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Soil fertility assessment and balanced fertilizer recommendation for improved crop productivity in Hanjihalli micro watershed using GIS and GPS

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Abstract
Soil nutrient inventory provides awareness on the potentialities and limitations of soil for its effective utilization. Judicious use of fertilizers in required amount will help to achieve higher yields. The present study was undertaken to assess the soil fertility status for fertilizer recommendation mapping of important crops grown in the micro watershed. Hundred composite soil samples were collected covering an agricultural area of 100 ha at 100 m grid intervals and analysed for soil reaction, salinity, organic carbon, major and secondary nutrients at laboratory using standard methods. Using Arc-GIS the data generated was processed and mapped. Kriging and inverse distance weighting interpolation method was followed. A raster map was developed using the grid points merged with analysed data and then vector spatial soil fertility maps were generated using Arc-GIS. Soil test based fertilizer recommendation help to enhance the soil fertility and crop productivity with minimal usage of fertilizers.

Keywords: Geographical information system, geographical positioning system, kriging, Arc-GIS

1. Introduction

Soil and water are the basic requirement of life and indiscriminate management of natural resources has led to the degradation of resource bases posing serious concern to the planners, researchers, general public and farmers. For sustained production of the system, soil and water needs scientific management and conservation in accordance with environment. Soil resource inventory provides awareness on the potentialities and limitations of soil for its effective utilization. These insight data on soil can be employed for soil and land resources management and development (Manchanda *et al*., 2002) [4]. Digital maps are precise powerful tools to relate the feature to any given geographical location as a strong visual impact. The most important technique is the precision management tools like geographical positioning system (GPS) and geographic information system (GIS). GIS analyzes and displays multiple data layers derived from various sources and provides valuable support to manage voluminous data being generated through conventional and remote sensing technology both in spatial and non-spatial format particularly in soil surveys (Zhang *et al.*, 2010) [5]. GPS helps in knowing accurate point of soil fertility variation.

Judicious use of fertilizers in required amount will help to achieve higher yields. It is very important to have information on the adequate dose of fertilizers based on soil test values for different soils. Therefore, adoption of soil testing as an analytical tool for fertilizer adjustment and recommendation assumes greater significance. Soil test based fertilizer application reduces the total amount of nutrients applied to a given field and given crop. The present study was conducted with the main objective of providing balanced nutrition through soil-test based fertilizer recommendation in Hanjihalli micro-watershed of Hassan district.

2. Materials and Methods

2.1 Study area

The Hanjihalli micro watershed is located in Alur Taluk of Hassan district with an extent of 100 ha. The Hanjihalli micro watershed is situated at 12º 55' 34.577" to 12º 55' 10.584" North latitude and 75º 59' 8.631" to 75º 59' 2.104" East longitude. The soils in the micro watershed are majorly of order Alfisols, which represents one of the more important soil orders for food and fiber production. The soils are red sandy loam in major areas and red loamy in the remaining areas. The climate is hot, moist, sub-humid and the annual rainfall ranges from 612 mm to 1054 mm. More than 60 per cent of the rain is received by southwest monsoon in the *kharif* season nearly 756.43 mm in *kharif* season during 2018. The study area is shown in Fig. 1.

2.2 Preperation of base map and delineation of study area
A tracing film was overlaid on the toposheet covering the study area. Boundary of the micro-watershed and important land features like roads, river, tanks *etc.* were extracted. Thus, a map having the above common land features was used as a base map for preparing different thematic maps. Study area was delineated with the help of topographic maps and the watershed atlas which was prepared by Karnataka State Remote Sensing Application Centre, Bangalore.

2.3 Soil Survey and Sample collection
The demarcation of the study area was done at 1:50,000 scale toposheet and 1:5000 scale

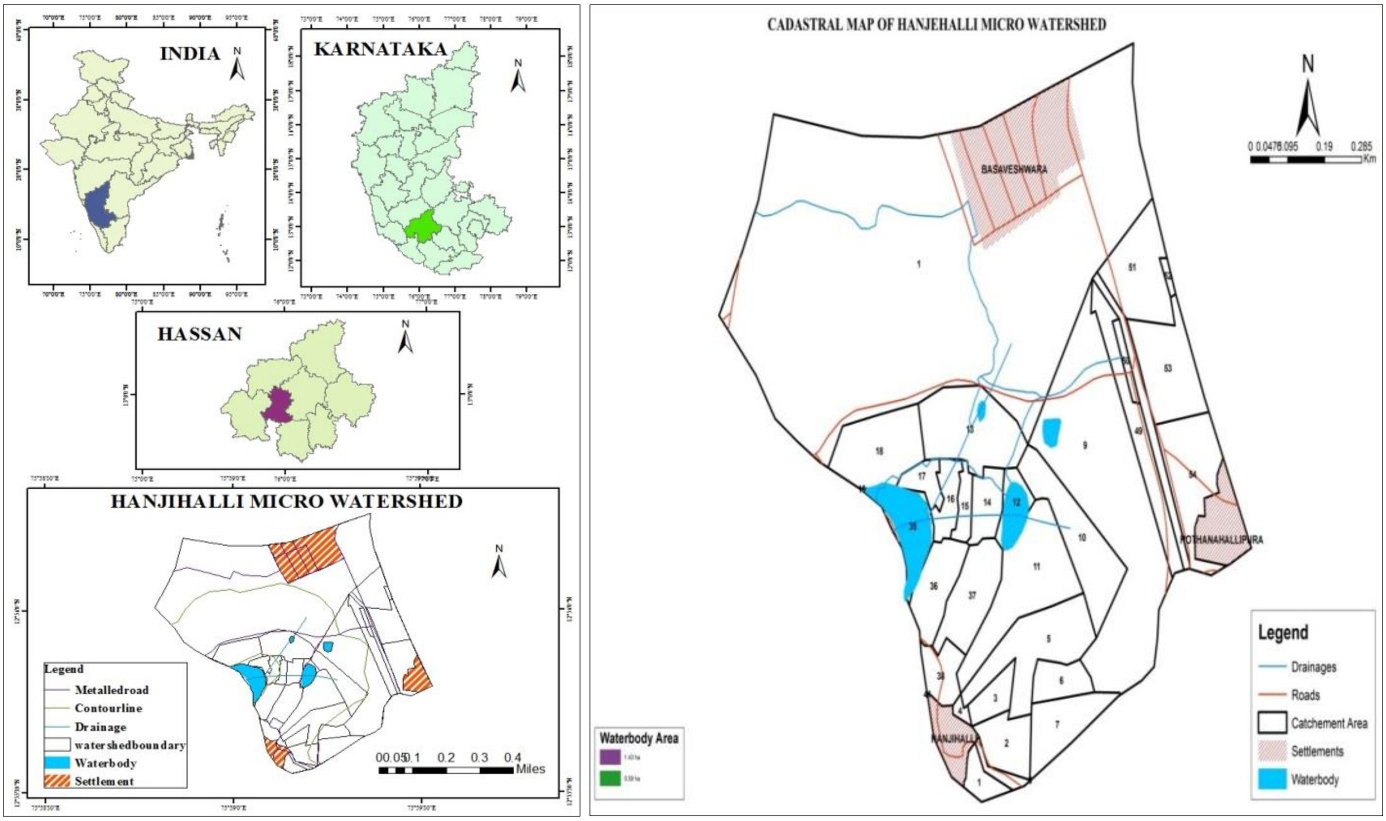


Fig 1: Location map of study area

base map with Cartosat-1 PAN 2.5 mts and resources at-2 LISS-IV MX-merged satellite imagery was used for soil survey. Hundred surface soil samples were collected at 100 m grid spacing (Figure 2). Later soil samples were analysed for soil chemical properties and nutrient content by using standard procedures.

2.4 Soil sample Analysis
The soil samples were air dried under shade, powdered using pestle and mortar and passed through 2 mm sieve. Later soil samples were analysed for soil reaction, electrical conductivity (Jackson, 1967) [1], organic carbon (Walkley and Black, 1934) [3] major and secondary nutrients (Black, 1965) [2] at laboratory using standard methods.

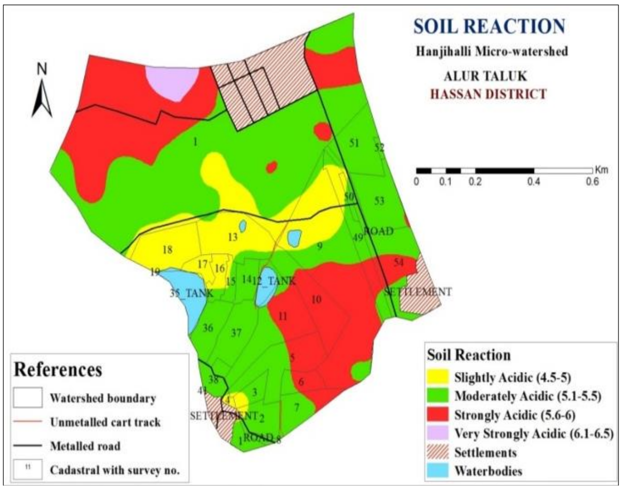
3. Results and Discussion
3.1 Development of soil fertility status maps
Hundred surface soil samples collected were anslysed and the nutrient status data generated was used to develop fertility maps of the study area using Arc-GIS software. The data obtained was processed in ArcGIS software to develop soil fertility database. By interpolation of point data based on soil test values soil spatial variability maps were prepared. Initially, the soil test values for all properties such as pH, EC, available N, available P_2O_5, available K_2O, exchangeable calcium and magnesium and available sulphur 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. Soil fertility maps are shown in Fig. 2.

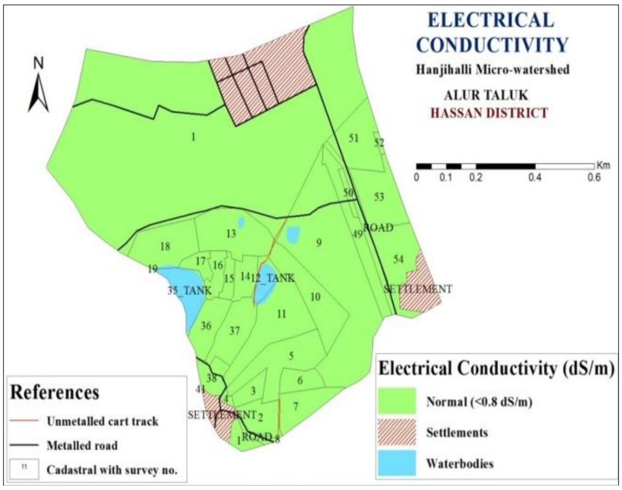
The soil fertility status maps were developed in Arc-GIS and majority of the area was low in Nitrogen, Phosphorus and Organic carbon, Potassium and sulphur was high and exchangeable calcium and magnesium were sufficient in the study area. Data range of various parameters depicted in the Table 1.

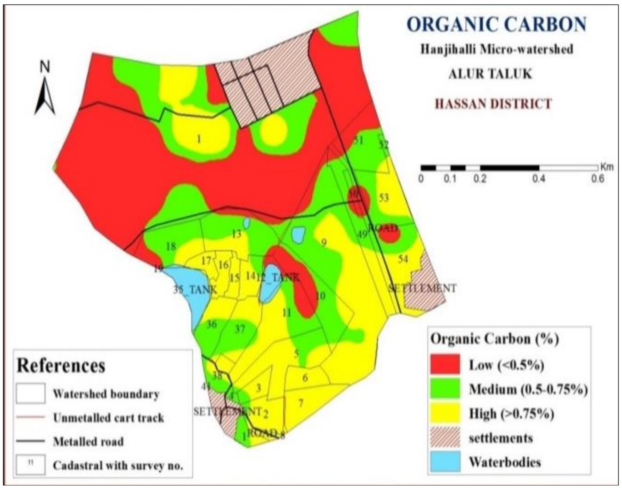
Table 1: Soil fertility range of Hanjihalli micro watershed

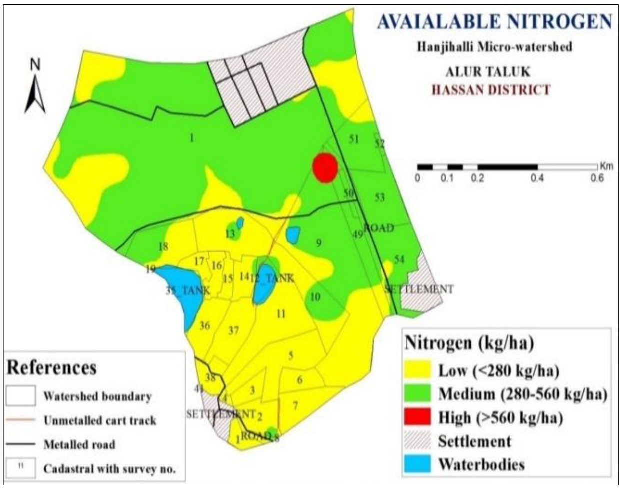
Parameters	Soil reaction- pH	Electrical conductivity- dS/m	Organic carbon- %	Nitrogen- kg/ha	Phosphorus-kg/ha
Range	4.12 to 7.26	0.002 to 0.303	0.16 to 1.86	180.45 to 560.51	10.15 to 89.18

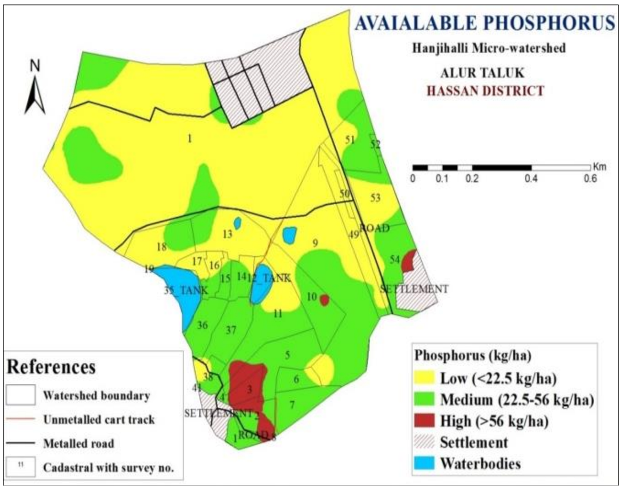
Parameters	Potassium-kg/ha	Available sulphur - ppm	Exchangeable calcium- meq/100 g	Exchangeable magnesium- meq/100 g
Range	63.36 to 691.92	3.25 to 61.12	0.28 to 8.75	0.14 to 5.75

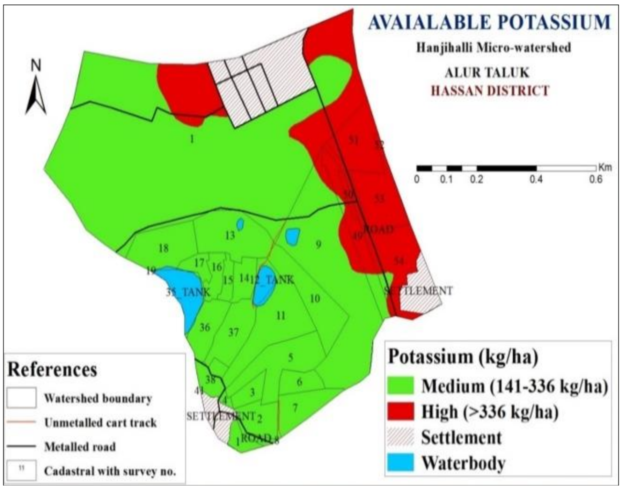

SOIL REACTION
Hanjihalli Micro-watershed
ALUR TALUK
HASSAN DISTRICT
References
Watershed boundary
Unmetalled cart track
Metalled road
Cadastral with survey no.
Soil Reaction
Slightly Acidic (4.5-5)
Moderately Acidic (5.1-5.5)
Strongly Acidic (5.6-6)
Very Strongly Acidic (6.1-6.5)
Settlements
Waterbodies

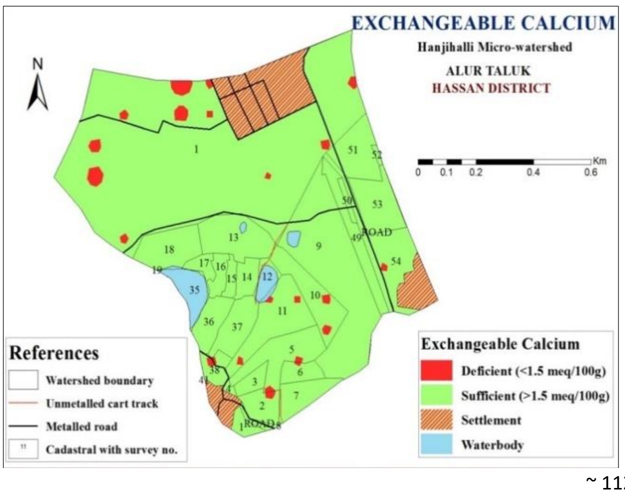

ELECTRICAL CONDUCTIVITY
Hanjihalli Micro-watershed
ALUR TALUK
HASSAN DISTRICT
References
Unmetalled cart track
Metalled road
Cadastral with survey no.
Electrical Conductivity (dS/m)
Normal (<0.8 dS/m)
Settlements
Waterbodies

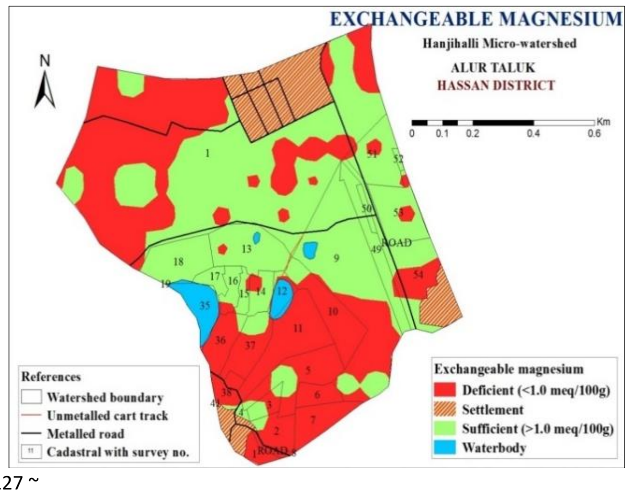

ORGANIC CARBON
Hanjihalli Micro-watershed
ALUR TALUK
HASSAN DISTRICT
References
Watershed boundary
Unmetalled cart track
Metalled road
Cadastral with survey no.
Organic Carbon (%)
Low (<0.5%)
Medium (0.5-0.75%)
High (>0.75%)
settlements
Waterbodies


AVAIALABLE NITROGEN
Hanjihalli Micro-watershed
ALUR TALUK
HASSAN DISTRICT
References
Watershed boundary
Unmetalled cart track
Metalled road
Cadastral with survey no.
Nitrogen (kg/ha)
Low (<280 kg/ha)
Medium (280-560 kg/ha)
High (>560 kg/ha)
Settlement
Waterbodies


AVAIALABLE PHOSPHORUS
Hanjihalli Micro-watershed
ALUR TALUK
HASSAN DISTRICT
References
Watershed boundary
Unmetalled cart track
Metalled road
Cadastral with survey no.
Phosphorus (kg/ha)
Low (<22.5 kg/ha)
Medium (22.5-56 kg/ha)
High (>56 kg/ha)
Settlement
Waterbodies


AVAIALABLE POTASSIUM
Hanjihalli Micro-watershed
ALUR TALUK
HASSAN DISTRICT
References
Watershed boundary
Unmetalled cart track
Metalled road
Cadastral with survey no.
Potassium (kg/ha)
Medium (141-336 kg/ha)
High (>336 kg/ha)
Settlement
Waterbody


EXCHANGEABLE CALCIUM
Hanjihalli Micro-watershed
ALUR TALUK
HASSAN DISTRICT
References
Watershed boundary
Unmetalled cart track
Metalled road
Cadastral with survey no.
Exchangeable Calcium
Deficient (<1.5 meq/100g)
Sufficient (>1.5 meq/100g)
Settlement
Waterbody


EXCHANGEABLE MAGNESIUM
Hanjihalli Micro-watershed
ALUR TALUK
HASSAN DISTRICT
References
Watershed boundary
Unmetalled cart track
Metalled road
Cadastral with survey no.
Exchangeable magnesium
Deficient (<1.0 meq/100g)
Settlement
Sufficient (>1.0 meq/100g)
Waterbody

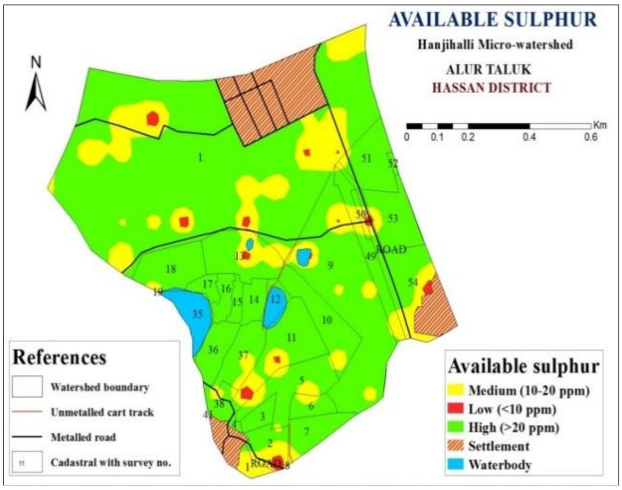


Fig 2: Fertility status maps of Hanjihalli micro watershed

3.2 Soil fertility status variability of Hanjihalli micro watershed

The organic carbon content of micro watershed ranged from 0.109 to 1.86 per cent with a mean value of 0.64 per cent with coefficient of variation of 68.65 per cent. Available nitrogen content varied from 180.45 to 560.45 kg ha^{-1} with a mean of 301.22 kg ha^{-1} showing a coefficient of variation of 24.66 per cent. The available phosphorus ranged from 10.15 to 89.18 kg ha^{-1} with a mean of 25.88 kg ha^{-1} and coefficient of variation of 66.33 per cent. The available potassium ranged from 63.36 to 691.92 kg ha^{-1}, with a mean of 267.23 kg $ha^{-1}$and coefficient of variation of 50.72 percent. The exchangeable calcium ranges from 0.28 to 8.75 meq/100 g with 58.47 per cent coefficient of variation. The exchangeable magnesium ranged from 0.14 to 5.75 meq/100g with coefficient of variation 76.48 per cent. The available sulphur ranged from 3.25 to 61.12 ppm with mean of 24.95 and coefficient of variation 54.64 per cent.

The highest variation was found with exchangeable magnesium (76.48%) in the watershed followed by organic carbon (68.65%) and lowest variation was found with soil reaction (pH) with 12.79 per cent. Sanjib kumar behara and Arvind kumar shukla (2015) [6] found that soil acidity (pH between 3.90 to 6.45) showed a low variability < 10 per cent, in contrast to other soil properties.

4. Conclusion

The study area fertility status varied widely due to both topographical features and management practices. The soil reaction of micro watershed was acidic (88 per cent) and 12 per cent area was neutral in soil pH. Since majority of the watershed is acidic in nature application of lime in the strongly acidic area (53 ha) and organic matter in moderately acidic (35 ha) area is recommended. Soil electrical conductivity was normal and soil organic carbon was low in (30%), medium in (26%) and high in (44%). The available nitrogen was low (53 ha), major portion of watershed was low (62 ha) in available phosphorus and available potassium was high (61 ha). The available sulphur was high (64 ha) and with sufficient exchangeable calcium and magnesium. The low soil fertility areas should be applied with higher organic manures and appropriate nutrients for higher productivity. The oilseed crops should be grown in the study area to utilize the available sulphur. Application of rock phosphate and phosphorus solubilizing bacteria can be utilized to improve the phosphorus availability.

5. Acknowledgement

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