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Assessment of soil nutrients of Khadijapur sub-watershed for enhancing crop productivity using remote sensing and GIS

Patil PL, Deepa Kalappanavar, Geetha GP, Basavashree Yadawad, Ramachandraih and Dasog GS

Patil PL
Sujala-III Project, Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Dharwad, Karnataka, India

Deepa Kalappanavar
Sujala-III Project, Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Dharwad, Karnataka, India

Geetha GP
Sujala-III Project, Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Dharwad, Karnataka, India

Basavashree Yadawad
Sujala-III Project, Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Dharwad, Karnataka, India

Ramachandraih
Sujala-III Project, Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Dharwad, Karnataka, India

Dasog GS
Sujala-III Project, Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Dharwad, Karnataka, India

Corresponding Author:
Patil PL
Sujala-III Project, Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Dharwad, Karnataka, India

Abstract
Soil test based fertility management for best suited crops can be used as an effective tool for enhanced productivity and crop production. The present study focused on mapping spatial variability of soil nutrients. Soil samples were collected at 250 m grid spacing, analyzed for soil reaction, salinity, organic carbon, major, secondary and micro nutrients at laboratory using standard methods. The data generated was processed in Arc-GIS platform to develop a database. Geostatistical analyst tool was used and Kriging interpolation technique was adopted. The analyzed data was interpolated to obtain a raster surface from points (grid points) to generate fertility maps using Arc-GIS. Fertilizer recommendations can be made for the crops to enhance their productivity. Soil test based application of balanced fertilizers would go a long way in enhancing soil fertility and productivity.

Keywords: Fertility management, spatial distribution, Kriging, interpolation, balanced fertilizers

Introduction
Soil is the basic requirement of life on earth. Soil nutrients play a vital role in crop production, its availability and spatial distribution need to be studied before planning for nutrient recommendation. Higher yields and intensive cropping make high demands for nutrients from soil, which leads to depletion of soil nutrient reserve. K removal by the intensive cropping is disproportionately higher than the amount of K added through fertilizer as evident from the results of Long term fertilizer experiments. The nutrients exported out of the farm in crop produces must be necessarily replenished to sustain soil fertility and therefore the production system for which balanced fertilizer application is the prerequisite and there is growing need for site specific balanced fertilizer recommendations according to the crop type, yield level and soil conditions.

Balanced fertilizer schedule were developed for rice, maize, cassava, peanut, potato, tobacco etc. by the applications of mathematical models and decision support systems. The soil salinity or sodicity hinders the crop growth and yield. The industrial by-product Ferro gypsum from the effluent treatment plant of titanium industry was evaluated as a substitute for gypsum to alleviate sodicity besides its effect on increasing crop yields in paddy and groundnut.

The challenge of crop nutrient management is to balance production and economic optimization with environmental impacts. Successful crop production is dependent upon effective nutrient management that includes identifying nutrient deficiencies and excesses. Soil sampling and soil testing provides an opportunity to check the “soil nutrient account” and is critical for developing a nutrient management plan. Knowing the nutrient requirements and nutrient removal by a crop is important for achieving a balance of nutrient inputs and crop removal outputs. Reliable nutrient recommendations are dependent upon accurate soil tests and crop nutrient calibrations based on extensive field research. The actual fertility status of soils has to be assessed before planning for any crop production, which will help in managing the nutrient/fertilizer application to various crops. The Geographic Information System (GIS) is an effective tool in the estimation of the spatial distribution in which interpolation can be undertaken utilizing simple mathematical models (e.g., inverse distance weighting, trend surface analysis and splines and Thiessen polygons), or more complex models (e.g., geo-statistical methods, such as Kriging). The review of comparative studies of interpolation methods applied to soil properties demonstrates that the selection of method can significantly influence the map accuracy. The present study was conducted with the main objective of providing balanced nutrition through soil-test based fertilizer recommendation in Khadijapur sub-watershed of Vijayapura district.

Materials and Methods
Study Area
Vijayapura district is located in the agro-climatic zone of Northern dry zone and South western ago ecological sub region. The entire sub-watershed area is underlain by basalt. Khadijapura sub-watershed is located at North latitude 16042’30" and 160 48‘30' and East longitude 750 38'30" and 750 43’ 00' covering an area of about 4884.33 ha, bounded by Mahalabagayatha, Thorvi, Jumnal and Sarwad villages. Extends over entire Koppal, Vijayapur, and Bellary district and five taluks of Belgaum, six of Bagalkot, two of Raichur, one of Dharwad and Davanagere, four of Gadag. The total geographical area of the zone is about 4.78 M ha. Most of the zone is at an elevation of 450-800 m MSL, but some area is between 800 and 900m. Average annual rainfall of the zone ranges from 464.5 to 785.7 mm. The soils are medium and deep black clay in major areas, sand loams in remaining areas. The main cropping season is *Rabi*. Maize, Bajra, Groundnut, Cotton, Wheat, Sugarcane and Tobacco are the important crops of the zone.

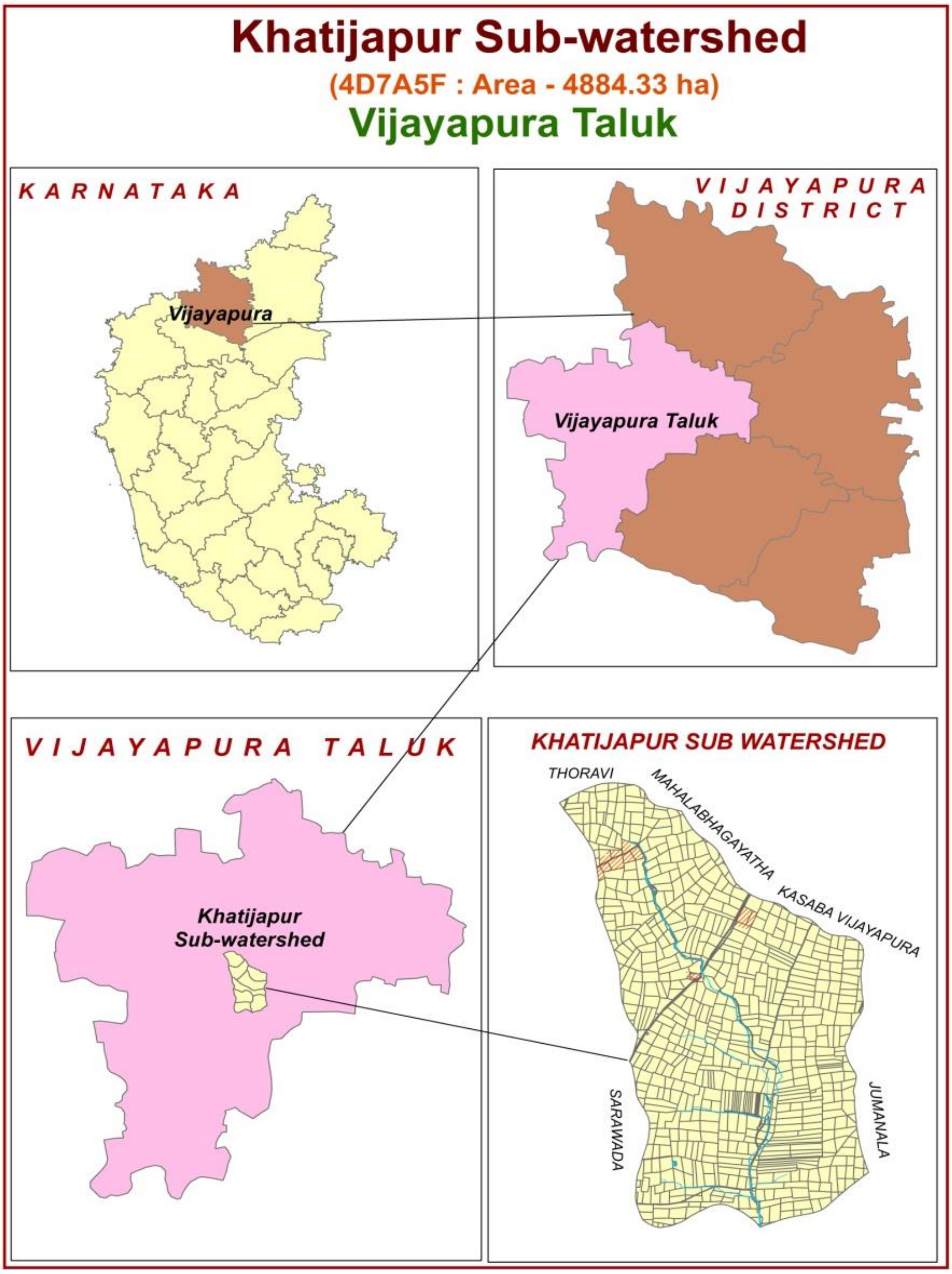


Fig 1: Location map of Khadijapur sub-watershed

Study area delineation in GIS Environment
Study area was delineated with the help of topographic map and watershed Atlas prepared by Karnataka State Remote Sensing Application Centre, Bangalore. Study area was extracted from the satellite imagery, permanent features like road, river, watershed boundary was extracted for preparation of base map. It is the base for preparation of thematic maps. Seven hundred eighty-seven surface soil samples were collected at 250 m grid spacing (Figure 2). These samples were subjected to analysis and the fertility data was generated.

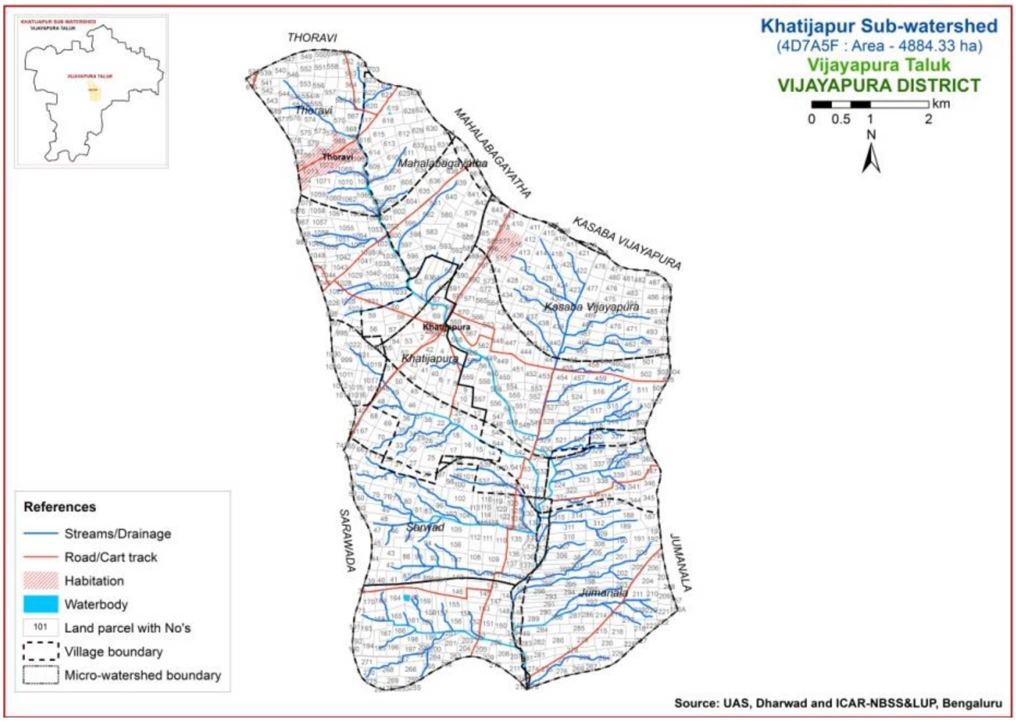


Fig 2: Cadastral map with grids and satellite map of Khadijapur sub-watershed.

A detailed traverse of the sub-watershed was made to identify the major landforms like uplands, midlands and lowlands. The transects for profile study were located and profiles were dug up to 150 cm depth or up to parent rock whichever was shallower, and studied for their morphological characteristics as per Soil Survey manual. Pedons were identified on different landforms in transect along the slope from the upper to lower slope and soil series maps were generated.

Soil sample Analysis

Soil samples were collected were analyzed for soil reaction, salinity, organic carbon, major, secondary and micro nutrients at laboratory using standard methods. The fertility data was generated and fed as input to the ArcGIS to create the fertility maps by interpolating the values.

Results and Discussion

Generation of soil fertility status

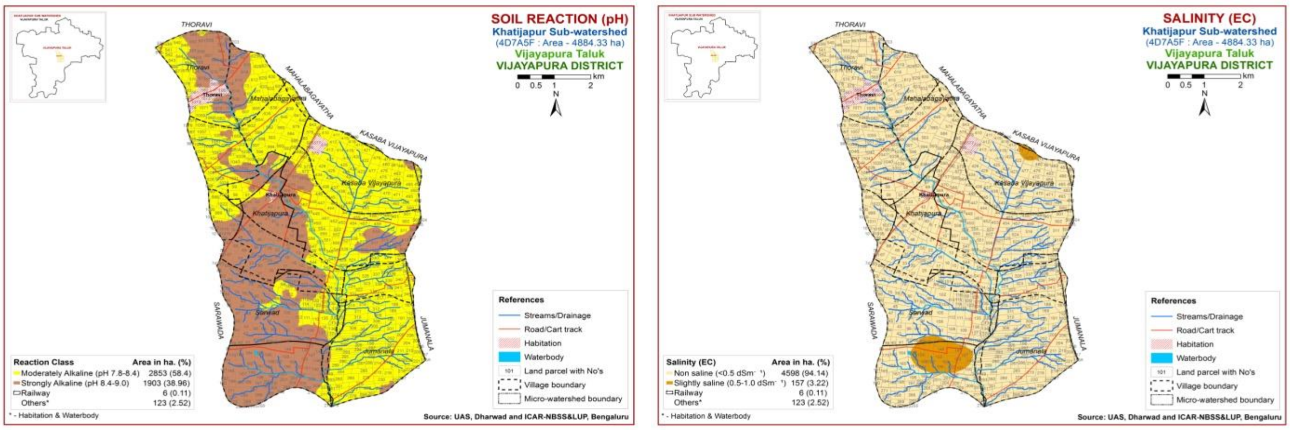
Seven hundred eighty-seven surface soil samples collected, analyzed and data was generated. The data generated was processed in ArcGIS platform to develop a database. Geostatistical analyst tool was used and kriging interpolation technique was adopted. The analyzed data was interpolated to obtain a raster surface from points (grid points) to generate fertility maps using ArcGIS

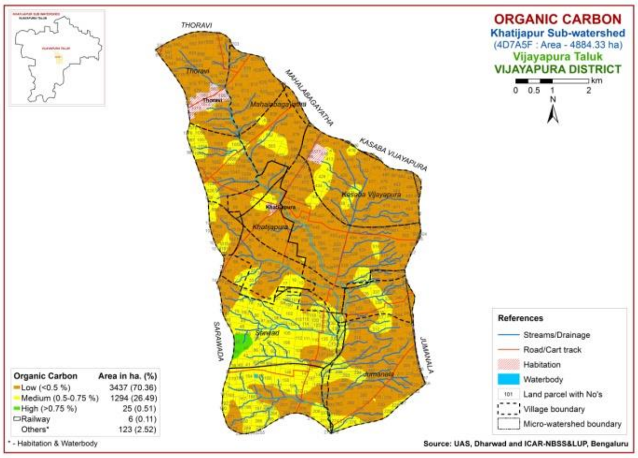
The fertility status maps were generated and majority of the area was medium to high in Nitrogen, Phosphorus, Organic carbon, Potassium, sulphur was medium, and micro nutrients of manganese and copper were in sufficient quantities (Figure 3). Data range of various parameters depicted in the Table 1.

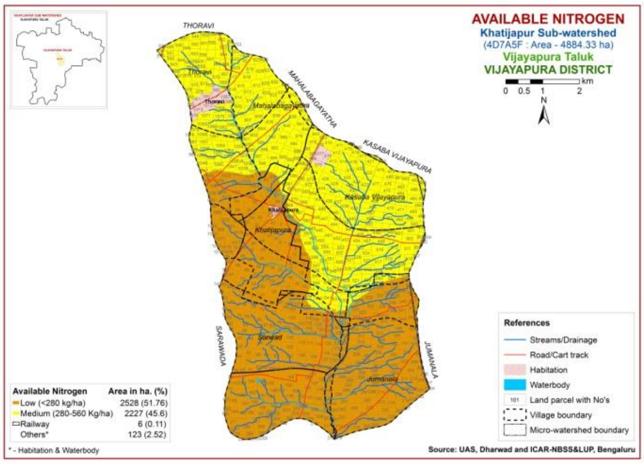
Table 1: Fertility data range in Khadijapur (4D7A5F) sub-watershed

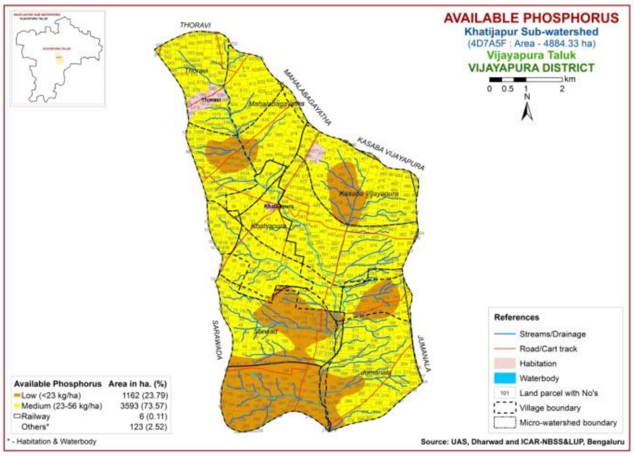
Parameters	Soil reaction- pH	Salinity- dS/m	Organic carbon- %	Nitrogen - kg/ha	Phosphorus - kg/ha	Potassium - kg/ha
Mean	8.40	0.27	0.44	270	25.9	658
Range	7.49-9.58	0.01-2.50	0.18-0.87	100-545	1.4-70.9	109-1056

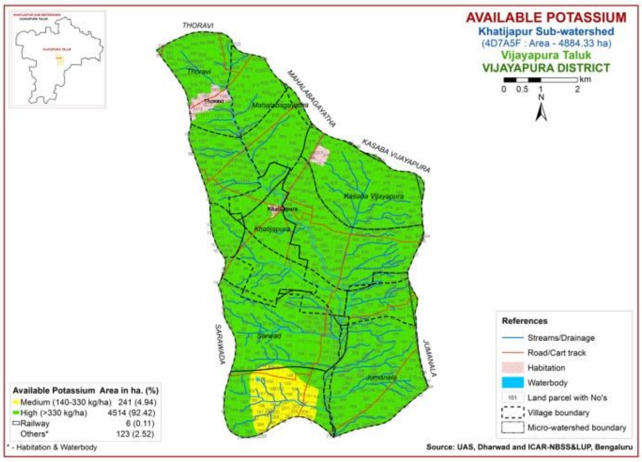
Parameters	Sulphur - ppm	Iron - ppm	Manganese - ppm	Copper - ppm	Zinc - ppm	Boron - ppm
Mean	14.8	3.18	5.40	1.06	1.08	0.43
Range	7.5-26.1	0.13-10.12	0.28-35.56	0.14-4.32	0.13-6.21	0.10-0.90

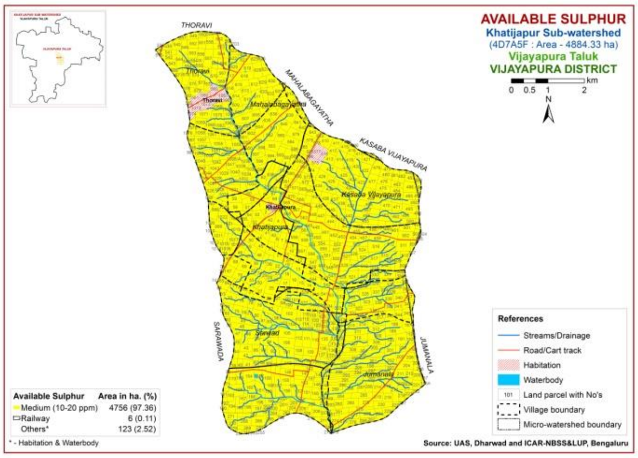


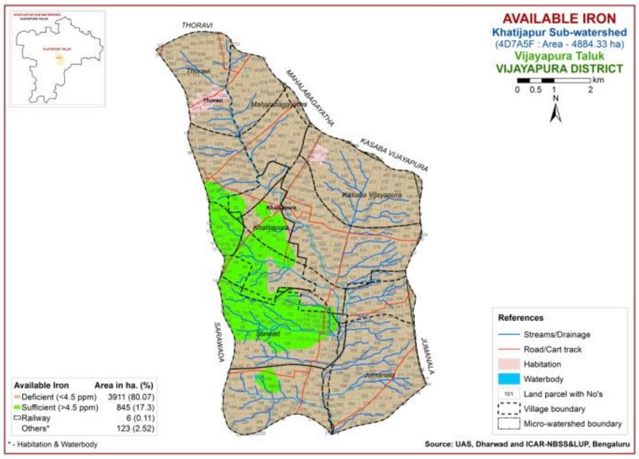

ORGANIC CARBON
Khatijapur Sub-watershed
(4D7A5F : Area - 4884.33 ha)
Vijayapura Taluk
VIJAYAPURA DISTRICT
THORAVI
MAHALABAGAYATHA
KASABA VIJAYAPURA
SARAWADA
JUMANALA
Organic Carbon Area in ha. (%)
Low (<0.5 %) 3437 (70.36)
Medium (0.5-0.75 %) 1294 (26.49)
High (>0.75 %) 25 (0.51)
Railway 6 (0.11)
Others* 123 (2.52)
References
Streams/Drainage
Road/Cart track
Habitation
Waterbody
Land parcel with No's
Village boundary
Micro-watershed boundary
* - Habitation & Waterbody
Source: UAS, Dharwad and ICAR-NBSS&LUP, Bengaluru

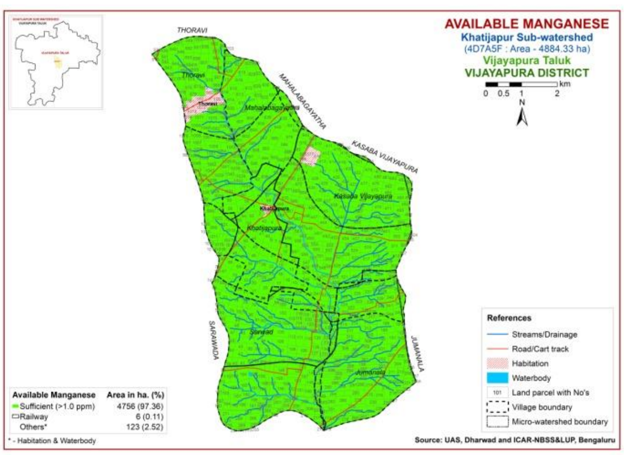

AVAILABLE NITROGEN
Khatijapur Sub-watershed
(4D7A5F : Area - 4884.33 ha)
Vijayapura Taluk
VIJAYAPURA DISTRICT
THORAVI
MAHALABAGAYATHA
KASABA VIJAYAPURA
SARAWADA
JUMANALA
Available Nitrogen Area in ha. (%)
Low (<280 kg/ha) 2528 (51.76)
Medium (280-560 Kg/ha) 2227 (45.6)
Railway 6 (0.11)
Others* 123 (2.52)
References
Streams/Drainage
Road/Cart track
Habitation
Waterbody
Land parcel with No's
Village boundary
Micro-watershed boundary
* - Habitation & Waterbody
Source: UAS, Dharwad and ICAR-NBSS&LUP, Bengaluru

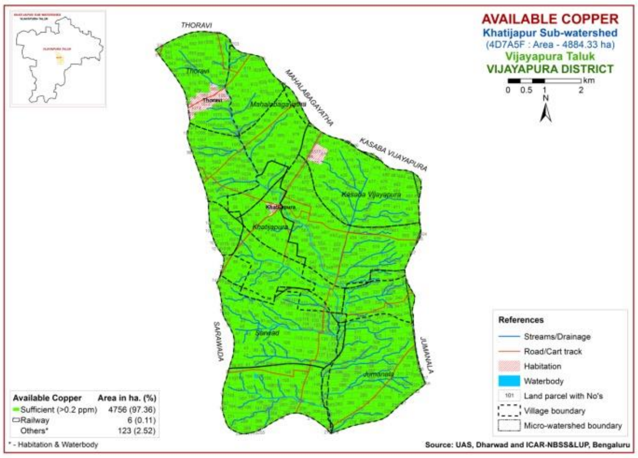

AVAILABLE PHOSPHORUS
Khatijapur Sub-watershed
(4D7A5F : Area - 4884.33 ha)
Vijayapura Taluk
VIJAYAPURA DISTRICT
THORAVI
MAHALABAGAYATHA
KASABA VIJAYAPURA
SARAWADA
JUMANALA
Available Phosphorus Area in ha. (%)
Low (<23 kg/ha) 1162 (23.79)
Medium (23-56 kg/ha) 3593 (73.57)
Railway 6 (0.11)
Others* 123 (2.52)
References
Streams/Drainage
Road/Cart track
Habitation
Waterbody
Land parcel with No's
Village boundary
Micro-watershed boundary
* - Habitation & Waterbody
Source: UAS, Dharwad and ICAR-NBSS&LUP, Bengaluru


AVAILABLE POTASSIUM
Khatijapur Sub-watershed
(4D7A5F : Area - 4884.33 ha)
Vijayapura Taluk
VIJAYAPURA DISTRICT
THORAVI
MAHALABAGAYATHA
KASABA VIJAYAPURA
SARAWADA
JUMANALA
Available Potassium Area in ha. (%)
Medium (140-330 kg/ha) 241 (4.94)
High (>330 kg/ha) 4514 (92.42)
Railway 6 (0.11)
Others* 123 (2.52)
References
Streams/Drainage
Road/Cart track
Habitation
Waterbody
Land parcel with No's
Village boundary
Micro-watershed boundary
* - Habitation & Waterbody
Source: UAS, Dharwad and ICAR-NBSS&LUP, Bengaluru


AVAILABLE SULPHUR
Khatijapur Sub-watershed
(4D7A5F : Area - 4884.33 ha)
Vijayapura Taluk
VIJAYAPURA DISTRICT
THORAVI
MAHALABAGAYATHA
KASABA VIJAYAPURA
SARAWADA
JUMANALA
Available Sulphur Area in ha. (%)
Medium (10-20 ppm) 4756 (97.36)
Railway 6 (0.11)
Others* 123 (2.52)
References
Streams/Drainage
Road/Cart track
Habitation
Waterbody
Land parcel with No's
Village boundary
Micro-watershed boundary
* - Habitation & Waterbody
Source: UAS, Dharwad and ICAR-NBSS&LUP, Bengaluru


AVAILABLE IRON
Khatijapur Sub-watershed
(4D7A5F : Area - 4884.33 ha)
Vijayapura Taluk
VIJAYAPURA DISTRICT
THORAVI
MAHALABAGAYATHA
KASABA VIJAYAPURA
SARAWADA
JUMANALA
Available Iron Area in ha. (%)
Deficient (<4.5 ppm) 3911 (80.07)
Sufficient (>4.5 ppm) 845 (17.3)
Railway 6 (0.11)
Others* 123 (2.52)
References
Streams/Drainage
Road/Cart track
Habitation
Waterbody
Land parcel with No's
Village boundary
Micro-watershed boundary
* - Habitation & Waterbody
Source: UAS, Dharwad and ICAR-NBSS&LUP, Bengaluru


AVAILABLE MANGANESE
Khatijapur Sub-watershed
(4D7A5F : Area - 4884.33 ha)
Vijayapura Taluk
VIJAYAPURA DISTRICT
THORAVI
MAHALABAGAYATHA
KASABA VIJAYAPURA
SARAWADA
JUMANALA
Available Manganese Area in ha. (%)
Sufficient (>1.0 ppm) 4756 (97.36)
Railway 6 (0.11)
Others* 123 (2.52)
References
Streams/Drainage
Road/Cart track
Habitation
Waterbody
Land parcel with No's
Village boundary
Micro-watershed boundary
* - Habitation & Waterbody
Source: UAS, Dharwad and ICAR-NBSS&LUP, Bengaluru


AVAILABLE COPPER
Khatijapur Sub-watershed
(4D7A5F : Area - 4884.33 ha)
Vijayapura Taluk
VIJAYAPURA DISTRICT
THORAVI
MAHALABAGAYATHA
KASABA VIJAYAPURA
SARAWADA
JUMANALA
Available Copper Area in ha. (%)
Sufficient (>0.2 ppm) 4756 (97.36)
Railway 6 (0.11)
Others* 123 (2.52)
References
Streams/Drainage
Road/Cart track
Habitation
Waterbody
Land parcel with No's
Village boundary
Micro-watershed boundary
* - Habitation & Waterbody
Source: UAS, Dharwad and ICAR-NBSS&LUP, Bengaluru

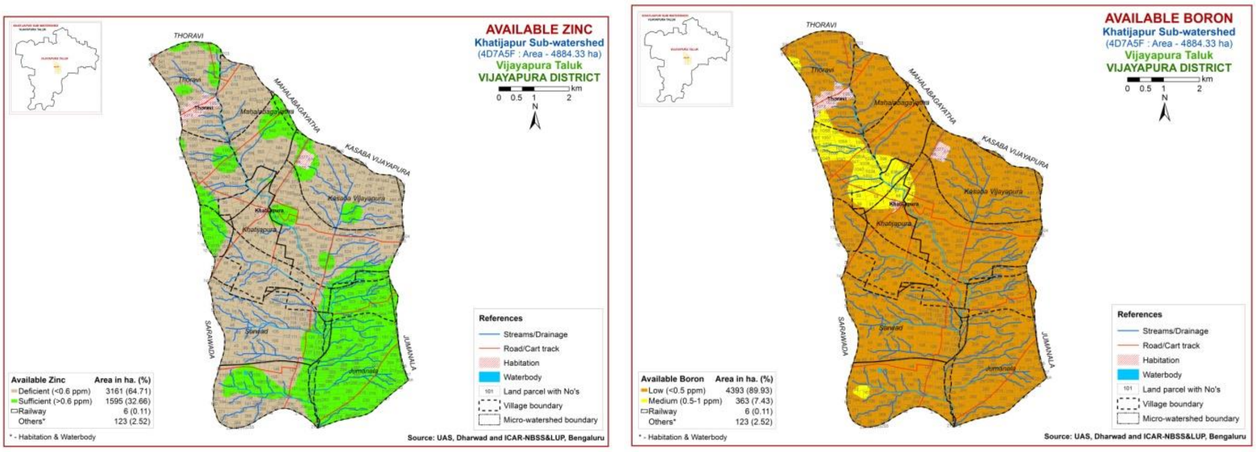


Fig 3: Fertility maps of Khadijapur sub-watershed

Conclusion

The pH of the soils in this sub-watershed ranged from moderately alkaline to strongly alkaline where 59.46 per cent of area (2904 ha) is moderately alkaline followed by strongly alkaline (39.36%). Organic carbon content is varies from low to high, available nitrogen, phosphorus and potassium is medium to high, where sulphur is medium and boron varies from low to medium. The available copper and manganese are in sufficient range. The areas which are low in nutrient status need to be improved by adding organic manures (FYM/Compost).

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