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Determination of soil carbon stock in the forest of Lalko valley Swat and its implication for REDD

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Abstract

Soil plays a vital role in mitigation of climate change as it serves as a prospective basin for atmospheric carbon. Every soil profile has its own soil organic carbon content (SOC). Present study was conducted at Lalko Valley district swat. This study focused on three specific objectives. At first SOC was determined at different soil depths. Second objective deals with the estimation of SOC. Third objectives serve the purpose of potential carbon storage in soil in perspective of REDD. Soil samples were taken at (0-15cm, 15-30cm, 30-60cm and 60-100cm) by core sampler. The soil samples were taken from three different plots. We used dry combustion method to asses SOC and hydrometer for soil texture. Reduction in SOC was recorded with increasing soil depth. Core method was used to determine soil bulk density. The recorded SOC indicate dissimilarities in degraded and forest sites.

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Introduction

Forests in the world contribute about 18% of total greenhouse gas (GHGs) emission if they are cleared up or degraded. However, if they are managed properly, then about one-tenth of the global carbon emissions can be sequestered through biomass and soil (FAO 2012). Soil in the biosphere is the largest carbon pool. About 60 percent of the world's terrestrial carbon is covered by the forest vegetation and soil (Winjum *et al.* 1992). Kirschbaum (2000) stated that soil contained about 2400 Gigatons of carbon upto 2m depth. Therefore, carbon sequestration in soil is reliable.

Soil is the biggest carbon store in the biosphere. Soil can seize carbon twice as much as it is present in the atmosphere (Dey 2005). Soil contains carbon about three times more than vegetation. Carbon storage below the ground surface is greater than aboveground surface (Post & Kwon 2008). It is widely accepted that the effects of global warming could be offset by the reduction of carbon (C) emissions and the protection and increase of C stocks worldwide (Solomon *et al.*, 2007).

The forest's ecosystem has the privileged potential to capture and store the carbon (Gibbs *et al.* 2007). The SOC stocks are the crucial baseline for do research on the impact of land use changes and climate change on SOC stocks dynamics, and therefore on soil carbon behavior and soil carbon emission to the atmosphere (Adger and Brown, 1994, Chaplot *et al.*, 2009).

Precise estimates of C stocks and fluxes of soil organic carbon (SOC) are needed to evaluate the impact of climate and land use change on soil carbon uptake and soil carbon emission to the atmosphere. The potential of carbon capturer through forest is diminish by land degradation and defrayal the forest area for agriculture purpose. Hence it is necessary to protect and conserve soil for the sequestration of carbon. Forest can be restored by afforestation and reforestation .Forests restored through community based forest management is considered as one of the flourishing forest management, and efficient reforestation practice in degraded land (*Pokharel et al.* 2005).

REDD mechanism introduced from Bali conference, 2007 might be the potential mitigating tool to address global environmental change. Integrating community forests under this mechanism in developing countries such as Pakistan, Bangladesh Nepal and India might be a good initiative to enhance environmental security (Dahal & Banskota 2009).

Increasing SOC stocks are widely discussed as a short to mid-term implementable solution to the rising atmospheric GHG concentrations, as soils are the largest carbon reservoir of terrestrial carbon cycle (smith. *et al*). Carbon storage in soils is the balance between the input of dead plant material and losses from decomposition and mineralization of organic matter (Parton *et al* 2010).

The Carbon stock estimate gives an idea of the quantity and quality of carbon available in the region as well as how it behaves in the water bodies, where carbon eventually degenerates into greenhouse gas emissions in the atmosphere, causing global warming and climate change impacts. Affect the whole ecosystem in a meaningful way. Appropriate mitigation measures to reduce greenhouse gas emissions were also given.

A number of reports available to estimate land biomass. However, estimates of underground carbon reserves are often not available. Therefore, in this study, we tried to study the soil carbon, its potential, and the benefits of REDD. Specific objectives of the study are:

- To study the soil properties dissemination in different soil depth.
- To measure Organic carbon stock in the soil.
- To assess the prediction of carbon storage in soil, and its implications for REDD

Material and methods

Study area

The Lalko Valley is located at the northern end of the Matta Tehsil of the Swat Valley, at a distance of 55 km from Saidu Sharif, a green and wooded area, covered in alpine pastures and receives heavy snowfalls in the winter season.

The total area of Lalko valley is 15636 (ha) in which the forest area is 8582 (ha). The coniferous forest covers an area of 6257 (ha) and the broad leaved forest covers an estimated area of 381 (ha), the area under conservation is 75 (ha) and the remaining is grazing land. The average minimum temperature in the Lalko valley in December is 4.8°C and the maximum average in July is 33.5°C in the same season. The average annual rainfall is in the range of 800 to 1500mm. The valleys of Lalko receive the maximum precipitation in the form of snow during the winter. The melting of the snow begins in March onwards depending on the elevation of the area (Khan, 2008).

Vegetation

The major species of the area are: Chir *(Pinus roxburghii*, Kail *(Pinus wallichiana),* Phulai *(Acacia modesta),* Sanatha *(Dodonaea viscosa),* Zaitoon *(Olea ferruginea),* Ber *(Zizyphus nummullaria),* Chinar *(Platanus orientallus),* Khurray *(Berberis lyceum)* etc.

Medicinal Plants

Several herbal medicine e.g. banafsha (*viola serpens*), Mushk-bala (*valeriana wallichii*), tarkha (*Artemisia spp*) are collected by the local people and sold to local shopkeepers.

Soil sampling, analysis and calculation

The soil sample was collected in March 2018. Three sample of plots (size = 20m × 25m) were randomly selected from each forest. A fundamental sample size of 5cm in diameter and 6cm in height was used for bulk density. The samples were taken from the four depths of the soil (0-15cm, 15-30cm, 30-60cm and 60-100cm). By taking the soil sample from different depths up to 1m, in some cases, bottom rock was found between 30 and 60cm and 60-100cm. In cases, the sample was not collected beyond the rock. The dry combustion method was used to determine the organic carbon of the soil (Nelson and Sommers, 1982). Similarly, the hydrometer method was used to determine soil texture (Wairiu and Lal 2003). Also, the central method was used to determine the apparent density (Blake and Hartge, 1986).

Based on the parameter, the soil depth (sample taken) the soil density in depth, and the organic carbon content in depth, carbon stock was calculated in the soil. The total carbon stock was obtained at a depth of one meter by adding stocks at a synchronous depth. Then, according to the unitary method, the stock was estimated per hectare with its reflection in the entire forest area.

Organic carbon stocks in soil were calculated using the following equation (Wairiu & Lal 2003):

Soil carbon stock (Kg/m2) = Total density (Kg/m3) x SOC content% x Depth of horizon (m) x CFst.

Where CFst is the correction factor, for stone content and gravel in soil. CFst = -1 (% stone +% gravel) / 100

Because of the interrelationship between plant communities and soil characteristics, the samples will be taken from a depth of 0-30 cm (under the organic layer). Soil properties, including soil texture, pH, soluble calcium, magnesium, total nitrogen, phosphorus, soluble sodium, and potassium were measured. The above properties were measured respectively by hydrometer method, pH scale, soluble EDTA method, Kjeldahl method, Olseon method and flame photometer.

The details of the method to assess the SOC Walkley and Black method are appropriate to calculate SOC of the terrestrial biosphere due to the high recovery rates, low cost and need of less time (Kumar *et al.*, 2014). Recently, the IRS has been applied to measure numerous soil properties, including OC content and composition in bulk soils and soil fractions because it is fast, economical, non-destructive and requires little or no pretreatment of the sample (Janik *et al.* 2007). The data were analyzed using Excel 2007 and the software Sigma plot 11. Descriptive statistics (mean, standard deviation) and tools such as the Pearson correlation, one-way ANOVA was used to evaluate the data.

Results and discussion

Soil description

In the North side rocks are mostly igneous; soils are gravely to stony sandy loam and gravely sandy clay loam. In the south, the rocks are generally metamorphic; soils are mainly sandy clay and sandy loam. In the center transition belt soils are much less gravely such as in the north and their texture is clayey or loamy. The texture of the soil together with the mineral density of the soil (clay, silt and sand), the organic matter of the soil and the arrangement of the particles determine the bulk density of the soil. Comparison of SOC content with soil bulk density in Bar Lalko, Kuz Lalko, Landai and Gharai did not show any significant differences

Bulk Density

The bulk density increases significantly with the depth of the soil. In the lower surface layer of the soil, there are usually less pores than the upper surface. It is likely due to soil organic matter, where aggregation and root infiltration decrease as soil depth increases and, therefore, density increases (Davidson and Ackerman 1993, USDA 2008). Low porosity organic soil, and poor organic matter containing soil are characterized by high bulk density. Therefore, sandy soil is characterized by relatively large density of clay soil and soils. Silt and clay, clay soil has high porosity, finer texture and low density. The deep distribution of soil parameters may explain this trend in observable density observed with soil depth. The cultivated land has a higher bulk density due to lower organic matter and vice versa with forest land. It may be due to SOC loss during natural forest conversion. This shift in forestland to cultivated land also changes the physical and chemical properties of soils (Kizilkaya & Dengiz 2010).

Table No1. Properties of soil of the study area.

Lalko Valley	Forest Sites	SOC (%)	Bulk Density (gm/cc)	Gravel Content (cc)	Soil Texture	SOC Kg/ha
Bar Lalko	site 1	1.73	1.21	33.41	Sandy loam	31399.5
	site 2	2.01	1.14	16.32	Silty loam	68742
	site 3	1.78	1.11	32.42	Sandy loam	118548
	site 4	1.34	1.08	26.11	Silty loam	130248
Kuz Lalko	site 1	1.51	1.37	20.26	Silty loam	31030.5
	site 2	1.73	1.33	22.24	Sandy loam	69027
	site 3	1.64	1.32	21.51	Silty loam	129888
	site 4	1.26	1.23	20.04	Clay loam	139482
Landhai	site 1	1.62	1.43	8.71	Silty loam	34749
	site 2	1.73	1.39	6.11	Silty clay	72141
	site 3	1.59	1.33	2.14	Clay loam	126882
	site 4	1.43	1.27	7.33	Silty clay	163449
Gharai	site 1	1.87	1.38	5.22	Clay loam	38709
	site 2	2.02	1.37	13.41	Sandy clay	83022
	site 3	1.78	1.34	11.43	Silty loam	143112
	site 4	1.36	1.27	7.21	Clay loam	155448

Site 1 is from (0-15cm), Site 2 (15-30cm), Site 3(30-60 cm) site 4 (60 to 90cm)

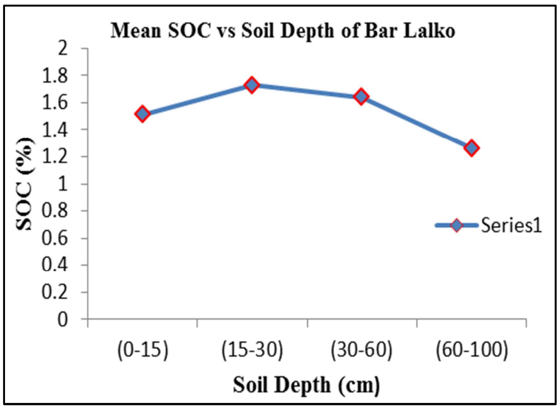
SOC Kg/ha= SOC*BD*SSD*1000

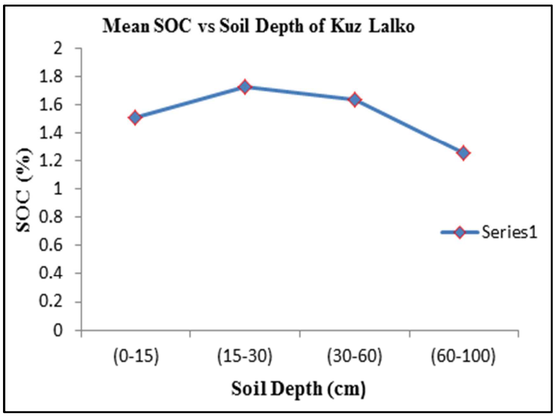
SOC: Soil organic carbon, BD: Bulk Density, SSD: Soil sample Depth.

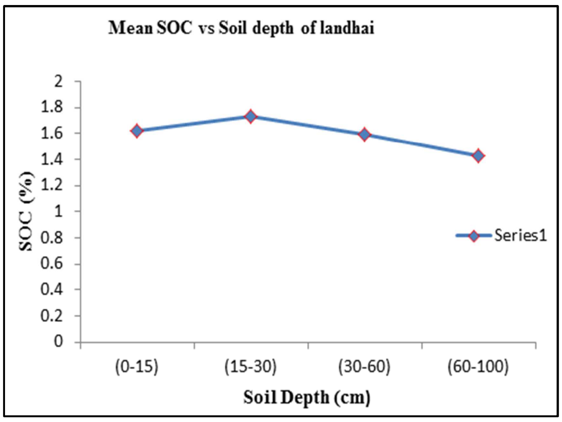
Soil organic carbon

A gradual decrease in SOC was observed with depth (Table 1). The physical and chemical properties of SOC are stabilized in the ground. Climate and vegetation are highly correlated with depth. SOC content under the surface can be more stable and contribute to carbon sequestration. Similarly, high steep slopes also reduce carbon content (Oste *et al.* 2005).

There are shallow soils with scattered plants and heavy rainfall. The top soil is eroded, causing loss of organic matter. Alongside the decline, the sit aula also referred to SOC's relationship to the aspect, nutrient stock, soil loss and altitude, etc. Although soil characteristics and other topographic features have an impact on soil carbon and total stocks, improved land use management reveals significant carbon storage capacity. Good forest management indicates that there is a thick crown cover, leading to a rise in SOC content in the surface layer of degraded sites (Sitaula *et al.*, 2005).







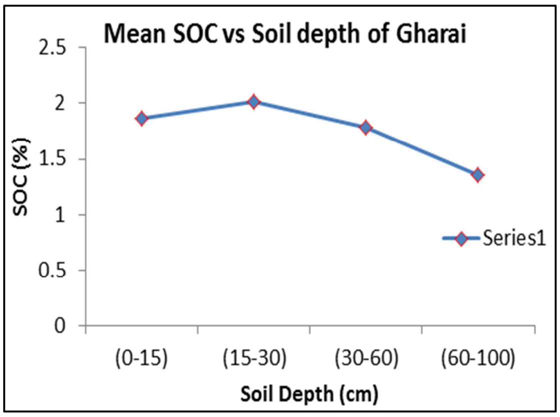


Fig. 1. Variation in SOC with soil depth in the forest of Lalko Valley.

Table 2. Differences in soil carbon stock (top soil 0-15cm).

Soil Organic Carbon (percent) in 0-15 cm depth					
		Forests	Degraded sites	Difference	gm/Tone
Bar Lalko	Site 1	1.79	0.51	1.28	12800
	Site 2	2.01	0.70	1.31	13100
	Site 3	1.68	0.34	1.34	13400
Average		1.82	0.51	1.31	13100
Kuz Lalko	Site 1	1.72	0.45	1.27	12700
	Site 2	1.97	0.56	1.41	14100
	Site 3	1.59	0.32	1.27	12700
Average		1.76	0.44	1.31	13100
Landhai	Site 1	1.77	0.44	1.33	13300
	Site 2	1.93	0.49	1.44	14400
	Site 3	1.63	0.31	1.32	13200
Average		1.77	0.41	1.36	13600
Gharai	Site 1	1.77	0.66	1.11	11100
	Site 2	2.03	0.59	1.44	14400
	Site 3	1.66	0.24	1.42	14200
Average		1.82	0.49	1.32	13200

The advantage of carbon sequestration by forest is being possible option for mitigating the global climate change. The table 2 shows that forest area can sequester more carbon than the degraded land. This table shows us the difference of soil organic carbon in forested land and degraded land, so by planting more trees we can reduce the carbon. If this land could be managed in for better land use, then significant carbon could be sequestered with additional economic benefits under REDD. There can be three best scenarios as discussed by Karky & Skutsch (2010) for the forest conservation. The first is protection for the fulfillment of subsistence needs such as timber, fuel wood, fodder, etc. The second is protection for subsistence needs including the carbon value. The carbon value could be called the revenue of the forest conservation and protection. The third scenario is only for the carbon value (exclude the use of forest resources).

Table 3. Soil Physiochemical properties of Lalko valley Swat.

	Plots	pH	Total Nitrogen (mg/kg)	Phosphorus (mg/kg)	Sodium (ppm)	Calcium (ppm)	Potassium (ppm)
Bar Lalko	Site 1	6.24	5.45	4.33	26	32	104
	Site 2	6.41	5.01	6.71	24	29	98
	Site 3	6.69	4.87	5.24	23	26	84
	Site 4	7.44	4.62	3.09	22	25	75
Kuz Lalko	Site 1	6.02	5.68	4.65	26	31	106
	Site 2	6.39	5.63	6.23	25	28	102
	Site 3	6.88	5.22	5.35	24	26	97
	Site 4	7.21	4.77	4.01	24	24	83
Gharai Lalko	Site 1	6.01	5.88	4.38	25	32	107
	Site 2	6.34	5.65	5.09	24	29	101
	Site 3	6.79	5.23	5.01	23	28	87
	Site 4	7.01	5.02	4.88	22	26	76
Landai Lalko	Site 1	6.03	5.55	4.78	27	28	105
	Site 2	6.45	5.32	4.99	26	27	97
	Site 3	6.87	5.21	5.02	25	27	90
	Site 4	7.13	4.99	4.87	24	25	88

Conclusion

Soil bulk density and soil SOC content are reduced by soil depth despite vegetation and texture. The similarity in SOC content and bulk density with different gravel content in forest soils affects carbon uptake. In the same way, the presence of more than one type of dominant tree in the forest affects the sequestration of carbon. More carbon can be isolated from the improved location of degraded forests. The cost of the improvement can be obtained from the economic benefits of carbon through the reduction of emissions derived from deforestation and forest degradation (REDD). Improved soil characteristics through silviculture, contribute to the benefits of environmental services, such as carbon sequestration, that help mitigate global environmental change. Among the different ways, the IRS and the Walkley and Black method were found as the best way to calculate SOC because of high carbon recovery, low cost and less time required. The estimation of carbon stocks in forests by satellite may be more beneficial in the future.

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