Soil organic carbon status under different land use systems and soil fertility status of Rachanahalli sub watershed, Yadgir district in Karnataka, India

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Abstract
The decline in productivity of Indian soils under rainfed area is due to deteriorating soil fertility and scanty rainfall with uneven distribution. The present study was carried out in Rachanahalli Subwatershed of Yadgir taluk and district, Karnataka under SUJALA-III project to assess the soil organic carbon status under different land use systems and soil fertility status through Land Resource Inventory (LRI) by using Remote Sensing, GIS Techniques and Field Survey. A total of 589 geo-referenced composite surface soil samples at 325x325 m grid interval along with land use details and soil morphological features of soil profiles were studied and collected. The soils were analysed for soil organic carbon and fertility status (macro and micronutrients) using standard methods of analysis. Based on the soil test values of Organic carbon and soil nutrients, the soils were grouped under low, medium, high/deficient or sufficient. The major land use systems identified in the subwatershed area were groundnut, paddy, cotton, redgram, sorghum, ragi, currently fallow, permanently fallow and scrub land. The Soil Organic Carbon status under different land use systems revealed that soils under groundnut cultivation have high organic carbon content as compared to other land use systems and lowest carbon content was in the scrub land areas. The soil fertility status of the study area revealed that majority of the soils are slightly to strongly alkaline in soil reaction. All the soils of the subwatershed are non saline. Soil organic carbon status is high to medium, available phosphorous is medium to low and available potassium is medium to high. Available sulphur and boron is medium to low in most of the soils. Available iron, copper and manganese are sufficient in the most of the soils. Available zinc is deficient in most of the soils in the Subwatershed. Apart from scanty and irregular rainfall in the semi arid tropical soils, the nutrient deficiency of soils have resulted in declined crop productivity. Hence, the site specific nutrient management based on crop requirement is a key to sustain crop productivity in rainfed areas.

Keywords: Soil organic carbon status, land use system, soil fertility, subwatershed

Introduction
Loss of soil organic carbon (SOC) negatively affects not only soil health and food production, but also exacerbates climate change. When SOM is decomposed, carbon-based greenhouse gases are emitted to the atmosphere. If this occurs at too high rates, soils can contribute to warming of our planet. On the flip side, many soils have the potential to increase their stock of carbon. In addition to the importance of SOM for soil properties, the accumulation of C in the soil organic carbon pool can be a way to mitigate climate change by reducing the atmospheric CO2 concentration. Global soil organic carbon stock in 0-30 cm soil depth is about 680 pg. (FAO 2017) [1]. Soils plays significant role in global carbon cycle as it contains about three times more C than in atmosphere C and ~3.8 times more C than in biotic pool (Zomer R., 2003) [18]. It can be a source or a sink of atmospheric C depending upon land use and management (Lal R., 2003.) [4]. Land use and vegetation cover type influence soil physico-chemical and C dynamics in soil (Swift R.S., 2001) [12]. Land use change (LUC) has contributed to soil degradation and changes in both quantity and quality of SOC which enhanced C emissions to atmosphere (Watson R.T., 2000, Ogle S.M., 2005) [10, 8]. Land management with less soil disturbance increased higher SOC accumulation, while intensive disturbance decreased SOC accumulation.
Land use change from native ecosystem to cultivated ecosystem causes loss of soil carbon. On the other hand, vegetation development on abandoned agricultural land enhances the C sequestration. Thus study of land use changes in field level is needed to determine the fate of C in the system. Soil organic carbon greatly influences soil properties and takes important role in agronomic production and environmental quality. C sequestration help to mitigate global warming, alleviate soil degradation and ensuring sustainable agriculture production (Swift R.S., 2001)\(^\text{[12]}\).

The Indian soils are gradually becoming less productive after few decades of Green Revolution. Among various factors responsible for declining crop productivity, poor land, water, nutrient and crop management are responsible for this situation. To reverse the situation, a paradigm shift in our approach of land, water and nutrient management is required. Intensively cultivated soils are being depleted with available nutrients that resulted in declined productivity. Therefore assessment of fertility status of soils to be carried out in maintaining soil fertility. Soil testing is usually followed by collecting composite soil samples in the fields without geographic reference. The results of such soil testing are not useful for site-specific recommendations and subsequent monitoring. Soil available nutrients status of an area using Global Positioning System (GPS) will help in formulating site-specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally (Mamaledesai N.R., et al., 2012)\(^\text{[1]}\).

However, there is not much literature on studies addressing land use change dynamics and its effect on C pool in ecosystem level and soil fertility status in this region. Therefore, a study was conducted to the assess effect of different land use systems on soil organic carbon dynamics and soil fertility status.

**Material and Methods**

The Rachanahalli Subwatershed is located in the northern part of Karnataka in Yadgir Taluk and District, Karnataka State (Fig. 1). It comprises parts of Neelahalli, Gudlagunta, Kanikal, Sambara, Ramapura, Balacheda, Baddepalli, Sydhapura, Rachanahalli, Daddala, Kadechoora, Mungala, Sangavara, Shettilli, Kondapura and Badiyala villages. It lies between 16°30'07"-16°38'02" north latitudes and 77°15'48"-77°20'32" east longitudes, covering an area of about 6359 ha. The topography of the region ranges from very gently sloping to gently sloping. Yadgir district falls under semi arid tract of the state and is categorized as drought-prone with total annual rainfall of 866 mm (Table 1). Rainfall distribution is shown in Figure 2. The average Potential Evapo-Transpiration (PET) is 141 mm and varies from a low of 81 mm in December to 199 mm in the month of May. The PET is always higher than precipitation in all the months except end of June to end of September. Generally, the Length of crop Growing Period (LGP) is 120-150 days and starts from 1st week of June to 4th week of October.

The Land Resource Inventory at 1:7920 scale was carried out in an area of 6359 ha. The methodology followed for carrying out land resource inventory was as per the guidelines given in Soil Survey Manual (IARI, 1971; Soil Survey Staff, 2006; Natarajan et al., 2015)\(^\text{[2, 11, 7]}\). The detailed survey of the land resources occurring in the subwatershed was carried out by using digitized cadastral map and IRS satellite imagery of Cartosat-1 and LISS IV merged at the scale of 1:7920 to identify geology, landscapes, landforms and other surface features. Apart from cadastral maps and images, toposheets of the area (1:50,000 scale) were also used for initial traversing, identification of geology and landforms, drainage features, present land use systems. The geo-referenced 589 soil samples were collected from farmer’s fields, for OC and fertility status (major and micronutrients), at 325x325 m grid interval in the year 2018 and were analyzed in the laboratory by following the methods outlined in the Laboratory Manual (Sarma et al, 1987, Katyal and Rattan, 2003)\(^\text{[10, 3]}\). By linking the soil fertility data to the survey numbers through GIS, soil fertility maps were generated by using Kriging method for the Subwatershed. The major land use systems identified in the study area were groundnut, paddy, cotton, red gram, sorghum, ragi, currently fallow, permanently fallow and scrub land. The soil organic carbon under different land use systems and fertility status of the subwatershed were analysed and compared with each other using descriptive statistical tools.
The soil fertility status (Fig. 3 to 8) revealed that the soils of the subwatershed are slightly to strongly alkaline in soil reaction in about 4876 ha (77%) area, neutral in 1146 ha (18%) and slightly acid in 6 ha (<1%) area. Most of the soils in the study are alkaline in soil reaction due to semi arid condition and scanty rainfall. Electrical conductivity of the entire subwatershed soils is <2dSm\(^{-1}\) and thus the soil are non saline. Soil organic carbon is high in an area of 2691 ha (42%), medium in 2696 ha (42%) and low in 641 ha (10%) area, the organic carbon in most of the soils is medium to high, this is due to addition of organic matter and improved management practices. Available phosphorous is high in 674 ha (11%), medium in 3065 ha (48%) and low in 2289 ha (36%) area, most of the soils are medium to low due to alkaline pH and calcareousness (Murthy, 1988). Available potassium is high in 1146 ha (18%), medium in 4663 ha (73%) and low in 219 ha (3%) area of the Subwatershed. Available sulphur is high in 258 ha (4%), medium in 1563 ha (25%) and low in 4208 ha (66%) area, this is due to induced management practices, where no addition of sulphur containing fertilizers to soil. Available boron is high in 1157 ha (18%), medium in 3522 ha (55%) and low in 1349 ha (21%) area. Available iron is sufficient in 5111 ha (80%) and deficient in 918 ha (14%) area, Available copper and manganese are sufficient in the entire cultivated area and available zinc is deficient in the entire cultivated area of the Subwatershed. Since, the soils are alkaline and rich in CaCO\(_3\), zinc may be precipitated as hydroxides and carbonates under alkali pH range. Therefore, their solubility and mobility may be decreased resulting in reduced availability (Vijayshekar et al. (2000) and Ravikumar et al. 2007\(^{[13, 9]}\)).

Based on LRI and soil fertility data, the LRI Cards (Fig. 9) are prepared for each of the land parcel and are distributed to the concerned farmers, which would help them in choosing the appropriate land use and applying right dose of fertilizers. This has a great potential to increase the crop production by implementing the proper land management and land use strategies developed for each of the land parcel in the watershed.

### Conclusion

Results from the present study conclude that different types of land use systems exert a profound influence on soil organic carbon in soils. Accordingly, extensively cultivated soils and barren/fallow lands had lower amounts of organic carbon than other land use and land cover systems, suggesting the need for sustainable cropping systems such as crop rotation, addition of organic matter and crop residues to increase the SOC. The soil fertility status of the study area confirms that most of the soils are not only thirsty but also hunger for crop nutrients, most of the nutrients are low to medium and deficient. The optimum land use plan prepared based on LRI data helps in not only maintaining soil productivity on a sustained basis but also in mitigating climate change.

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Fig 3: Soil Reaction

Fig 4: Soil Organic Carbon
Fig 5: Available Phosphorous

Fig 6: Available Potassium
Fig 7: Available Sulphur

Fig 8: Available Boron
Fig 9: LRI Card

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