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GIS Techniques for Soil Fertility Assessment and Soil Health Improvement in Watershed Area of Northern Karnataka

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ABSTRACT

The ever-growing global population and increasing demands for food security have led to intensified agricultural practices, which in turn have altered soil biotic and abiotic factors, significantly impacting soil health and ecosystems. Soil health is a critical component for achieving sustainable agriculture. Current land and crop management practices have resulted in issues such as yield stagnation, nutrient depletion, soil degradation and decline in soil quality. To ensure food security and long-term sustainability, it is essential to conserve and manage land and soil resources while maintaining soil fertility. In this context, a sub-watershed in Jalawadha, covering an area of 780.86 ha in Devara Hipparagi taluk, Vijayapura district, Karnataka, was selected for soil nutrient assessment. Using GIS techniques, 13 mapping units were delineated based on soil-site characteristics. The study revealed that soil pH ranged from moderately to strongly alkaline. Organic carbon (OC) levels were low in 79.33 percent of the watershed area, and medium in 19.47 percent. Regarding major nutrients, most of the area had low levels of available Nitrogen (N) and Sulphur (S), medium levels of available Phosphorus (P), and high levels of Potassium (K). The GIS-based LRI of Jalawadha sub-watershed revealed alkaline soils with deficiencies of organic carbon, nitrogen, and sulphur, but adequate phosphorus and high potassium. These imbalances stress the need for integrated fertility management through balanced fertilizers with organic mulching, manures, crop residue incorporation, and amendments, which are vital to restore soil health, enhance productivity, and ensure sustainable agriculture.

Keywords: GIS techniques, Soil fertility assessment, Soil health, Sustainable agriculture, Watershed.

INTRODUCTION

Rainfed areas contribute over 40 per cent to India's total food production, but they are often characterized by low productivity, land degradation and the adverse effects of climate change. To achieve sustainability in these areas, it is essential to protect and improve land resources such as soil fertility and available soil moisture (Sharma and Paliyal, 2015). The intensive cultivation of crops has led to the depletion of nutrients from the soil (Meena and Dudi, 2018). Soil assessments for various nutrient statuses are vital for enhancing soil fertility and improving land productivity (Biradar *et al,* 2020; Sunil *et al,* 2020). Integrating these assessments with site-specific management practices can help maintain ecological balance. The adoption of organic amendments and conservation-based approaches further ensures resilience and long-term sustainability of rainfed farming systems. It is well established that dryland soils are both thirsty and hungry (Wani, 2008), which underscores the need for effective nutrient management to increase the productivity of rainfed watersheds. Geographic Information Systems (GIS) offer a powerful tool to integrate spatial information such as agro-climatic zones, land use and soil management, providing valuable insights for better land management (Adornado and Yoshida, 2008). Collecting soil samples with geographic references and conducting soil tests helps to develop site-specific recommendations for improving soil health. By identifying nutrient constraints in specific areas using Global positioning systems (GPS), we can make balanced and precise fertilizer recommendations, optimizing resource use. With this objective in mind, the current study focused on soil-site characterization to assess the nutrient status in the soils of the Jalawadha sub-watershed.

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Table 1. Soil fertility ratings for available nutrients.

Parameter	Low	Medium	High
Electrical Conductivity (EC), dSm $^{-1}$	2-4	4-8	>8
Organic carbon (OC), %	<0.5	0 5.0-0.75	>0.75
Macronutrients (kg ha^{-1})			
Nitrogen (N)	<280	280-560	>560
Phosphorus (P_2O_5)	<23	23-57	>57
Potassium (K_2O)	<145	145-337	>337
Sulphur (S), mg kg^{-1}	<10	10-20	>20
	Deficient		**Sufficient**
Calcium (Ca), ppm	<1.5		>1.5
Magnesium (Mg), ppm	<1		>1
Micronutrients (mg kg^{-1})			
Iron (Fe)	<4.5		>4.5
Zinc (Zn)	<0.6		>0.6
Copper (Cu)	<0.2		>0.2
Manganese (Mn)	<1.0		>1.0

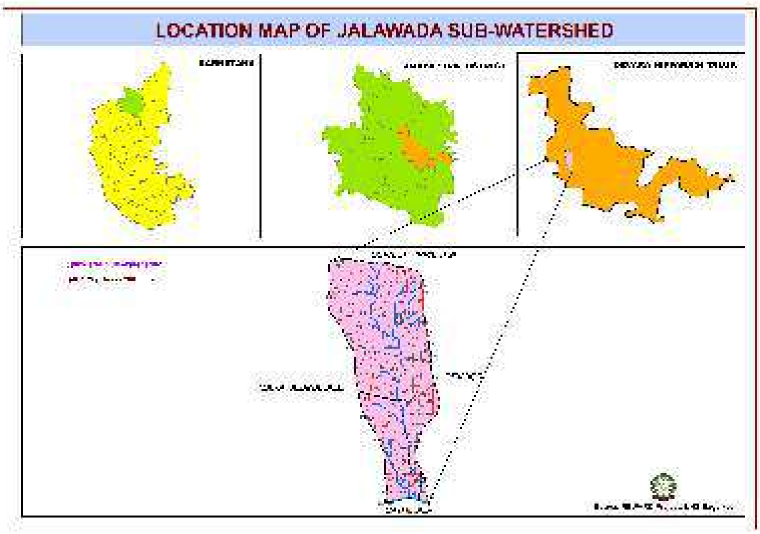

Fig. 1: Location and Extent of Jalawadha sub watershed

MATERIALS AND METHODS

Description of study area

The Shorten-Jalawadha subwatershed (780.87 ha) is located in the hot semi-arid agro-ecological region of India, between 16°36'30" to 16°55'30" N latitudes and 76°0'0" to 76°24'0" E longitudes (Fig.1), in Devara Hipparagi taluk, Vijayapura district, Karnataka. The length of crop growing period in this area is around 120-150 days. The dominant soils are medium to deep black clay, with shallow to moderately shallow in some areas.

Soil survey, sampling, and fertility mapping methodology

Soil survey was conducted using IRS LISS IV and Cartosat-1 satellite images, following the Field Guide for Land Resource Inventory (LRI) of the Sujala-III project (ICAR-NBBSS & LUP, 2016). The survey recorded surface characteristics such as slope, erosion, gravelliness, calcareousness, stoniness and texture. A total of 77 composite soil samples were collected at 320 m grid intervals, analyzed for macro and micronutrient status, salinity, pH, organic carbon and other fertility parameters. Soil chemical and fertility analyses followed standard procedures (Jackson, 1973; Olsen and Sommers, 1982; Sahrawat and Burford, 1982; Nelson and Sommers, 1996;). Fertility maps were created using GIS, integrating data and spatial analysis in ArcGIS 10.8.2 (Mary Silpa and Nowshaja, 2016; Mishra and Babu, 2009).

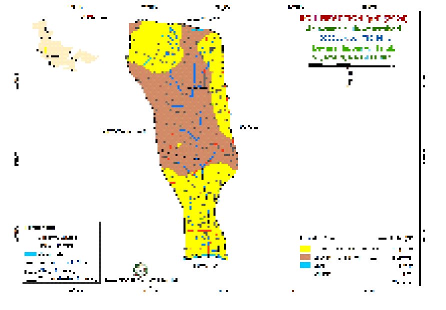

Fig. 2: Soil reaction map of Jalawadha subwatershed

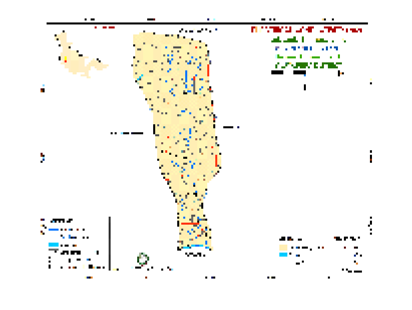

Fig. 3: Electric conductivity map of Jalawadha subwatershed

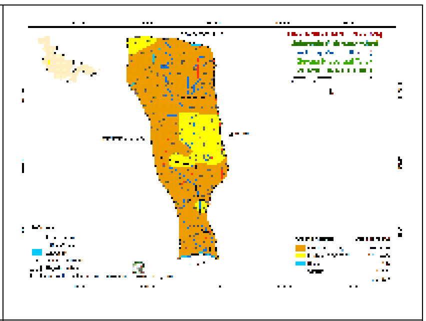

Fig. 4: Organic carbon map of Jalawadha subwatershed

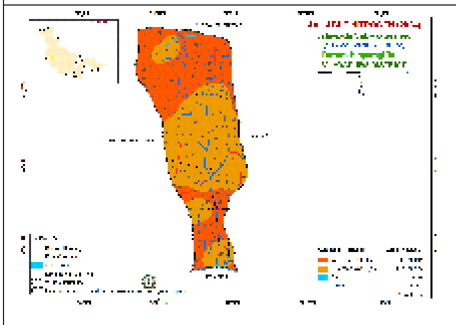

Fig. 5: Available nitrogen map of Jalawadha subwatershed

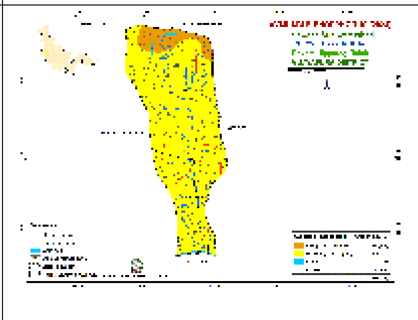

Fig. 6: Available phosphorus map of Jalawadha subwatershed

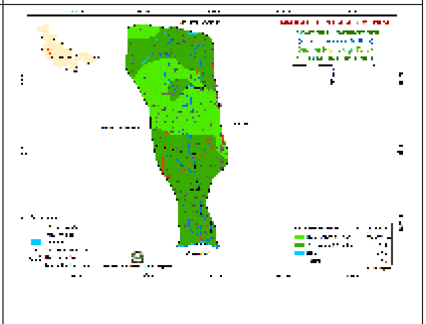

Fig. 7: Available potasium map of Jalawadha subwatershed

RESULTS AND DISCUSSION

Soil reaction and electrical conductivity

Jalawadha sub watershed soil were moderately alkaline to strongly alkaline in reaction (7.8- 9.0). Mapping of soil pH by GIS technique showed that major sub watershed area (50.91%) is strongly alkaline followed by 47.9% area is moderately alkaline (Fig. 2). Higher soil reaction in the sub watershed might be due to calcareousness, sodicity and low leaching intensity and accumulation of bases in sub horizons. The soils in Jalawadha sub watershed were nonsaline in major area (98.8 %) (Fig. 3). GIS mapping based on surface samples from Jalawadha sub watershed revealed that major area *i.e.* 79.33 percent has been classified as low and 19.47 per cent as medium in organic carbon status (Fig. 4). Low organic carbon in these soils is due to the prevalence of arid condition which causes faster degradation of organic matter besides little or no application of organic manures to soils and less vegetative cover in the fields, thereby reducing organic carbon accumulation. The similar results were reported by Prabhavati *et al* (2015).

Available macro nutrients

GIS mapping of Jalawadha sub watershed for available N depicts that the soils ranged from very low (46.04% area) to low (52.76% area) (Fig. 5). The low N content is attributed to higher fixation and volatilization losses in black soils, low organic matter content in soils and intensive crop cultivation without proper fertilization. The results are in agreement with findings of Pulakeshi *et al* (2012) and Ravikumar *et al* (2007). Most of the study area (90.01%) was classified as medium and about 8.8 percent area is low in available phosphorus content (Fig. 6). Medium P_2O_5 availability in these soils is related to their high pH, calcareousness and low organic matter content. Present results are similar with findings of Ravikumar *et al* (2007) and Patil *et al* (2011). About 60.66 percent of the sub watershed area was very high and 37.14 per cent area was high in available K in the soils (Fig. 7). Water soluble and exchangeable K invariably higher in the surface soils of Karnataka (Patil *et al,* 2011), hence such soils can maintain sufficient exchangeable K and supply adequate K to plants. The medium to high available potassium in sub watershed might be attributed to predominance of parent material having potash rich micaceous and feldspar minerals. Similar results were observed by Srikant *et al* (2008) and Pulakeshi *et al* (2012). The study revealed that available S content in sub watershed soils ranged from low to high classes. Majority of the study area (85.53%) was low and 13.28 percent area is medium in available S status. Low and medium levels of available sulphur were due to lack of sulphur addition to fields and continuous removal of S from soils by high yielding crop varieties (Srikant *et al,* 2008 and Pulakeshi *et al,* 2012).

CONCLUSION

From the study, it can be concluded that, soils of Jalawadha sub watershed in Northern dry zone of Karnataka are moderately to strongly alkaline with no salinity. Soil organic carbon content was low. Most of the sub watershed area was low in available nitrogen, medium in available phosphorus, very high in potassium and low in sulphur. The use of GIS technology for mapping of soil nutrients helps in easy and quick interpretation of soil fertility and site-specific management of nutrient deficiency. The 25 percent additional fertilizer of particular nutrient should be applied than recommended rate to the specific areas where deficiency is seen to improve the crop productivity. Integrated nutrient management practices such as agroforestry systems, crop rotation, use of organic inputs (compost and FYM), chemical fertilizers and improved crop varieties that can be adapted in nutrient deficit areas to improve the soil fertility in the long term. Soil conservation practices should be adopted to reduce soil erosion, loss of nutrients along with runoff water and nutrient mining should be reduced to maintain fertile soil in watershed area and to achieve the sustainability through soil health along with improving the economy of the watershed areas.

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REFERENCES

Adornado H A and Yoshida M (2008). Crop suitability and soil fertility mapping using geographic information system (GIS). *Agri Info Res* **17**: 60-68.

Biradar S A, Devarnavadagi V S, Hotkar S, Kolhar B C and Rathod S C (2020). Performance of Pigeon pea (*Cajanus cajan* L.) based intercropping system with millets under Northern dry zone of Karnataka. *J Krishi Vigyan* **9**(1): 277-281.

ICAR-NBSS & LUP (2016). Field guide for land resource inventory SUJALA-III Project, Karnataka, National Bureau of Soil Survey and Land Use planning, Regional centre, Bangalore.

IRS-LISS Indian Remote Sensing- Linear Imaging Self-Scanning Sensor

Jackson M L (1973). Soil Chemical Analysis. 1st Edition, Prentice Hall Ltd., New Delhi, India.

Lindsay W L and Norvell W A (1978). Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Sci Soc America J* **42**: 421-428.

Mary Silpa T J and Nowshaja P T (2016). Land Capability Classification of Ollukara block panchayat using GIS. *Procedia Technology* **24**: 303-308.

Meena M L and Dudi A (2018). Increasing greengram production through frontline demonstrations under rainfed conditions of Rajasthan. *J Krishi Vigyan* **7**(1):144-148.

Mishra P and Ravi Babu R (2009). Simulation of storm sediment yield from an agricultural watershed using remote sensing, GIS and MUSLE. *J Soil Water Cons* **8**: 12-21.

Nelson D W and Sommers L E (1996). Total carbon, organic carbon, and organic matter. In Methods of Soil Analysis, Part 3. Chemical Methods (D.L. Sparks, Ed.). Madison, Wisc. SSSA and ASA. pp. 961-1010.

Olsen S R and Sommers L E (1982). Phosphorus. In: Methods of Soil Analysis, Part 2, second edition, Madison, Wisconsin. American Society of Agronomy and Soil Science pp. 403-430.

Patil P L, Radder B M and Aladakatti Y R (2011). Effect of moisture regimes, zinc and iron levels on yield, wue and nutrients uptake in chilli + cotton cropping system. *J Indian Soc Soil Sci* **59**: 401-406.

Prabhavati K, Dasog G S, Patil P L, Sahrawat K L and Wani S P (2015). Soil fertility mapping using gis in three agro-climatic zones of Belgaum District, Karnataka. *J Indian Soc Soil Sci* **63**: 173-180.

Pulakeshi P, Patil P L, Dasog G S, Radder B M, Bidari B I and Mansur C P (2012). Mapping of nuntrients status by geographic information system (GIS) in Mantagani village under northern transition zone of Karnataka. *Karnataka J Agri Sci* **25**: 332-335.

Ravikumar M A, Patil P L and Dasog G S (2007). Mapping of nutrients status of 48A distributary of Malaprabha right bank command of Karnataka by GIS Technique. I-Major Nutrients. *Karnataka J Agri Sci* **20**: 735-737.

Sahrawat K L and Burford J R (1982). Modification of alkaline permanganate method for assessing the availability of soil nitrogen in upland soils. *Soil Sci* **133**: 53-57.

Sharma U and Paliyal S S (2015). Forms of soil potassium as influenced by long term application of chemical fertilizers and organics in rainfed maize-wheat cropping system. *J Krishi Vigyan* **3**(2): 48-53.

Singh B P, Kumar A, Krishna G, Mardi G, Kumar S and Singh R K (2021). Higher levels of phosphorus affects production and productivity of pigeonpea (*Cajanus cajan*) under rainfed condition. *J Krishi Vigyan* **10**(1): 114-117.

Srikant K S, Patil P L, Dasog G S and Gali S K (2008). Mapping of available major nutrients of a microwatershed in northern dry zone of Karnataka. *Karnataka J Agri Sci* **21**: 391-395.

Sunil C M, Mahadevu P, Yogesh G S, Hanagi C and Mohankumar A B (2020). Performance of blackgram varieties under rainfed conditions of chamarajanagar district in Karnataka. *J Krishi Vigyan* **8**(2): 215-218.

Wani S P (2008). Taking soil science to farmers' doorsteps through community watershed management. *J Indian Soc Soil Sci* **56**: 367-377.

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