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Investigating the Soil Carbon Storage Dynamic and Sequestration Potentiality in the Tropical Coral Island (St. Martin) of Bay of Bengal

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

With a limited amount of carbon storage, Saint Martin Island possesses a very unique soil and environmental characteristics. It needed to be documented about the carbon and organic matter percentage years ago for the proper measurement of carbon sequestration but the work was not completed. As the investigation started to collect the data, the experiment faced many obstacles at every stages because the information we needed was too less to conduct any experiment. We see that SOC (soil organic carbon) densities vary widely among various soil depths and various locations. Different land types and land use requires different carbon storage. The percentage of organic matter count and carbon storage in this Island is typically lower than other parts of the Bangladesh. The MAT (Medication-Assisted Treatment) and MAP framework was included with the variable climatic conditions which made a conclusion that the environmental impact and

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consequences are needed to be estimated for the improvement of soil condition and betterment of future research. With the analysis of carbon storage, we included some information about soil bulk density, wet soil mass and dry soil mass, and carbon stock indifferent vertical scale that may lead to better understanding about carbon storage and sequestration potentiality of that place in the future which may open a new windows of knowledge of carbon storage flux and global warming. To determine the degree of carbon sequestration in this Island a large number of proper experiments are needed to be done.

Keywords: Saint Martin Coral Island; changing environment; global warming; soil carbon sequestration; vertical carbon storage.

1. INTRODUCTION

Saint Martin is the small island of Bay of Nengal with 8 km^2 area in the northeastern part of the part of the Bay of Bengal and about 9 km south of the tip of the Teknaf and forming the southernmost part of Bangladesh. It is about 8 km west of Northwest coast of Myanmar, at the mouth of Naf River [1]. It also called Narikel Gingira and Coconut Island. At the corner newly formed island named Chera Dip Island. It is posited 20.34 to 20.39 norths Latitude and 92.18 to 92.21 Longitude. It carries 4000 peoples most of them are fisher. The first human settlement grown in 1800 A.C. The coral island length of 6 km and width 0.5 km. it has 200 m of offshore with 1.3 m^2 colony [1]. The coral Island has five areas: Uttar Para, Golachipa, Modha para and Dakhin Para [2]. It is isolated in the monsoon season due to high rainfall in this season. From October to February, mild weather remains, on the other hand, from March to September, high temperature and unpredictable weather condition is very noticeable. The Saint Martin coral Island is formed from the sedimentation of Ganges, Barhmaputra and Jamura river which sediment is almost 6% of global sediment. The Saint Martin coral island can be playing an important role for the sequestration and release of carbon from the soil body. Soil organic carbon plays an important role for the environment [3]. In recent decades, Understanding of carbon dynamics in different ecosystem has increased significantly. One of the major emission CO_2 is of 8-20% of total emission of CO_2 from land use and deforestation which is concerning [4,5]. Climate change and correlated policies have a very high impact on tropical communities and ecosystems thus underscoring an importance of vigorous carbon estimation of soil [6].

Soil is the most important natural resources of our planet for surviving life because of it holding and storing different micro and macro nutrients which helps to grow plant and subsequently plays importance role for our existence [7]. Among them, Carbon plays more important mechanism for our environment [8]. Soil organic carbon is a vital element stored by different dynamics processes like- Photosynthesis, Decomposition, Deposition, Soil respiration and so on. Soil carbon or organic matter absorbed and desorbed by different minerals and colloidal particle which allow to retain with the soil body, otherwise it will leached with the infiltrated water into the ground and losing the capacity of holding nutrients into the soil and pollutes the followed ground water [7]. So, Soil organic carbon is very essential part for the soil body to maintain its physical, chemicals and Biological sustainability. In recent time, manmade activities like, deforestation, intense cultivation, and urban living have negatively impacted organic carbon content and lowered the carbon holding capacity of the soils under study.. The more release of carbon from the soil body, the more increase of carbon di oxide and other greenhouse gases to the atmosphere is contributing to the global warming and other climatic conditions [7].

Bangladesh is a newly formed delta that suffering huge land degradation and erosion [9] that may lead polluting the environment most prominently water of the river, lakes, ground water and surface water [10] but the river water quality is mostly polluted rather than surface water and surrounding oceans [11,12]. As a reason the the surrounding of water quality of Saint Martin coral island is moderately superior to the average river water quality. The extreme unusable water quality found in the sewage wastewater in the Dhaka city rather than anywhere of the country [13]. The overall reason behind the dirty histories of polluted water behind under the soil erosion, fertility status, soil properties [14,15,16] and the excessive uses of pesticides like diazinon [17]. These pollution of land and water may leads to many diseases like cancer, skin diseases, diarrhea and so on by direct or indirect contact [18].

The amount of C in soil represents a significant portion of the carbon found in terrestrial ecosystems of the planet. Total C in terrestrial ecosystems is approximately 3170. Of this amount, nearly 80% (2500 GT) is found in soil Soil carbon can be either organic (1550 GT) or inorganic carbon (950 GT). The latter consists of elemental carbon and carbonate materials such as calcite, dolomite, and gypsum [19]. The amount of carbon found in living plants and animals is comparatively small relative to that found in soil (560 GT). The soil carbon pool is approximately 3.1 times larger than the atmospheric pool of 800 GT [12]. Only the ocean has a larger carbon pool, at about 38,400 GT of C, mostly in inorganic forms [20]

There was no research oriented about carbon storage of Saint Martin coral island. This is the first steps to scientific research study of the Islands. So, as a first step for assessment of carbon storage analysis and estimated carbon storage which helps in the future research. Present study can leads future research comparison and better analysis. As a tropical coastal zone, a variety of ecosystem services (e.g. food sources, first layer of defense system such as tsunami if mangrove forest present) are provided [21]

2. MATERIALS AND METHODOLOGY

To assess the carbon storage analysis, the soil samples are collected from 5 different points and 3 full profile of soil up to 100 cm of Soil. All of the survey sites were owned and/or managed by pastoral farmers, who gave permission for the survey. The field studies did not involve any endangered or protected species.

2.1 Study Areas

Our study was conducted in the Saint Martin coral island which is only one coral island of Bangladesh. The mean annual temperature (MAT) ranges from 14 to 31˚C, and the mean annual precipitation (MAP) varies from approximately 150 to 400 mm. The typical landforms in the study region are gently rolling plains, and floodplain region. The vegetation types along the ESET region mainly include meadow steppe, typical steppe and desert steppe.

2.2 Data Collection

Field sampling was performed from late January to mid-February 2017, when the grassland community biomass was at its peak. Four field sites were established from the north to the north along with the Saint Martin Coral Island (Fig 1). The position of each site was located with a GPS (S1 Table). At each site, an area of 10 × 10 m was delineated, and three 1 × 1 m quadrates were then randomly placed within this area. We harvested the aboveground parts of the plants in each quadrat, and the dry weight of the plants was obtained by oven-drying at 60˚C for 24 h until a constant weight was obtained. Three soil profiles were collected within each quadrate. Each soil profile was extracted to a depth of 100 cm, and the samples were divided into depth increments of 0-10, 10–20 cm, 20-40cm, 40-60 cm, 60-80 cm, 80-100 cm and 100-120 cm.

Each of these samples was collected using a standard container with a volume of 100 cm3 and a cloth pocket. All of the soil samples were air-dried and then oven dried at 105˚C to determine their bulk densities. Before the soil samples were further analyzed to determine the soil organic carbon concentration and soil texture, visible plant roots and rock fragments were manually removed by sieving the samples through a 2 mm screen [6].

The soil organic carbon concentration was measured via wet combustion with K2Cr2O7. A Master size S3500 instrument (Microtrac Incorporated, USA) was employed to measure the soil texture, including the clay content (<0.002 mm), silt content (0.002–0.02 mm), and sand content (0.02–2 mm). For each soil layer, the soil organic carbon concentration, soil bulk density and soil pH were represented by the average of the values from three spatially random profiles. The soil texture was measured using a composited sample for each soil layer from the three soil profiles. The MAP and MAT were obtained at a 30 arc-second (~1 km2) resolution from the World Clim database.

Human is turbaned is the main human activity in the region. The spatial distribution of human density was used as an indicator of the grazing intensity in the region. Sheep density data from the year 2012 were provided by the Food and Agriculture Organization of the United Nations and were extracted with respect to each site's location.

Fig. 1. Study area of Saint Martin Coral Island of Bangladesh.

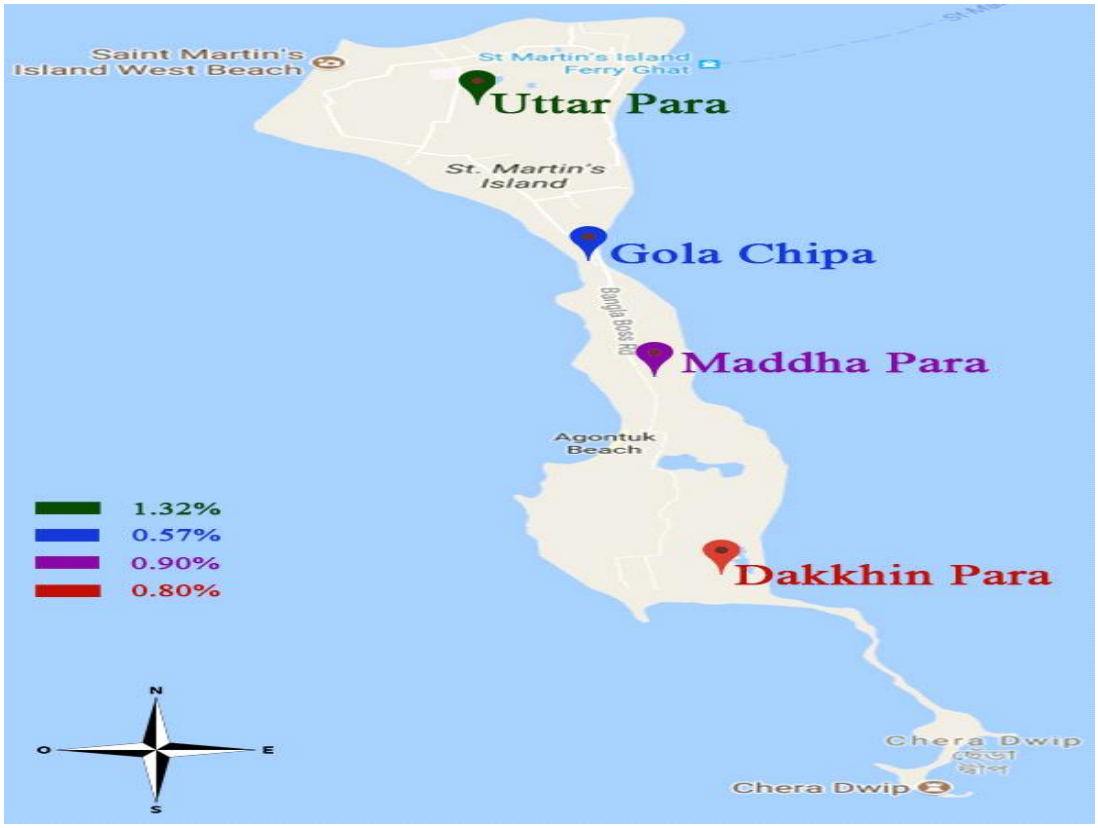

Fig. 2. The sampling point of Saint Martin Coral Island into the Bay of Bengal

Table 1. Amount of soil organic carbon (kg C/ha) of Uttar Para, Saint Martin Island, Cox`s-Bazar

Location	Depth(cm)	Carbon percen-tage(%)	Organic matter (%)	Wet soil mass (g)	Dry soil mass (g)	Moisture content	Bulk density (g/cm3)	Soil organic carbon(kg c/ha)
138	0-30	0.76	1.32	154.45	118.67	23.17	1.45	33060
138-1	0-10	0.82	1.41	153.29	116.42	24.05	1.42	29820
138-1	0-20	0.76	1.32	155.67	119.45	23.27	1.46	21580
138-1	20-40	0.5	0.87	180.97	151.86	16.09	1.85	18500
138-1	40-60	0.39	0.68	127.76	105.98	17.05	1.29	10060
138-1	60-80	0.34	0.59	126.34	103.47	18.10	1.26	8570
138-1	80-100	0.31	0.54	173.27	142.61	17.69	1.40	7564

2.3 Data Analysis

The soil organic carbon storage was assessed using the SOCD in the three soil layers of 0-10, 10–20 cm, 20-40 cm, 40-60 cm, 60-80 cm, 80-100 cm and 100-120 cm and the sum for the three layers. We employed an ordinary least squares regression to examine the relationships between the SOCD of four soil layers (of 0-10, 10–20 cm, 20-40 cm, 40-60 cm, 60-80 cm, 80-100 cm and 100-120 cm and each of the different controlling factors (MAT, MAP, Sand, Silt and clay content) along there region.

The climatic variables in the framework included the MAT and MAP. In this framework, we hypothesized that climate, soil texture and grazing would directly influence the SOCD and that climate and grazing would affect the soil texture. Furthermore, climate, soil texture and grazing would indirectly influence the SOCD through community productivity.

4. RESULTS AND DISCUSSION

The storage of soil organic carbon was assessed in various depths of four sites named Uttar Para, Golachipa, Maddha Para and Dakkh in Para in the Saint Martin Island, Cox's-Bazar. The amount of organic carbon is changeable accompanied with the variations of depth in each location. In Uttar Para, the percentage of carbon is high (0.82%) in 0-10 cm depth than any other depths in that location.

The organic matter percentage is also high in the same depth. This condition is also same for the other sites that are Golachipa, Maddha Para and Dakkhin Para because all these locations are high in carbon percentage and organic matter percentage at 0-10 cm depth. On the contrary, the wet soil mass and dry soil mass varies from each locations to other with their depths. The climate and soil texture of each location varies from depths to depths and it indirectly affects the soil mass. In Uttar Para, the wet soil mass and the dry soil mass both are high in 20-40 cm depth and lowest in 60-80 cm. In Golachipa Para, they are both high in 80-100 cm. But in Maddha Para, the wet soil mass is high in 80-100 cm and dry soil mass is high in 40-60 cm depth. In Dakkhin Para, the wet soil and dry soil both are high in 20-40 cm depth.

The sites we selected differed in many ways such as local climate, species composition, soil characteristics, variation among sites; history of land uses on those sites sometimes directly affects the amount of soil organic carbon per hector. The amount of soil organic carbon in these four sites are related with the depths, soil masses, organic matter, carbon percentage, bulk density, moisture content etc. The values of bulk density in each location represent the different composition from every random layer which helps to measure about the carbon storage in that area. In the Uttar Para and Dakkhin Para, Saint Martin Island, the highest bulk density is at 20-40 cm depth which is 1.85 g/cm^{3}and 1.79 g/cm^3 respectively. In Gola Chipa Para, the bulk density is high at 80-100 cm depth and lowest at 40-60 cm depth. In Maddha Para, the bulk density ranges from 1.19 to 1.40 g/cm^{3}in various depths.

Apart from the bulk density, the soil moisture content and organic carbon are also variable at different depths. It is a well-known fact that the chemical composition of the moisture in the pores of the soil is important for the prevention of future groundwater pollution and agriculture. The proper measurement of soil moisture content helps to maintain the plants and soil and to manage the nature. Besides the relation with organic carbon storage, soil moisture value is an important parameter for geo engineering.

It influences the soil shear strength, soil mass and dust formation. To provide a proper knowledge about total carbon sequestration of Saint Martin Island, the determination of moisture content of these four sites has been done. In Gola Chipa Para and Maddha Para, the moisture content is both high at 80-100 cm depth and low at 60-80 cm depth. In Uttar Para, soil moisture is high at 0-10 cm and in Dakkhin Para it is high at 0-30 cm depth. The amount of soil moisture determines when certain earth related activities can be carried out. In agricultural aspects, a key pathway of carbon sequestration is from plant biomass. The soil carbon sequestration also helps to build soil fertility and protects from soil compaction .In addition, besides helping in the mitigation of greenhouse gas emissions, soil carbon sequestration has many other benefits that are important to the society. In the degraded soils the conservation tillage impact of organic carbon sequestration generally appears greater than fertile soil. From the data of the four sites of Saint Martin Island, we can see that each of the four sites are high in soil organic carbon at 0-30 cm depth. In Uttar Para the soil organic carbon ranges from 33060 to 8570 kg C/ha. In GolaChipa Para it is from 17620 to 5740 kg C/ha and in Maddha Para 21387.32 to 5933.028 kg C/ha. And lastly, the soil organic carbon in Dakkhin Para ranges from 23320 to 6570 kg C/ha.

There are many reasons for being variables in the amount of soil organic carbon distributions in each location. Variation in soils in different location at Saint Martin Island is somehow influenced by the soil depth, climatic condition and various external factors. As the soil types and local climate condition of this area is different from other areas of the country, this directly affect the total carbon storage.

All this factors directly or indirectly influence the agricultural condition and economic solvency of this island. But recently slow erosion is occurring in the northwest part of the island. It should be a matter of concern because of the betterment of the agricultural purposes and scopes of this island. Although there are few works that highlights the soil types and soil conditions of this island, we tried to include about the soil carbon estimation and the carbon sequestration into these research works. For this work, the carbon percentage, wet and dry soil mass, moisture content and other things have been experimented. This experiments shows charts where we can see that in every layer of soil depth these properties are variables. The carbon storage in Saint Martin are less than other areas of the country because of the soil type. The dominant soil in this part is sandy type which is less capable of storing organic matter. This sandy soil generally cannot able to hold organic carbon. Organic carbon in soil prefers adhering to clay soil which is unavailable in this island.

Moreover, the tourism sector nowadays is getting upgraded and it has a great negative impact on the soil fertility and soil structure. Soil organic matter is the key point for any type of soil fertility which is low in Saint Martin Island. It plays a vital role in nutrient absorbance, crop productivity, physical, chemical and biological properties of soil which improves the quality of the soil. [22,18]. But due the various reasons the soil organic matter in Saint Island is relatively low than rest of the country. As there are no previous records of the amount of carbon storage and sequestration of this Island, it is a little bit difficult to compare about the carbon storage ratio. Information on carbon percentage and soil carbon balance of this Island is needed to be estimated for the benefits of upcoming research work which will lead to gain a vast knowledge about the environmental statistics and carbon cycle of this Island. Moreover, one of the reasons of being short in amount of carbon storage is excessive erosion in these areas.

Due to the heavy winds and unique structure of coral reefs of this Island, soil is getting heavily eroded and making the Island less fertile. Also, to ensure food security and supplement for the people and tourists of his Island, soils are cultivated at a wide range. As the cultivable land of this Island is not much, mixed and excessive cultivation is common. This excessive cultivation is destructive for soil fertility. So, it results a huge negative impact on the soil carbon storage and carbon sequestration. From the four sites of this Island we collected the data which shows that the carbon percentage and organic matter are very low than the average range [22].

In Uttar Para the percentage of carbon is 0.31-0.82 %and organic matter is 0.54-1.4% whereas the average organic matter percentage I Bangladesh is 5%. In GolaChipa Para and Maddha Para the carbon percentage is 0.22-0.35% and 0.23-0.63% respectively. The organic matter of these two sites ranges from 0.38-0.61% and 40-1.09%. The rest one site is Dakkhin Para and it carries carbon percentage 0.19-0.47% and organic matter 0.33-0.81%.

Table 2. Amount of soil organic carbon (kg C/ha) of gola chipa, Saint Martin Island, Cox`s-Bazar

location	Depth(cm)	Carbon Percen-tage(%)	Organic matter(%)	Wet soil mass (g)	dry soil mass (g)	Moisture Content	Bulk Density (g/cm3)	Soil organic carbon(kg C/ha)
139	0-30	0.33	0.57	156.82	146.18	6.78	1.78	17620
139-1	0-10	0.35	0.61	145.46	134.14	7.78	1.64	5740
139-1	0-20	0.32	0.55	144.65	132.85	8.16	1.63	10430
139-1	20-40	0.28	0.49	142.34	130.75	8.14	1.60	8960
139-1	40-60	0.24	0.42	140.30	129.04	8.03	1.58	7580
139-1	60-80	0.24	0.42	150.45	141.95	5.65	1.74	8350
139-1	80-100	0.22	0.38	180.73	151.75	16.03	1.86	8180

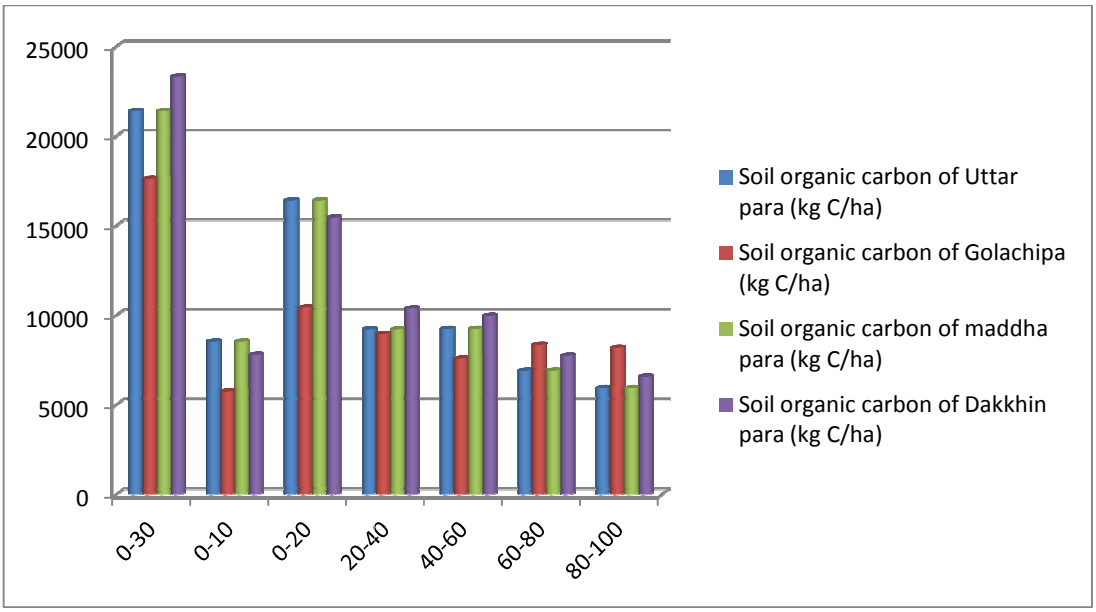

Fig. 3. The soil organic carbon storage variation with the vertical depth of soil profile at four different sampling point of the coral island

Table 3. Amount of soil organic carbon (kg C/ha) of Maddha Para, Saint Martin Island, Cox`s-Bazar

Location	Depth(cm)	Carbon percen-tage (%)	Organic matter (%)	Wet soil mass (g)	Dry soil mass (g)	Moisture content	Bulk density (g/cm3)	Soil organic carbon(kg c/ha)
140	0-30	0.52	0.90	150.56	139.98	7.03	1.37	21387.32
140-1	0-10	0.63	1.09	150.23	138.26	7.97	1.35	8531.057
140-1	0-20	0.59	1.02	149.41	141.92	5.01	1.39	16401.79
140-1	20-40	0.34	0.59	151.36	138.32	8.62	1.35	9212.121
140-1	40-60	0.33	0.57	149.67	142.84	4.56	1.40	9233.355
140-1	60-80	0.29	0.50	127.25	121.65	4.40	1.19	6910.442
140-1	80-100	0.23	0.40	159.68	131.69	17.53	1.29	5933.028

These all amounts are too less than other parts of the country. So it is experimentally shown that the carbon stock in this area is extremely low which affects the all over agricultural and environmental conditions. There also exists temperature imbalance which affects the carbon sequestration. Temperature above the sea level remains high at days and at night the

Table 4. Amount of soil organic carbon (kg C/ha) of Dakkhin Para, Saint Martin Island, Cox`s-Bazar

Location	Depth(cm)	Carbon percen-tage(%)	Organic matter (%)	Wet soil mass (g)	Dry soil mass (g)	Moisture content	Bulk density (g/cm3)	Soil organic carbon(kg c/ha)
141	0-30	0.46	0.80	148.71	138.19	7.07	1.69	23320
141	0-10	0.47	0.81	147.67	137.65	6.79	1.66	7800
141	0-20	0.46	0.80	147.09	136.98	6.87	1.68	15460
141	20-40	0.29	0.50	154.35	146.04	5.38	1.79	10380
141	40-60	0.28	0.49	152.86	145.08	5.09	1.78	9970
141	60-80	0.22	0.38	151.99	144.04	5.23	1.76	7740
141	80-100	0.19	0.33	145.98	141.56	3.03	1.73	6570

temperature falls down. This high temperature may have some effects on SOC stock. There are some studies shows that loss of carbon stock occurs in the high temperature areas has an impact on soils of that area. Besides, all these factors, grazing intensity is one of the most important factors determining the SOC of any area. This factor has a negative effect on soil carbon sequestration in Saint Martin Island. The overall climatic conditions and soil texture both play a vital role controlling soil carbon storage. Each of the four sites of this Island represents an overview of total carbon stock which will lead to determine about the agricultural and vegetation probability and knowledge on environmental consequences [22].

4. CONCLUSION

The relationship among integrated nutrient management and carbon storage systems should be evaluated. From many experiments it is proved that intensive crop cultivation may reduce the soil organic carbon through oxidation process. As Saint Martin Island is facing a large number of populations, agricultural and human activities have been increased a lot. Not only natural phenomenon, but also manmade activities are the reasons of less carbon storage in this Island. The carbon cycle and carbon sequestration has a potential effect on the environmental consequences which lead to determine about the carbon rating of that area for further research and analysis.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Islam MZ. St. Martin Pilot Project, National Conservation Strategy (NCS) Implementation Project-1, Final Report, Ministry of Environment & Forest, Government of the People's Republic of Bangladesh; 2001.
2. Islam MZ. First reef check survey in Bangladesh. Reef Check Newsletter. 2006;6(2).
3. Chowdhury, Sifatul Quader. "St Martin's Island". In Islam, Sirajul; Jamal, Ahmed A. Banglapedia: National Encyclopedia of Bangladesh (Second ed.). Asiatic Society of Bangladesh; 2012.
4. Van der Werf GR, Morton DC, DeFries RS, Olivier JG, Kasibhatla PS, Jackson RB, Collatz GJ, Randerson JT. CO2 emissions from forest loss. Nature geosciences. 2009; 2(11):737-738.
5. IPCC in the fourth assessment report climate change (eds Pachauri RK, Reisinger A.) (IPCC); 2007.
6. Thompson PM, Islam MA. (Eds.). Environmental Profile of St. Martin's Island, United Nations Development Programme, Dhaka; 2010.
7. Weil RR, Brady, N.C. and Weil, R.R., 2016. *The nature and properties of soils*. Pearson.
8. Ontl TA, Schulte LA. Soil carbon storage. Nature Education Knowledge. 2012;3(10): 35.
9. Hassan MA, Ratna SJ, Hassan M, Tamanna S. Remote sensing and GIS for the spatio-temporal change analysis of the East and the West River bank erosion and accretion of Jamuna River, Bangladesh. Journal of Geoscience and Environment Protection. 2017;5(9):79-92.
10. Mahmud MA, Hussain KA, Hassan M, Jewel AR, Shamsad SZKM. Water quality assessment using physiochemical parameters and heavy metal concentrations of circular rivers in and around Dhaka city, Bangladesh. International Journal of Water Research. 2017;7(1):23-9.

11. Trisha TH, Aktar M, Hassan M, Shamsad S. An investigation of geo-hydro-chemistry and physiochemical properties of irrigation water quality of Faridpur District, Bangladesh; 2017.
12. Haque S, Rayhan AS, Islam MM, Sultana Z, Nargis A, Hassan M. Assessment of irrigation water quality of Pabna District (North-Western Part) of Bangladesh for securing risk-free agricultural production. American Journal of Water Science and Engineering. 2017;3(6):67-71.
13. Hassan M, Hassan R, Mahmud MA, Pia HI, Hassan MA, Uddin MJ. Sewage waste water characteristics and its management in urban areas- a case study at Pagla sewage treatment plant, Dhaka. Urban and Regional Planning. 2017;2(3):13-6.
14. Hassan M, Hassan R, Pia HI, Hassan MA, Ratna SJ, Aktar M. Variation of soil fertility with diverse hill soils of Chittagong hill tracts, Bangladesh. International Journal of Plant & Soil Science. 2017;18(1):1-9.
15. Hassan M, Ahmed AA, Hassan MA, Nasrin R, Rayhan AB, Salehin SM, Rahman MK. Changes of soil fertility status in some soil series of Tista flood plain soils of Bangladesh, during 1996-2016. Asian Research Journal of Agriculture. 2017; 5(3):1-9.
16. Ahmed AA, Hassan M, Ahmed SU, Rahman MK. Fertility status on some tista floodplain soils of Bangladesh. International Journal of Scientific & Engineering Research. 2017;8(6):579-82.
17. Hassan M, Hassan R, Haque S, Sultana Z, Aktar M. Improvement of purification method for diazinon from soil matrix. International Journal of Agriculture, Environment and Bioresearch. 2017;2(4): 230-40.
18. Mahmud MA, Hassan M, Hassan R, Mondal R, Rahman MK .Human health risk assessment due to cadmium (cd) accumulation through consumption of chinese cabbage grown in cadmium-contaminated soil. Journal of Biodiversity Conservation & Bioresource Management. 2017;3(1):1-8.
19. Lal R. Soil carbon sequestration impact on global climate change and food security. Science. 2004;304:1623-1627.
20. Houghton RA. Balancing the global carbon budget. Annual Review of Earth and Planetary Sciences. 2007;35:313-347.
21. Giesen W, Wulffraat S, Zieren M, Cholten L. Mangrove guidebook for Southeast Asia. Mangrove guidebook for Southeast Asia; 2007.
22. Bhattacharyya B, Prakash V, Kundu S, Srivastva AK, Gupta HS, Mitra S. Long term effects of fertilization on carbon and nitrogen sequestration and aggregate associated carbon and nitrogen in the Indian sub-Himalayas. Nutrient Cycling in Agroeco systems. 2009;86(1):1–16.

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