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Assessment of SOC Stock, Their Changes Overtime and Prediction of SOC Stock Using Roth-C Model for Benchmark Soils of Different Agro-climatic Zones of Tamil Nadu

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A study was conducted in different agroclimatic zones of Tamil Nadu with the objective of assessment of Soil Organic Carbon (SOC) stock and its changes overtime, prediction of SOC stock under existing and alternate cropping pattern using Roth C model. Fifteen benchmark soils were selected in different agroclimatic zones of Tamil Nadu based on their land use and areal extent to assess SOC level and its changes overtime. Results revealed that, during 1997 and 2007 SOC was higher in forest ecosystem of pedon 15 (Ooty series) and in pedon 14 (Pechiparai series) of horticultural land use. Among seven agroclimatic zones of Tamil Nadu soil series in five agroclimatic zones viz., Periyanaickenpalayam series (Western zone), Peelamedu series (Southern zone), Vallam series (North eastern zone), Vannappatti series (North western zone) and Padugai series (Cauvery delta zone) were selected to predict SOC stock for the year 2025 and 2050 except hilly and high rainfall zone due to high organic carbon content in these agroclimatic zones. Results showed that, among the soil series selected for the study, Vannappatti and Padugai series registered the highest Total Organic Carbon (TOC), Biomass Carbon (BIO) and Humified Organic Carbon (HUM) under existing cropping pattern while Periyanaickenpalayam, Peelamedu and Vallam series had high TOC, BIO and HUM under alternate cropping pattern. Among five selected soil series, Periyanaickenpalayam, Peelamedu and Padugai series recorded 7.5 g kg^{-1} TOC during 2025 and 2018, 2100 and 2035, 2013 and 2014 under existing and alternate cropping pattern respectively.

Key words : Soil organic carbon (SOC), land use, benchmark soil, agro climatic zones, Roth C model.

SOC is vital for ecosystem function having a major influence on soil structure, water holding capacity, cation exchange capacity and the soils ability to form complexes with metal ions and store nutrients (Van Keulen, 2001). Restoration of soil quality through soil organic carbon (SOC) management has remained the major concern for tropical soils. Important factors controlling SOC levels include climate, hydrology, parent material, soil fertility, biological activity, vegetation patterns and land use. SOC is sensitive to impact of human activities *viz*., deforestration, biomass burning, land use changes and environmental pollution. Appropriate management of soils to increase SOC levels increase the productivity and sustainability of agricultural ecosystems and vice-versa (Cole *et al.*, 1997). The comprehensive knowledge on soil organic carbon stock and its change forms an essential prerequisite in future land resource management programmes.

In the recent past, the green house effect has been of great concern and has led to several studies on the quality, kind, distribution and behaviour of SOC. Global warming and its effect on soils in terms of SOC management has led to several quantitative estimates for global carbon content in the soils.

The first comprehensive study of organic carbon status in Indian soils was conducted by Jenny and Raychaudhuri (1960). Their study confirmed the effects of climate on carbon reserves in the soils. However this estimate was based on a hypothesis of enhancement of organic carbon level, judging by success stories of afforestation programmes on certain unproductive soils.. The soil carbon sequestration potential of 39.3 to 49.3 Tg C / Yr (mean of 43.3 Tg C/Yr) can be significant towards reducing the net emission from fossil fuel combustion and decreasing the rate of enrichment of CO_2. Excluding carbonate rocks, soils represent the largest terrestrial stock of C, holding approximately 1500x10^{15}g C (Batjes, 1996). This is approximately twice the amount held in the terrestrial vegetation. In most soils (except calcareous soils) the majority of this C is held in the form of SOC (Batjes and Sombrock, 1997).

Soil organic carbon links to ecosystem processes and functions including primary

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production (Stursova and Sinsabaugh, 2008), nutrient cycling (Scholes *et al.,* 2009), soil structural stability and water holding capacity (Holm *et al.,* 2003), each of which contribute to other supporting, provisioning and regulating services, such as climate regulation, food and timber production. Conversely, forms of land use and management causing CO_2 release to the atmosphere can alter ecosystems, reducing their carbon storage and sequestration capacity, furthering climate change through coupled ecosystem-atmosphere feedbacks (IPCC, 2007). Depletion of terrestrial carbon stores has important potential effects on ecosystem functions and their ability to provide non-carbon ecosystem goods and services (MA, 2005). Understanding how different land use and management systems maintain and enhance both carbon storage and other ecosystem services is therefore a key research challenge.

Predicting changes in soil carbon stocks as a consequence of land management can assist in soil fertility management, determining levels of input required to maintain desirable soil carbon levels and reduction of soil carbon-di-oxide emissions. Roth C, SOC simulation model used to predict the turnover of SOC over time varying with soil type, temperature, moisture content, cropping pattern and plant cover as been described in detail. RothC-26.3 was tested in long term experiments on a range of soils and climatic conditions in Western and Central Europe. In a majority of cases, this model was tested on long-term experimental sites with detailed descriptions of the sites conditions and treatments (Barancikova, 2007; Ludwig *et al.,* 2007). Because of its simplicity and the generally good availability of the input data required, this model is used also for the estimation of the SOC stock on agricultural land.

This model can also be used to determine global terrestrial pool sizes, the distribution of C and N, to estimate the effects of rising temperature and increasing CO_2 on global SOC stocks. Cropping pattern and the residues returning to soil influences SOC and improves soil quality (Entry *et al.,* 1996).

With this background, present study was carried out in benchmark soils of different agro-climatic zones of Tamil Nadu with the objective of assessment of SOC stock, changes over time and prediction of SOC stock using Roth C model for the year 2025 and 2050 under existing and alternate cropping pattern.

Materials and Methods

Study area

Tamil Nadu lies between 76o 14' and 80o 21' E longitudes and 84o and 13o 54' N latitude. It has a total geographical area of 129.91 Lakh ha. Based on the altitude, annual rainfall and annual PET (Potential Evapotranspiration), Tamil Nadu has been divided into seven agroclimatic zones viz., Western zone, Southern zone, North eastern zone, Cauvery delta zone, North western zone, High rainfall and Hilly zone .

Assessment of SOC stock and changes overtime

Fifteen benchmark soils were selected in different agroclimatic zones of Tamil Nadu for the present study based on their land use and areal extent. They were three from Western zone, six from Southern zone, two from Cauvery Delta zone, one each from North Western, North Eastern, High rainfall and Hilly zone (Table 1). During the year 1997, the benchmark soils distributed in different agroclimatic zones of Tamil Nadu were studied for pedogenic properties by Krishnan and soil samples of each benchmark soils were stored for further study in Remote Sensing Unit, Department of Soil Science and Agricultural Chemistry. In the current study, profiles were opened at the same sites using Global positioning system (GPS) and SOC was analysed using Chromic acid wet digestion method by Walkley and Black (1934). To estimate the SOC change over (1997 – 2007), the benchmark soil samples for the year 1997 which were stored for further study were used and analysed for SOC content.

Prediction of SOC stock using Roth.C model

Five benchmark soils *viz*., Irugur series from Western zone, Peelamedu series from Southern zone, Vannappatti series from North Western zone, Padugai series from Cauvery Delta zone and Vallam series from North Eastern zone were selected for prediction of total organic carbon stock using Roth C model under existing and alternate cropping pattern. Soil wise existing and alternate cropping pattern for each agroclimatic zone collected from web site of Tamil Nadu Agricultural University (www.tnau.ac.in) was considered in the development of model (Table 2). High rainfall and hilly zone were left out due to their high organic carbon content.

Three different data files viz., weather file, land management file and scenario file are required for Roth C model. Monthly weather variables like total precipitation, mean temperature and total evapotranspiration (Table 3), surface clay content, depth and soil organic carbon content of respective benchmark soils were used to create weather file (Table 4). Monthly weather variables were collected from respective research stations of Tamil Nadu Agricultural University from 1997-2007.

Management variables like soil cover (fallow or covered), residue input and manure input were used to create land management file for both alternate and existing cropping pattern. Soil cover was determined by knowing the cropping pattern in each location of respective benchmark soil. Residue input was calculated from total biomass of the crops. 1/ 10th of total biomass was assumed to be residue input for all crops. Recommended dose of 12.5 t ha^{-1} FYM was assumed to be manure input. Estimates of decomposability of crop residues (a Decomposable Plant Matter / Residual Plant Matter ratio of 1.44) and Inert Organic Matter (IOM) content were required to create scenario file. IOM content was calculated for all five benchmark soils with the organic carbon content using the procedure outlined in Roth. C model.

In performing a run, the model was equilibrated to 10, 000 years and it was then run from 2008 to 2100, using the data created in the weather, land management and scenario files for each benchmark soil for both existing and alternate cropping pattern. The output file provides the informations on TOC stock, BIO, HUM and total carbon lost to the atmosphere under existing and alternate cropping pattern for each year from 2008 to 2100.

Projections for SOC level were predicted under two scenarios *viz*., for specific years (2025 and 2050) and period (number of years required to attain 5.0 g kg^{-1} and 7.5 g kg^{-1} of soil organic carbon at the selected benchmark soil sites).

Results and Discussion

SOC stock in different land use systems

SOC was high under horticulture {(tea plantations) / forestry (shola forest)} followed by soils under horticulture (rubber, banana, areacanut and coconut), pasture, orchard crops (vegetable and fruits), agriculture and cultivable waste land during the years of 1997 and 2007 (Fig 1).

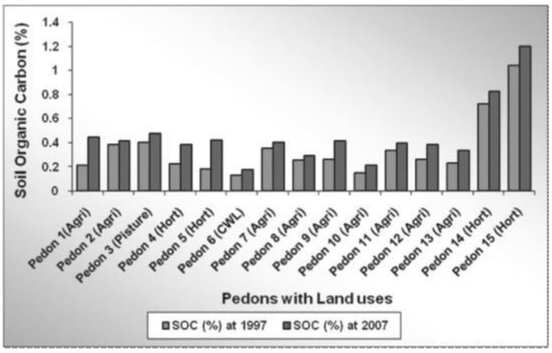

Fig. 1. Soil organic carbon per cent of selected benchmark soils in agroclimatic zones of Tamilnadu during 1997and 2007

The higher SOC content in pedons 14 and 15 was mainly due to climatic conditions prevailing in those locations. Because forest ecosystem in hills and mountains in pedon 15 offer most conducive soil-climatic environment for higher accumulation of SOC, thus helping in maintaining soil quality. Such an environment exists not only in hills and mountains but also at places like pedon 14. Similar findings were recorded by Eswaran *et al.* (1993) who noted that about 40% of the SOC stock of the global soils reside in forest ecosystems.

Soils under pasture (pedon 3) recorded high SOC than agriculture and horticulture. This may be due to higher allocation of photosynthate (50%) to below ground to a dense, fibrous root system, a reduction in organic matter decomposition rates, the cessation of plowing and tillage and a reduction in wind and water erosion (Brye and Kucharik, 2003).

Average value of SOC was higher in horticulture system (pedons 4, 5, 14 and 15) than agriculture system (pedon 1, 2, 7, 8, 9, 10, 11, 12 and 13). Because in general there was higher humic acid recovery in soils under horticulture system than agricultural system (Naitam and Bhattacharrya, 2003).

Soils under agricultural crops (pedon 1, 2, 7, 8, 9, 10, 11, 12 and 13) showed lesser SOC content because ploughing increases mineralization of SOC by mixing crop residues in soil, bringing it closer to microbes, increasing O_2 concentration in soil, disrupting aggregates and exposing physically protected organic matter to microbial and enzyme activity thereby reducing SOC content in soil (Pratap Narain, 2001).

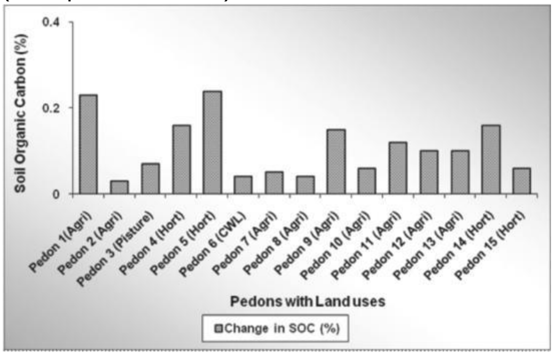

Fig. 2 Change in soil organic carbon per cent of selected benchmark soils in agroclimatic zones of Tamilnadu (1997-2007)

Among agricultural systems, SOC was higher in rice (pedons 1, 9, 11 and 12) followed by cotton (pedon 7) and sunflower crop (Pedon 2). In case of rice -based land use under submerged conditions, the rate of decomposition of native organic matter is comparatively low because of lack of oxygen and low availability of alternate electron acceptors (Swarup *et al.,* 1999). Cotton is a longer duration crop and also produce more biomass than groundnut, gingelly, pulses and millets thereby effectively increasing SOC (Naitam, 2001).

Among the land uses, cultivable waste land (pedon 6) showed lowest SOC as it has sparse vegetation of grasses which are well prone to water and wind erosion, which removes top soil. SOC content were generally high in topsoil than subsurface soil.

SOC stock in different soil types

Among the soil types, the average value of SOC percentage was high in high level laterite (Pedon 15) followed by low level laterite soil (pedon 14), black soil (pedons 2 and 7), alluvial soil (pedons 9,

Table 1. Details of pedon locations and their site characteristics in different agroclimatic zones of Tamil Nadu

Pedon No.	Village	Taluk	District	Agroclimatic zones	Benchmark soil	Major land use	Major crops
1.	Bhavanisagar	Gobichettipalayam	Tiruppur	Western zone	Irugur series (Red loam)	Agriculture	Paddy, groundnut,turmeric
2.	Coimbatore	Coimbatore	Coimbatore	Western zone	Periyanaickenpalayam series (Black soil)	Agriculture	Sunflower, millets
3.	Palladam	Palladam	Coimbatore	Western zone	Palladam series (Red sterile)	Pasture	-
4.	Thenkasi	Thenkasi	Tirunelveli	Southern zone	Thenkasi series (Red loam)	Horticulture	Coconut, guava, citrus
5.	Periyakulam	Periyakulam	Theni	Southern zone	Palaviduthi series (Deep red)	Horticulture	Fruit trees, vegetables
6.	Sathankulam	Tuticorin	Tuticorin	Southern zone	Udangudi series (Red sandy)	Cultivable waste land	Theri lands
7.	Aruppukkottai	Aruppukkottai	Virudhunagar	Southern zone	Peelamedu series (Black soil)	Agriculture	Cotton, sunflower
8.	Vamban	Alangudi	Pudukkotai	Southern zone	Vayalogam series (Low level laterite)	Agriculture	Pulses, groundnut
9.	Madurai	Madurai	Madurai	Southern zone	Madukkur series (Alluvial soil)	Agriculture	Rice
10.	Paiyur	Krishnagiri	Krishnagiri	North western zone	Vannappatti series(Thin red)	Agriculture	Millets, ground nut
11.	Sikkal	Nagappattinam	Nagapattinam	Cauvery delta zone	Kohur series(Alluvial soil)	Agriculture	Rice
12.	Aduthurai	Tiruvidaimarudur	Thanjavur	Cauvery delta zone	Padugai series (Alluvial soil)	Agriculture	Rice
13.	Vridhachalam	Vridhachalam	Cuddalore	North eastern zone	Vallam series (Low level laterite)	Agriculture	Groundnut, gingelly
14.	Pechiparai	Kalkulam	Kanniyakumari	High rainfall zone	Pechiparai series (Low level laterite)	Horticulture	Rubber, banana,arecanut, coconut
15.	Ooty	Udhagamandalam	Nilgiris	Hilly zone	Ooty series (High level laterite)	Horticulture / Forestry	Tea plantations, Shola forest

11 and 12), red (pedons 1, 3, 4, 5, 6 and 10) and low level laterite soil (pedons 8 and 13) during 1997 and 2007. This showed that the variation in SOC was mainly due to variation in texture (Bhadnal and Singh, 2002) and mineralogy (Bhattcharryya and Ghosh, 1994). Soil properties influence the decomposition of organic 'C' in the soil because they determine the living conditions for microbes and protect 'C' in the soil (Christensen, 1992).

Table 2. Existing and alternate cropping pattern of selected benchmark soils of Tamil Nadu to predict carbon using Roth C model

Agroclimatic zones	Name of soil series and location	Existing cropping pattern	Alternate cropping pattern
Western zone	Periyanaickenpalayam, Coimbatore	Pearl millet (March-June) – Maize (July-Oct.) – Pulses (Nov.-Jan.)	Groundnut (June-Sep.) – Rice (Oct.-Jan.) Maize (Feb.-May) in command areas
Southern zone	Peelamedu, Aruppukkottai	Groundnut (July-Jan.)- Cotton (Feb.-June)	Rice (Sep.-Jan.) – Cotton (Feb.-Aug.) in tankfed Areas
North western zone	Vannappatti, Paiyur	Groundnut (June-Sep.) – Wheat (Oct.-Feb.) – Pulses (Feb.-May)	Maize (June-Sep.) – Groundnut (Oct.-Jan.) Gingelly (Feb.-May)
Cauvery delta zone	Padugai, Aduthurai	Rice (June-Sep.) – Rice (Oct.-Jan.) – Pulses (Feb.-May)	Pulses (June-Sep.) – Rice (Oct.- Jan.) – Cotton (Feb – May)
North eastern zone	Vallam, Vridhachalam	Rice (Aug.-Jan.) – Groundnut (Feb.-Apr.) – Gingelly (Apr.-June)	Rice (June-Sep.) – Rice (Oct.-Jan.) – Pulses (Feb.-May) in command areas

In high level (pedon 15) and low level laterite (pedon 14) soils climate and land use might have played major role to influence SOC. High CEC with heavy texture improved SOC content in black soils (pedons 2 and 7). In alluvial soils (pedons 9, 11 and 12), mainly cropping pattern, submerged condition and further high CEC and clay content increased SOC content. In red (pedons 1, 3, 4, 5, 6 and 10) and low level laterite soil (pedons 8 and 13) mainly crusting was the problem commonly observed. This decreased SOC content by removing surface soil.

Table 3. Monthly average of climatic data (1997 - 2007) used in Roth C model to develop weather data file for selected locations of benchmark soils in different agroclimatic zones of Tamil Nadu.

Locations	Coimbatore (Western zone)			Aruppukkottai (Southern zone)			Paiyur (North western zone)			Aduthurai (Cauvery delta zone)			Vridhachalam (North eastern zone)		
Month	Temp (°C)	RF (mm)	ET (mm)	Temp (°C)	RF (mm)	ET (mm)	Temp (°C)	RF (mm)	ET (mm)	Temp (°C)	RF (mm)	ET (mm)	Temp (°C)	RF (mm)	ET (mm)
Jan	24.4	4.2	2.4	26.2	2.6	3.2	24.4	0.3	0.1	24.4	17.2	2.59	29.0	14.1	16.4
Feb	25.9	11.4	3.1	27.6	17.2	3.8	25.8	1.4	0.5	25.9	12.4	3.15	30.7	106.2	19.4
Mar	28.0	39.5	4.0	29.9	16.7	4.4	28.3	5.5	3.1	27.9	9.9	3.97	33.8	7.5	22.5
Apr	29.3	55.6	4.6	31.4	62.5	4.4	35.9	19.3	4.6	30.8	3.5	4.76	36.1	49.4	21.3
May	29.1	55.2	3.5	32.3	81.9	4.3	30.7	35.8	4.0	31.4	72.4	4.89	38.0	86.1	21.9
Jun	27.7	35.6	3.6	32.1	33.9	4.6	30.6	16.8	3.6	31.4	17.8	6.70	36.9	49.7	22.1
Jul	27.3	41.1	3.2	31.6	48.8	4.4	29.8	22.5	3.4	30.8	36.7	6.01	35.9	47.7	13.5
Aug	26.9	49.9	2.2	30.9	105.2	4.1	28.8	54.6	3.2	29.5	85.9	4.77	34.7	114.4	15.1
Sep	27.2	59.6	2.5	43.8	118.4	3.7	28.4	64.6	3.2	29.1	105.2	3.56	34.8	122.6	45.8
Oct	26.4	220.4	2.1	28.5	235.6	3.0	31.9	65.8	3.8	27.9	175.5	2.57	31.9	192.0	10.7
Nov	25.1	155.5	1.6	26.9	189.8	2.5	25.9	30.4	1.9	26.2	285.5	2.21	29.8	241.2	14.4
Dec	23.9	40.4	1.5	26.1	62.1	2.8	23.9	18.1	1.8	24.6	156.4	1.99	28.8	367.5	14.2

Temp - Air temperature , RF - Rainfall , ET – Evapo transpiration

The amount of SOC stored within an ecosystem, is dependent on the quantity and quality of organic matter returned to the soil matrix, the soils ability to retain organic carbon (a function of texture and cation exchange capacity), and abiotic influences of both temperature and precipitation (Grace *et al.,* 2006)

Change in levels of SOC over years (1997 – 2007)

Between eleven years of period (1997 - 2007) SOC build up was higher in soils under horticulture system (pedons 4, 5 and 14) followed by soils under rice cultivation (Pedons 1, 11 and 12) (Fig 2). It has been generally observed that cereal based systems

Table 4. Variables used in Roth C model for selected benchmark soils of different agroclimatic zones of Tamil Nadu

Agro climatic zones	Name of soil series and location	Measured Variables		
		Depth (cm)	Clay (%)	SOC (g kg^{-1})
Western zone	Periyanaickenpalayam,Coimbatore	22	22.3	6.50
Southern zone	Peelamedu, Aruppukkottai	19	37.5	6.20
North western zone	Vannappatti, Paiyur	20	3.98	3.50
Cauvery delta zone	Padugai, Aduthurai	21	35.8	6.90
North eastern zone	Vallam, Vridhachalam	21	5.90	5.20

contribute to higher organic matter especially in paddy-paddy systems (Singh *et al.*, 2003).

In horticultural land use biomass accumulation might be high due to litter fall thereby increasing humic acid recovery than other land use. In rice – rice, rice – rice –fallow or rice – rice - pulse cropping system decomposition of SOC might be low due to anaerobic environment and hence increased SOC accumulation (Swarup *et al.*, 1999). The fallow period further helps in accumulation of organic matter mostly because of drop in tillage. The pulse crop after rice contributes to SOC from litter fall, moribund root tissues and decomposition of root nodules (Goyal *et al.*, 1992). Application of green manures in cereal based cropping system increases SOC content. And it further improves

Table 5. Predicted variables using Roth C model for the year 2025 and 2050 under existing cropping pattern for benchmark soils of Tamil Nadu

Agro climatic zones	Name of soil series and location	Modelled Variable	2025				2050			
		IOM (t C ha^{-1})	BIO (t C ha^{-1})	HUM (t C ha^{-1})	TOC (t C ha^{-1})	Amount of CO_2 emitted (t ha^{-1})	BIO (t C ha^{-1})	HUM (t C ha^{-1})	TOC (t C ha^{-1})	Amount of CO_2 emitted (t ha^{-1})
Western zone	Periyanaickenpalayam, Coimbatore	1.0142	0.286	13.29	16.58 (7.50)	4.53	0.289	14.30	17.60 (8.01)	4.58
Southern zone	Peelamedu, Aruppukkottai	0.9611	0.254	12.53	15.35 (7.00)	4.29	0.26	13.31	16.14 (7.31)	4.33
North western zone	Vannappatti, Paiyur	0.5011	0.191	8.36	11.03 (5.00)	4.40	0.195	9.72	12.39 (5.61)	4.47
Cauvery delta zone	Padugai, Aduthurai	1.0856	0.331	14.58	18.12 (8.20)	4.82	0.336	16.02	19.57 (8.90)	4.90
North eastern zone	Vallam, Vridhachalam	0.7866	0.158	9.12	11.52 (5.20)	4.62	0.158	9.19	11.60 (5.30)	4.65

·( ) Total organic carbon (TOC) in g kg^{-1}

structure of the soil and reduces the pH, ESP and increases the hydraulic conductivity of soils (Cotching *et al.*, 2002 and Bhattacharyya *et al.*, 2000).

Prediction of Soil organic carbon stock using Roth C model under existing and alternate cropping pattern.

The total organic carbon, biomass carbon, humified organic matter and carbon-di-oxide lost to the atmosphere for the year 2025 and 2050 under alternate and existing cropping pattern were high in Padugai series followed by Periyanaickenpalayam series, Peelamedu series, Vallam series and Vannappatti series. The Padugai series also require lesser years to attain 7.5 g kg^{-1} total organic carbon followed by Periyanaickenpalayam and Peelamedu series (Table 5). This could be due to rice based cropping pattern that is being followed in Padugai series.

The mechanisms involved in preferential accumulation of organic matter in rice soils have been explained mainly due to anaerobiosis and the associated chemical and biochemical changes that take place in submerged soils following their prolonged flooding under water. The decomposition of soil or added organic matter is relatively fast, complete and efficient under aerobic condition where oxygen is the electron acceptor. However, the decomposition of organic matter in the absence of oxygen is slow, incomplete and inefficient besides, the formation of recalcitrant complexes with organic matter in these soils render organic matter less prone to microbial attacks (Sahrawat, 2004). All these factors along with decreased decomposition of organic matter leads to net accumulation of organic matter in rice-rice cropping system.

Periyanaickenpalayam and Peelamedu series hold better carbon levels than Vallam and Vannappatti series. This was mainly due to the high clay content in Periyanaickenpalayam (22.3 per cent) and Peelamedu series (37.5 per cent) than in

Table 6. Predicted variables using Roth C model for the year 2025 and 2050 under alternate cropping pattern for benchmark soils of Tamil Nadu

Agro climatic zones	Name of soil series and location	2025				2050			
		BIO (t C ha^{-1})	HUM (t C ha^{-1})	TOC (t C ha^{-1})	Amount of CO_2 emitted (t ha^{-1})	BIO (t C ha^{-1})	HUM (t C ha^{-1})	TOC (t C ha^{-1})	Amount of CO_2 emitted (t ha^{-1})
Western zone	Periyanaickenpalayam, Coimbatore	0.307	13.80	17.33 (7.90)	4.65	0.313	15.25	18.78 (8.50)	4.71
Southern zone	Peelamedu, Aruppukkottai	0.288	12.78	15.85 (7.20)	4.54	0.293	13.97	17.03 (7.70)	4.60
North western zone	Vannappatti, Paiyur	0.178	8.24	10.76 (4.90)	4.32	0.181	9.55	12.07 (5.50)	4.39
Cauvery delta zone	Padugai, Aduthurai	0.301	14.22	17.54 (8.00)	4.57	0.305	15.31	18.64 (8.50)	4.62
North eastern zone	Vallam, Vridhachalam	0.177	9.28	11.87 (5.40)	4.90	0.178	9.60	12.18 (5.50)	4.92

·( ) Total organic carbon (TOC) in g kg^{-1}

Vannappatti (3.98 per cent) and Vallam series (5.90 per cent). Generally, clay content with high surface area, protects organic carbon from decomposition after developing stable clay organic complexes (Bruke *et al.*, 1989).

High total organic carbon, biomass carbon and humified organic matter content were recorded in Vannappatti and Padugai series under existing cropping pattern than alternate cropping pattern, while high contents of total organic carbon, biomass carbon and humified organic matter were noticed under alternate cropping pattern than in existing cropping pattern in Periyanaickenpalayam, Peelamedu and Vallam series. This variation may be attributed to introduction of high biomass crops in alternate cropping pattern viz., rice, maize in case of Periyanaickenpalayam, Peelamedu and Vallam series (Table 6) (Pratap Narain, 2001). Introduction of diversified cropping systems with high biomass producing crops may improved SOC (Manna *et al.,* 2008) in the selected soil series.

Table 7. Years predicted using Roth C model to attain 5.0 g $kg^{-1}$and 7.5 g kg^{-1} percent soil organic carbon under existing and alternate cropping pattern for benchmark soils of Tamil Nadu

Agro climatic zones	Name of soil series and location	Initial TOC (t C ha^{-1})	Existing cropping pattern		Alternate cropping pattern	
			5.0 (11.0 t C ha^{-1})	7.5 g kg^{-1} (16.5 t C ha^{-1})	5.0 (11.0 t C ha^{-1})	7.5 g kg^{-1} (16.5 t C ha^{-1})
Western zone	Periyanaickenpalayam, Coimbatore	14.30 (6.50)	-	2025 (16.58)	-	2018 (16.55)
Southern zone	Peelamedu, Aruppukkottai	13.64 (6.20)	-	2100 (16.42)	-	2035 (16.50)
North western zone	Vannappatti, Paiyur	7.70 (3.50)	2021 (10.61)	-	2028 (11.01)	-
Cauvery delta zone	Padugai, Aduthurai	15.18 (6.90)	-	2013 (16.56)	-	2014 (16.49)
North eastern zone	Vallam, Vridhachalam	11.44 (5.20)	-	-	-	-

Years predicted using Roth C model to reach 5.0 g kg^{-1} and 7.5 g kg^{-1} TOC

Among five selected soil series, Periyanaickenpalayam, Peelamedu and Padugai series recorded 7.5 g kg^{-1} TOC during 2025 and 2018, 2100 and 2035, 2013 and 2014 under existing and alternate cropping pattern, respectively. But in Vannappatti and Vallam series both under existing and alternate cropping pattern could not reached 7.5 g kg^{-1} TOC. Because, these soil series are red soils and their nutrient holding capacity, clay content and CEC were less compared to Periyanaicken palayam and Peelamedu series (black soils) and Padugai series (Alluvial soil) (Table 7).

From the current study two conclusions could be drawn *viz*., during 1997 and 2007, among the agricultural land uses, buildup of SOC in soils under cereal-based cropping system was high and among the agroclimatic zones of Tamil Nadu in the plains Cauvery delta zone showed higher SOC.

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