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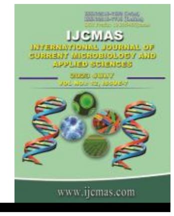

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Spatial Assessment of Potato Growing Areas of Meghalaya Using Geospatial Technology

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ABSTRACT

High resolution temporal satellite imageries of 2021-2022 were visually interpreted to assess spatial distribution of potato in East Khasi Hills district of Meghalaya. Soil Health Card data combined with soil testing results of soil samples collected during field visit were used to prepare spatial soil fertility maps. The study revealed that potato is grown over an area of 6321.4ha and it is distributed in all blocks of the study district except Shella Bholaganj. Highest potato fields are found in Mawsynram and Mawphlang blocks followed by Mawkynrew and Mawryngkneng blocks covering 81% area. It is also found that potato is grown in slightly to moderately acidic soils which are rich in organic carbon with moderate availability of phosphorus and potassium. Sufficient micronutrients (Cu, Fe and Zn) are available in the soils of more than 85% potato fields. Soils of more than 90% fields are deep, well drained and soil texture varies from sandy clay loam, clay loam to sandy clay. Potato is mostly cultivated in gentle to moderately sloping lands above 1300m altitude from mean sea level.

Introduction

Potato is the second most important crop in Meghalaya after Paddy, and it is the most important cash crop of the State. This crop is grown over 18,943 ha (7.4% of the net cropped area) with an annual production of 1 87,348 metric tons during 2019-20 (DES, 2020). The agro-ecology of the State is very suitable for growing potatoes in two seasons a year, i.e., summer (Feb– March to June– July) and autumn (Aug– Nov, Dec). The main potato growing season of Meghalaya is summer that covers 12577 ha area (65% of total potato growing land) with total production of 143122 metric tons (76% of total potato production), and yield is 11380 kg/ha, higher than autumn potato, i.e. 6947 kg/ha. Potato is mainly grown in cooler regions as a rain-fed crop in higher altitudes, providing a conducive ecosystem for optimum crop production (http://megagriculture.gov.in). Potato cultivation in the state is primarily confined to the central Shilling plateau consisting of three districts, i.e., East Khasi Hills, West Khasi Hills and South West Khasi Hills districts, inhabited mainly by the Khasi tribe (Figure 1). These three districts cover about 94% of the total potato growing areas and produce about 96% (179153MT) of the total potato production in the State. Potato farmers of the Shillong plateau are widely acknowledged to be amongst the best farmers in the country who accept new technology, new varieties/seeds and new plant protection measures with enthusiasm and follow the prescribed package of practices religiously. Kufri Jyoti, Kufri Megha, Kufri Giriraj, and Kufri Kanchan are the recommended varieties for the State (https://kvk.icar.gov.in).

Accurate and real-time information on the spatial distribution of potato derived from satellite images are very helpful for cultivators, manufacturers of fertilizer/pesticide and agriculture extension agencies to prepare effective plans for manufacturing as well as supply of inputs and marketing of the products.

The spatiotemporal distribution and dynamics of potato cultivation in a state help government agencies to understand supply and formulate food security policies. In this context, remote sensing and GIS-based methods have already been proven effective tools for mapping areas under different crops (Neog, 2006; Anonymous, 1947; Pushkarnath, 1976; NESAC, 2019 Sali rice report).

Satellite imageries are very useful in preparing accurate and dynamic crop maps with less cost within a short time. Single date or time series satellite images, optical as well as microwave/Synthetic Aperture Radar (SAR) data had been used for mapping of rice and other major crops at national, regional, district and field level scale (Das *et al.*, 2020, 2021; Yin *et al.*, 2019; Qin *et al.*, 2015; Nguyen *et al.*, 2015; Neetu *et al.*, 2014; Karydas *et al.*, 2015; Ok *et al.*, 2015). Temporal remote sensing data, soil, physiography, rainfall and temperature information were used to identify suitable areas for expansion of different crops in North East India (Das *et al.*, 2018; Handique *et al.*, 2016; Das *et al.*, 2018). The crop rotation information derived from multi-date LISS-I images of Indian Remote Sensing Satellite (IRS) was used to characterize the land use utilization pattern (Panigrahy and Chakraborty, 1998).

Satellite remote sensing data with its synoptic, temporal coverage of an area in multi-spectral bands has been used successfully for the survey of early potato crop and analysing the changes in comparison to previous years using temporal IRS WiFS data (Singh *et al.*, 2002). Sentinel-1A C-SAR and Sentinel-2A Multi-Spectral Instrument (MSI) data were used for the identification of beans, beetroot, grass, maize, potato, and winter wheat in 2016 (Rei Sonobe *et al.*, 2017). In precision agriculture, the effects of different crop management activities, such as timing and frequency of irrigation, fertilizer applications, date of planting, population density and crop health monitoring, were determined traditionally through field surveying or biophysical modelling on crop growth and yield under different environmental conditions (Molahlehi *et al.*, 2013; Al-Gaadi *et al.*, 2016). Such methods are time-consuming. However, the advancement of technologies, such as remote sensing, global positioning system, geographic information systems, and artificial intelligence, has significantly improved precision agriculture systems (Mulla, 2013). The remote sensing technique is considered an effective tool for crop growth monitoring, disease detection and irrigation scheduling based on the interaction of electromagnetic radiation with soil and canopy reflectance, which helps to improve profitable tuber yield and quality and minimize the negative impacts on the natural resources (Banerjee *et al.*, 2020; Sanchez *et al.*, 2020; Sun *et al.*, 2020; Dutta Gupta and Pattanayak, 2017; Oppenheim and Shani, 2017; Suh *et al.*, 2018). Remote sensing systems, integrating advances in imaging, data processing, and computing technologies, thus have the potential to monitor the crop growth status and help make decisions for crop management (Pavón-Pulido *et al.*, 2017; Say *et al.*, 2017).

Potato is a major commercial crop of Meghalaya and information on spatial distribution of the crop is an important input for preparing proper plan for increasing crop productivity. Therefore, the present study has been taken up to study the spatial distribution of potato in East Khasi hills district (Figure 2) and its characterization for proper crop management plans.

Materials and Methods

Mapping of potato growing areas

High resolution temporal satellite imageries of 2021-2022 available in the Google Earth were used to delineate potato fields. Field survey has been carried out during potato growing season and collected Ground Truth (GT) data using Global Positioning System (GPS). Pre-field Ground Truth (GT) data was collected during December, 2020 during the early stages of field preparation and transplantation of potatoes. Post-field G.T data were collected in April, 2021 and November, 2021.

Pre-field GT data has been used to identify and differentiate summer and autumn potato from other crops on satellite images. Visual image interpretation technique was applied to extract information on spatial distribution of potato in East Khasi hills district of Meghalaya. Potato map was finalized after field verification with GT data.

Preparation of soil fertility maps

Soil samples from 383 locations representing potato fields were collected during field survey for GT data collection. Soil samples were analyzed in soil testing laboratory. The soil sample analysis results along with Soil Health Card data collected from SHC web portal https//soilhealth.dac.gov were used to generate soil fertility maps. Soil fertility map for nine parameters, namely soil acidity (pH), soil salinity (EC), organic carbon (OC), available phosphorus (P) and potassium (K), zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) were generated by using Inverse Distance Weighted (IDW) interpolation technique of Spatial Analyst tools of Arc toolbox (16).

Derivation of thematic maps

Soil depth, texture and drainage maps were derived using GIS environment from soil map prepared at 1:50,000 scale by NESAC (North Eastern Space Applications Centre) under NRIS (Natural Resource Information System) project. Digital Elevation Model (DEM) generated from Cartosat images under SISDIP project has been used to derive slope and elevation map using surface function of Spatial Analyst Tools of ArcGIS software.

Characterization of potato fields

The potato map of the study area was overlaid with various thematic maps i.e. pH, EC, OC, P, K, Zn, Fe, Cu, Mn, soil depth, texture, drainage, slope and elevation map in GIS environment (ArcMap10.8.1). Overlay function of Analysis Tools of Arc GIS software was used to derive a composite map describing soil site characteristics of potato fields of the study area.

Results and Discussion

Spatial distribution of potato

Analysis of temporal satellite images along with ground truth data revealed that summer potato is cultivated across the entire district except Shella Bholaganj block where cultivable land is very less due to steep slopes. It is found that summer potato covers maximum area of 5509.8 ha (87.2 % of total potato growing areas) followed by autumn potato distributed over 740.8 ha area (Figure 3). The study reveals that farmers of Mylliem, Mawphlang, Mawryngkneng and Mawkdok block have used same piece of land for growing of summer potato followed by autumn potato (Table 1). Highest potato growing areas are distributed in the Mawsynram and Mawphlang blocks followed by Mawkynrew and Mawryngkneng blocks covering 81% area of the study district (Table 2).

Spatial assessment of soil fertility

Soil samples locations (latitude & longitude) collected with the help of GPS has been linked to soil analysis results in GIS platform and a point layer has been generated. The point layer has been interpolated and derived spatial soil fertility maps of nine parameters (Table 3). It is observed that soils of major areas of the study area are slightly and moderately acidic in nature, rich in organic carbon with moderate availability of phosphorus and potassium (Figure 4). Soils of more than 85% area contain sufficient micronutrients Cu, Fe and Zn except Mn which is deficient in 31% area.

Soil site characteristics

Soil texture, depth and soil drainage maps were derived from soil map using ArcGIS software. It is observed that soils of more than 90% potato fields are deep, well drained to excessively drained and soil texture varies from sandy clay loam, clay loam to sandy clay. Elevation of the study area varies from 800m to 1900m and 80% potato fields are found at higher elevation which is more than 1300m.

The study reveals that potato is grown on very gently slops to steep slopes but major areas (67%) are found on gentle to moderate sloping areas (Table 4 & Figure 5).

The study gives an example of utilization of freely available high resolution satellite images for spatial assessment of potato in East Khasi hills district of Meghalaya. Characterization of potato fields in reference to soil site characteristics utilizing geospatial technology provides information for preparing proper crop management plan.

Soil analysis results collected from Soil Health Card dashboard and soil samples collected from field visit has been converted to spatial soil fertility maps which are very useful for recommending a proper dose of soil fertilizers and other nutrient management practices to increase crop production without soil degradation and helps in sustainable agriculture. Slope and soil map of the study area gives visualization about potential and constraints of particular potato fields and hence helps in crop management plans to increase potato productivity in the state.

Table.1 Season wise area under potato in East Khasi Hills district of Meghalaya

Potato season	Block	Area (ha)
Autumn	Mawphlang	84.6
	Mawryngkneng	239.9
	Mawsynram	218.1
	Mylliem	198.2
Summer	Mawkdok	629.6
	Mawkynrew	714.2
	Mawphlang	1477.4
	Mawryngkneng	632.7
	Mawsynram	1675.4
	Mylliem	349.6
	Pynursla	30.9
Summer followed Autumn	Mawkdok	2.9
	Mawphlang	38.3
	Mawryngkneng	22.8
	Mylliem	6.8
	Total	6321.4

Table.2 Spatial distribution of potato in East Khasi Hills district of Meghalaya

Block	Area (ha)	%area
Mawsynram	1675.4	26.5
Mawphlang	1477.4	23.4
Mawkynrew	714.2	11.3
Mawryngkneng	632.7	10.0
Mawkdok	629.6	10.0
Mylliem	349.6	5.5
Mawryngkneng	239.9	3.8
Mawsynram	218.1	3.5
Mylliem	198.2	3.1
Mawphlang	84.6	1.3
Mawphlang	38.3	0.6
Pynursla	30.9	0.5
Mawryngkneng	22.8	0.4
Mylliem	6.8	0.1
Mawkdok	2.9	0.0
Total	6321.4	100.0

Table.3 Area under different soil fertility classes

Parameters	Class	Area(ha)	Area (%)
pH	Strongly acidic	137.44	2.17
	Moderately acidic	2872.17	45.44
	Slightly acidic	3063.9	48.47
	Neutral	247.86	3.92
OC	Low	5.97	0.09
	Medium	9.03	0.14
	High	6306.37	99.76
Phosphorus	Low	1544.79	24.44
	Medium	4373.72	69.19
	High	402.86	6.37
Potassium	Low	2264.09	35.82
	Medium	3234.83	51.17
	High	822.45	13.01
Cu	Sufficient	6321.37	100
Fe	Deficient	353.24	5.59
	Sufficient	5968.13	94.41
Mn	Deficient	1989.64	31.47
	Sufficient	4331.73	68.53
Zn	Deficient	728.93	11.53
	Sufficient	5592.44	88.47

Table.4 Area under different classes of soil site parameters

Site parameters	Class	Area(ha)	Area (%)
Elevation (m)	800-1300	1277.43	20.21
	<1300	5043.75	79.79
Slope (%)	Level to very gently sloping (0-3%)	964.71	15.27
	Gently sloping (3-8%)	2346.12	37.11
	Moderately sloping (8-15%)	1926.42	30.47
	Moderately steep sloping (15-30%)	972.47	15.38
	Steep sloping (30-45%)	111.64	1.77
Soil depth	Deep	5742.84	91.28
	Moderately deep	18.69	0.3
	Slightly deep	532.47	8.43
Soil texture	Clay	973.027	15.5759
	Clay loam	1963.64	31.4332
	Sandy clay loam	2181.72	34.5549
	Sandy clay	1065.69	17.0591
	Sandy loam	62.9503	1.00769

Fig.1 District-wise area under potato during 2016-2020
(Source: DES, Govt. of Meghalaya)

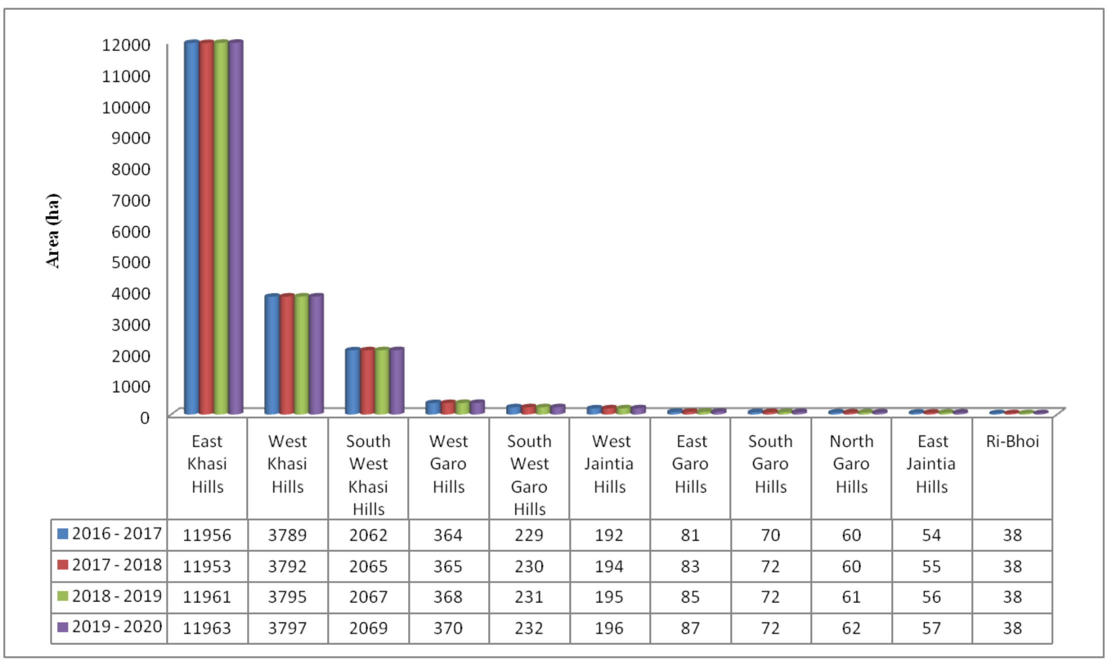


Fig.2 Location of study area

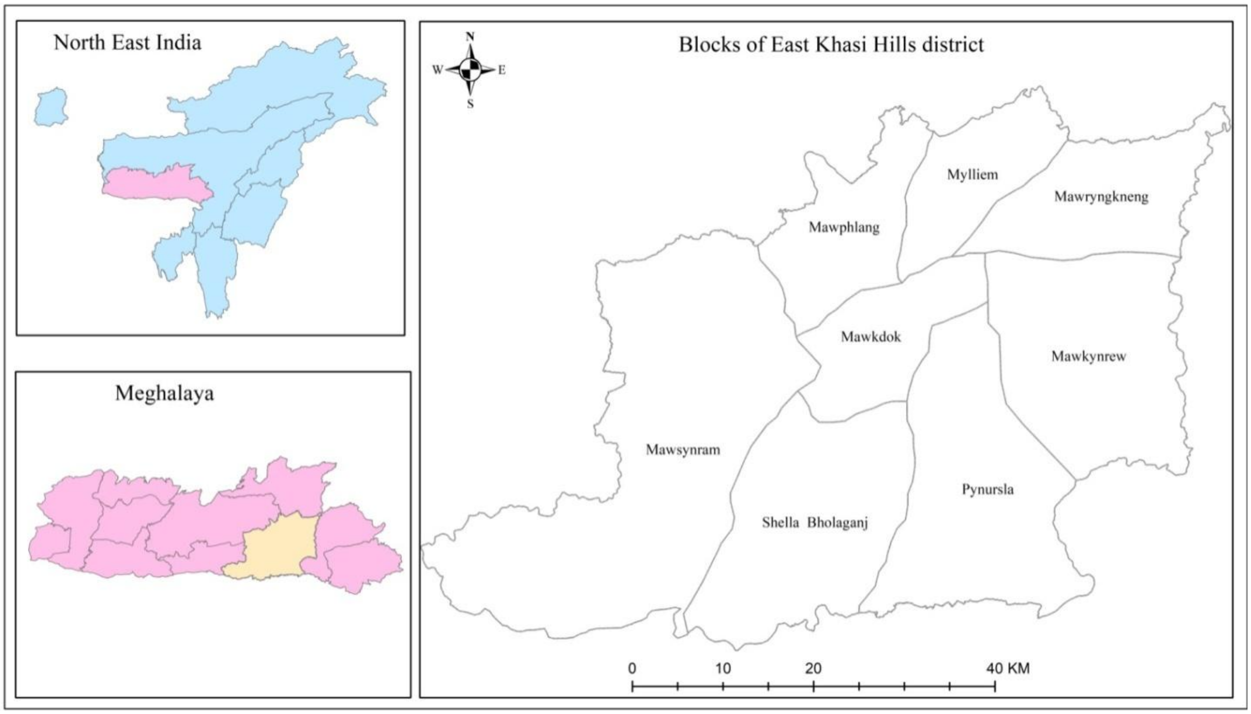


Fig.3 Spatial distribution of potato in East Khasi Hill district of Meghalaya.

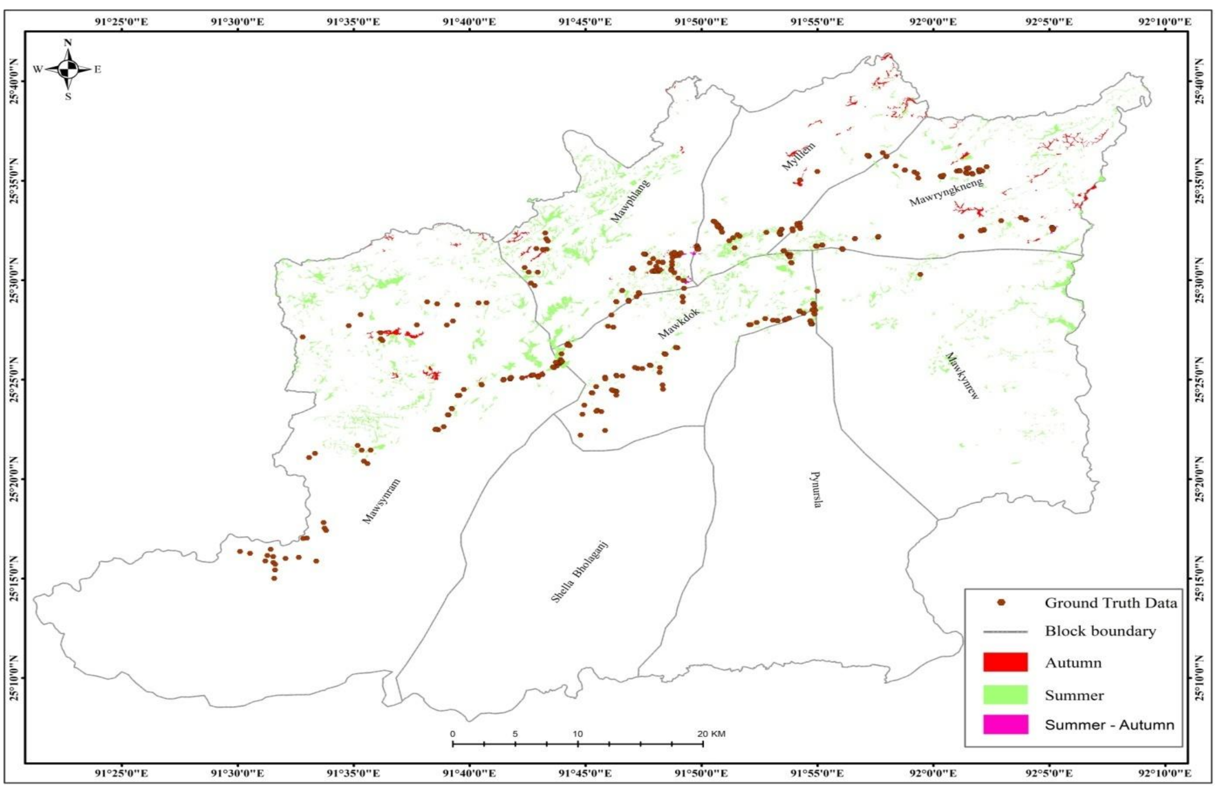


Fig.4 Soil fertility maps of potato fields of East Khasi Hill district of Meghalaya (All 8 fertility maps)

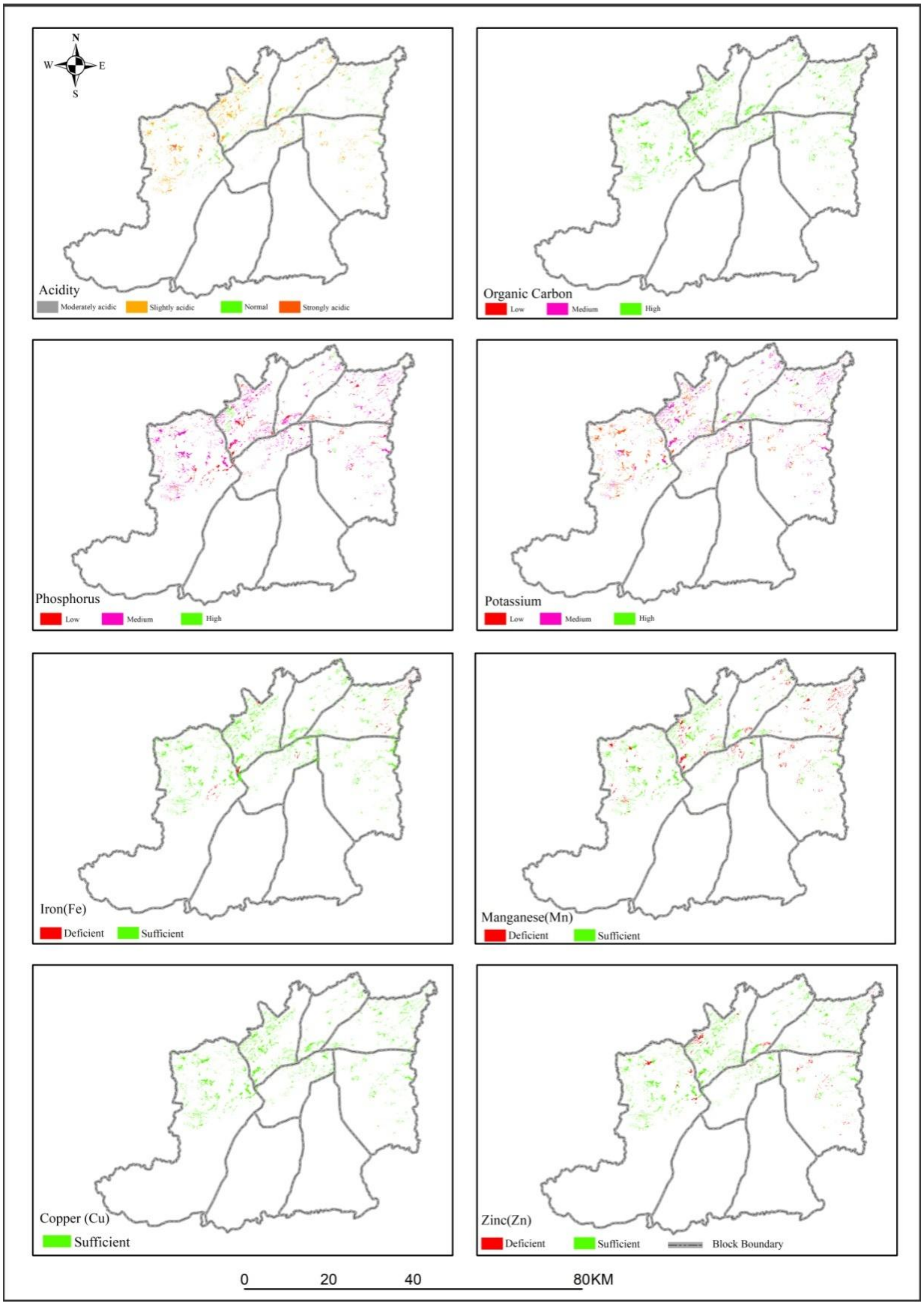
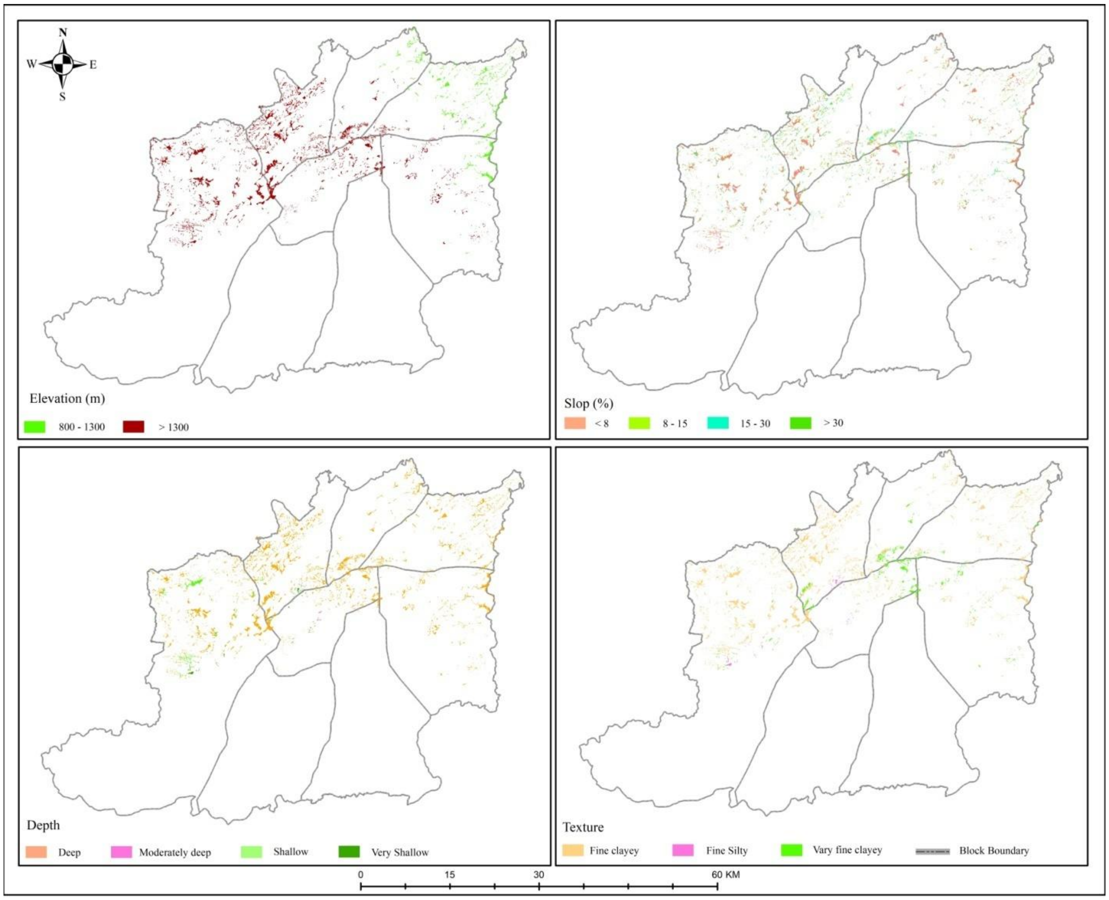


Fig.5 Soil site characteristics of potato fields (Slope, elevation, soil depth, soil texture map)



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