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Original Research Article

Expansion of Khasi Mandarin in Meghalaya Using Geospatial Technology

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Abstract: Suitable areas for expansion of khasi mandarin in Meghalaya were identified through land evaluation in GIS environment using information on soil physical, chemical and fertility properties, slope, elevation, rainfall and temperature. The study reveals that 10,457 ha area covering 64.37% of the total study area is suitable for the expansion of Khasi mandarin. Because of steep to very steep slopes, very shallow soil, strongly acidic soils, and low available soil nutrients, 35.63% area is not suitable for Khasi mandarin. It is observed that 64.88% (i.e. 6784.45 ha) area is marginally suitable and 3672.83 ha (35.12%) area is moderately suitable for Khasi mandarin expansion. The maximum area is marginally suitable because of the severe limitation of slope and moderate limitation of soil drainage and soil fertility. Based on constraints of slope (t), drainage (w), soil depth and texture (s) and soil fertility (f); the moderately and marginally suitable areas were classified into 31 and 26 sub classes respectively.

Keywords: Geospatial technology, Khasi mandarin, Soil fertility, Soil health card, Meghalaya.

INTRODUCTION

Citrus is grown widely in the north eastern region of India covering 115482 hectares occupies first position on area basis. Mandarin is cultivated in all states of NEH Region and Meghalaya is the leading state with largest area (De *et al.*, 2017). Meghalaya is the major producer of this orange covering 9148 ha area with a production of 44139 M.T during 2019-2020 and it is the most important commercial fruit, both in the northern and southern slopes of the State (NESAC, 2021). The juicy Khasi Mandarin orange variety, called 'the pride of Meghalaya' has made it to the world's first food atlas (Govind *et al.*, 1999). The variety from the hill state of Meghalaya is among the 175 food items from India that are included in the world's first food atlas.

East Khasi hills district is the major producer of Khasi mandarin in Meghalaya covering 4252 ha area (46% of total orange plantation) producing 23585 M.T fruits which are 53% of the total state production (Fig 1). Best quality Khasi mandarin is produced on the southern slope of Meghalaya. Pynursla block of East Khasi hills district is situated on the southern slope of Meghalaya and it is an important block which is producing good quality Khasi mandarin which has huge demand in the market. Therefore, there is tremendous scope for increasing production by expanding areas under Khasi mandarin plantation to new potential areas. In this context, geospatial tools comprising Remote Sensing (RS), Geographical Information System (GIS) and Global Positioning System (GPS) are very important in integrating, analysing and disseminating satellite derived information for identification of potential areas for expansion of khasi mandarin plantation in the state (NESAC, 2021). Directorate of Agriculture, Govt. of Meghalaya is utilising the remote sensing based spatial information for agriculture development (Das *et. al.*, 2009, Das *et. al.*, 2018, Das *et. al.*, 2020 and NESAC 2021). Suitable areas for boro rice expansion in Meghalaya were identified using geospatial technology based on land evaluation using information on soil, slope, elevation, rainfall and temperature (Das *et.al*, 2018). For planning the expansion of khasi mandarin plantation, it is essential to delineate the area suitable for the crop. The Directorate of Agriculture, Government of Meghalaya wants to expand khasi mandarin plantations in the state with scientific inputs. Therefore the department requested NESAC to take a pilot study and identify areas suitable for expansion of khasi mandarin plantation using space technology and other related information on soil, climate, topography, etc.

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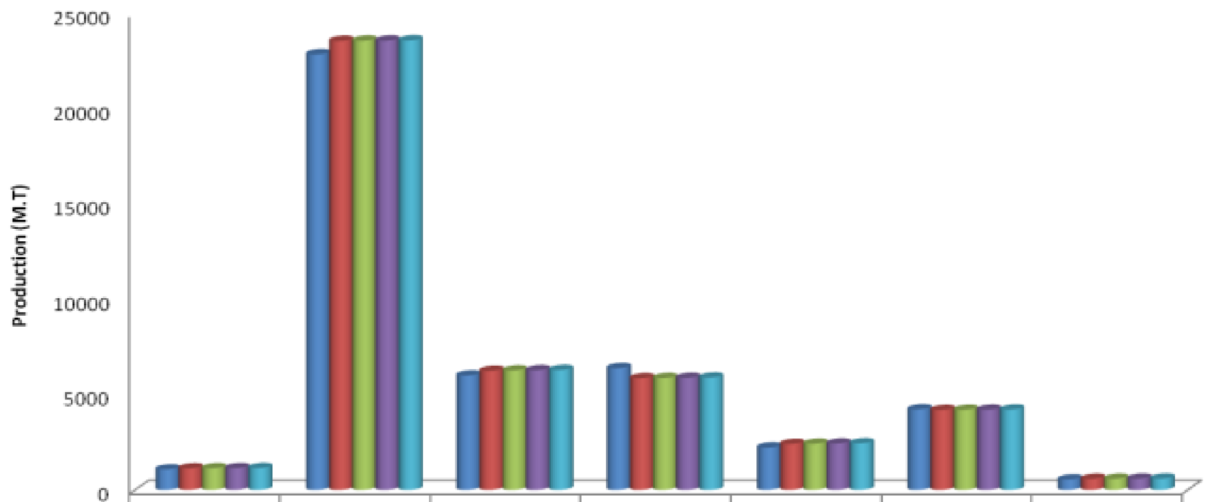

	Ri-Bhoi	East Khasi Hills	West Khasi Hills	Jaintia Hills	East Garo Hills	West Garo Hills	South Garo Hills
2015 - 16	1073	22857	5999	6386	2218	4220	548
2016 - 17	1127	23560	6246	5857	2404	4189	577
2017 - 18	1132	23571	6264	5867	2414	4196	580
2018 - 19	1137	23575	6276	5878	2424	4202	584
2019 - 20	1142	23585	6289	5892	2434	4209	588

Fig. 1: Khasi mandarin production in Meghalaya

STUDY AREA

The study is carried out in the Pynursla block of the East Khasi Hills district of Meghalaya. There are about 156 villages in the block and agriculture is the main occupation of the people of villages. Rice, pineapple, tea, ginger, winter vegetables, turmeric, and khasi mandarin are the major crops grown in the study area (https://eastkhasihills.gov.in/).

Land use land cover map (LULC) was prepared from Resourcesat 2 LISS IV image of 2019. Visual image interpretation technique was applied to extract various land use classes existing in the study area. Various scene elements, such as tone, texture, shape, size and association were considered during image interpretation [Lille sand *et al.,* 2004]. Ground truth data were collected to confirm various land use. Non-agricultural, open tree-clad (open forest) and culturable wastelands were extracted from LULC map that covers 16247.23 ha area was considered as study area for identifying suitable areas for khasi mandarin (Fig 2).

MATERIALS AND METHODS

Suitable areas for khasi mandarin were identified through land evaluation following FAO guidelines. Soil fertility maps, slope, elevation, soil depth, texture, drainage, flooding, stoniness and LULC map was used to identify suitable areas for mandarin plantations.

***Preparation of Soil fertility maps using GIS and Soil Health Card data**:*

Soil fertility maps of the study area were prepared from soil health data downloaded from SHC portal https//soilhealth.dac.gov.in. The downloaded data has been edited and brought to GIS compatible format and a point layer has been generated by entering latitude, and longitude information of 6982 soil samples. The point layer contains soil sample numbers, village names, and soil sample analysis results. The soil analysis data available in the SHC portal includes nine parameters i.e. pH, EC, OC (Physical parameters); P, K (Macro-nutrients) and Zn, Fe, Cu, Mn (Micronutrients). The point layer has been interpolated and spatial soil fertility maps have been generated (Fig 3). The inverse Distance Weighted (IDW) interpolation technique available in the Spatial Analyst tools of Arc Toolbox was used.

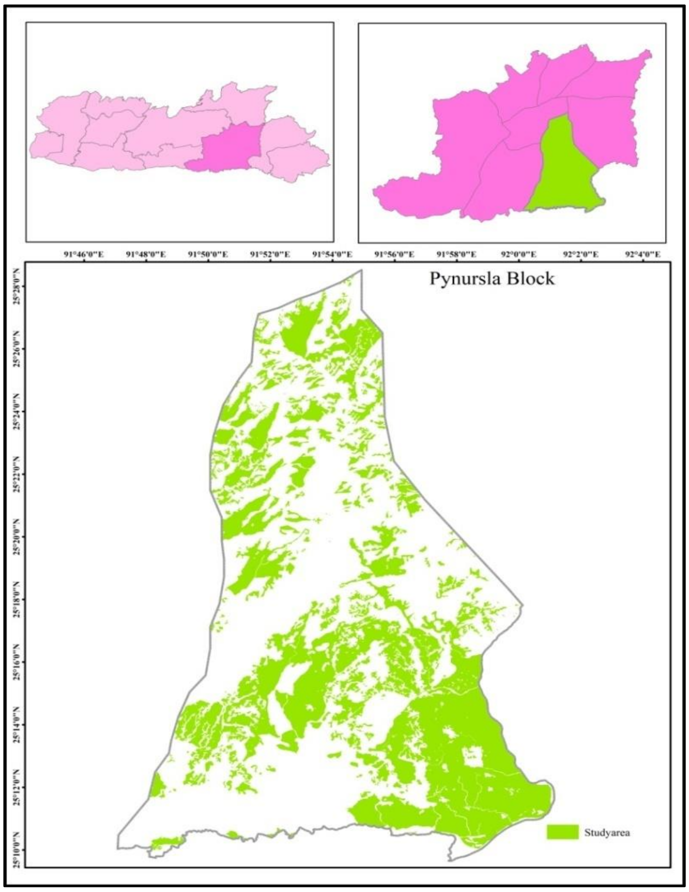

Fig. 2: Location of the study area

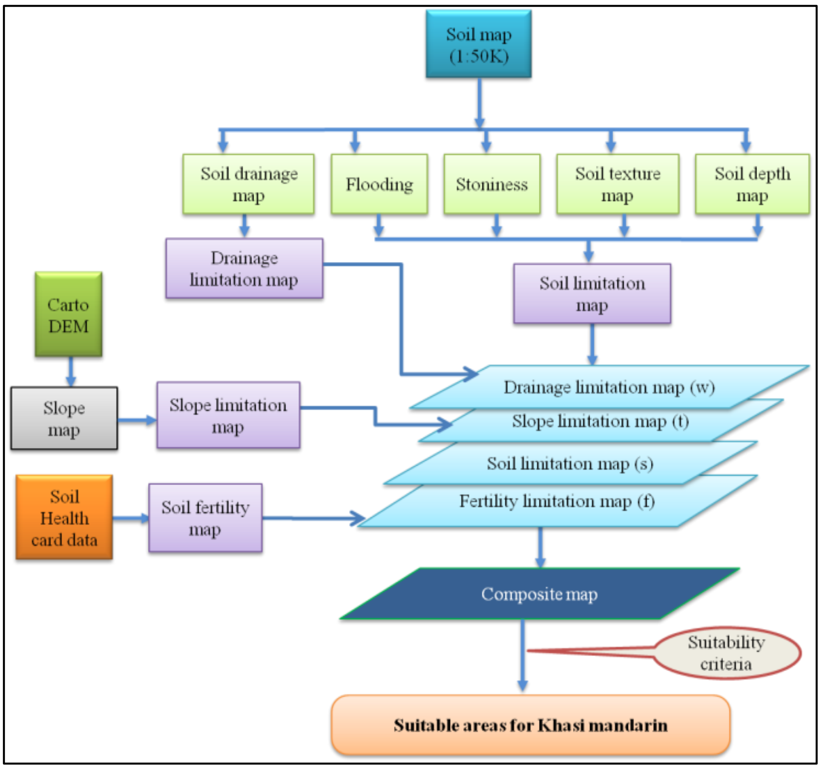

Fig. 3: Flow chart of the methodology

Identification of areas suitable for expansion of Khasi mandarin:

Evaluation of land is the prerequisite for identifying suitable areas for Khasi mandarin (Sys, 1985; Sys *et al.*, 1991, 1993). Suitable areas for Khasi mandarin were identified based on the evaluation of soil site suitability following the FAO guidelines (1976, 1983, 1985, 1990, and 2007). It provides information about different opportunities and constraints for use of the land and therefore, helps to decide on optimal utilizations of resources, which is an essential prerequisite knowledge for land use planning and development. Moreover, during soil site suitability analysis, the main limiting factors for the growing of Khasi mandarin were identified. This enables decision-makers viz., land use planners, land users, and agricultural support services to develop a management plan so that such constraints could be overcome to increase productivity. The land is categorized into different suitability classes and sub-classes based on terrain characteristics (slope), and soil properties viz., depth, texture, drainage, flooding, stoniness, and fertility.

The existing soil map prepared at 1:50,000 scales by the North Eastern Space Applications Centre was used to generate texture, drainage, flooding, stoniness, and depth map (Fig 4). Soil fertility maps namely soil acidity (pH), zinc (Zn), and organic carbon (OC), were used for soil site suitability evaluation (Fig 5). The slope map was derived from 10m Carto- DEM generated under the SISDIP project by NESAC.

Different thematic maps related to soil and slope were overlaid in a GIS environment (Arc Map 10.8) and by using the overlay function of Analysis Tools of Arc GIS software, a composite layer was prepared. The composite layer with attributes of all input layers was used to compare the requirements of Khasi mandarin with the existing land quality and values of degree of limitation ranging from 0 (suggesting no limitation) to 4 (suggesting very severe limitation) were assigned (Sys *et al.*, 1993). Suitability classes of land were assigned according to the 'number and the intensity of limitations' method and classified as Highly Suitable (S1), Moderately Suitable (S2), Marginally Suitable (S3), and Not Suitable (N). Suitability sub-classes were assigned based on major limitations or main kinds of improvement measures required for Khasi mandarin plantations (FAO guidelines, 2007). The detailed methodology is illustrated in Fig 3.

RESULTS AND DISCUSSION

Soil fertility mapping:

Nine fertility maps namely pH, EC, OC (Physical parameters) and P, K (Macro-nutrients), and Zn, Fe, Cu, and Mn (Micronutrients) were generated for the study area. From the study (Fig 5), it is found that the soils of the entire study area are non-saline and rich in organic carbon. Soils of 57.03% area are slightly acidic followed by moderately acidic soils that cover 42.63% area. Strongly acidic soils are also observed in 0.34% area. The availability of phosphorus and potassium in soils of the study area varies from low to high. Medium available phosphorus is found in soils of 48.52% area followed by high and low phosphorus content which covers 37.76% and 13.72% area respectively. The availability of potassium is medium in soils of 50.48% area followed by low and high potassium covering 33.03% and 16.48% area.

The study has also revealed soils of the study area are having sufficient micronutrients. The availability of Zinc (Zn) is high in soils of 94.05% area followed by medium and low zinc content covering 5.55% and 0.40% (64.55 ha) area respectively. (Fig 6)

Identification of areas suitable for expansion of Khasi mandarin

Suitable areas for Khasi mandarin were identified based on the evaluation of soil site suitability following the FAO guidelines (1976, 1983, 1985, 1990, and 2007). The suitable areas for Khasi mandarin were identified within 16246.34 ha area that includes land use classes namely open tree-clad, bamboo, grasslands, cultivable wastelands, and other non-agriculture land covers.

From the study, it is found that 10,457 ha area covering 64.37% of the total study area is suitable for the expansion of Khasi mandarin (Fig 7). Because of steep to very steep slopes, very shallow soil depth, strongly acidic soils, and low available soil nutrients, 35.63% area is found to be not suitable for the expansion of the Khasi mandarin plantation in the Pynursla block.

The soil site suitability analysis revealed that the study area is moderately and marginally suitable for the expansion of khasi mandarin. The study area is not highly suitable for khasi mandarin because of sloppy terrain and acidic soils. It is observed that 64.88% (i.e. 6784.45 ha) area is marginally suitable and 3672.83 ha (35.12%) area is moderately suitable (Table 1). The maximum area is marginally suitable because of the severe limitation of slope and moderate limitation of soil drainage and soil fertility. Based on constraints of slope (t), drainage (w), soil (s) and soil fertility (f); the moderately and marginally suitable areas were classified into 31 and 26 sub classes respectively (Table 2a and 2b).

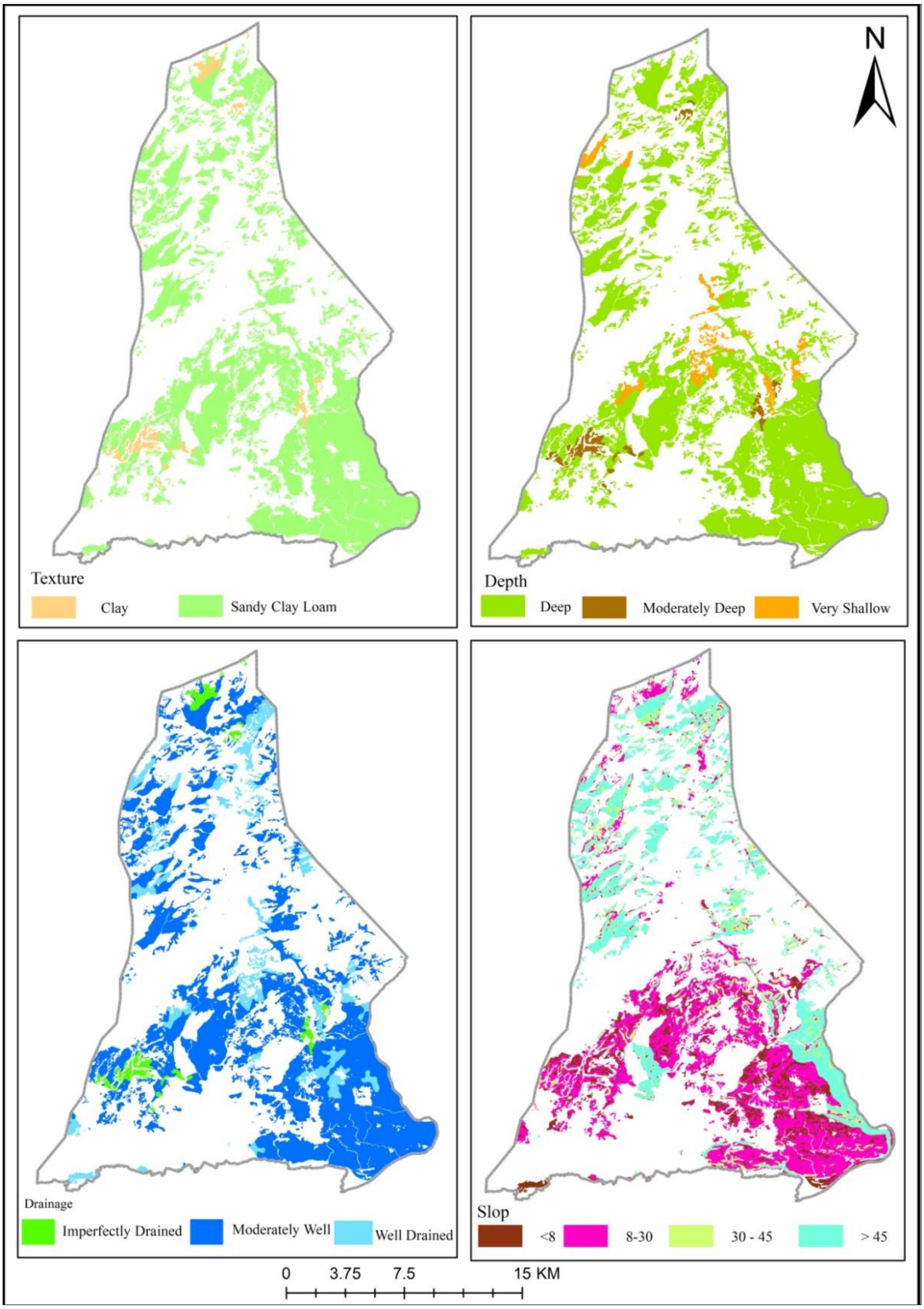

Fig. 4: Different thematic maps of the study area

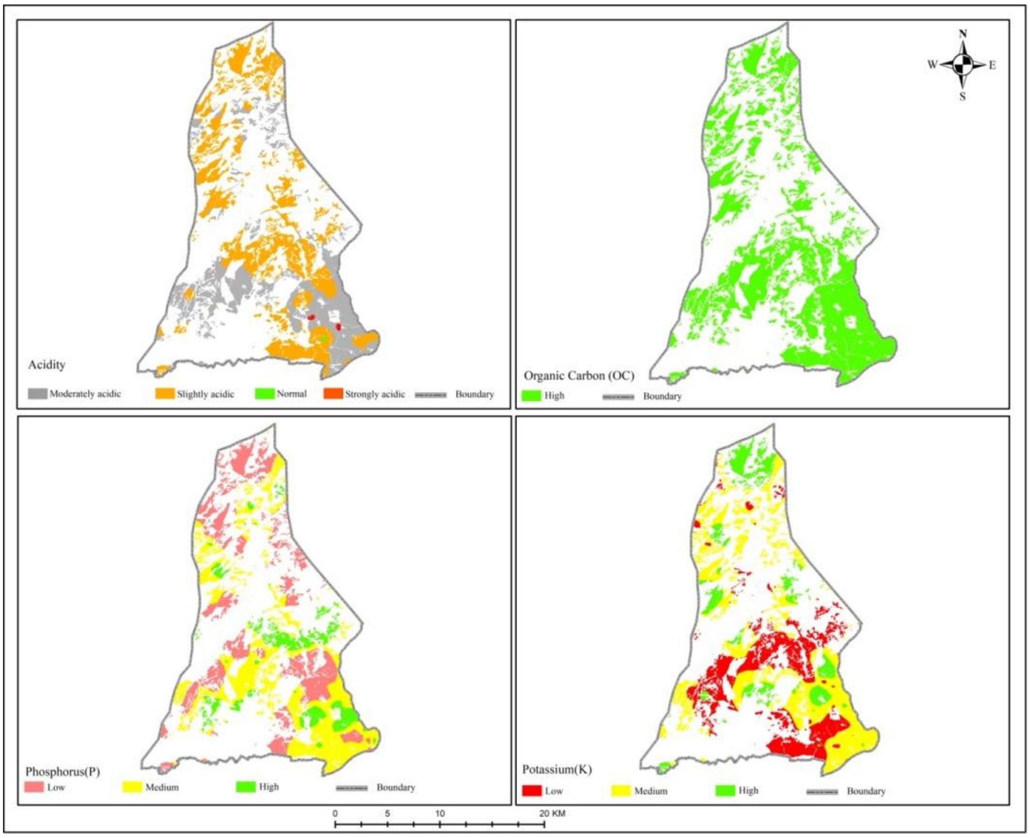

Fig. 5: Soil pH, OC, P and K map of the study area

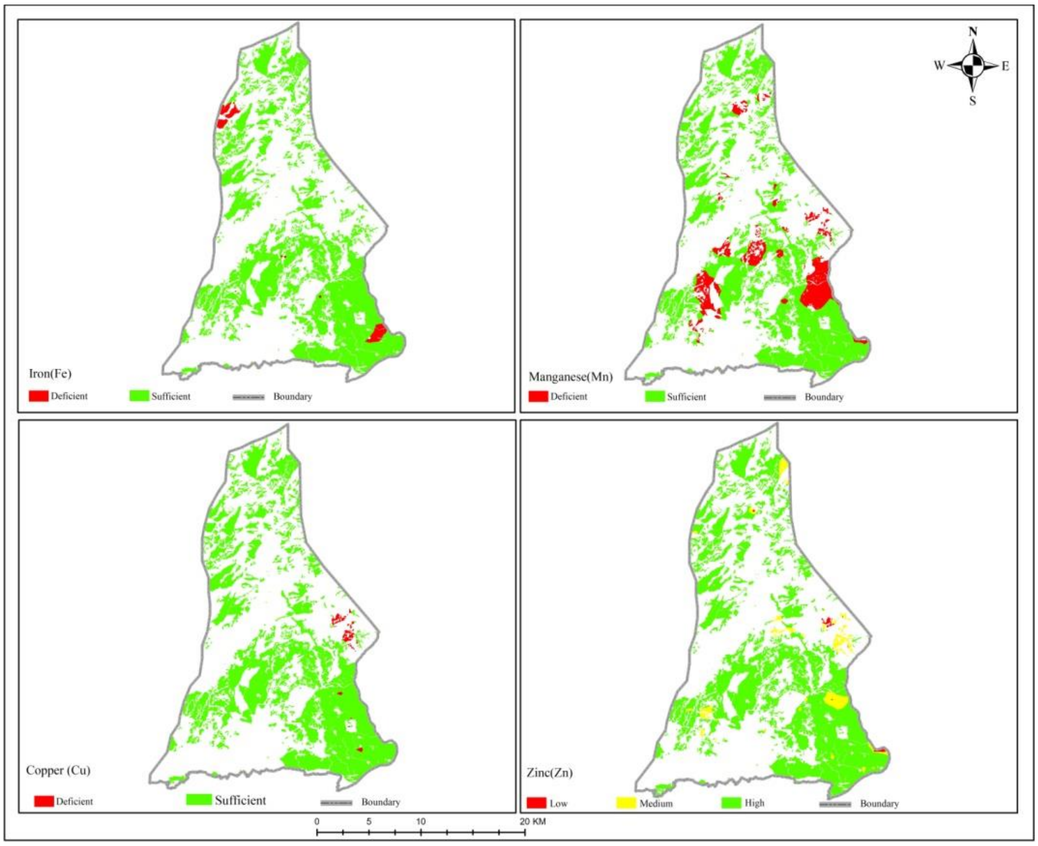

Fig. 6: Soil Fe, Mn, Cu and Zn map of the study area

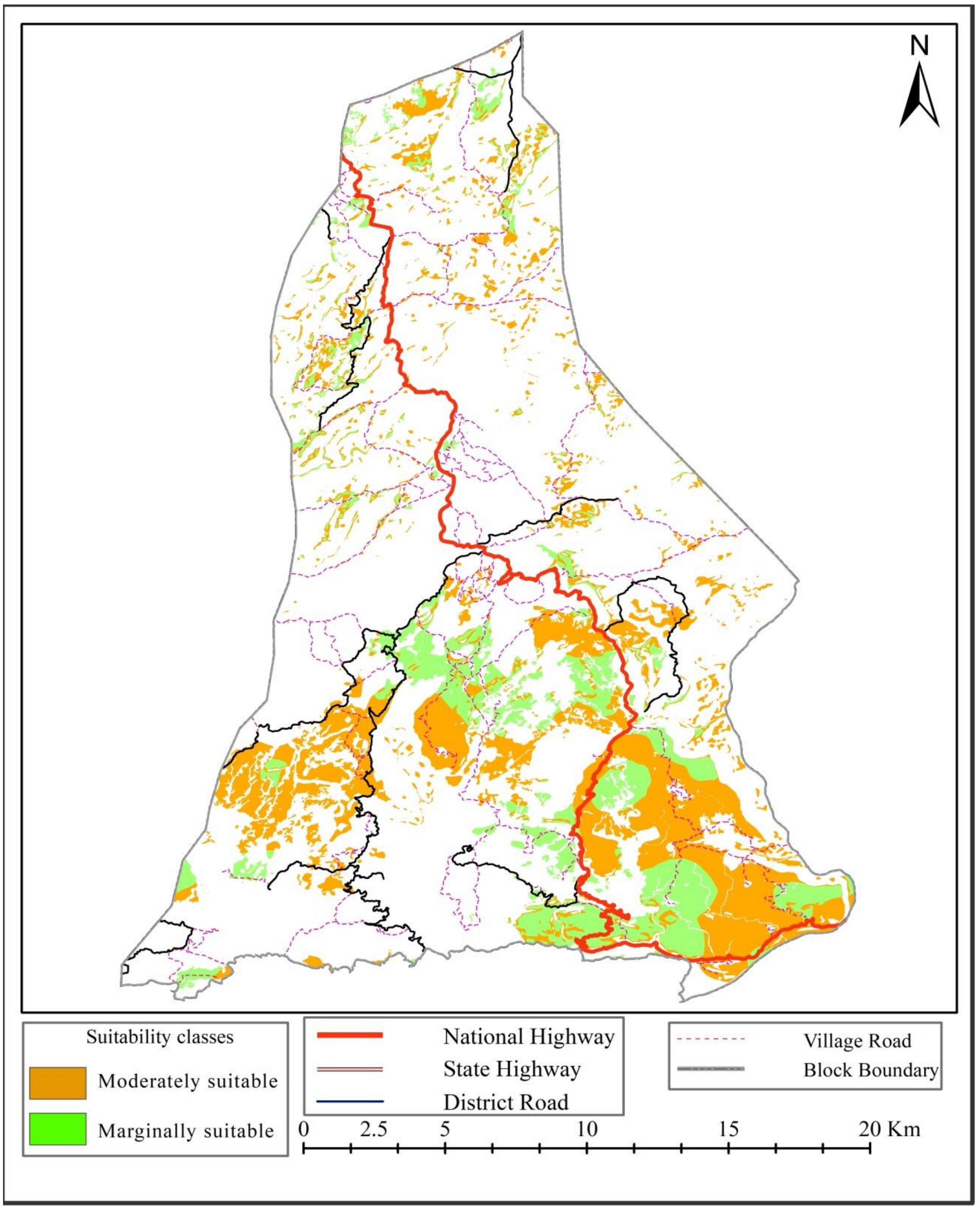

Fig. 7: Areas suitable for expansion of Khasi Mandarin

Table 1: Area under different Suitability class

Suitability Class	**Area (ha)**	**% area**
Moderately Suitable (S2)	3672.83	35.12
Marginally Suitable (S3)	6784.45	64.88

Table 2a: Area under Moderately Suitable (S2) subclasses of Khasi mandarin

Suitability Class	**Suitability Subclass**	**Area (ha)**	**Limitation/improvement**
S2	S2wf	20.36	Drainage and fertility(pH)
	S2wf	1.43	Drainage and fertility (pH, P)
	S2wf	107.11	Drainage and fertility (pH, P, K)
	S2wf	4.59	Drainage and fertility (pH, P, K, Zn)
	S2wf	90.26	Drainage and fertility (pH, K)
	S2wf	7.08	Drainage and fertility (pH, K, Zn)
	S2wf	0.57	Drainage and fertility (pH, Zn)
	S2f	57.64	Fertility (pH)
	S2f	0.02	Fertility (pH, P)
	S2f	10.53	Fertility (pH, P, K)
	S2f	25.20	Fertility (pH, K)
	S2f	1.46	Fertility (pH, K, Zn)
	S2f	0.72	Fertility (pH, Zn)
	S2f	30.62	Fertility (P)
	S2f	1844.96	Fertility (K)
	S2twf	263.31	Slope, drainage, and fertility (pH)
	S2twf	45.51	Slope, drainage, and fertility (pH, P)
	S2twf	474.69	Slope, drainage, and fertility (pH, P, K)
	S2twf	48.48	Slope, drainage, and fertility (pH, P, K, Zn)
	S2twf	1.23	Slope, drainage, and fertility (pH, P, Zn)
	S2twf	414.90	Slope, drainage, and fertility (pH, K)
	S2twf	8.26	Slope, drainage, and fertility (pH, K, Zn)
	S2twf	0.66	Slope, drainage, and fertility (pH, Zn)
	S2tf	38.53	Slope and fertility (pH)
	S2tf	8.47	Slope and fertility (pH, P)
	S2tf	85.80	Slope and fertility (pH, P, K)
	S2tf	11.91	Slope and fertility (pH, P, K, Zn)
	S2tf	63.27	Slope and fertility (pH, K)
	S2tf	3.41	Slope and fertility (pH, K, Zn)
	S2tf	1.84	Slope and fertility (pH, Zn)
	S2tf	0.01	Slope and fertility (K)

Table 2b: Area under Marginally suitable (S3) subclasses

Suitability Class	**Suitability Subclass**	**Area (ha)**	**Limitation/improvement**
S3	S3w	103.887	Drainage
	S3wf	102.335	Drainage and fertility (pH)
	S3wf	17.1452	Drainage and fertility (pH, P)
	S3wf	134.207	Drainage and fertility (pH, K)
	S3wf	0.3911	Drainage and fertility (P, K)
	S3wf	75.2219	Drainage and fertility (K)
	S3f	2563.61	Fertility (pH)
	S3f	386.686	Fertility (pH, P)
	S3f	321.915	Fertility (pH, P, K)
	S3f	771.462	Fertility (pH, K)
	S3f	367.644	Fertility (P, K)
	S3f	4.80863	Fertility (P, K, Zn)
	S3t	850.955	Slope
	S3tw	33.2242	Slope and drainage
	S3twf	3.4308	Slope, drainage, and fertility (pH)
	S3twf	1.20487	Slope, drainage, and fertility (K)
	S3tf	417.51	Slope and fertility (pH)
	S3tf	55.69	Slope and fertility (pH, P)
	S3tf	106.51	Slope and fertility (pH, K)
	S3tf	24.6271	Slope and fertility (P)
	S3tf	124.609	Slope and fertility (P, K)
	S3tf	0.01534	Slope and fertility (P, Zn)
	S3tf	313.755	Slope and fertility (K)
	S3tf	0.07412	Slope and fertility (K, Zn)
	S3tf	3.16972	Slope and fertility (Zn)
	S3f	0.35956	Fertility (Zn)

Conclusion

From the study, it is observed that geospatial technology is a very useful tool for soil fertility mapping from Soil Health Card data, mapping of land use land cover, and identifying suitable areas for expansion of Khasi mandarin. The soils of the study area are deep, non-saline, slightly to moderately acidic in reaction, sandy clay loam to clay in texture, rich in organic carbon, moderately well drained, and contain medium available phosphorus and potassium and high Zinc. From the soil site suitability evaluation it is found that 64.37% area is suitable for growing Khasi mandarin in the cultivable wastelands and open forest areas of Pynursla block.

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