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SOIL FERTILITY ANALYSIS AND MAPPING OF MICRONUTRIENTS IN COMMAND AREA OF HANJIHALLI VILLAGE TANK OF KARNATAKA, INDIA THROUGH REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM (GIS)

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ABSTRACT

The aim of the study was to analyze and map the soil micronutrient status in the command area of Hanjihalli village tank through remote sensing and geographical information system (GIS). Sixty-three composite soil samples from surface (0-15 cm) were collected across the command area of Hanjihalli village tank covering an agricultural area of 63 ha at 100 m grid intervals. The GPS data at each sample location was collected. Inverse distance weighting (IDW) technique and kriging were adopted to generate thematic maps of the soil properties. The process of digitization and generation of maps was carried out with Arc GIS 10 software. Experimental results revealed that available iron ranged between 3.79 to 56.70 mg kg^{-1} with a mean value of 25.33 mg kg^{-1} and coefficient of variation 51.62 per cent. Available copper ranged between 0.08 to 5.58 mg kg^{-1} with a mean value of 1.20 mg kg^{-1} and highest coefficient of variation of 107.91 per cent. Available zinc ranged between 0.02 to 0.94 mg kg^{-1} with a mean value of 0.37 mg kg^{-1} and coefficient of variation 69.45 per cent. Available manganese ranged between 0.14 to 34.10 mg kg^{-1} with a mean value of 7.39 mg kg^{-1} and coefficient of variation 107.28 per cent. This technique was found to be effective in identifying the micronutrients availability throughout the study region, thereby helping policy makers to frame fertilizer distribution and application policy for future.

Key words : Soil fertility, Remote sensing, Geographical information system, Thematic maps, Micronutrient.

Introduction

Soil is the most wondrous gift of nature to all the earthlings. It is vital natural resource base perform fundamental functions for benefit of mankind and environment. Share of India in global degraded soil area is about 10%, it was largely impelled by anthropogenic misuse of soil *via* nonscientific, indiscriminate and non-sustainable intensive agricultural practices. It has become more imperative now than before to protect and preserve quality of soil resource to sustainably build productivity. In mainstream agricultural production systems are affected to a greater extent due to variations in climate, soil and topography of different regions. The maximized use of major chemical fertilizers like Urea, DAP, MOP, *etc*., has not only created a huge disturbance in soil nutrient distribution and availability but has also forced crops to be more sensitized towards other micronutrients. Concerted efforts have been made through the All India Coordinated Research Project on micronutrients to delineate the soils of India regarding the deficiency of micronutrients as a result of which it has been analyzed that at present about 48.1% of Indian soils are deficient in diethylene triamine penta acetate (DTPA) extractable zinc, 11.2% in iron, 7% in copper and 5.1% in manganese. Apart from the deficiency of above micronutrients, boron and molybdenum deficiencies have also been reported in some areas. The reports of AICRP on micronutrient have also stated that the areas with multi micronutrient deficiencies are limited and for such areas simple fertilizers are sufficient to exploit the potential of crops and cropping systems. Based on the extent of deficiency, cultivated area, and crop removal, it has been projected that the micronutrient fertilizer demand will rise by 2025, thereby creating a vacuum in sustainable fertilizer usage approach (Anand, 2005; Vikas *et al.*, 2020). For sustainable agricultural management, all these factors need to be analyzed on spatio-temporal basis.

To conserve and manage the soil resources, it's important to have resource inventory of soil characteristics, fertility and water resources of the catchment and command area. Soil resource inventory provides awareness on the potentialities and limitations of soil for its effective utilization. It also provides sufficient information on soil characteristics, landform, terrain and vegetation. These insight data on soil can be employed for soil and land resources management and development (Manchanda *et al.*, 2002).

In the year 2018, the global population has crossed 7.5 billion and it may reach 9.6 billion by 2050. Hence to meet the demands, the agriculture production has to be increased to 3 billion tonnes from current 2.1 billion tonnes. The growing population pressure demand for food, fibre and fuel, appropriate management of this indispensable natural resource is of vital significance for sustenance.

One of the difficulties frequently met for making decisions are lack of the scientific data pertaining to our natural resources. Food production must be increased by at least 40 per cent by 2025 to meet the desires of 33 per cent increase in human population and to satisfy trends for enhanced nutrition (Bos *et al*., (2005). To encounter these targets of food production for a wealthy population, increase in food grain and hence the development in agriculture sector is inevitable. As land is limited, increased food production from finite land resources is one of the challenging tasks for coming decades.

Digital maps are very potential tools to attain this. Maps narrate the feature to any given geographical site has a powerful visual impact. Maps are thus important for monitoring and computing vary over time scale and help in decision making. The method used in the preparation of map started with ground survey. The Survey of India (SOI) topographic map are the most primitive true maps of India depicting various land use/ cover classes as well as water logging. The most important technique is remote sensing and GIS. Remote sensing is currently recognized as a vital tool for viewing, analysing, characterising and to make decisions about land, water and atmosphere components. Remote sensing has developed as a powerful tool for studying soil resources as it aids to study the soils in spatial domain in time and lucrative manner (Saxena, 2003). Geographical Information System (GIS) analyses and display manifold data layers resulting from various sources and provides valuable information to handle voluminous data generated by conventional and RS technology both in spatial and non-spatial format predominantly in soil surveys.

Reliable nutrient recommendations are depending on accurate soil tests and crop nutrient standardizations based on extensive field research. The actual fertility status of soils has to be evaluated before planning for any crop production, which will aid in managing the nutrient/ fertilizer application to crops. Thorough soil survey was undertaken to know the soil fertility status of Hanjihalli village tank. System of farming in this area has changed gradually during last many years; hence, it was imperative to assess the fertility and measures for improving their productivity. Existing information on these soils is meager.

Hanjihalli lies in Hassan district of the Indian state of Karnataka. Its contribution to agricultural production is very phenomenal, where in paddy is the only crop growing in this command area in the *kharif* season. Hence, an attempt was made to delineate the micronutrient status of the soils by using remote sensing and geographical information system technique for sustainable crop production in the study area.

Material and Methods

The command area of Hanjihalli village tank is located in Alur Taluk of Hassan district with an extent of 63 ha. The command area of Hanjihalli village tank is situated at 12^o 55' 28.647" to 12^o 56' 1.221" North latitude and 75^o 58' 38.419" to 75^o 59' 14.882" East longitude. The Hanjihalli village tank comes under Southern Transition Zone (Zone VII) of Karnataka. The soils in the command area are majorly of order *Alfisols*, which represents one of the more important soil orders for food and fiber production. The soil texture varies from loamy sand to clay. They have a clay enriched subsoil and relatively medium to high native fertility. The climate is hot, moist, sub-humid and the annual rainfall ranges from 612 mm to 1054 mm. The average minimum and maximum temperature being 18.20^{o}C and 29.12^{o}C, respectively.

Database creation

The satellite data used for the study was provided by Karnataka State Remote Sensing Applications Centre, Bengaluru. The merged data of Cartosat-1 (PAN) and Resourcesat-2 (LISS IV) MX in the form of digital and geo-coded were analyzed in GIS environment long with cadastral maps. The required topographic map (C43E13) at 1:5000 scale covering the study area was collected from the Survey of India and utilized for the study. The command area ancillary data was collected in the method of published reports, district hand book, maps. During the ground truth collection, the climatic data and the socio-economic conditions concerning to the study area were collected. For study purpose, digital cadastral map of command area procured from the Karnataka State Remote Sensing Applications Centre (KSRSAC), Bengaluru was used. For database creation and union of various thematic maps the Geographic Information System (GIS) with Arc GIS software was used. During the present investigation we used GARMIN 72H GPS receiver in stand-alone mode to collect the information regarding the geographical location of the ground truth sites and soil sampling sites. The cadastral map of command area of Hanjihalli village tank in presented in Fig. 1.

Soil sample collection and analysis

Sixty-three composite soil samples from surface (0-15 cm) were collected across the command area of Hanjihalli village tank covering an agricultural area of 63 ha at 100 m grid intervals. The GPS data at each sample location was collected. The soil samples were air dried under shade, powdered using pestle and mortar and passed through 2 mm sieve. Later soil samples were analyzed for micronutrient content by using standard procedures Lindsay and Norvell (1978).

Preparation of thematic maps

The ArcGIS 10 software was used in this study. Based on the location data obtained, prepared point feature showing the position of samples in MS excel format and linked with the spatial data by join option in ArcMap. The spatial and the non-spatial database developed are integrated for the generation of spatial distribution maps. The principle method of preparation of thematic maps is Interpolation technique. It is centered on the existence of a spatial structure where observations close to each other are more alike than those that are far apart (spatial autocorrelation). The average degree of dissimilarity between unsampled values and a nearby data value is measured by experimental variogram and thus can depict autocorrelation at various distances. A suitable model is derived by using weighted least squares and parameters from analysis of the experimental variogram. By interpolation of point data based on soil test values soil spatial variability maps were prepared. Initially, the soil test values for available micronutrients were mapped using ArcGIS software. Soil test values were grouped into different classes representing the low, medium and high ranges. Subsequently, the point data was interpolated to create a continuous surface in the map. Ordinary kriging was used as interpolation tool for mapping of soil test values. The commonly used interpolation tool in mapping agriculture data is inverse distance weighting (IWD).

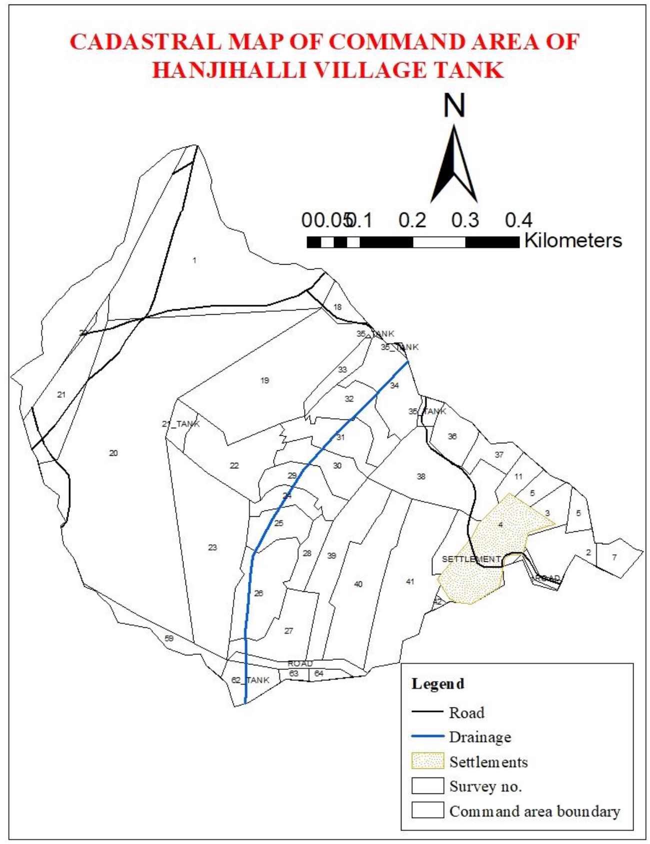

Fig. 1 : Cadastral map of command area of Hanjihalli village tank.

Results and Discussion

GIS based soil spatial variability mapping

The field level spatial variability of soil properties is an important tool for assessing any area. The fertility maps of a given area generated by using GIS technology helps to evaluate the spatial and temporal variability of soil fertility and to compute complex spatial relationships among soil fertility factors. Spatial interpolation of point based measurements of soil properties maps of spatial variability of all the soil properties were prepared using GIS techniques. Inverse distance weighting (IDW) and

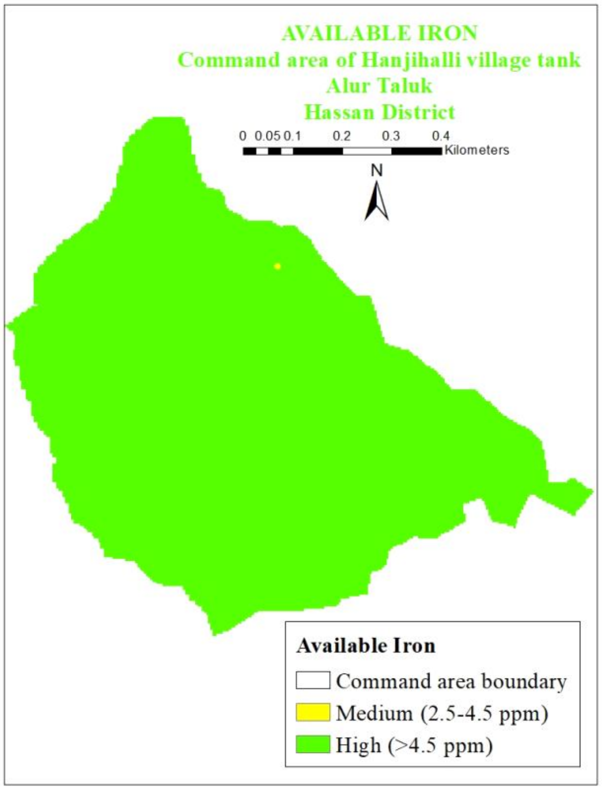

Fig. 2 : Spatial distribution of available iron in command area of Hanjihalli village tank.

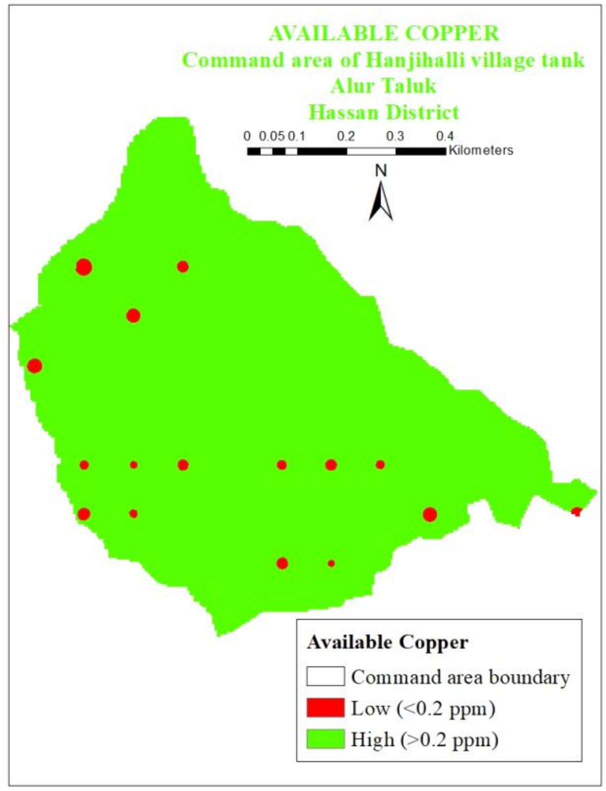

Fig. 3 : Spatial distribution of available copper in command area of Hanjihalli village tank.

kriging are commonly used for interpolation in agriculture (Weisz *et al*., 1995 and Franzen and Peck, 1995).

Soil fertility maps were prepared for DTPA extractable micronutrients using the kriging method at a scale of 1:5000. The study area is divided into different fertility classes where each class represents a specific range of fertility status of nutrients. The results of the spatial variation maps prepared are presented below (Table 1 and Figs. 2 to 5).

Available iron

The DTPA-extractable iron ranged from 3.79 to 56.70 mg kg^{-1} with a mean value of 25.33 mg kg^{-1} with standard deviation of 13.08 and coefficient of variation 51.62 per cent. It was estimated that 98 per cent of samples were high in available iron (>4.5 mg kg^{-1}) and remaining 02 percent samples were medium in available iron content (2.5 – 4.5 mg kg^{-1}). The high iron content is attributed to acidic soil pH (<6.5) and organic matter acts as chelating effect protected the iron from oxidation and precipitation, which consequently increased the solubility and availability of iron. Similar findings were also reported by Chandrashekara *et al*. (2014) and Nayak *et al*. (2002).

Available copper

Available copper status in command area of Hanjihalli village tank ranged from 0.08 to 5.58 mg kg^{-1} and mean value of 1.20 mg kg^{-1} and standard deviation of 1.30 with CV 107.91 per cent. 47 soil samples (75%) of the

Table 1 : The extent of spatial distribution of DTPA-extractable micronutrients of command area of Hanjihalli village tank.

Micronutrients	Command area of Hanjihalli village tank	
	Area (ha)	Area (%)
Available iron class		
Medium (2.5-4.5 mg kg^{-1})	1	02
High (>4.5 mg kg^{-1})	62	98
Available manganese class		
Low (<1 mg kg^{-1})	18	29
Medium (1-2 mg kg^{-1})	06	09
High (>2 mg kg^{-1})	39	62
Available zinc class		
Low (>0.6 mg kg^{-1})	52	83
Medium (0.6-1.0 mg kg^{-1})	11	17
Available copper class		
Low (<0.2 mg kg^{-1})	16	25
High (>0.2 mg kg^{-1})	47	75

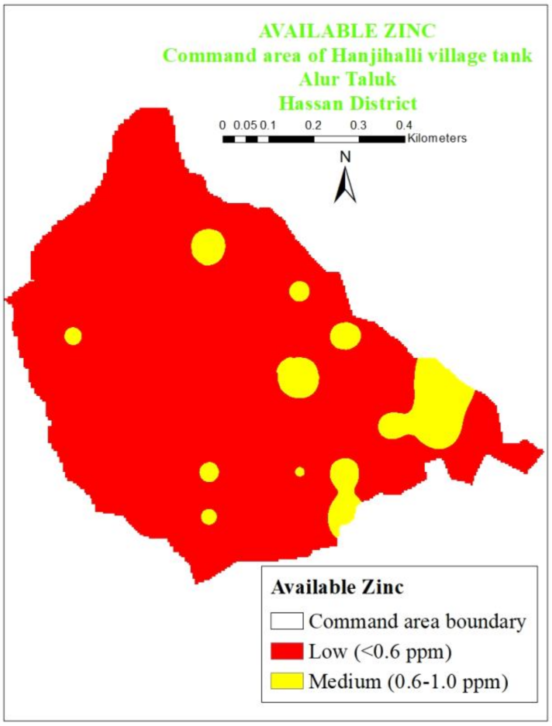

Fig. 4 : Spatial distribution of available zinc in command area of Hanjihalli village tank.

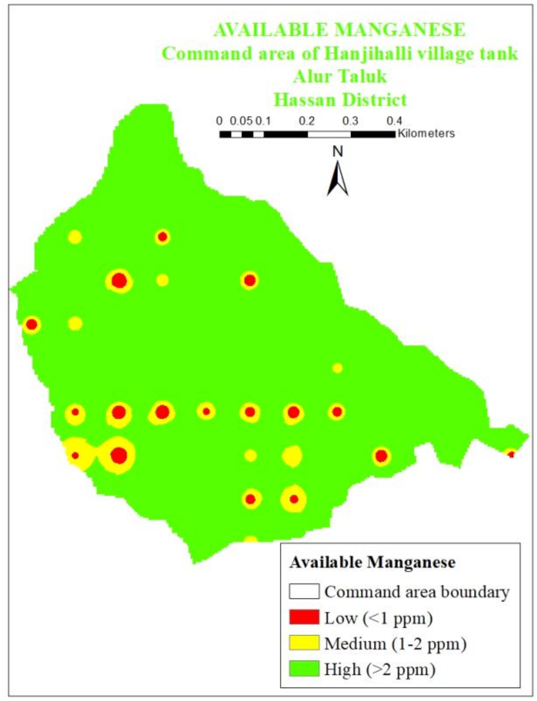

Fig. 5 : Spatial distribution of available manganese in command area of Hanjihalli village tank.

command area were high in available copper status and 16 ha (25%) under low copper status. This higher concentration of available copper was associated with chelating of organic compounds, released upon decomposition of organic matter left after harvesting of crop and also low organic matter status in the study area. Similar findings were reported by Kusuma Patil (2012). 16 soil samples were low in available copper range.

Available zinc

The soil available zinc varied from 0.02 to 0.94 mg kg^{-1} and mean value of 0.37 mg kg^{-1} and standard deviation of 0.26 with coefficient of variation 69.45 per cent. Majority (83%) of the command area is low (<0.6 ppm) and 17% area with medium range, as the soil pH predominantly regulates the solubility and also availability of micronutrient cations in the soil.

In general, its deficiency is most widespread in red lateritic soils of Karnataka. The Zn deficiency might be due to intensive cultivation of low land paddy coupled with light textured soils, eroded soils, low organic matter content. Some of the soils were neutral in pH status, which might be resulted in zinc precipitation as hydroxides and carbonates Similar findings were reported by Ravikumar (2006).

Available manganese

The available manganese status of soils ranged from 0.14 to 34.10 mg kg^{-1} and mean value of 7.39 mg kg^{-1} and standard deviation of 7.93 with coefficient of variation 107.28 per cent. 39 ha (62%) of the command area was high (>2 ppm) in available manganese content. This was attributed to presence of reduced (Mn^{+2}) form in surface soil, which contributed to available manganese pool in the soil. The results are in line with findings of Mishra *et al*. (2014). 18 ha (29%) area was lower in available manganese content and 6 ha (09%) area under medium manganese status. The low pH, redox conditions coupled with high soil organic constituents predominantly regulates the availability and solubility of manganese (Kusuma Patil, 2012).

Conclusion

Available iron ranges between 3.79 to 56.70 mg kg^{-1} with a mean value of 25.33 mg kg^{-1} and coefficient of variation 51.62 per cent. Available copper ranges between 0.08 to 5.58 mg kg^{-1} with a mean value of 1.20 mg kg^{-1} and highest coefficient of variation of 107.91 per cent. Available zinc ranges between 0.02 to 0.94 mg kg^{-1} with a mean value of 0.37 mg kg^{-1} and coefficient of variation 69.45 per cent. Available manganese ranges between 0.14 to 34.10 mg kg^{-1} with a mean value of 7.39 mg kg^{-1} and coefficient of variation 107.28 per cent. Soil fertility varies within fields and across fields which influence on the productivity of an area. The study shown that micronutrients have high coefficient of variation depicting the existence of spatial variability of soil fertility within field.

The mapping technique was found to be effective in identifying and mapping the micronutrients availability throughout the study region, thereby helping policy makers to frame fertilizer distribution and application policies for future. Also, under this context, GIS-based soil fertility mapping has appeared as a promising alternative to mass area testing and generated maps can be used as a decision support tool for nutrient management techniques, which will be helpful in adopting a rational approach compared to farmer practices or blanket use of state recommended fertilization.

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Competing interests

Authors have declared that no competing interests exist.

Authors contributions

This work was carried out in collaboration with all authors. Author Vinay Kumar, M., designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors Jayadeva, H. M. edited the analyses of the study. Authors Kamala Bai, S., Sathish, A. and Viresh Kumargoud edited and managed the literature and analysis. All authors read and approved the final manuscript.

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