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

Rajendra Hegde, TN Somashekar, SP Chaitra, GM Arpitha, G Bardhan, MB Mahendra Kumar, BA Dhanorkar, KV Niranjana and P Chandran

Rajendra Hegde
Principal Scientist &Head,
ICAR-National Bureau of Soil Survey
and Land Use Planning, Regional
Centre, Bengaluru, Karnataka, India

TN Somashekar
Senior Research Fellow
ICAR-National Bureau of Soil Survey
and Land Use Planning, Regional
Centre, Bengaluru, Karnataka, India

SP Chaitra
Senior Research Fellow
ICAR-National Bureau of Soil Survey
and Land Use Planning, Regional
Centre, Bengaluru, Karnataka, India

GM Arpitha
Senior Research Fellow
ICAR-National Bureau of Soil Survey
and Land Use Planning, Regional
Centre, Bengaluru, Karnataka, India

G Bardhan
Research Associate
ICAR-National Bureau of Soil Survey
and Land Use Planning, Regional
Centre, Bengaluru, Karnataka, India

MB Mahendra Kumar
Senior Research Fellow
ICAR-National Bureau of Soil Survey
and Land Use Planning, Regional
Centre, Bengaluru, Karnataka, India

BA Dhanorkar
Chief Technical Officer
ICAR-National Bureau of Soil Survey
and Land Use Planning, Regional
Centre, Bengaluru, Karnataka, India

KV Niranjana
Chief Technical Officer
ICAR-National Bureau of Soil Survey
and Land Use Planning, Regional
Centre, Bengaluru, Karnataka, India

P Dr. Chandran
Director (Acting)
ICAR- National Bureau of Soil
Survey and Land Use Planning,
Nagpur, Maharashtra, India

Corresponding Author:
TN Somashekar
Senior Research Fellow
ICAR-National Bureau of Soil Survey
and Land Use Planning, Regional
Centre, Bengaluru, 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 are high in soil organic carbon followed by paddy, cotton, currently fallow, red gram, sorghum, ragi, permanently fallow and scrubland. The 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 SOC stocks, thus mitigating 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]. Soil 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) [15]. 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) [14, 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) [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) [5].

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^{0}30’07”–16^{0}38’02” north latitudes and 77^{0}15’48”–77^{0}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 semiarid 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) [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 were used 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) [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.

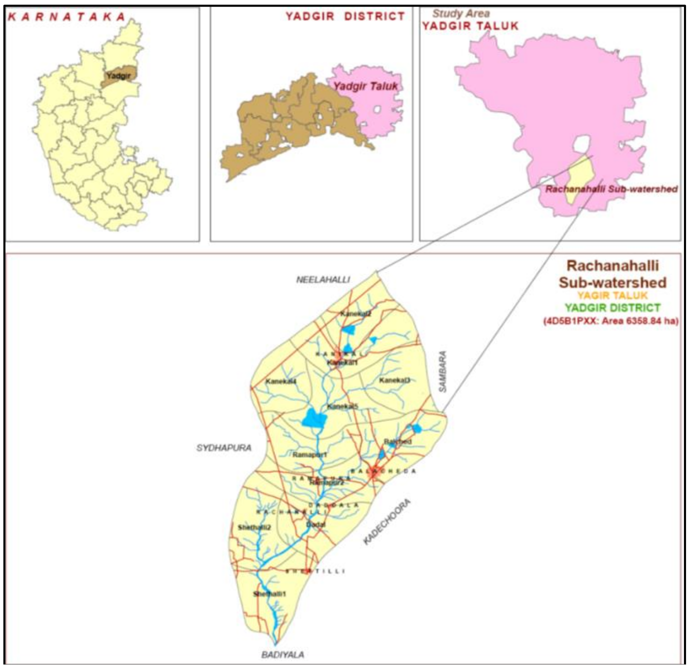

Fig 1: Location Map of Rachanahalli Subwatershed, Yadgir Taluk and District, Karnataka

Table 1: Mean Monthly Rainfall, PET, 1/2 PET at Yadgir Taluk, Yadgir District

Sl. No.	Months	Rainfall	PET	1/2 PET
1	January	4.30	86.0	43.0
2	February	2.30	125.5	62.7
3	March	15.10	166.0	83.0
4	April	18.50	179.8	89.9
5	May	36.0	198.8	97.9
6	June	118.0	175.1	87.5
7	July	171.80	156.3	78.1
8	August	182.9	150.3	75.1
9	September	179.7	142.0	71.0
10	October	105.3	138.5	69.2
11	November	26.4	97.60	48.6
12	December	6.0	80.90	40.4
Total		866.3		

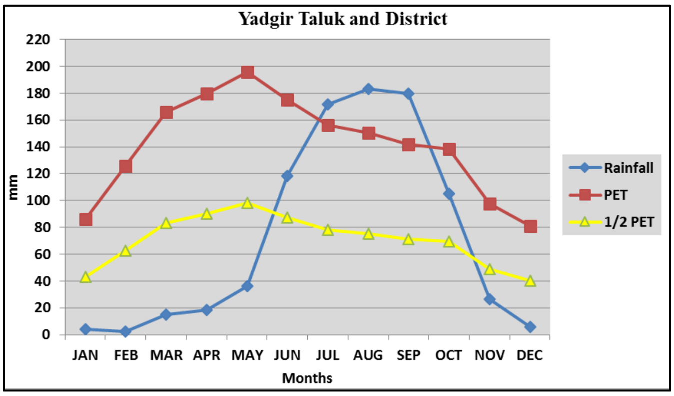

Fig 2: Rainfall distribution in Yadgir Taluk and District

Result and Discussion

The soil organic carbon status of the study area under different land use systems is presented in Table 2. The results revealed that the soils under groundnut cultivation are high in soil organic carbon content and ranged from 0.07 to 2.73% with mean value of 0.91% followed by paddy ranging from 0.07 to 2.10% with mean value of 0.81% and cotton with minimum and maximum of 0.10 to 2.40 and mean 0.79%. The extreme variation in range is due to management induced variation, currently fallow land with mean 0.75%, redgram 0.74%, sorghum 0.71%, ragi 0.66%, permanently fallow land 0.61% and scrubland 0.49%. The soils under groundnut cultivation have high organic carbon content as compared to other land use systems, this is due to intensive management and addition of organic manures, crop residues with improved methods of cultivation and lowest carbon content was in the scrub land areas, these areas are more prone to over grazing, lack of soil and water conservation structures, hence loss of top fertile soil and these lands with less or no vegetative cover which resulted in low soil organic carbon content.

Table 2: Soil Organic Carbon under different Land Use Systems

Land Use	Mean	Min	Max	SD
Cotton	0.79	0.10	2.40	0.44
Currently Fallow land	0.75	0.10	3.05	0.52
Groundnut	0.91	0.07	2.73	0.54
Jowar	0.71	0.04	2.09	0.38
Fallow Land	0.61	0.19	1.36	0.32
Paddy	0.81	0.07	2.10	0.56
Ragi	0.66	0.31	0.95	0.27
Redgram	0.74	0.03	3.20	0.48
Scrub land	0.49	0.10	0.95	0.30

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 CaCO3, 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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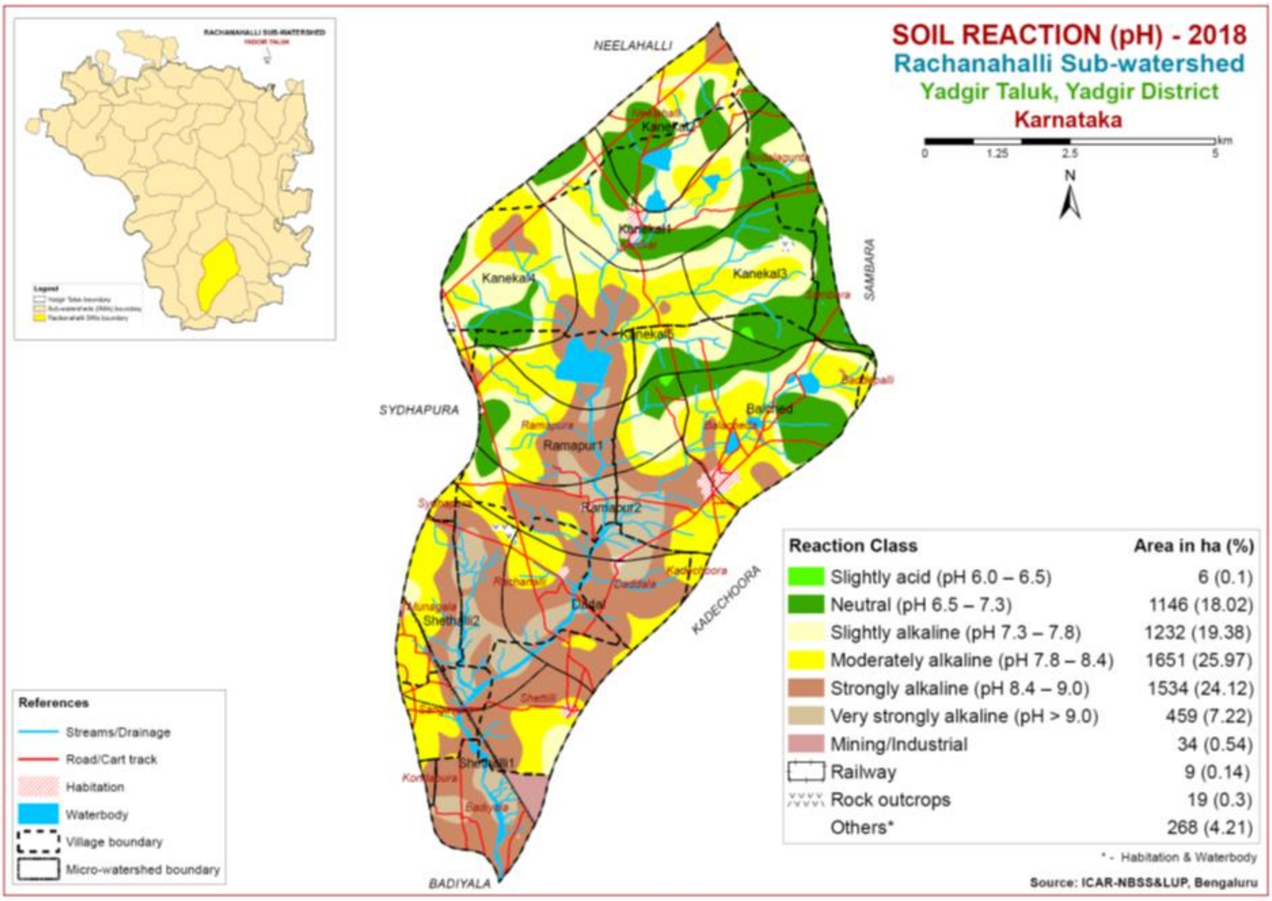


Fig 3: Soil Reaction

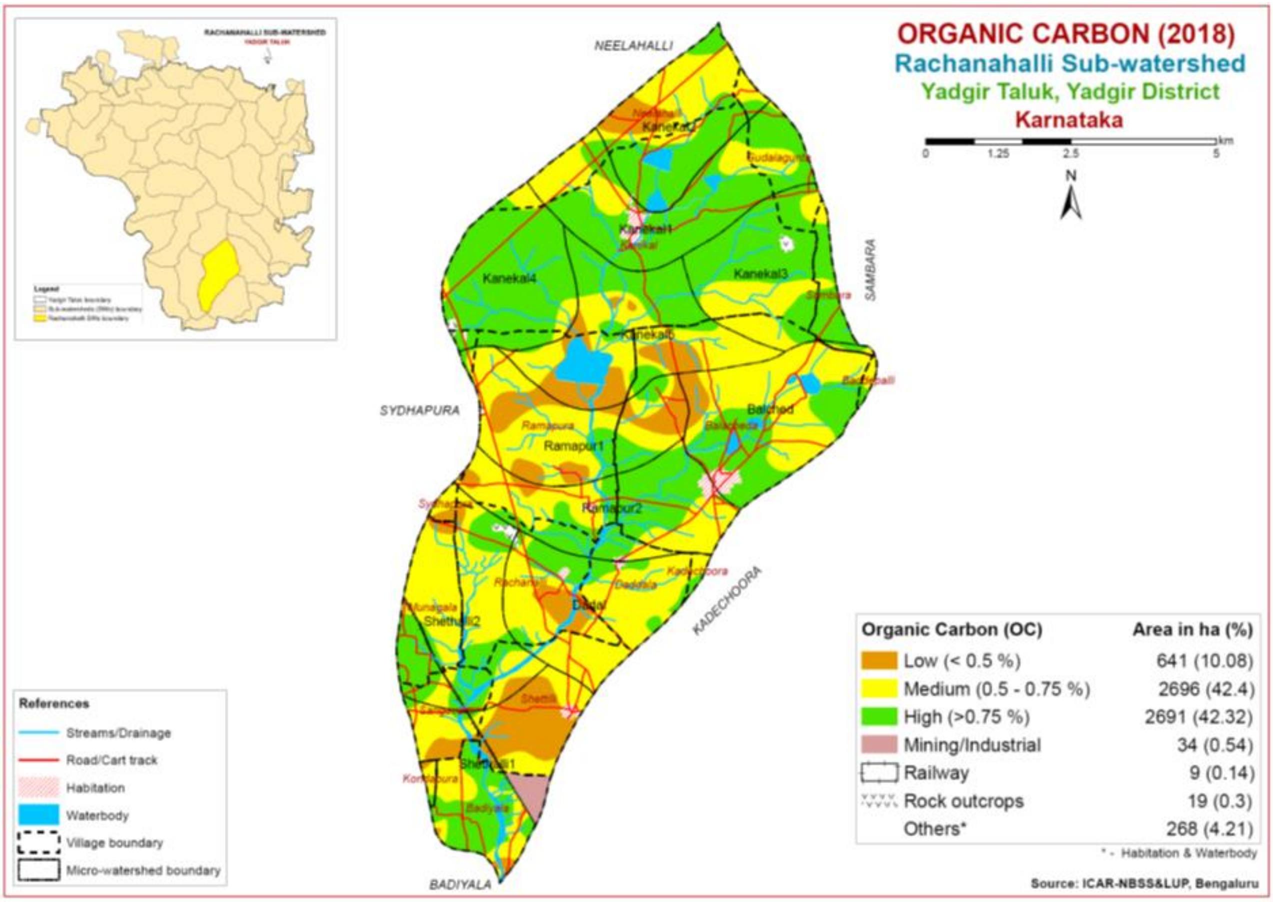


Fig 4: Soil Organic Carbon

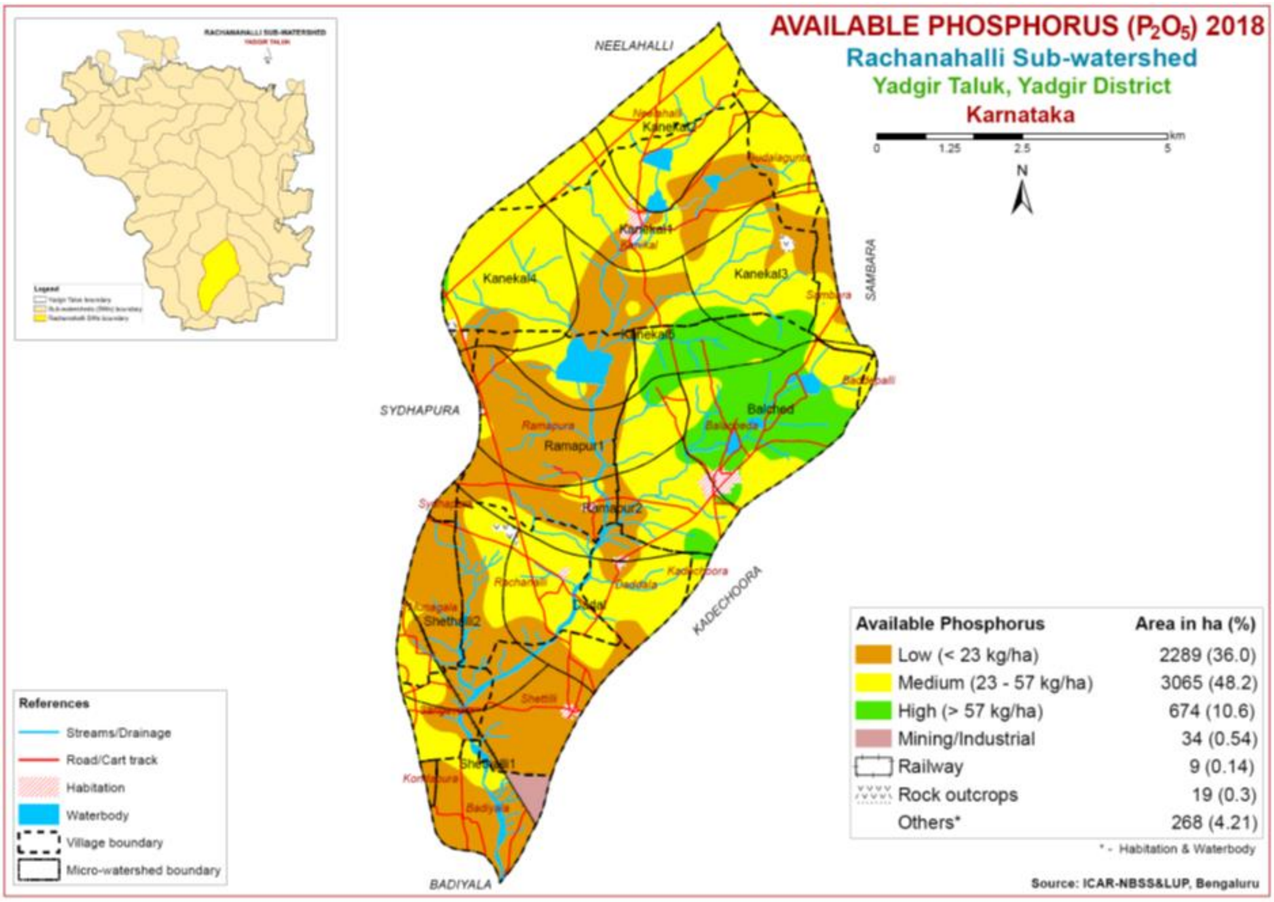


Fig 5: Available Phosphorous

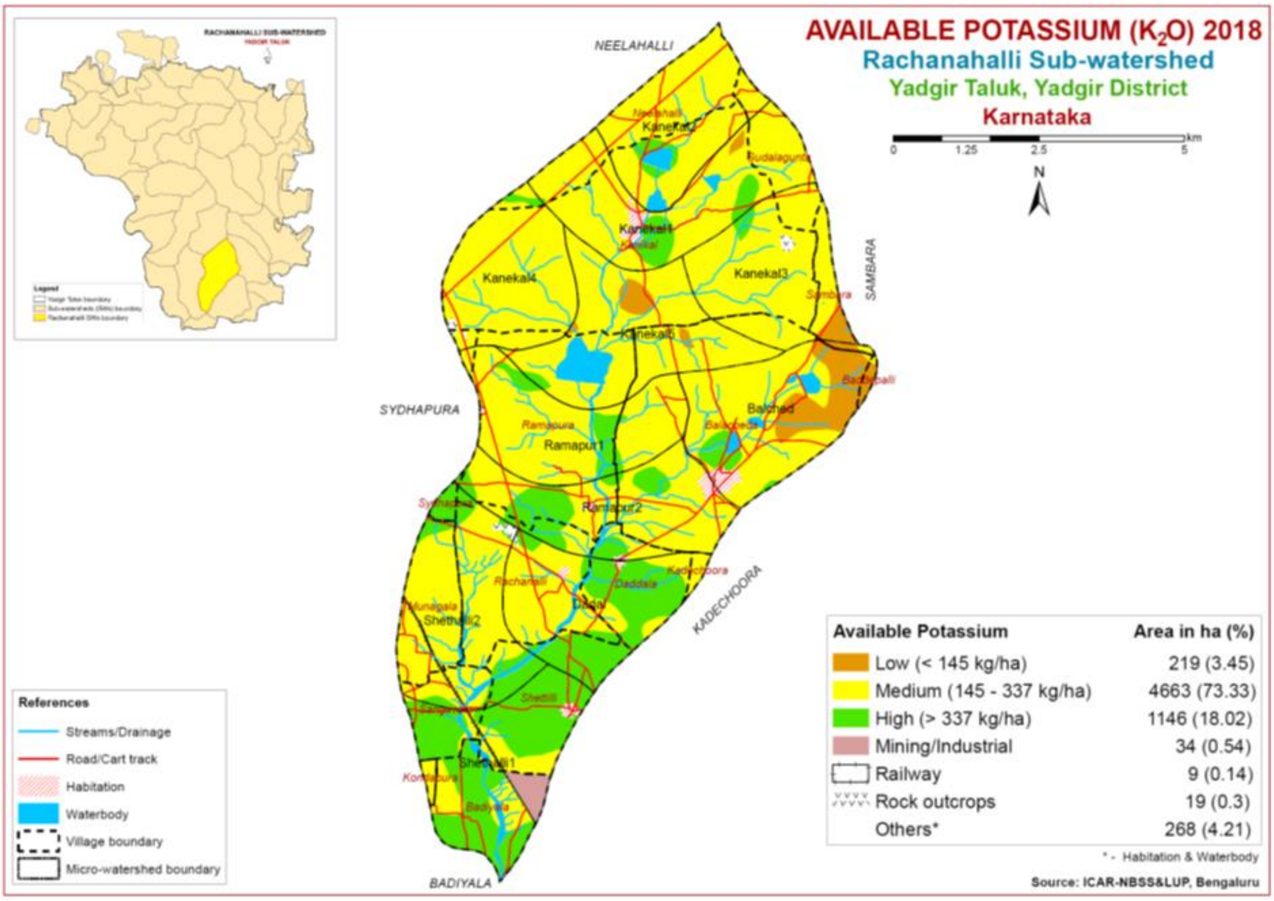


Fig 6: Available Potassium

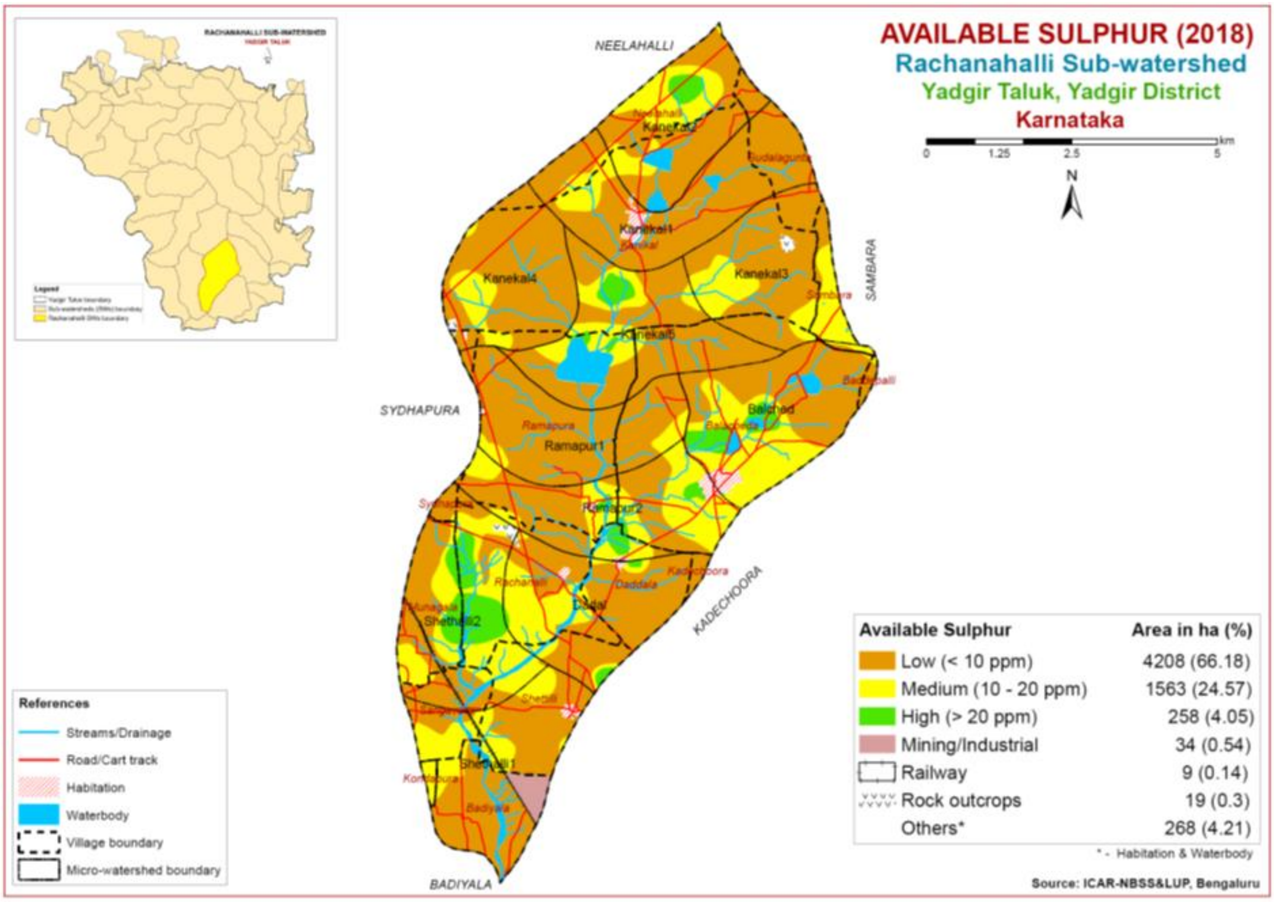


Fig 7: Available Sulphur

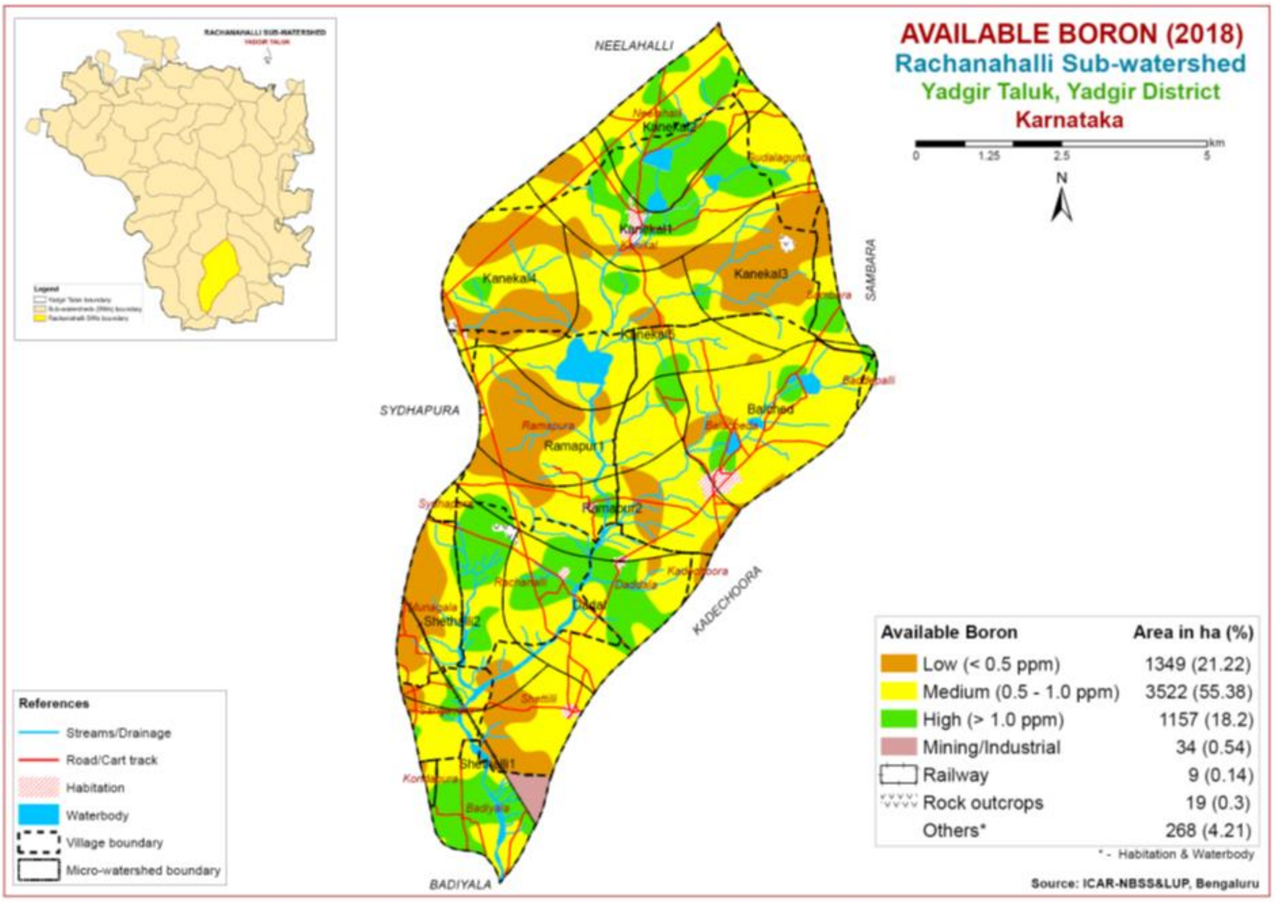
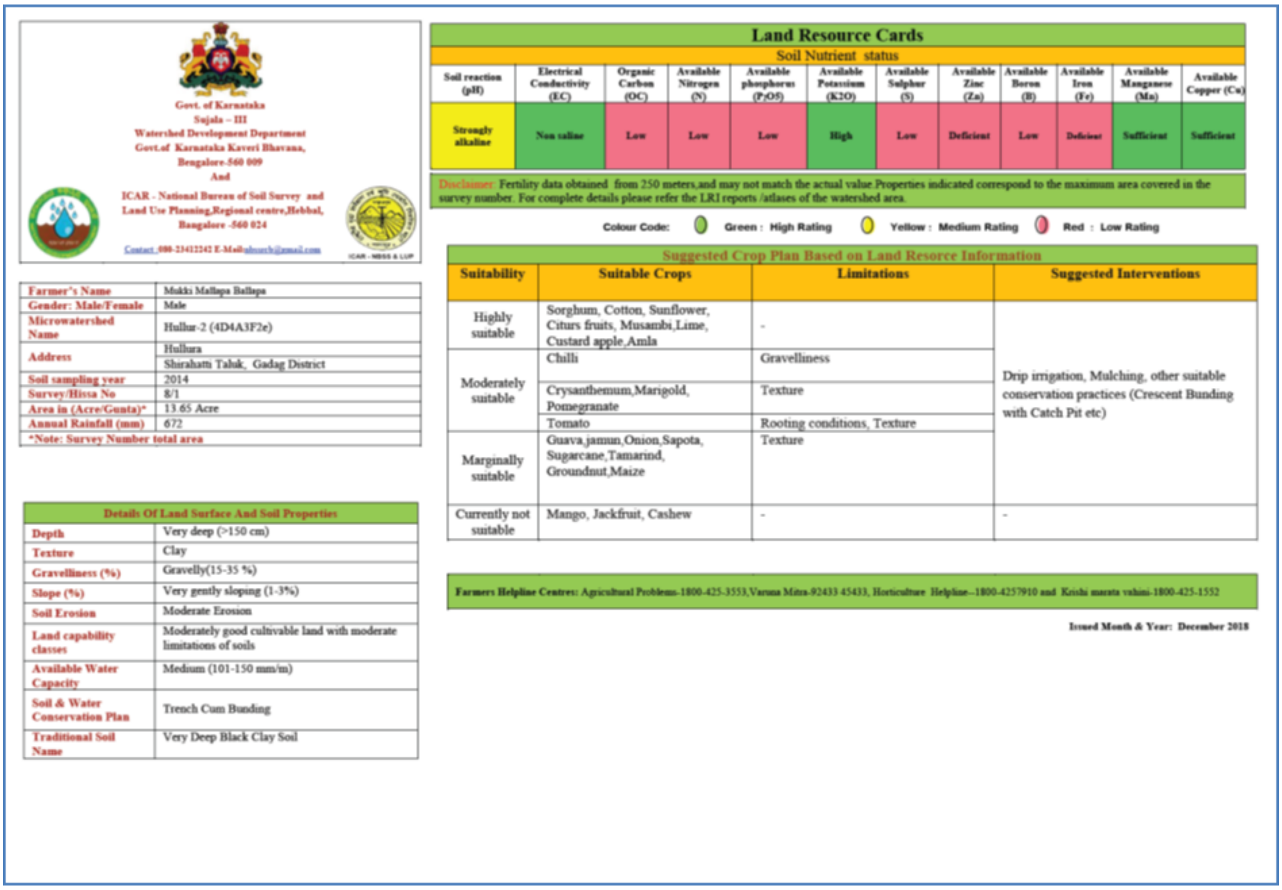


Fig 8: Available Boron



Govt. of Karnataka
Sujala – III
Watershed Development Department
Govt.of Karnataka Kaveri Bhavana,
Bengalore-560 009
And
ICAR - National Bureau of Soil Survey and
Land Use Planning,Regional centre,Hebbal,
Bangalore -560 024

Contact :080-23412242 E-Mail:[illegible]

Farmer's Name	Mukki Mallapa Ballapa
Gender: Male/Female	Male
Microwatershed Name	Hullur-2 (4D4A3F2e)
Address	Hullura Shirahatti Taluk, Gadag District
Soil sampling year	2014
Survey/Hissa No	8/1
Area in (Acre/Gunta)*	13.65 Acre
Annual Rainfall (mm)	672
***Note: Survey Number total area**	

Details Of Land Surface And Soil Properties

Depth	Very deep (>150 cm)
Texture	Clay
Gravelliness (%)	Gravelly(15-35 %)
Slope (%)	Very gently sloping (1-3%)
Soil Erosion	Moderate Erosion
Land capability classes	Moderately good cultivable land with moderate limitations of soils
Available Water Capacity	Medium (101-150 mm/m)
Soil & Water Conservation Plan	Trench Cum Bunding
Traditional Soil Name	Very Deep Black Clay Soil

Land Resource Cards

Soil Nutrient status

Soil reaction (pH)	Electrical Conductivity (EC)	Organic Carbon (OC)	Available Nitrogen (N)	Available phosphorus (P₂O5)	Available Potassium (K2O)	Available Sulphur (S)	Available Zinc (Zn)	Available Boron (B)	Available Iron (Fe)	Available Manganese (Mn)	Available Copper (Cu)
Strongly alkaline	Non saline	Low	Low	Low	High	Low	Deficient	Low	Deficient	Sufficient	Sufficient

Disclaimer: Fertility data obtained from 250 meters,and may not match the actual value.Properties indicated correspond to the maximum area covered in the survey number. For complete details please refer the LRI reports /atlases of the watershed area.

Colour Code: 🟢 Green : High Rating 🟡 Yellow : Medium Rating 🔴 Red : Low Rating

Suggested Crop Plan Based on Land Resorce Information

Suitability	Suitable Crops	Limitations	Suggested Interventions
Highly suitable	Sorghum, Cotton, Sunflower, Citurs fruits, Musambi,Lime, Custard apple,Amla	-	Drip irrigation, Mulching, other suitable conservation practices (Crescent Bunding with Catch Pit etc)
Moderately suitable	Chilli	Gravelliness	
	Crysanthemum,Marigold, Pomegranate	Texture	
	Tomato	Rooting conditions, Texture	
Marginally suitable	Guava,jamun,Onion,Sapota, Sugarcane,Tamarind, Groundnut,Maize	Texture	
Currently not suitable	Mango, Jackfruit, Cashew	-	-

Farmers Helpline Centres: Agricultural Problems-1800-425-3553,Varuna Mitra-92433 45433, Horticulture Helpline--1800-4257910 and Krishi marata vahini-1800-425-1552

Issued Month & Year: December 2018

Fig 9: LRI Card

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