ESTIMATION OF SOIL ORGANIC CARBON STOCKS UNDER DIFFERENT LAND USES TO MITIGATE CLIMATE CHANGE

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ABSTRACT

This research paper reviews current knowledge on changes in soil organic carbon stocks under different land use in Bewar Block of Mainpuri District, Uttar Pradesh, India. Soil organic carbon (SOC) is prone to changes in land use and climate. It's role is significant in the climate change because small modifications in the soil carbon status may have diverse effect on the global carbon balance hence on climate change. Changes in land use are the second source of Green house gases emissions to the atmosphere after fossil fuel burning. Understanding soil organic carbon (SOC) status and projection of its future condition is essential for future CO_2 *emission estimates and management options for storing carbon. So, for a better understanding of the SOC dynamics and its driving factors, we collected data of the Bewar, U.P. India and conducted the digital soil mapping. Firstly, we briefly characterize the Bewar block in different land uses using Remote Sensing technology with the help of ARC GIS software via making LULC characterization in order to know the variety of land uses in the study area. After that laboratory analysis is performed to detect the SOC status along with its TOC stocks, physical and chemical parameters. In this study, we analyzed topsoil samples (0–15 cm) depth and (15-30 cm) depth from 12 locations which were taken in post-monsoon (Nov-Dec) and pre-monsoon season (Apr-May). SOC, Ph, EC. soil bulk density, its structure and porosity were measured to estimate SOC stocks. The results showed that obtained SOC values are below 1% in both the seasons. There is inherently wide spatial variability in SOC contents in Bewar Block with low SOC concentration levels located in Mainpuri District. The mean SOC stock in the Bewar topsoil layer was 151.344 tC* $ha^{-}1$ *in post-monsoon season and 145.848 tC* ha^{-1} *in pre- monsoon season. It is all over that land use is that the main drivers for SOC changes during this space which affects the climate change. SOC loss was exceptional underneath the land use conversion whereas cropland has goodly potential to sequester SOC. Bound changes in agricultural practises (conservation tillage) or changing some unproductive croplands into grasslands or forestlands will increase carbon sequestration in soils.*

Keyword: - *Soil Carbon Stocks, SOC, TOC stocks, LULC characterization.,*

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1. INTRODUCTION

Soils are the largest store of terrestrial carbon on Earth. Globally, soils hold at least two trillion tonnes of organic carbon, around three times as much as the atmosphere, But due to agriculture, the world's soils have lost 116 billion tons of organic carbon or roughly a fourth of all carbon emitted by humans since the Industrial Revolution. That means more carbon in the atmosphere, less productive soil for crops to grow in, and reduced ability for soil to retain water. The recent historical Paris Agreement (COP21, 2015) aims to limit global warming to well below 2 °C, ideally below 1.5 °C. In order to achieve this, emissions reductions need to be accompanied by mitigation activities. A relatively small increase in the soil organic carbon stocks in the topsoil would significantly reduce the

CO_2 concentration in the atmosphere, hence, can limit the climate change. The goal of 4 per 1000 carbon sequestration in soils was presented as a way to reduce CO_2 emissions by increasing global soil carbon (C) stocks by 0.4% per year [1].

Land cover and land use change has a very prominent effect on soil carbon stock and its spread in ecosystem, and therefore plays a vital role in relation to global carbon dynamics [2]. In order to know the land use variations digital soil mapping is one of the best method, it examine the spatial variation of soil information with diverse data and statistical techniques. Digital mapping of SOC has been conducted by extraction the soil-environment relationship with varieties such as topography, vegetation indices, climate, land use, soil types). Remote sensing plays an important role in soil carbon stock study because this technology can be applied in different conditions and different types of soil. It can provide valuable information of soil carbon status, considering soil color, the soil having darker having high soil carbon stock and the soil having lighter in color having less carbon stock.

1.1 Soil Organic Carbon(SOC)

Soil organic C (SOC) comprises of the remains of plants and animals. As a component of soil organic matter (45–60%), SOC is a heterogeneous mixture of organic materials including fresh litter, carbohydrates, and simple sugars, complex organic compounds, some inert materials, and pyrogenic compounds. The SOC is a highly reactive component, and is the basis of numerous pedogenic processes. Because of a high surface area and charge density, it reacts with clay and minerals to form organo–mineral complexes [3].

1.2 Dynamics and need of Soil Carbon Pool

It can have a strong impact on atmospheric chemistry and the global C cycle (Lal 2004). For example, if it were possible to increase soil C pool globally by 4% to 3-m depth, it would cause a drawdown of atmospheric CO_2-C by 240 Pg, the amount equivalent to the reduction of >100 ppmv of CO_2. However, the logistics of achieving such an increase even over a decadal scale are insurmountable at the present level of scientific advances [3].

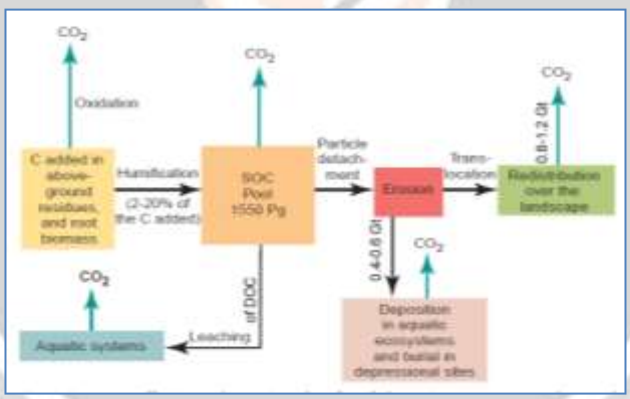

Fig-1: Processes affecting soil organic carbon (SOC) dynamics. Arrows pointed upward indicate emissions of CO_2 into the atmosphere.

Quantity, quality, and dynamics of SOC are critical to soil health (Lal 2014). Threshold level of SOC in the root zone is 1.5–2.0%. Maintenance of SOC pool at above the threshold/critical level is essential to:

1. Soil structure and aggregation which govern soil tilth and aeration.
2. Water retention and use efficiency which control tolerance to drought, heat wave, and abrupt climate change.
3. Nutrient retention and use efficiency which moderate nonpoint source pollution, water quality, and toxic algal blooms.
4. Rhizospheric processes which influence elemental transformations and creation of disease-suppressive soils.
5. Gaseous emissions (e.g., CO_2, CH_4, N_2O) which moderate atmospheric chemistry and regulate climate change. Above all, numerous soil-related constraints to agronomic productivity can also be alleviated through enhancement and sustainable management of the SOC pool.
6. To maintain the soil quality, its heath.

2. MATERIALS AND METHODS

2.1 Description of Study Area

The study area is taken as "Bewar Block" of Mainpuri district, Uttar Pradesh. It is located between latitude of 27.22^0 N to longitude of 79.29^0 E. it is located in the Mainpuri district of state Uttar Pradesh, India. Mainpuri district is one of the districts in Agra division of Uttar Pradesh state of India. It is bounded on the North by Etah District, on the East by District Farrukkhabad and Kannauj, on the South by District Etawah and on West by the District Firozabad and Etah. The district has a population density of 670 inhabitants per square kilometre (1,700/sq m). its agro-climatic conditions are Semi-arid, with maximum temperature 45.6°C and minimum 7.4°C, Rainfall 620-750 mm, Alluvial soil originated from Ganges and its tributaries. Soil of the study area is Loam and Sandy loam Soil with ph less than 8.0, Sandy Loam and Saline Soil with pH more than 8.5, Irrigated through Borewells and Sandy - Loam Soil with pH 8-9, with very low water table.

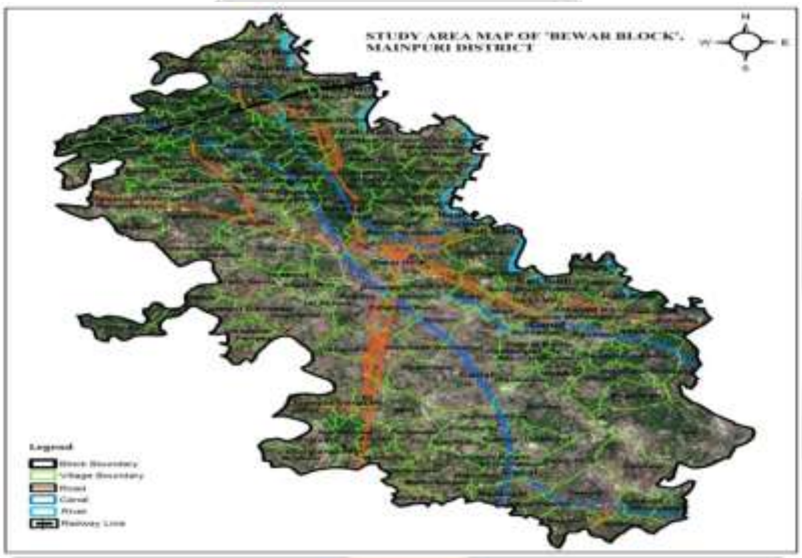

Fig-2: Map of Bewar block, UP, India

2.2 Data acquisition and collection

A high spatial resolution sentinel image (2020) will be obtained from U.S. Geological Survey (USGS earth explorer) for the study. The spectral characteristics of the Sentinel satellite data are shown in below-

- Satellite IRS-P6
- Satellite Operator ISRO
- Sensor sentinal
- Data Type Optical
- Sensor Type Multispectral
- Spatial Resolution [m] 10

Ancillary data include ground reference data (often called ground truth data) collected from actual ground surveys collected independently. A global positioning system (GPS) was used to verify the ground truth information collected during the field work in 2020 and recorded. After that the images were classified by performing dizitation technique in order to classify area in various land use such as: cropland, wasteland, agro-forestry and forests.

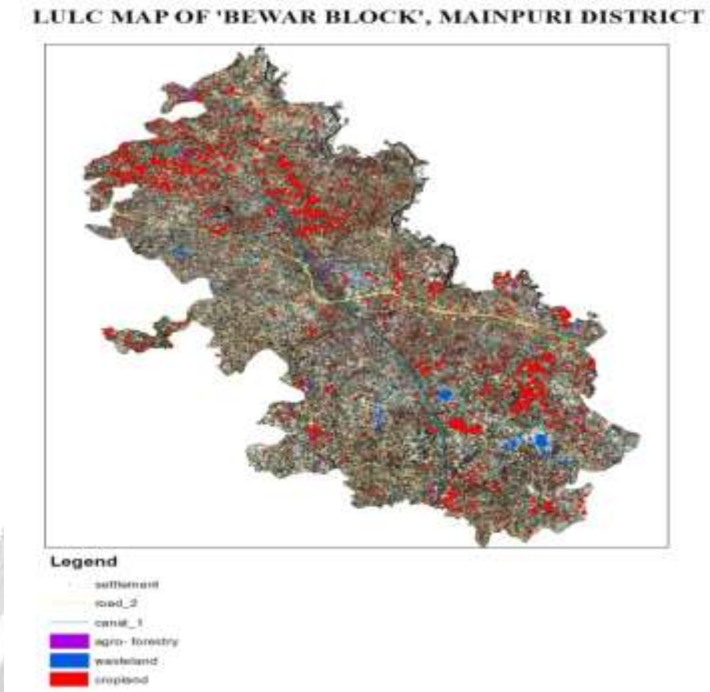

Fig- 3: Relative distribution of land use types of Bewar Block

2.3 Soil sampling and analysis

Soil Sample is collected during the post- monsoon season(rabi crops) and pre- monsoon(kharif crops) seasons from the different areas of Bewar Block, Mainpuri district. Soil samples were collected with the sampling tag in air free polythene bag with the help of auger and trowel at depth of (0-15 cm) and (15-30 cm) . Total number of composite samples collected from four land use and two soil depth was 96. Samples were then dried and sieved for analysis in the laboratory. Soil texture is measured by texture triangle, Bulk density was estimated using core sampler (auger) and soil organic carbon determined by Walkley and Blake method (Allison 1975). Along with these properties porosity, ph, Electrical conductivity etc. are also measured in order to know the soil health. The sampling points were: Jasrajpur, Malai Hussainpur, Meerpur chhedami, Jamaura, Chandanpur, Banakiya, Ramnagariya, Daudpur, Jasma, Jote, Chilaunsa and Karpia.

2.4 Soil carbon stock calculation and effect of land use changes

Following the Intergovernmental Panel on Climate Change (IPCC) guidelines, the SOC stock was calculated for soil to a depth of 30 cm. Data collected from field survey during post-monsoon and pre-monsoon was used to calculate SOC stock for 2020. To calculate SOC stock Eq. 1 was used given by Wairiu and Lal 2003 [4]-

SOC= Carbon content (%) * BD * depth

Where,
SOC = soil organic carbon stock in tC/ha
C content = soil organic carbon (%)
BD = soil bulk density (g cm^{-3})
d = soil layer thickness (cm)
Summation of carbon stock in each soil depth gives the total C pool in each land use type of the region.

3. RESULTS AND DISCUSSION

After performing laboratory analysis of samples, some results are obtained which are mentioned below-

Table-1: Compile Result of all parameters of Post-monsoon Season

S.No.	Sample points	Soil texture	Bulk density(g/cm3)		Porosity(%)		Organic carbon(%)		Ph		EC(miliSiemens/m)	
			(0-15cm depth)	(15-30cm depth)	(0-15cm depth)	(15-30cm depth)	(0-15 cm depth)	(15-30 cm depth)	(0-15 cm depth)	(15-30 cm depth)	(0-15 cm depth)	(15-30cm depth
1	Jasrajpur	loamy soil	1.24	1.27	53.2	52	0.44	0.365	8.1	8	0.265	0.285
2	Malai Hussainpur	loamy soil	1.24	1.27	53.2	52	0.255	0.42	8.3	8.1	0.315	0.33
3	Meerpur Chhedami	loamy soil	1.24	1.27	53.2	52	0.325	0.35	8	8	0.115	0.14
4	Jamura	loamy soil	1.24	1.27	53.2	52	0.375	0.395	7.8	7.8	0.225	0.205
5	Chandanpur	loamy soil	1.24	1.27	53.2	52	0.6	0.635	7.9	8	0.2	0.22
6	Banakia	loamy soil	1.24	1.27	53.2	52	0.59	0.195	7.8	7.9	0.3	0.27
7	Ramnagariy a	medium loam	1.34	1.37	49.4	48.3	0.31	0.33	8.4	8.2	0.395	0.37
8	Daudpur	medium loam	1.34	1.37	49.4	48.3	0.5	0.49	7.2	7.1	0.415	0.415
9	Jasmai	medium loam	1.34	1.37	49.4	48.3	0.42	0.44	7.9	7.5	0.405	0.415
10	Jote	sandy loam	1.09	1.15	58.8	56.6	0.61	0.4	7.3	7.4	0.695	0.605
11	Chilaunsa	loamy sand	1.19	1.22	55	53.9	0.33	0.295	7.2	7.3	0.305	0.315
12	Karpia	loamy sand	1.19	1.22	55	53.9	0.56	0.435	7.1	7.4	0.275	0.3

Table-2: Organic carbon stocks for Post-monsoon Season

S.No.	Sample points	Carbon Stock (tC/ha)	
		@ 15cm depth	@ 30cm depth
2	Malai Hussainpur	4.65	10.287
1	Jasrajpur	8.184	16.002
3	Meerpur Chhedami	5.952	13.355
4	Jamura	6.882	12.954
5	Chandanpur	11.16	23.622
6	Banakia	10.974	22.098
7	Ramnagariya	6.231	12.741
8	Daudpur	10.251	20.961
9	Jasmai	8.442	18.084

10	Jote	9.973	20.7
11	Chilaunsa	5.890	12.81
12	Karpia	9.996	20.496
	TOTAL	**98.585**	**204.104**

Table-3: Compile Result of all parameters of Pre-monsoon Season

S.No.	Sample points	Soil texture	Bulk density (g/cm3)		Porosity(%)		Organic carbon(%)		Ph		EC(miliSiemens/m)	
			(0-15cm depth)	(15-30cm depth)	(0-15cm depth)	(15-30cm depth)	(0-15cm depth)	(15-30cm depth)	(0-15cm depth)	(15-30cm depth)	(0-15cm depth)	(15-30cm depth)
1	Jasrajpur	loamy soil	1.25	1.26	52.83	52.45	0.43	0.371	8.2	8	0.273	0.291
2	Malai Hussainpur	loamy soil	1.25	1.26	52.83	52.45	0.29	0.422	8.4	8.2	0.335	0.351
3	Meerpur Chhedami	loamy soil	1.25	1.26	52.83	52.45	0.34	0.36	8.1	8.2	0.211	0.241
4	Jamura	loamy soil	1.25	1.26	52.83	52.45	0.36	0.4	7.9	8	0.228	0.215
5	Chandanpur	loamy soil	1.25	1.26	52.83	52.45	0.35	0.658	8	8.3	0.25	0.3
6	Banakia	loamy soil	1.25	1.26	52.83	52.45	0.6	0.2	8	8.1	0.32	0.3
7	Ramnagariya	medium loam	1.35	1.39	49.05	47.54	0.307	0.34	8.5	8.6	0.395	0.37
8	Daudpur	medium loam	1.35	1.39	49.05	47.54	0.504	0.5	7.4	7.3	0.415	0.415
9	Jasmai	medium loam	1.35	1.37	49.05	47.54	0.43	0.45	8.1	7.7	0.405	0.415
10	Jote	sandy loam	1.09	1.17	58.86	55.84	0.61	0.43	7.5	7.6	0.695	0.605
11	Chilaunsa	loamy sand	1.19	1.22	55.09	54.96	0.342	0.31	7.4	7.6	0.312	0.322
12	Karpia	loamy sand	1.19	1.22	55.09	53.96	0.55	0.44	7.3	7.6	0.285	0.321

Table-4: Organic carbon stocks of Pre-monsoon Season

S.No.	Sample points	Carbon Stock (tC/ha)	
		@ 15cm depth	@ 30cm depth
1	Jasrajpur	8.062	16.632
2	Malai Hussainpur	5.437	11.718
3	Meerpur Chhedami	6.375	13.23
4	Jamura	6.75	12.852

5	Chandanpur	6.562	13.23
6	Banakia	11.25	21.924
7	Ramnagariya	6.075	12.927
8	Daudpur	10.125	21.267
9	Jasmai	8.707	18.348
10	Jote	9.973	21.06
11	Chilaunsa	6.069	12.81
12	Karpia	9.817	20.496
	TOTAL	**95.202**	**196.494**

Table-5: Comparison Of Organic Carbon (OC %) under different Land Uses

Land use type	**Sample size**	**Pre-monsoon (OC%)**		**Post-monsoon (OC%)**		**Average (OC%)**	
		(0-15cm) depth	**(15-30cm) depth**	**(0-15cm) depth**	**(15-30cm) depth**	**(0-15cm) depth**	**(15-30cm) depth**
Cropland	48	0.428	0.43	0.395	0.395	**0.411**	**0.412**
Wasteland	16	0.445	0.455	0.445	0.455	**0.445**	**0.455**
Forests	8	0.61	0.60	0.61	0.60	**0.61**	**0.60**
Agro- forestry	24	0.413	0.42	0.41	0.42	**0.416**	**0.42**

Table-6: Comparison of Total Organic Carbon (TOC) Stocks Of Post-Monsoon And Pre-Monsoon Season

Land use type	**Post-monsoon TOC Stocks (tC/ha)**		**Pre-monsoon TOC stocks (tC/ha)**		**Total TOC Stock (tc/ha)**	
	(0-15cm) depth	**(15-30cm) depth**	**(0-15cm) depth**	**(15-30cm) depth**	**(0-15cm) depth**	**(15-30cm) depth**
Cropland	47.892	98.318	44.436	89.586	92.328	187.904
Wasteland	15.886	33.306	15.886	33.306	31.772	66.612
Forests	9.973	20.7	9.973	21.66	19.946	42.36
Agro- forestry	28.668	51.786	24.907	52.542	53.575	104.328

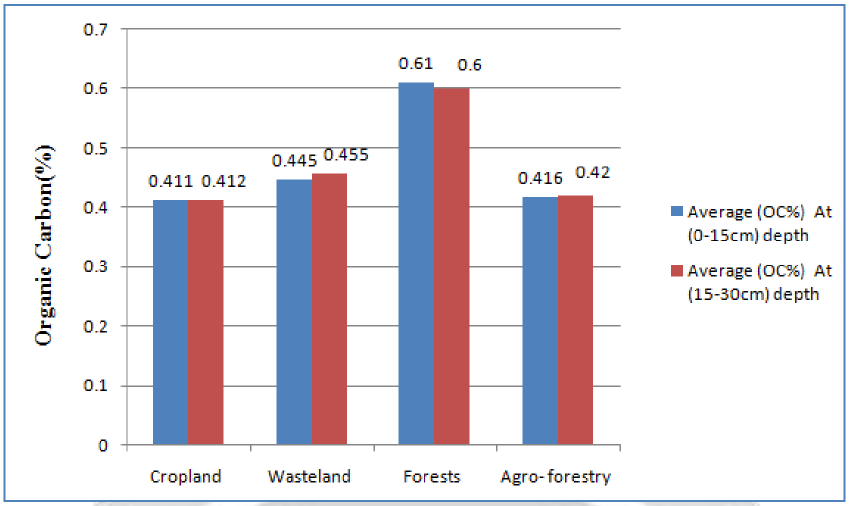

Chart-1: Graphical representation of Average OC(%) under different land uses

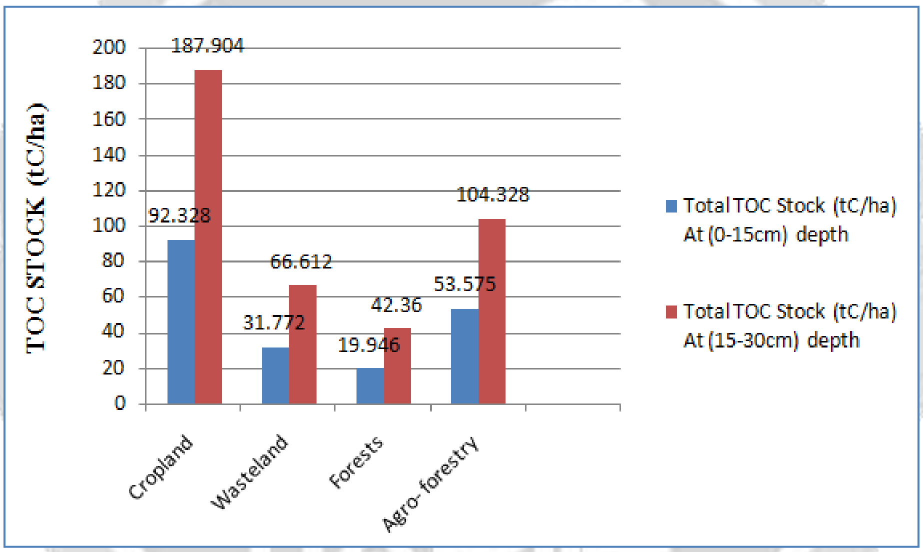

Chart-2: Graphical representation of TOC Stocks under different land uses

4. CONCLUSIONS

To determine the dynamics of land use change, interpretation of multitemporal satellite imagery was found to be a practical method. After mapping on the software ARCGIS, different types of land use are identified in theBewar block which are Cropland, wasteland,forest and Agro forestry. This study also investigated the effect of land use change dynamics on SOC stock. Changes in the SOC pools were observed due to changes in land use or land management practices. The organic carbon content found in different land use i.e. in cropland (0.43%) for upper layer and (0.36%) for bottom layer, in wasteland (0.44%) for upper layer and (0.36%) for bottom layer, in Forests (0.61%) for upper layer and (0.40%) for bottom layer, in Agro- forestry (0.41%) for upper layer and (0.42%) for bottom layer. From the results it is concluded that present organic carbon content in soil is very less from the standard values i.e. 1.5 to 2%, therefore soil management has to work for enhancing the soil organic carbon status.
Total organic carbon stocks in upper and lower layer of soil of cropland is (92.328 tC/ha & 187.904 tC/ha) , upper and lower layer of soil of wasteland is (31.77 tC/ha & 66.612 tC/ha), upper and lower layer of soil of forests is (19.946 tC/ha & 42.36 tC/ha), in upper and lower layer of soil of Agro-forestry is (53.575 tC/ha & 104.328 tC/ha).

This study concluded that land use change has a potential impact on soil carbon storage due to change or loss in vegetation which leads to alteration in input and output of carbon in soil. Efforts should be made to implement proper land use management practices, such as application of deep rooted crop in rotation, Medicinal and aromatic cropping on waste land, balanced incorporation of fertilizer and organic manure, bio-fertilizers etc. should be used to enhance the SOC content. Conversion of land use from cultivated to managed perennial plantation can enhance soil carbon stock. Land use management is an essential step for preserving existing soil carbon and also aids in increasing soil carbon.

5. ACKNOWLEDGEMENT

Not applicable

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