INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 14, No. 3, p. 92-99, 2019

RESEARCH PAPER OPEN ACCESS

Soil carbon storage potential in deodar (*Cedrus deodara*) Forest of Kumrat Valley, Pakistan

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Key words: Soil Carbon stock, *Cedrus deodara* forest, Kumrat Valley.

http://dx.doi.org/10.12692/ijb/14.3.92-99 Article published on March 15, 2019

Abstract

Soil carbon stock plays an important role in the global carbon cycle. The study was carried out in Kumrat valley to assess the soil organic carbon potential of *Cedrus deodara* forest along with altitudinal gradient. . The soil organic carbon was analyzed by oxidizable organic carbon. The elevation of the study site ranges from 2360 to 2560 (m). The geographic location of the study site was 35°32' 11.44 N and 72° 13'45.03'E. The stratified random sampling method was used for soil data collection at the depth of 0-15cm and 16-30cm. The results of the study showed that the average soil pH was recorded at 6.04. The mean soil bulk density was recorded 1.03 (g cm^3). The average amount of soil organic carbon stock was recorded 75.45 (t ha^{-1}) at lower elevation while the average amount of soil organic carbon stock was recorded 62.00 (t ha^{-1}) at a higher elevation. Our study showed a decreasing trend of soil carbon with elevation. It's concluded that potential and capability of soil carbon stocks do not only depend on forest types and altitude but other environmental factors (climate, edaphic, topographic and biological etc.) are responsible for determination of soil carbon stock at a different elevation. Further, the necessary steps should be considered to conserve and protect the forest land, rangeland and agriculture land for the enhancement of soil organic carbon.

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Introduction

Soil Carbon stock is the largest Carbon pool in the terrestrial ecosystems. Soil act as largest carbon sink and facilitates carbon sequestration (Saeed *et al.*, 2019). Its store's maximum carbon after trees and plants, a slight change in the Soil carbon stock can have impacts on global carbon cycle (Johnson *et al.*, 2007). The rising temperature and climate change is reinforced by the increasing the carbon dioxide emission from soil (Yang *et al.*, 2010). Monitoring of forest carbon is critical for mitigation of climate change (Ahmad *et al.*, 2018; Mannan *et al.*, 2019; Saeed *et al.*, 2019). The environmental pollution, deforestation, biomass burning, and land cover change enhance greenhouses effect resulting alter the dynamic of Soil Carbon (Mao *et al.*, 2015). Soil carbon is important to both mitigate CO_2 emission and enhance forest stability and production (Lal *et al*, 2004). Soil organic Carbon is sensitive to land cover change. Land use change greatly impacts the soil carbon stock, soil degradation, cropland loss, deforestation and desertification resulting decrease in forest area from 31.6 % to 30.6% globally since 1990 (FAO, 2015). Furthermore, land use change can change soil properties including soil bulk density, Soil PH, Soil carbon and nitrogen content (Houghton *et al.*, 1999; Callesen *et al.*, 2003,). The study area is dominated by national tree (*Cedrus deodara*), distributed at ranges from 2000 to 3000m (Moinuddin *et al.*, 2009). In Pakistan, although different studies have been conducted on carbon stock of subtropical forests (Nizami, 2012; Amir *et al.*, 2018) and Deodar forest (Amir *et al.*, 2015) and in forest plantations (Ahmad *et al.*, 2015, Saeed *et al.*, 2016). But a specified study on assessment of Soil carbon storage potential is not conducted yet. So, the objective of the study shows an approach to quantify soil organic carbon, and signify the relationship of soil parameters with elevation.

Materials and methods

Study area

The present was carried out in Soil of *Cedrus deodara* forest which located in Kumrat valley, Dir upper, KPK, and Pakistan. The elevation of the study site ranges from 2360 to 2560 (m). The geographic location of the study site was 35°32' 11.44 N and 72° 13'45.03'E. The average precipitation of the study area ranges from 700-1500 mm. Temperature ranges from 0.7-30°C. The soil of the study site was rich in humus and organic matter. The soil was loamy in nature (Fig.1).

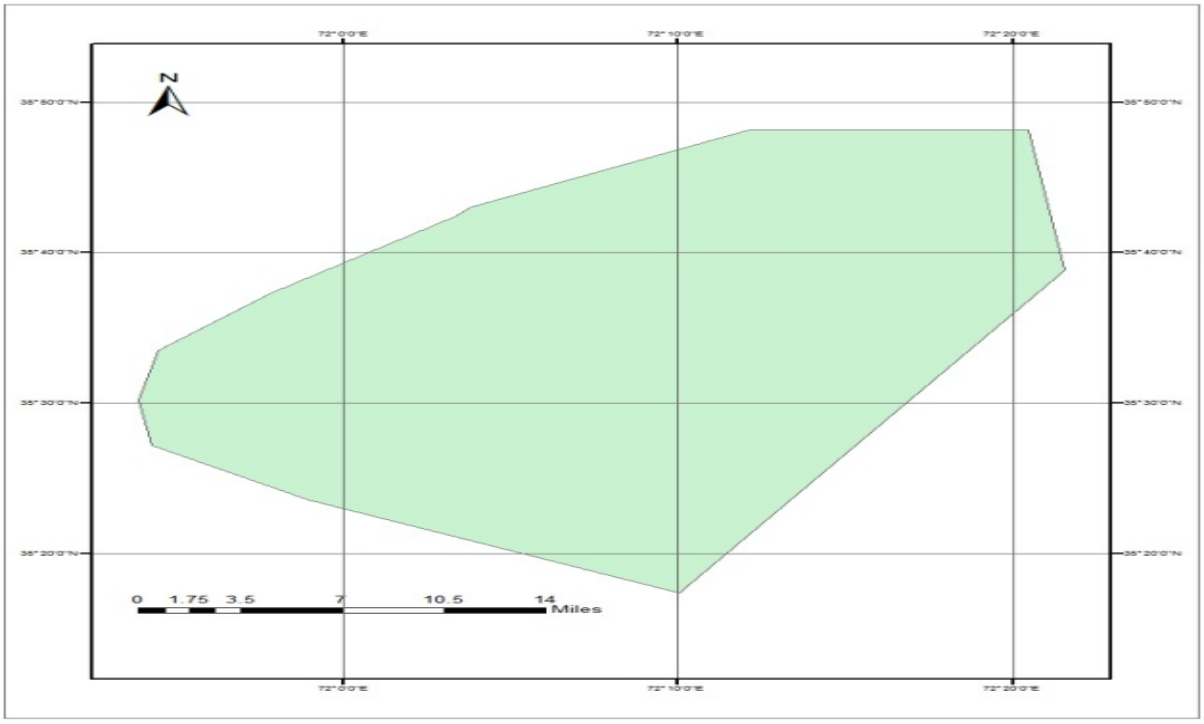

Fig. 1. Range of study area, Kumrat Valley.

Research design

The area maps and topographic sheets were taken from the respective forest department. The soil samples were selected randomly at the depth of 0-15cm and 16-30 cm within different strata of *Cedrus deodara* forest by using Soil core instrument. Coordinates and elevation (m) of each sample area was determined by GPS. The stratified sampling method was used at the different study site. The stratification was done on basis of forest cover of pure *Cedrus deodara* forest (PCDF). Average ten soil samples were taken with total 30 samples replications.

Soil, Bulk density, and Carbon determination

The soil PH was determined by taking air-dried soil (50 g) and distilled water (50 ml) into a glass beaker (500 ml) for titration. Later, reading of Soil PH was recorded by PH Meter (Mc Lean, 1982).

The collected soil samples of *Cedrus deodara* forest were brought to the laboratory to keep it in the oven for 48 hours at 72 °C, and then soil bulk density of samples was determined from the weight of soil sample and volume of soil core (104cm^3). Soil carbon content was measured by Walkley and Black method (Walkley and Black, 1934). Soil carbon (t ha^{-1}) was calculated from the soil organic carbon (SOC %), soil bulk density (g/cm^3) and thickness of horizon (cm). The following equation was used to find out soil carbon (Adnan *et al.*, 2014; Amir *et al.*, 2018).

$$SOC\ (t\ ha^{-1}) = SOC\ (\%) \times SBD\ (g\ cm^3) \times TH\ (cm) \times 100$$

Where, SOC = Soil Organic Carbon, SOC= Soil Organic Content, SBD= Soil Bulk Density and TH=Thickness of Horizon.

Statistical analysis

The software (Sigma plot, statistic etc.) were used for statistical analysis. Mean Standard deviation, CV%, and Standard error were calculated. Regression models were developed in order to study the relationship between soil organic carbon and elevation.

Result and discussion

Soil PH

The average soil pH (0-30 cm) was 6.04 which showed the acidity in nature. The minimum soil pH of the *Cedrus deodara* forest land was recorded 5.835 at 7892 ft. elevation while the maximum soil pH was recorded 6.22 at 8093 ft. elevation near the forest land was 4.85.

In order to know the relationship between soil pH and Elevation and Soil PH values, the regression model was developed as shown in Fig. 2.

The relation of soil pH and elevation is polynomial quadratic. The value of R^2 was 0.14 showed that weak relation between elevation and soil PH. The results of Soil PH at each site are given in Table 1.

Table 1. Soil pH values at an elevation.

Elevation (m)	Latitude	Longitude	pH (0-15cm)	pH (15-30cm)	Average pH (0-30cm)
2360	35°31'.56"N	72°13'.38"E	5.91	6.32	6.11
2383	35°31'.76"N	72°14'.14"E	5.93	6.48	6.20
2405	35°31'.54"N	72°13'.31"E	5.11	6.56	5.83
2425	33°31'.56"N	72°13'.35"E	5.7	6.15	5.92
2467	35°31'.80"N	72°14'.19"E	5.78	6.66	6.22
2500	35°31'.87"N	72°14'.14"E	5.4	6.37	5.88
2528	35°31'.90"N	71°24'.16"E	5.27	6.69	5.98
2528	35°32'.88"N	72°09'.17"E	5.3	6.66	5.98
2543	35°39'.1"N	72°14'.16"E	5.91	6.5	6.20
2560	35°32'.98"N	72°14'.22"E	5.6	6.61	6.10

Table 2. Soil bulk density at the depth of 0-15cm, 16-30cm and 0-30 cm with elevation.

Elevation (m)	Weight (g) (0-15cm)	Weight (g) (15-30cm)	Volume (cm^3)	Bulk density (g cm^3) (0-15cm)	Bulk density (g cm^3) (15-30cm)	Average Bulk density (g cm^3) (0-30cm)
2360	107	112	104	1.02	1.07	1.05
2383	112	105	104	1.07	1.00	1.04
2405	101	106	104	0.97	1.01	0.99
2425	110	115	104	1.05	1.10	1.08
2467	100	110	104	0.96	1.05	1.00
2500	95	114	104	0.91	1.09	1.00
2528	107	121	104	1.02	1.16	1.09
2528	102	105	104	0.98	1.00	0.99
2543	104	109	104	1	1.04	1.02
2560	100	118	104	0.96	1.13	1.04

The Soil PH may vary with the altitude, aspects and soil depth. The interaction of soil PH values with aspects, altitude, and soil depth were found significantly different. The reduction in pH value at a different site depends upon accumulation and slow decomposition of organic matter, which releases acids (Qasba *et al.*, 2017). Previous studies showed that forest litter could change the soil PH value, increase acidity for coniferous species and decrease acidity for deciduous and herbaceous species (Xu *et al.*, 2006; Sariyildiz *et al.*, 2015;).

Table 3. Soil organic matter and carbon of *Cedrus deodara* forest with elevation.

Elevation (m)	Soil organic matter % (0-15cm)	Soil organic matter % (15-30cm)	Total soil organic matter %	Soil Organic Carbon (t ha^{-1})
2360	2.68	1.14	3.82	69.9
2383	3.36	0.94	4.3	78.06
2405	3.52	1.25	4.77	82.60
2425	3.14	0.98	4.12	77.55
2467	2.74	1.19	3.93	69.04
2500	3.02	0.78	3.8	66.44
2528	2.14	0.98	3.12	59.51
2528	0.88	1.83	2.71	46.93
2543	2.8	1.1	3.9	69.49
2560	2.2	1.51	3.71	67.66

Soil Bulk density

The soil particles were assessed in each study site. The average soil bulk density ranged from 1.03 (g cm^3). The minimum average soil bulk density was recorded 0.99(g cm^3) while maximum soil bulk density was recorded 1.01(g cm^3). The details of soil bulk density at the depth of 0-15cm and 16-30cm is given in Table 2. In order to find out the relationship between soil bulk density and elevation, the regression model was developed. The relationship between soil bulk density and elevation is polynomial quadratic. The value of R^2 was 0.06 showed positive correlations as shown in Fig. 3.The present findings of the study showed variation in soil bulk density with respect to elevation while previous studies confirmed that soil bulk density was higher at a lower altitude as compared to higher altitude (Kidanemariam *et al.*, 2015, Sevgi, 2003). The current result showed variation may be due to an aspect, soil depth and climatic condition.

Soil organic carbon

For the determination, the Soil organic carbon, the soil organic matter (SOM) was calculated by Walkley and Black method in the laboratory. The average total Soil Organic matter was recorded 3.81%. A regression model was developed for the relation of soil organic matter and elevation. The relation between soil organic matter and elevation was negative.

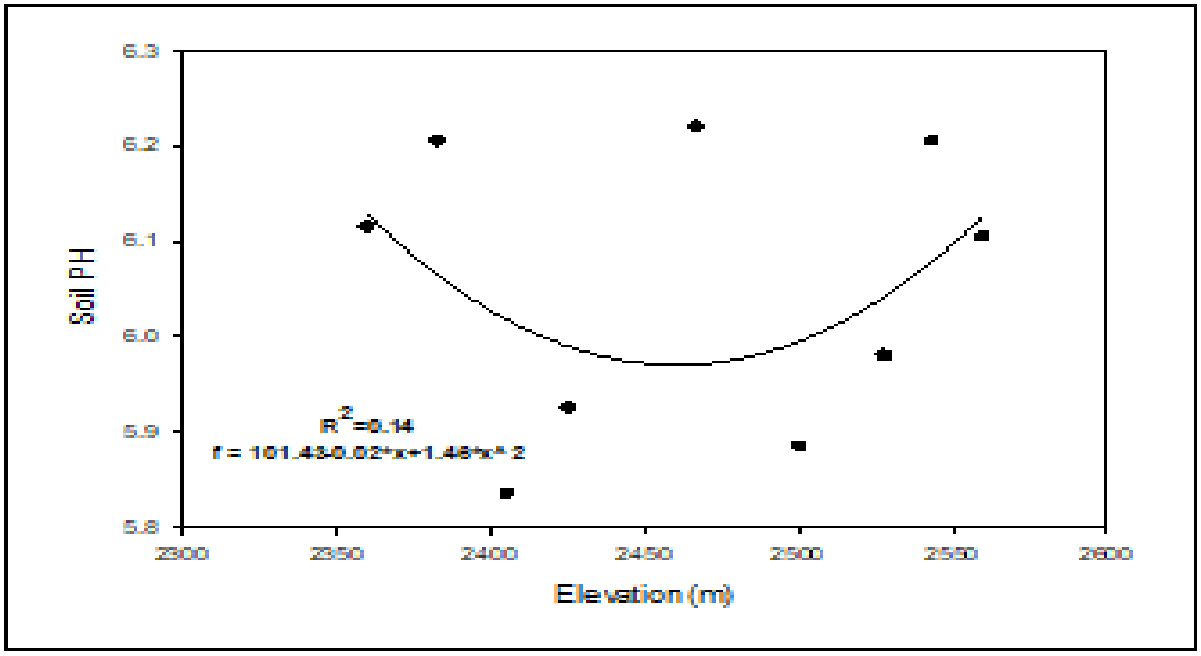

Fig. 2. Regression between Elevation and Soil PH.

The value of R^2 was 0.39 shown in Fig. 4. The results of the present study show that the average soil organic carbon soil of *Cedrus deodara* forest land hold 68.73 (t ha^{-1}) at average 2470 (m) elevation. The regression model was developed to better understand the relationship between soil organic carbon and elevation as shown in Fig. 5. The relation is poly nominal quadratic. The value of R^2 was 0.40.

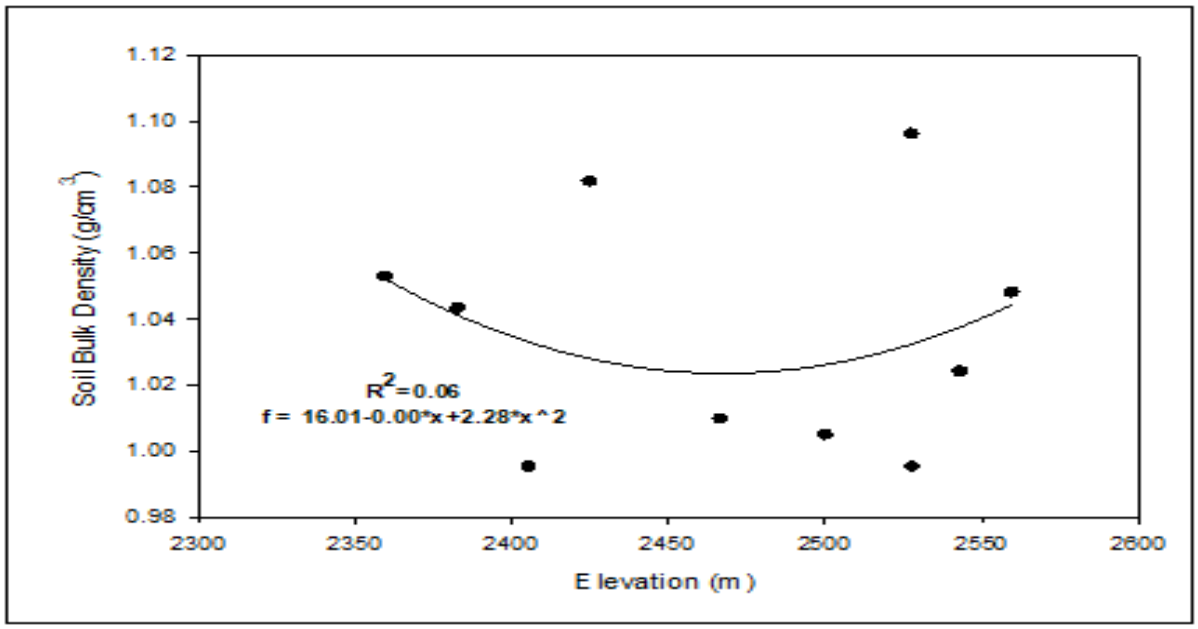

Fig. 3. Regression between Elevation and Soil Bulk density.

The average soil organic carbon was recorded 75.45(t ha^{-1}) at lower elevation while 62.00(t ha^{-1}) was recorded at higher elevation as shown in Table 3. The soil organic matter percentage is decreasing with increase in altitude. It may be due to less amount of organic material available for the plant to survive with low temperature at higher altitude (Bromley, 1995).

The present result showed a negative correlation between organic matter content with altitude. Some

previous studies reported the effects of soil organic matter contents along an elevation gradient, soil organic matter decrease with the increase in elevation (Panthi, 2010). Similarly, the soil carbon also decreases with the increase in elevation gradient, May due to change in climatic condition and accumulation of organic matter.

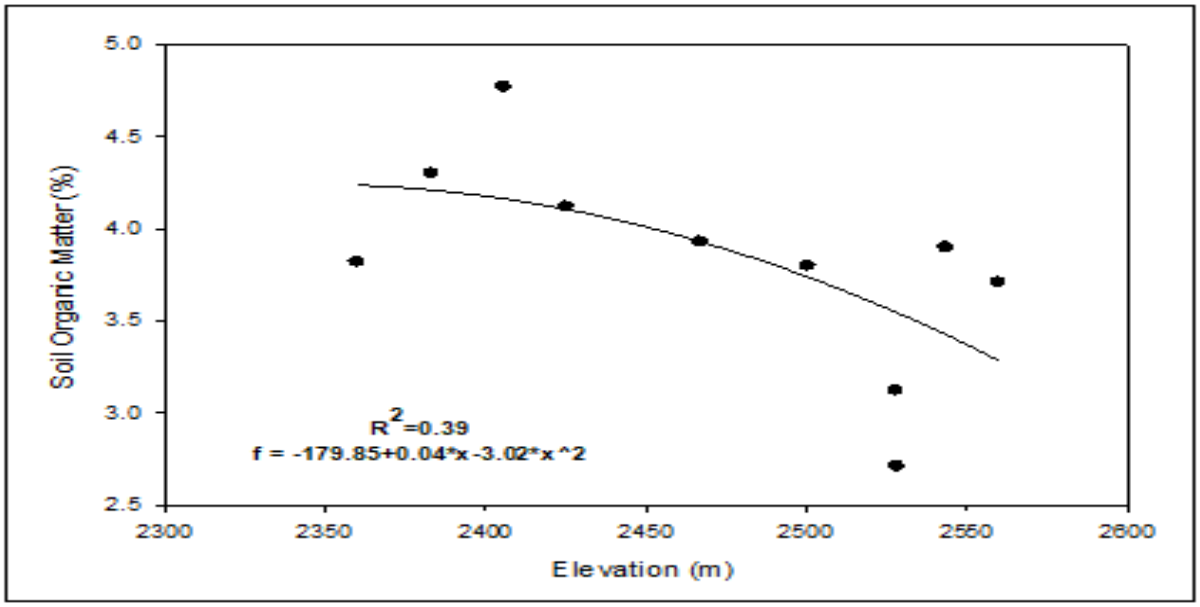

Fig. 4. Regression between Elevation and Soil organic matter.

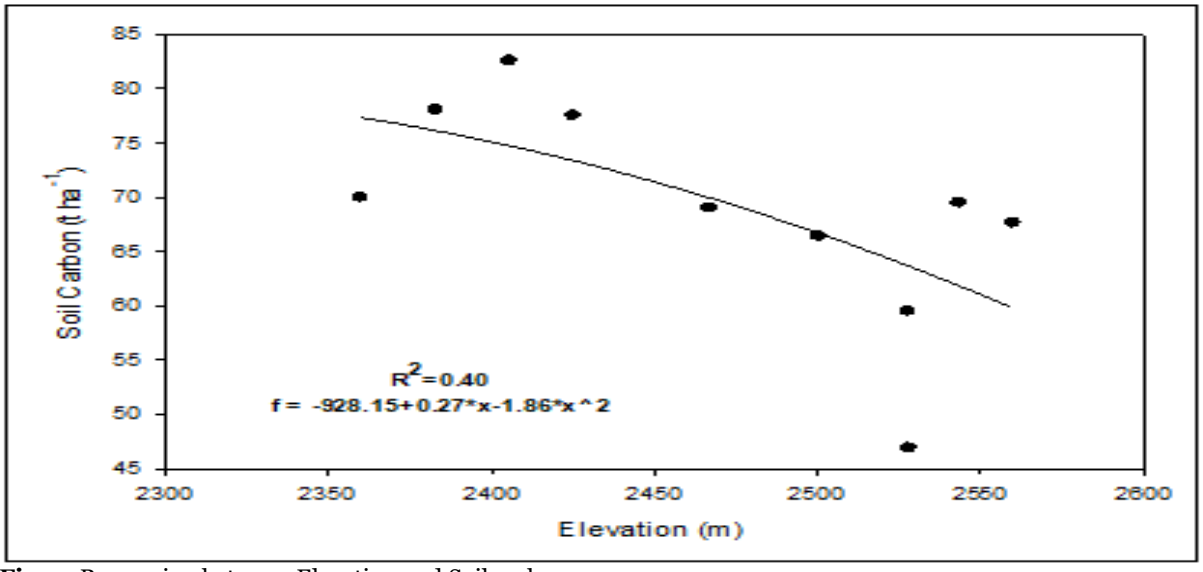

Fig. 5. Regression between Elevation and Soil carbon.

Conclusion

The study concluded that the average Soil carbon stock potential of *Cedrus deodara* forest in Kumrat valley was recorded 68.73 (t ha^{-1}). The soil is the second highest carbon sink after trees. So, further studies should be conducted to examine the capability of soil carbon and confirm future prediction in different forest types. Moreover, the areas were founded remote and due to raising severe human disturbance and livestock population, the area was affected harshly. So, the forest department is directed to raise awareness of local people and give special attention to this new raising problem.

Acknowledgment

The research was supported by the Beijing Forestry

University Innovation Program Project (BLRW200939). More ever, the authors would like to thank Department of forestry, Shaheed Benazir Bhutto University, Sheringal, Dir Upper, KPK, Pakistan for providing equipment's and facilities.

References

Ahmad A, Amir M, Mannan A, Saeed S, Shah S, Ullah S, Liu Q. 2018. The Carbon Sinks and Mitigation Potential of Deodar (Cedrus deodara) Forest Ecosystem at Different Altitude in Kumrat Valley, Pakistan. Open Journal of Forestry **8(04),** 553.

Ahmad A, Nizami SM. 2015. Carbon stocks of different land uses in the Kumrat valley, Hindu Kush Region of Pakistan Journal for Research **26,** 57–64.

Amir M, Khan A, Ahmad A, Khan A. 2015. Carbon Stocks of Pure Cedrus Deodara Forest in Kumrat Valley, Dir Upper, KPK, Pakistan. International Journal of Scientific & Engineering Research **6(4),** 1146.

Amir M, Liu X, Ahmad A, Saeed S, Mannan A, and Muneer M. 2018. Patterns of Biomass and Carbon Allocation across Chronosequence of Chir Pine (Pinus roxburghii) Forest in Pakistan: Inventory-Based Estimate. Advances in Meteorology, Article ID 3095891, 8 pages.
https://doi.org/10.1155/2018/3095891

Bromley P. 1995. The effect of elevation Gain on soil. Environmental studies, p 102.

Callesen I, Liski J, Raulund-Rasmussen K, Olsson M, Tau-Strand L, Vesterdal L, Westman C. 2003. Soil carbon stores in Nordic well drained forest soils—relationships with climate and texture class. Glob. Change Biology **9,** 358-370.

FAO. 2015. Global Forest Resources Assessment. – FAO, Rome.

Houghton R, Hackler J, Lawrence K. 1999. The US carbon budget: contributions from land-use change. Science **285,** 574.

Johnson DW, Todd DE, Trettin CF, Sedinger JS. 2007. Soil carbon and nitrogen changes in forests of walker branch watershed, 1972 to 2004. Soil Science Society of America Journal **71,** 1639–1646.

Kidanemariam A, Gebrekidan H, Mamo T, Kibret K. 2012. Impact of Altitude and Land Use Type on Some Physical and Chemical Properties of Acidic Soils in Tsegede Highlands, Northern Ethiopia. Open Journal of Soil Science **2,** 223-233.

Kidanemariam A, Gebrekidan H, Mamo T, Kibret K. 2012. Impact of Altitude and Land Use Type on Some Physical and Chemical Properties of Acidic Soils in Tsegede Highlands, Northern Ethiopia. Open Journal of Soil Science **2,** 223-233.

Lal R. 2004. Soil carbon sequestration impacts on global climate change and food security Science **304,** 1623–1627.

Mannan A, Liu J, Zhongke F, Khan TU, Mukete B, ChaoYong S, Amir M. 2019. Application of land-use/land cover changes in monitoring and projecting forest biomass carbon loss in Pakistan. Global Ecology and Conservation, e00535.
https://doi.org/10.1016/j.gecco.2019.e00535

Mao DH, Wang ZM, Li L, Miao ZH, Ma WH, Song CC, Ren CY, Jia MM. 2015. Soil organic carbon in the Sanjiang Plain of China: Storage, distribution and controlling factors. Biogeosciences **12,** 1635–1645.

McLean EO. 1982. Soil pH and lime requirement. Methods of soil analysis. Part 2. Chemical and microbiological properties, (methodsofsoilan2), 199-224.

Moinuddin A, Wahab M, Khan N, Siddiqui MF, Khan MU, Hussain ST. 2009. Age and

Growth Rates of Some Gymnosperms of Pakistan: A Dendrochronological Approach. Pakistan Journal of Botany **41,** 849-860.

Nizami SM. 2012. The inventory of the carbon stocks in sub tropical forests of Pakistan for reporting under Kyoto Protocol Journal for Research **23,** 377–384.

Panthi J. 2010. Altitudinal Variation of Soil Fertility: A Case Study From Langtang National Park. M.Sc thesis. Central Department of Environmental Science Tribhuvan University Kathmandu, Nepal.

Qasba S, Masoodi TH, Bhat SJA, Paray PA, Bhat A, Khanday M. 2017. Effect of Altitude and Aspect on Soil Physico-Chemical Characteristics in Shankaracharya Reserved Forest, International Journal of Pure & Applied Bioscience **5(1),** 585-596. http://dx.doi.org/10.18782/2320-7051.2650.

Saeed S, Ashraf MI, Ahmad A, Rahman Z. 2016. The Bela forest ecosystem of District Jhelum, a potential carbon sink. Pakistan Journal of Botany **48,** 121-129.

Saeed S, Sun Y, Beckline M, Chen L, Lai Z, Mannan A. 2019. Altitudinal Gradients and Forest Edge Effect on Soil Organic Carbon In Chinese Fir (Cunninghamia Lanceolata): A Study From Southeastern China. Applied Ecology and Environmental Research **17(1),** 745-757.

Saeed S, Yujun S, Beckline M, Chen L, Zhang B, Ahmad A. 2019. Forest edge effect on biomass carbon along altitudinal gradients in Chinese Fir (*Cunninghamia lanceolata*): A study from Southeastern China. Carbon management, 1-12.

Sariyildiz T, Anderson JM, Kucku M. 2005. Effects of tree species and topography on soil chemistry, litter quality and decomposition in northeast Turkey. Soil Biology and Biochemistry **37,** 1695-1706.

Sevgi O. 2003. Altitudinal Nutrition Growth Relations of Black Pine (Pinus nigra Arnold) at Bayramic Forest Enterprise (Kaz mountains). Doctorate Thesis at University of Istanbul Science Institute.

Walkley A, Black IA. 1934. An Examination of Degtjareff Method for Determining Soil Organic Matter and a Proposed Modification of the 288 J. Ecol. Nat. Environ. Chromic Acid Titration Method. Soil Science **37,** 29-37.

Xu JM, Tang C, Chen ZL. 2006. The role of plant Residues in pH change of acid soils differing in initial pH. Soil Biology and Biochemistry **38,** 709-719.

Yang YH, Fang JY, Ma WH, Smith P, Mohammat A, Wang SP, Wang W. 2010. Soil carbon stock and its changes in northern China's grasslands from 1980s to 2000s. Global Change Biology **16,** 3036–3047.