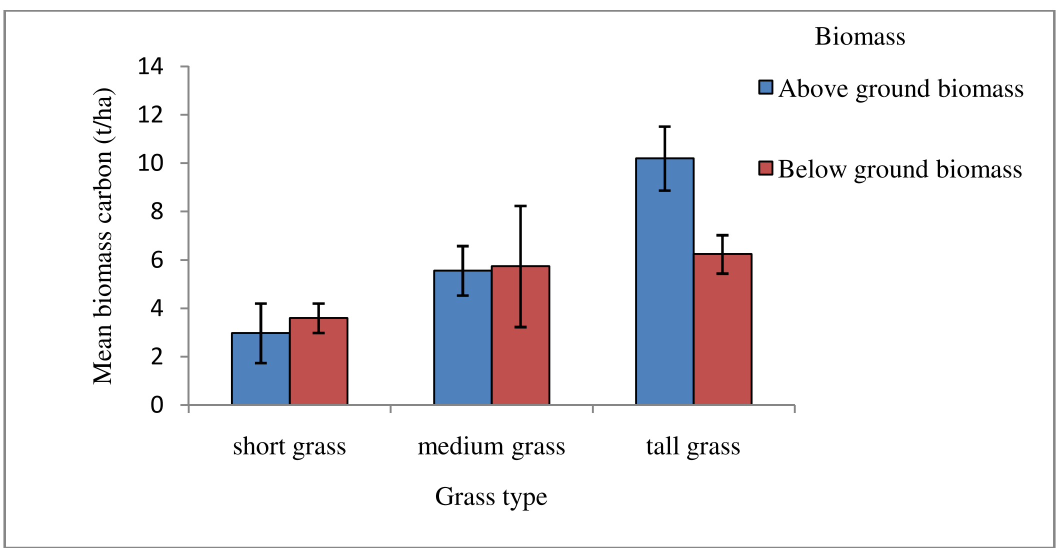

Figure-3: Biomass carbon stock in the grassland of KTWR (error bars represents standard deviations of 10 samples).

Discussion: Grasses of short grass area were short sized due to frequent grazing its characteristics being short and composed of different varieties of short grasses also. Due to fragile growth of its vegetative and root parts and due to its soft tissues hastens its death and decomposition thus increasing more carbon content in soil. The grazing activity might be favorable for promoting the nutrient to the soil and grasses and thus also stimulating the growth of plant varieties. The grasses that are stimulated through grazing provide a habitat for many species. The animals urine and feces "recycle nitrogen, phosphorus, potassium and other plant nutrients and return them to the soil"[29]. The organisms in the soil might be benefited by the nutrients and thus these organism aids in carbon storage in the soil. But, in tall grass area there is less or no grazing, mostly same grasses were found creating monoculture. On comparison to short grass area and medium grass area, tall grass area has low carbon stock as because the tall elephant grasses *(Erianthus ravenna)* has low rate of decomposition due to its hard living tissue, more surface area lowers the rate of decomposition furthermore its nature of being dominant to other species leading to less diversity. Grasses of tall grass area were mostly perennial, most of the living and dead tall grasses never really make it into the soil. Moreover, unlike short grass area there is hardly little deposition of animal urine and feces.

Biomass of tall grasses of tall grass area stored huge amount of carbon followed by medium grasses of medium grass area while the short grasses of the short grass area which is heavily grazed has less amount of carbon. This is due to high above ground biomass together with high belowground biomass of tall grasses. The higher above ground biomass and below ground biomass was attributed due to its characteristics being tall and luxuriant, vibrant, deeper and bulky above and below ground biomass. Deep penetrating roots store and hoard carbon away from the soil. This may be for the reason that less amount of carbon in tall grass area. The lowest carbon stock was observed in biomass of short grass area even though short grass area has more carbon in its soil pool. This may be due to its characteristic being short, more palatable and is mostly grazed by wild water buffalo.

Conclusion

From this study, it is clear that short grasses areas which have been mostly grazed contained highest soil carbon stock and on the other hand tall grasses area have highest biomass carbon stock with highest above and below ground biomass. Schuman et al. reported that the shoot turnover rate was 36 and 39% under light and heavy grazing compared to 28% in ungrazed enclosures[31]. According to them animal traffic may enhance the physical breakdown of the soil and leads to increased soil carbon storage but on the other hand immobilization of carbon in standing dead plant materials in ungrazed grasslands may lead to less carbon in the soil. Thus, it appears that grazing has positive impacts on soil carbon storage. It becomes necessary to protect globally threatened species wild water buffalo and their habitat because according to literature, Rai[32] more than 87% of their time is spent grazing on sprouting thatch grass (*Saccharum spontaneum*), resting, and wallowing around these habitats. The integrity of soils of the grass cover should be maintained by reducing disturbance that is associated with soil erosion or harvesting.

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References

1. Lean G.D. and Markham A. (1990). Atlas of the environment. Prentice hall press, 'New York, 192.
2. Prentice K.C., Crames W., Harrison S.P., Leemans R., Monserud R.A. and Solomon A.M. (1992). A global biome model based on plant physiology and dominance, soil properties and climate. *Journal of biogeography,* 117-134.
3. LMP (1993). Livestock Master Plan. *The livestock Sector, 111*, Asian Development Bank.
4. MoPE (2004). Nepal Initial National Communication to the Conference of the Parties of the United Nations Framework Convention on Climate Change. July, 2004. Kathmandu, Nepal: Ministry of population and Environment.
5. Oli B.N. and Shrestha K. (2009). Carbon Status in Forests of Nepal: An Overview. *Forest and Livelihood*, 8(1), 62-66. https://www.forestaction.org (Accessed 07/01/2018)
6. Sah J.P. (1997). Koshi Tappu Wetland, Nepal's Ramsar Site. IUCN, Bangkok, Thailand, 273.
7. GoN (2008). National Climate Change Policy. Draft policy prepared for discussion by Ministry of Environment, Science and Technology, Government of Nepal.
8. Bhuju U.R., Shakya P.R., Basnet T.B. and Shrestha S. (2007). Nepal Resource Book: Protected Areas, Ramsar Sites and World Heritage Sites. ICIMOD, Minestry of Environment, Science and Technology, in cooperation with United Nations Environment Programme, Regional Office for Asia and the pacific. Kathmandu, Nepal.
9. WMI and IUCN in Coll. With DNPWC, ORNIS Consult (1994). Biodiversity of KTWR and its adjacent areas: Applied database for integrated biodiversity conservation in Nepal.
10. Karki J.B. (2008). Koshi Tappu Ramsar Site: Updates on Ramsar Information Sheet on Wetlands. *The Initiation*, 2(1), 10-16.
11. Siwakoti M. (2006). An overview of floral diversity in terai region of Nepal. *Our nature.,* 4, 83-90.

12. Chettri D.T. and Pal J. (2010). Diversity of Mammals in and around koshi Tappu Wildlife Reserve. *Our Nature*., 8, 254-257.

13. Chettri D.T. (2010). Diversity of herpetofauna in and around Koshi Tappu Wildlife Reserve. *Bibechana,* 6, 15-17.

14. GON M. and DNPWC K. (2009). Koshi Tappu Wildlife Reserve and Buffer Zone Management Plan (2009-2013). Government of Nepal, Ministry of Forests and Soil Conservation Department of National Parks and Wildlife Conservation Koshi Tappu Wildlife Reserve, Kathmandu.

15. BCN (2010). Bird Check List of the Koshi Tappu Wildlife Reserve; Bird Conservation Nepal : Kathmandu, Nepal.

16. CSUWN (2009). Baseline Survey Report, Koshi Tappu Wildlife Reserve; Conservation and Sustainable Use of Wetlands in Nepal, Babar Mahal.: Kathmandu, Nepal.

17. Chettri N., Uddin K., Chaudary S. and Sharma E. (2013). Linking Spatio – Temporal Land Cover Change to Conservation in the Koshi Tappu Wildlife Reserve, Nepal. *Diversity,* 5, 335-351.

18. Agarwal A., Babel M.S. and Maskey S. (2014). Analysis of future precipitation in the Koshi river basin, Nepal. *Journal of hydrology*, 513, 422-434.

19. Bharati L., Gurung P., Maharjan L. and Bhattarai U. (2016). Past and future variability in the hydrological regime of the Koshi Basin, Nepal. *Hydrological Sciences journal,* 61(1), 79-93.

20. ICIMOD and MoFSC (2014). An integrated assessment of the effects of natural and human disturbances on a wetland ecosystem: A retrospective from the Koshi Tappu wildlife Reserve. Nepal: ICIMOD and Ministry of forest and soil Conservation.

21. Uddin K., Murthy M.S.R., Wahid S.M. and Matin M.A. (2016). Estimation of soil erosion dynamics in the Koshi basin using GIS and remote sensing to assess priority areas for conservation. *PloS one*, 11(3), e0150494.

22. Neupane N., Murthy M.S.R., Rasul G., Wahid S., Shrestha A. and Uddin K. (2013). Integrated Biophysical and Socioeconomic s Model for Adaption to Climate Change for Agriculture and Water in the Koshi Basin. In Leal Filho, W. (Ed). *Handbook of Climate Change Adaption*, 1835-1859. Springer Berlin Heidelberg.

23. Lamsal P., Pant K.P., Kumar L. and Atreya K. (2014). Diversity, Uses, and Threats in the Ghodaghodi Lake Complex, a Ramsar Site in Western Lowland Nepal. ISRN Biodiversity, 1-12.

24. Sharma B., Rasul G. and Chettri N. (2015). The Economic Value of Wetland Ecosystem Services: Evidence from Koshi Tappu Wildlife Reserve, Nepal. *Ecosystem Services,* 12, 84-93. https://www.academia.edu.com (Accessed 07/01/2018)

25. Walkley A. and Black I.A. (1934). An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science.,* 37**,** 29-38.

26. Whittaker R.H. (1975). Communities and Ecosystems. New York: Mac Millian Publishing.

27. Maharjan M. (2010). Soil carbon and nutrient status of rangeland in Upper Mustang. *Institute of Forestry, Tribhuvan University, Pokhara, Nepal*. (M.Sc. Thesis).

28. Limbu D.K., Koirala M. and Shang Z. (2013). Total carbon storage in Himalaya rangeland of Milke-Jaljale area, Eastern Nepal. *Journal of Agricultural Science and Technology,* A3, 775-781.

29. Ingram L., Stahl P., Schuman G., Buyer J., Vance G., Anjegunte G. and Derner J.D. (2008). Grazing impacts on soil carbon and microbial communities in a mixed-grass ecosystem. *Soil Science Society of America journal,* 72(4), 939-948.

30. Fissore C., Espelleta J., Nater E.A., Hobbie S.E. and Reich P.B. (2009). Limited potential for terrestrial carbon sequestration to offset fossil-fuel emissions in the Midwestern U.S. *Frontiers in Ecology and the Environment,* 8, 409-413.

31. Schuman G.E., Reeder J.D., Manley J.T., Hart R.H. and Manley W.A. (1999). Impact of grazing management on the carbon and nitrogen balance of a mixed-grass rangeland. *Ecological Applications,* 9, 65-71.

32. Rai N.R. (2013). Activities of patterns of Wildlife Reserve, Nepal; A case study of Kusaha area. M.Sc. Thesis, Tribhuvan University.