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Soil Fertility Mapping Using GIS in Meghalaya Plateau

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A B S T R A C T

Soil fertility maps namely pH, EC, OC, P and K were generated using Geographic Information System from grid wise soil health data collected from SHC Portal. The study revealed that soils of Meghalaya are non saline, acidic in nature and contains high organic carbon. It is found that 69.61% area of the State is covered by slightly acidic soils followed by moderately acidic (27.25%) and strongly acidic (0.09%) soils. Soils of the State is high in organic carbon that covers 88.22% area followed by medium and low that covers 11.52% and 0.26% area. It has also been observed that 69.89% soil of the State is having medium available phosphorus followed by low and high phosphorus content that covers 18.73% and 11.38% area respectively. Soils of the State are low in available potassium that covers 47.35% area whereas medium and high potassium is found in 45.54% and 7.11% area respectively. It is also observed that 98.77% soils of Garo hills are slightly acidic whereas 91.98 % area of Jaintia hills is moderately acidic in nature. Soils of Khasi hills are mostly slightly acidic that covers 68.66% area followed by moderately acidic and neutral soils that covers 24.69% and 6.49% respectively. High organic carbon content is highest in Jaintia Hills that covers 99.45% area followed by 98.90% and 69.64% area in Khasi Hills and Garo Hills respectively.

Keywords

Soil fertility map, Soil Health Card, GIS, Meghalaya

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Introduction

Effective soil fertility management is possible through site specific nutrient management considering spatial variations in fertility parameters that reduces over or under use of fertilizer. Based on location specific variability in nutrient availability in soil, optimum doses of fertilizers/ nutrients can be applied to soil as per the crop nutrient demand (Dobermann and Cassman, 2002). There are several techniques for soil fertility evaluation. Amongst all, the most popular as well as more appropriate method is soil testing that provides information about quantity of nutrients available in soils based on which optimum doses of fertilizer is recommended for economic production of different crops (Khadka *et al.,* 2019). Thus sustainable soil management is possible through soil analysis (Panda, 2010). Soil properties varies spatially from a small to larger area might be due to effect of intrinsic (climate, parent materials and physiography) and extrinsic factors such as indigenous fertility status, soil management practices, nature of standing crop, cropping intensity and crop rotation (Cambardella and Karlen, 1999). Introduction of new technologies such as Global Positioning Systems (GPS) and Geographic Information Systems (GIS) helps depicting the spatial variability of soil fertility across a field in the form of maps. For preparing thematic soil fertility maps, collection of soil samples along with recording of location of the samples using GPS is very important (Mishra and Saren, 2013). Similarly, GIS is a powerful tool for deriving spatial map based on soil sample analysis data collected from different locations (Jena *et al.*, 2015 & Sood *et al.*, 2009). GIS provide the platform for conversion of location specific (point) information to spatial maps for entire block/district/state. GIS provides platform for easy access, retrieval and manipulation of huge spatial and non spatial data useful for handling multiple data from diverse origin (Mandal and Sharma, 2009). Several studies have proved that geo-statistical analysis is very useful to characterize the spatial variability of different soil properties (Reza *et al.*, 2016; Singh *et al.*, 2018; Ravikumar, 2004; Huang, 2007; Weindorf, 2010; Liu, 2013; Prabhavati, 2015; Bandyopadhyay, 2018). Furthermore, GIS generated soil fertility maps may serve as a very effective decision support tool for sustainable nutrient management for economic crop production (Iftikar, 2010).

National Mission for Sustainable Agriculture (NMSA) aims at enhancing agricultural productivity especially in rainfed areas through Soil Health Management (SHM). Integrated Nutrient Management (INM) is the main aim of SHM that can be achieved through judicious use of chemical fertilizers containing macro nutrients, secondary and micro nutrients in conjunction with organic manures and bio-fertilizers for improving soil health and its productivity. Soil Health Card (SHC) scheme is a Government of India's scheme promoted by the Department of Agriculture & Co-operation under the Ministry of Agriculture. It is being implemented through the Department of Agriculture of all the State and Union Territory Governments. A SHC is given to each farmer that contain information on soil nutrient status of his fields and advice him on the dosage of fertilizers for different crops and also the needed soil amendments, that he should apply to maintain soil health in the long run. The SHC gives the information for a particular location (latitude, longitude) which is collected by using GPS. If the farmers get maps showing spatial variability of nutrient status of his fields, it will be more effective for site specific nutrient management. Information on spatial variability of soil fertility parameters for the Meghalaya Plateau is lacking. Therefore, Department of Agriculture & Co-operation under the Ministry of Agriculture has instructed Department of Agriculture of all the State and Union Territory Governments to generate village level fertility map. In this background, Directorate of Agriculture, Govt. of Meghalaya has entrusted North Eastern Space Applications Centre (NESAC) to generate soil fertility map by using Soil Health Card data for the entire state of Meghalaya Fig. 1.

Materials and Methods

For preparation of soil fertility map for the study area, Soil Health Card data has been collected from SHC web portal https//soilhealth.dac.gov.in. Grid wise soil health data of Meghalaya has been downloaded from the soil health card dashboard. The downloaded data has been cleaned and edited in Microsoft Excel and the non spatial data has been brought to GIS compatible format. The non spatial data has been converted to spatial data as a point layer by entering latitude, longitude information of 49000 soil samples by using ArcGIS 10.3 software. The point layer contains soil sample numbers, village name and soil sample analysis results of pH (soil acidity), EC (soil salinity), OC (organic carbon), available P (Phosphorus) and K (potassium). The point layer has been interpolated and spatial maps have been generated for five parameters i.e. pH, EC, OC (Physical parameters) and P, K (Macro-nutrients). Inverse Distance Weighted (IDW) interpolation technique available in the Spatial Analyst tools of Arc Toolbox was used for generation of spatial maps showing soil nutrient variability at different places. The methodology is described in details in Fig. 2.

Results and Discussion

The soil fertility maps generated by interpolation depict the variation in soil nutrient availability, soil acidity and soil salinity in Meghalaya. The study revealed that soils of Meghalaya are non saline and acidic in nature. Soils of the state are mostly slightly acidic in nature that covers 69.61% area followed by moderately acidic and neutral soils that cover 27.25% and 3.05% area respectively. Very negligible area is covered by strongly acidic soil that covers only 0.09% area of the state. Soils of Meghalaya are found to be rich in organic carbon covering 88.22% area followed by medium organic carbon that covers 11.52% area of the state. Low organic carbon is found only in 5939.03ha areas that constitute 0.26% area of the state. The availability of phosphorus and potassium in soils of the state varies from low to high. It has been observed that soils of 69.89% area is medium in available phosphorus followed by low and high phosphorus that covers 18.73% and 11.38% area respectively. The available potassium is low in 47.53% area followed by medium that covers 45.54% area. In the state, high available potassium is found in very limited areas that covers only 7.11% area.

Geographically Meghalaya is known as Meghalaya plateau and traditionally divided into Garo, Khasi and Jaintia Hills. The Khasi Hills is comprised of 4 districts namely East Khasi hills, West Khasi hills, Ri Bhoi and South West Khasi hills district where Khasi tribe is the most dominant inhabitant. Garo tribe is the dominant inhabitant of Garo hills and divided into 5 districts i.e. East Garo hills, North Garo hills, South West Garo hills, South Garo hills and West Garo hills district. Jaintia Hills inhabited by Jaintia tribe in majority is divided into East Jaintia hills and West Jaintia hills district. The state soil fertility maps have been divided into 3 regions i.e. Garo hills (Fig. 3), Khasi hills (Fig. 4) and jaintia hills (Fig. 5). The study revealed that 98.77% soils of Garo hills are slightly acidic whereas 91.98 % area of Jaintia hills is moderately acidic in nature. Soils of Khasi hills are mostly slightly acidic that covers 68.66% area followed by moderately acidic and neutral soils that covers 24.69% and 6.49% respectively. Soils of very negligible area of Khasi hills and Jaintia hills are found to be strongly acidic in reaction. Neutral soils are observed highest in Khasi hills followed by Jaintia hills and Garo hills that cover 7.87 % and 0.05% area respectively. The soils in all the three region of the state is found to be high in organic carbon content that covers 99.45%, 98.90% and 69.64% area in Jaintia Hills, Khasi Hills and Garo Hills respectively. Soils of Khasi and Jaintia hills contain high organic carbon because of low temperature which restricts decomposition of organic matter (Table 1).

From the study it is observed that soils of Garo hills are mostly medium in available phosphorus that covers 79.57 % area. Soils of 19.94 % area of Garo hills are low in phosphorus content and very negligible areas are having rich in phosphorus. It is also found that availability of phosphorus is low to high in Khasi hills and Jaintia hills. Soils of Khasi hills are medium in available phosphorus that covers 60.46% area followed by high and low available phosphorus that covers 21.47% and 18.06% respectively. Soils of Jaintia hills are mostly medium in available phosphorus which covers 74.81% area followed by low and high phosphorus that covers 17.91% and 7.28% area respectively.

From the study, it is found that soils of Garo hills are low in available potassium which covers 78.87% area followed by medium available potassium covering 21.07% area. Soils of Khasi hills are medium in available potassium covering 57.27% followed by low and high potassium covering 31.79% and 10.94% area respectively. Jaintia hills soils are having medium available potassium in 66.86% area followed by low and high potassium in 21.16% and 11.98% area respectively.

Table.1 Area under different fertility classes in Garo, Khasi and Jaintia hills

Parameters	Districts	Garo hills		Khasi hills		Jaintia hills	
	Class	Area(ha)	% area	Area(ha)	% area	Area(ha)	% area
pH	Strongly acidic	0.00	0.00	1651.02	0.16	353.73	0.09
	Moderately acidic	9751.95	1.18	257360.27	24.69	343528.65	91.98
	Slightly acidic	814549.91	98.77	715713.71	68.66	29390.85	7.87
	Neutral	429.67	0.05	67688.51	6.49	197.99	0.05
OC	Low	4599.92	0.56	1289.99	0.12	43.06	0.01
	Medium	245815.71	29.81	10174.63	0.98	2026.72	0.54
	High	574315.93	69.64	1030948.90	98.90	371401.45	99.45
EC	Non Saline	824731.53	100.00	1042413.51	100.00	373471.22	100.00
P	Low	164436.19	19.94	188270.63	18.06	66878.99	17.91
	Medium	656250.54	79.57	630291.55	60.46	279409.22	74.81
	High	4044.82	0.49	223851.32	21.47	27183.01	7.28
K	Low	650484.37	78.87	331386.94	31.79	79023.81	21.16
	Medium	173775.95	21.07	596959.73	57.27	249688.66	66.86
	High	471.22	0.06	114066.84	10.94	44758.76	11.98

Fig.1 Location of study area

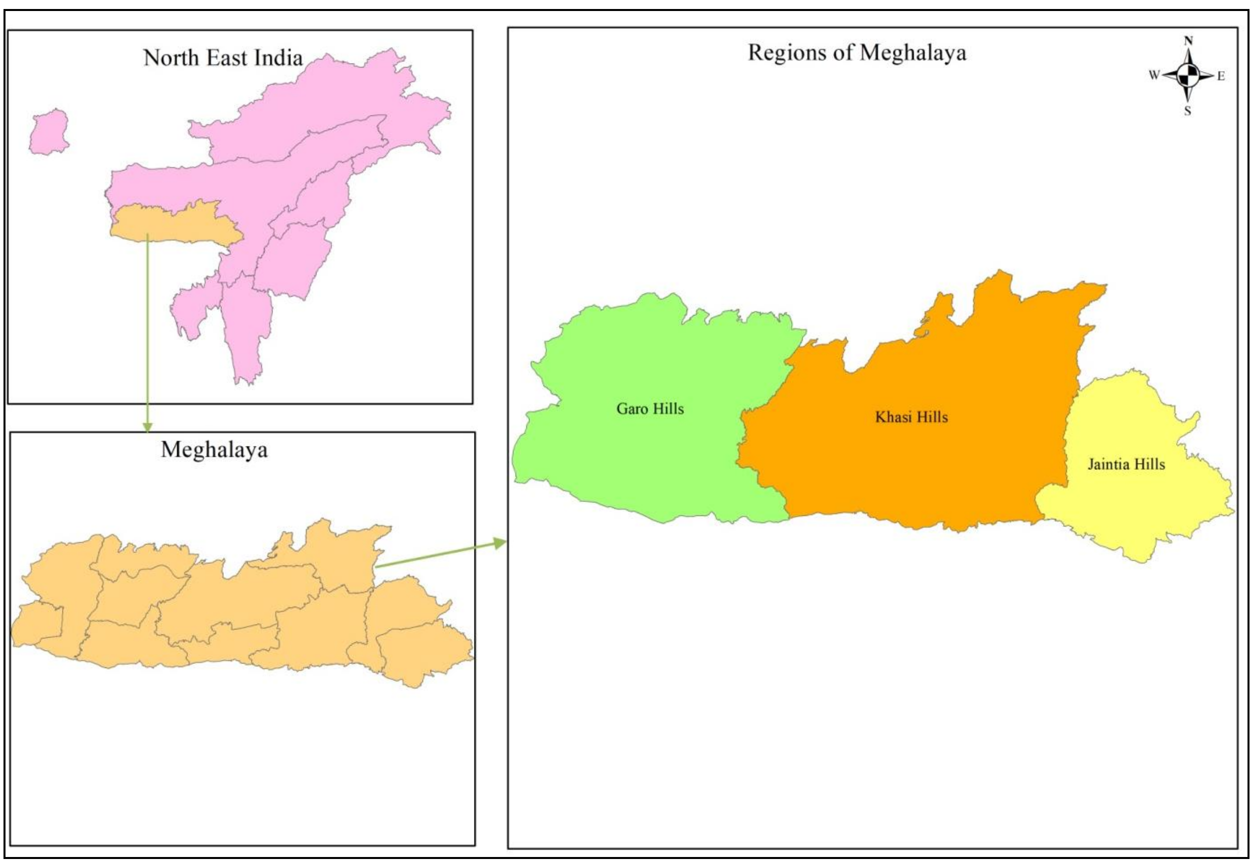


Fig.2 Flow chart of the methodology for soil fertility mapping

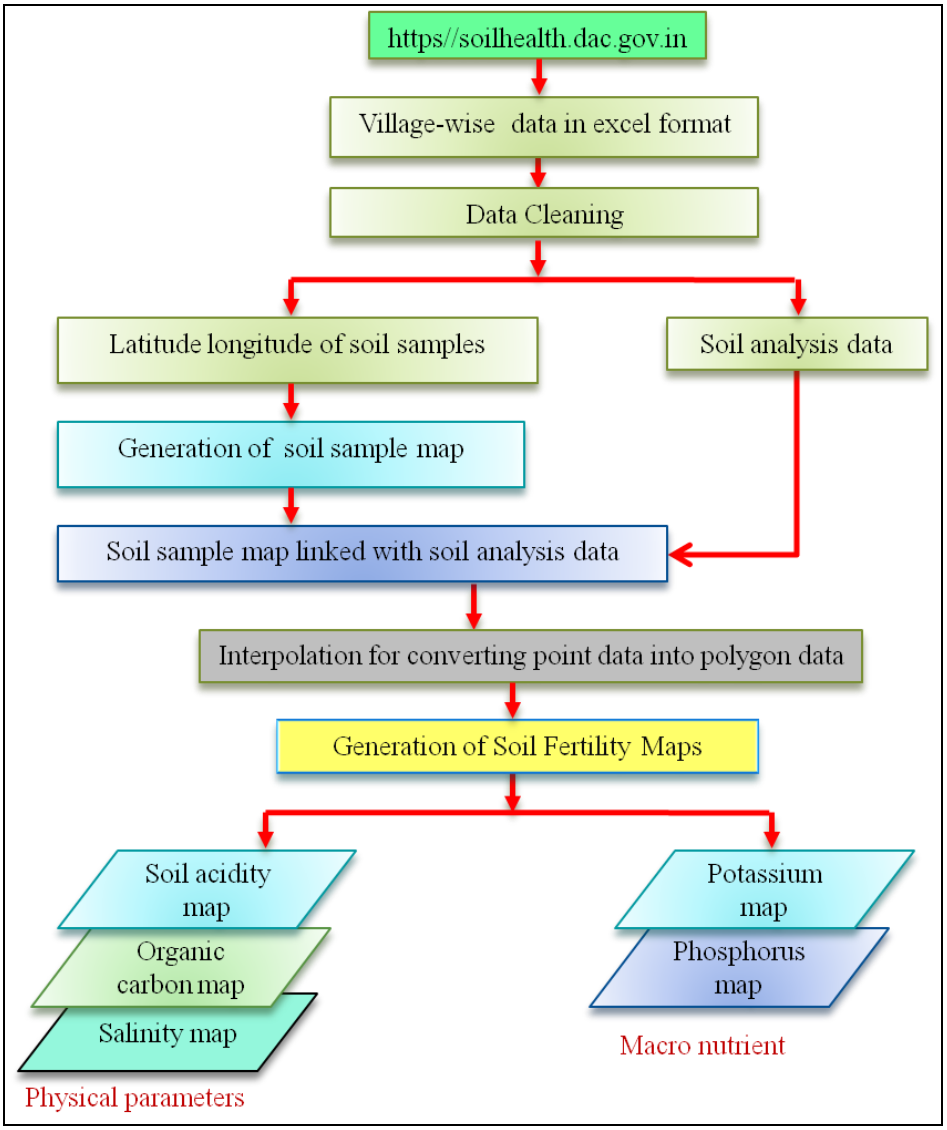


Fig.3 Soil fertility map of Garo hills of Meghalaya

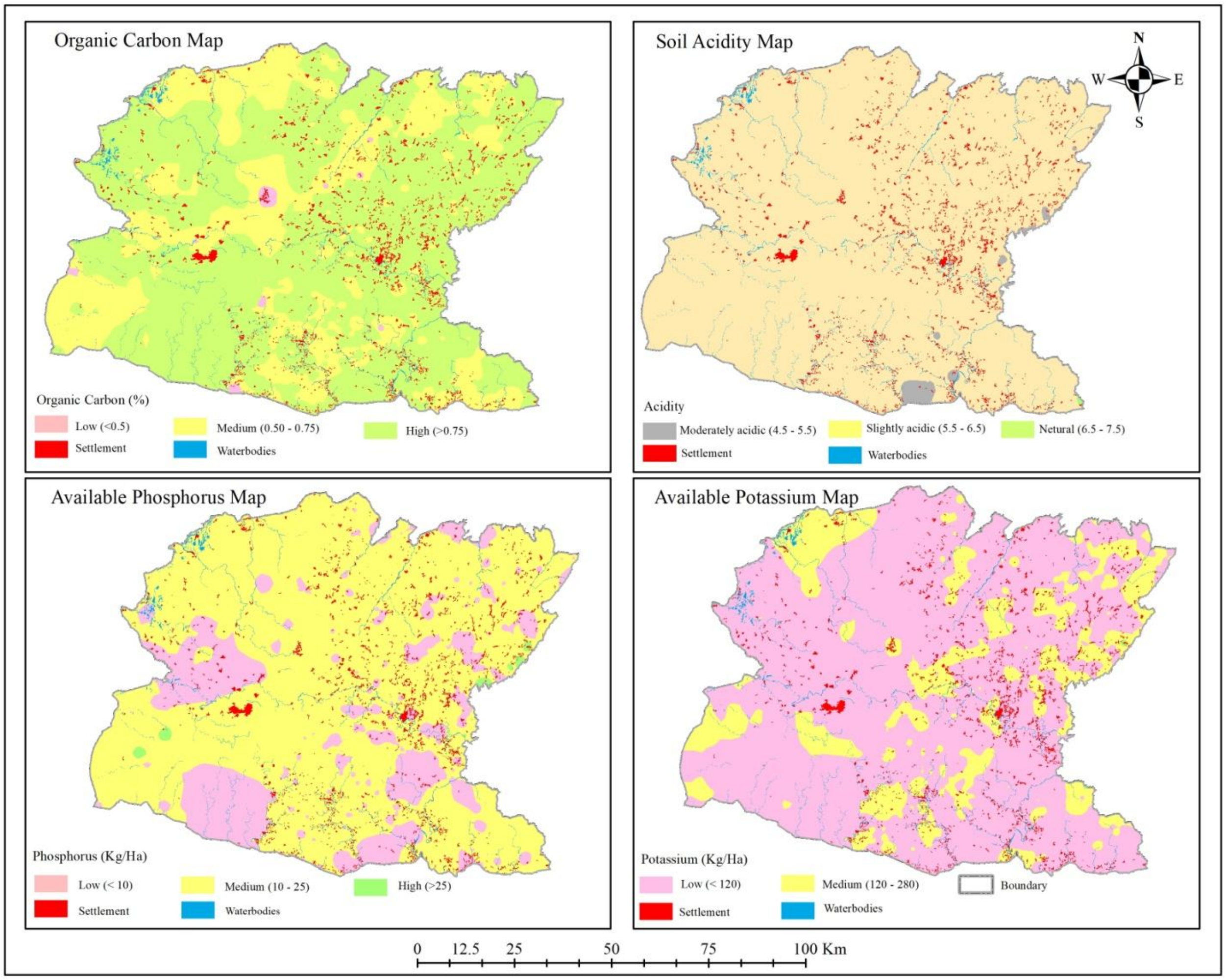


Fig.4 Soil fertility map of Khasi hills of Meghalaya

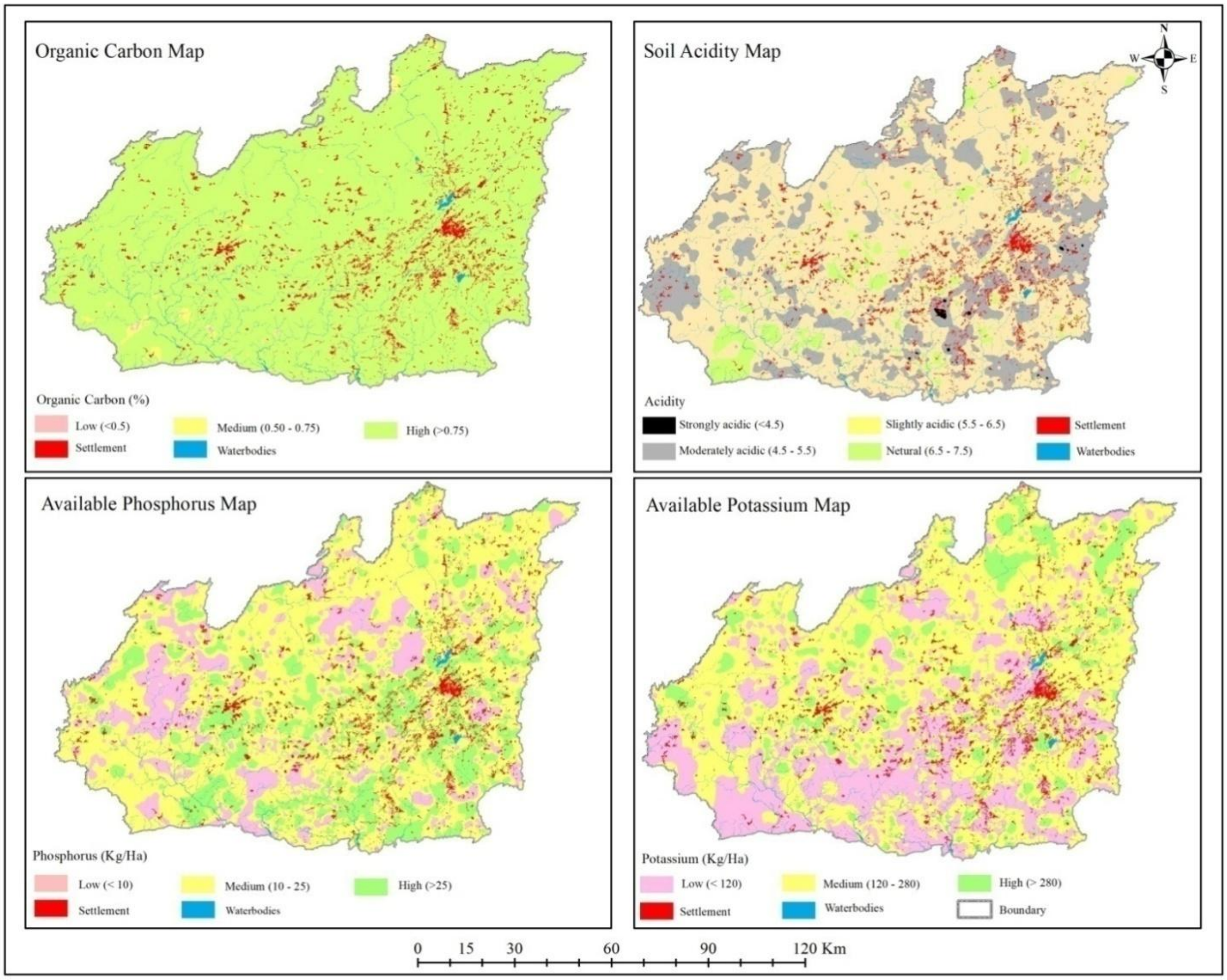
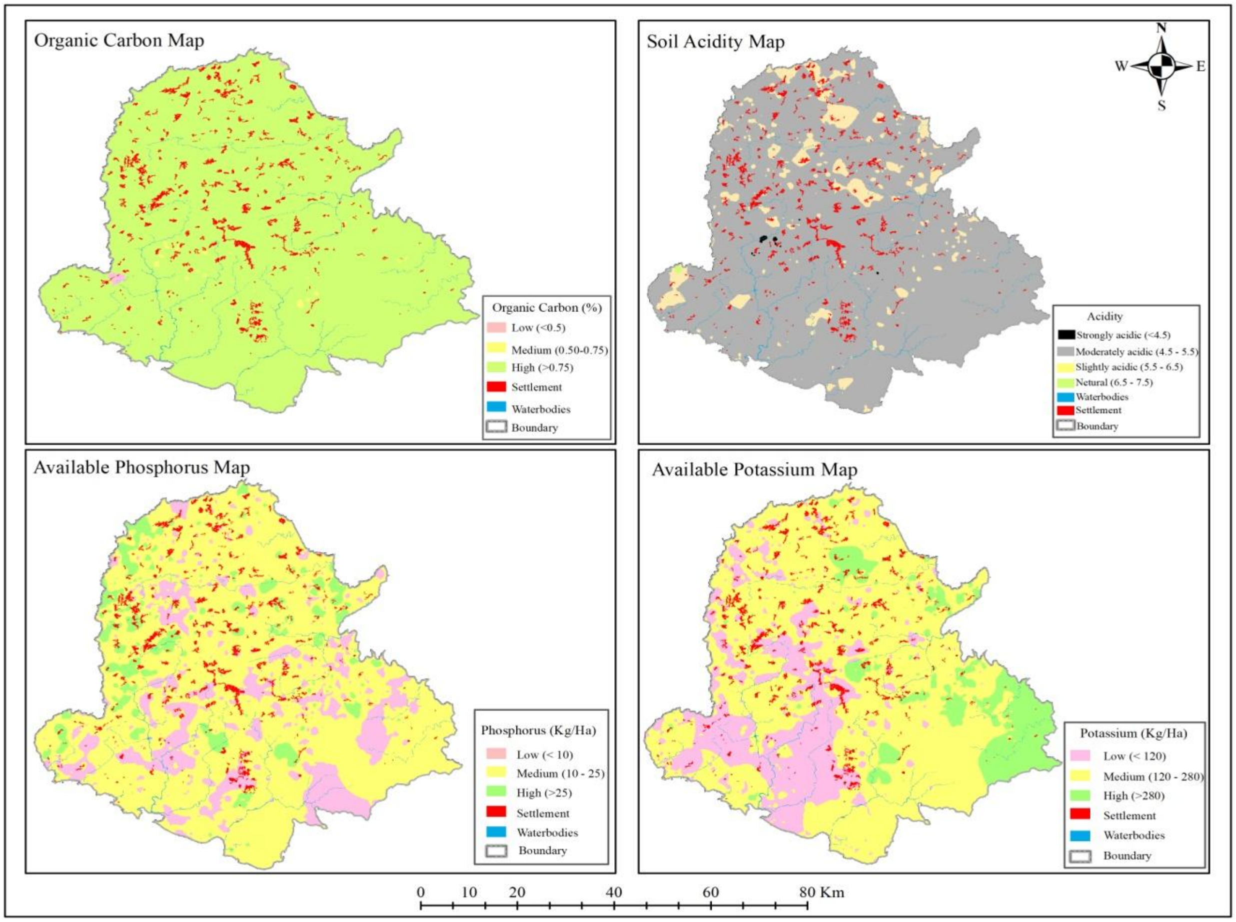


Fig.5 Soil fertility map of Jaintia hills of Meghalaya



The study gives an example of utilization of geospatial technology in conversion of non spatial Soil Health Card data into simpler visual interpretations or spatial maps which will be useful for recommending proper dose of soil fertilization and other nutrient management practices to increase crop production reduce soil degradation and helps in sustainable agriculture. Soils of the state are non saline, acidic in reaction, high to medium in organic carbon and available phosphorus varies from medium to high. Available potassium varies from medium to low.

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