Expansion of boro rice in Meghalaya using space technology

Pratibha T. Das, B. K. Handique and P. L. N. Raju*

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. The study showed that 635 ha area is highly suitable followed by 581.74 sq. km and 219.07 sq. km area is marginally and moderately suitable respectively. The suitable areas are distributed in 20 blocks of 8 districts. More than 50% of suitable areas are distributed in West Garo hills. The highest suitable areas are found in Selsella and Dadenggre block. The findings of this study are being used by the user department for expanding boro rice cultivation in the state.

Keywords: Boro rice, geospatial tools, Meghalaya, site suitability.

MEGHALAYA is mainly based on rural economy. About 81% of the state's population resides in rural areas and their livelihood depends on agriculture. Agricultural developmental activities of the state control employment and income generation to a great extent. Therefore, agriculture plays a predominant role in the state's economy. However, the state is yet to reach the national level both in economic and agricultural growth rate. Though 81% of the state's population depends on agriculture, the net cropped area is quite less and is only about 9.87% of the total geographical area of the state. The food grains produced are not sufficient to feed a population of 2.3 million and the state needs to buy 1.22 lakh tonnes food grains annually from other states[1]. To bridge the deficit between demand and availability to consumers, the Government of Meghalaya launched the Meghalaya State Rice Mission (MSRM) in 2013, consisting of an integrated set of programmes aimed at narrowing the gap between rice production and consumption by doubling the production of rice – a major staple food of the state[2]. One of the key components of MSRM is to increase the area under boro rice from the existing area of 13,000 hectares to 39,000 hectares. For planning the expansion of boro rice, it is essential to delineate the area suitable for boro rice production. Hence, delineation of area suitable for boro rice cultivation in different districts is essential. The Directorate of Agriculture, Government of Meghalaya therefore requested NESAC to study and identify areas suitable for expansion of boro rice in the state (Figure 1) using space technology and other related information on soil, climate, topography, etc.

The authors are in the North Eastern Space Applications Centre, Department of Space, Govt of India, Umiam 793 103, India.
*For correspondence. (e-mail: thakuriapratibha@rediffmail.com)

Areas suitable for a particular crop were identified by analysing land suitability through land evaluation process which assess the performance of a particular land when used for a specified purpose. It involves interpretation of different information on climate, soils, land forms, vegetation and other aspects of land and compares the existing land quality with the requirements of alternative land use[3]. For evaluating land suitability for different crops, satellite images were used to estimate biophysical parameters and different indices along with analysis of cropping systems and mapping of land-use/land-cover during different seasons[4,5]. However, by using remote sensing data alone, crop suitability for a particular area cannot be suggested unless the data derived from remote sensing images are integrated with site-specific climate and soil data. Various physiographic units can be delineated from remote sensing images along with derivation of ancillary information like slope and aspect of the study area. Different thematic maps prepared from remote sensing images coupled with information on soil properties and soil sites from soil maps can be integrated in the Geographical Information System (GIS) to assess suitability of various soil and biophysical conditions to a particular crop. The present study was carried out to assess soil site suitability for boro rice using geospatial technologies to expand the area under boro rice in Meghalaya.

Identification of potential areas for expansion of boro rice

Land evaluation for soil site suitability for boro rice was done according to FAO guidelines[3,6–8]. It provides information about different opportunities and constraints for use of the land and therefore helps to take a decision on optimal utilization of resources, which is an essential

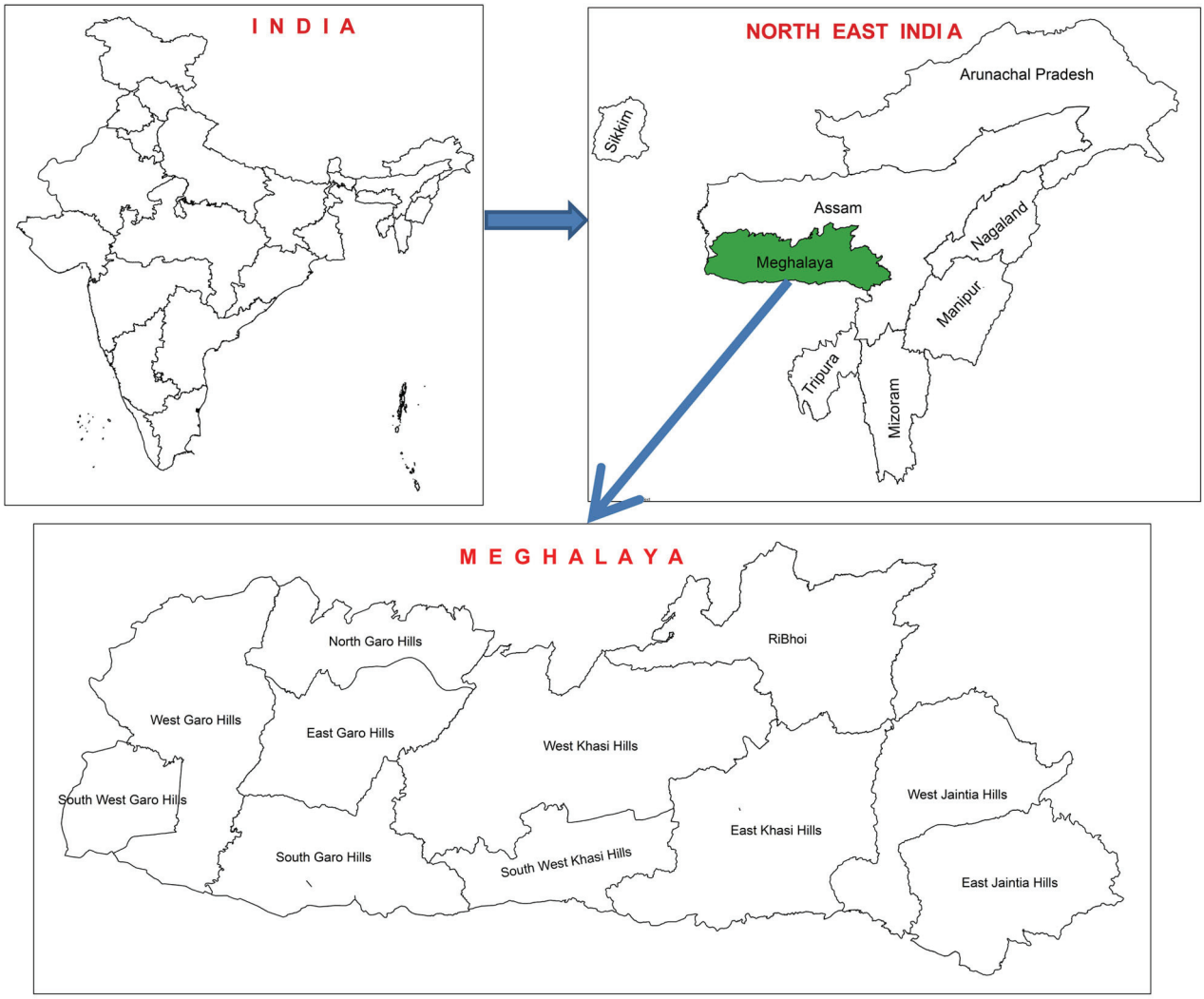

Figure 1. Location map of the study area.

Table 1. Criteria for determination of land suitability classes

Suitability classes	Criteria
Highly suitable (S1)	Land units with no or only 4 slight limitations
Moderately suitable (S2)	Land units with more than 4 slight limitations and/or no more than 3 moderate limitations
Marginally suitable (S3)	Land units with more than 3 moderate limitations and/or one or more severe limitation
Not suitable (N)	Land units with very severe limitation

Table 2. Area under different suitability classes

Suitability class	Area (sq. km)	Area (%)
Highly suitable (S1)	6.35	0.8
Moderately suitable (S2)	219.07	27.1
Marginally suitable (S3)	581.74	72.1
Total	807	100.0

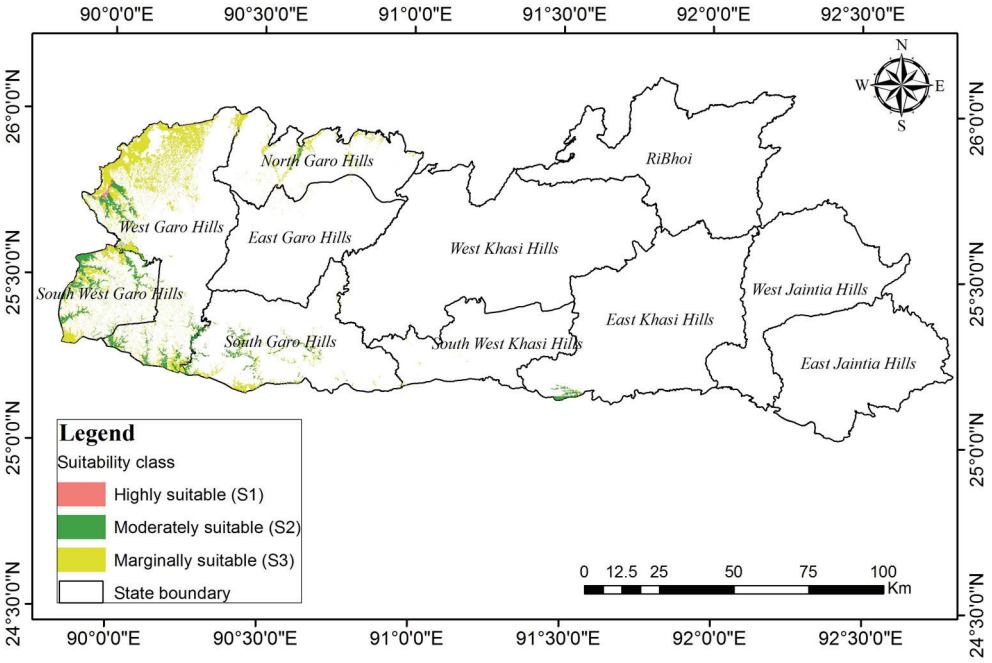

Figure 2. Suitable areas for expansion of boro rice cultivation in Meghalaya.

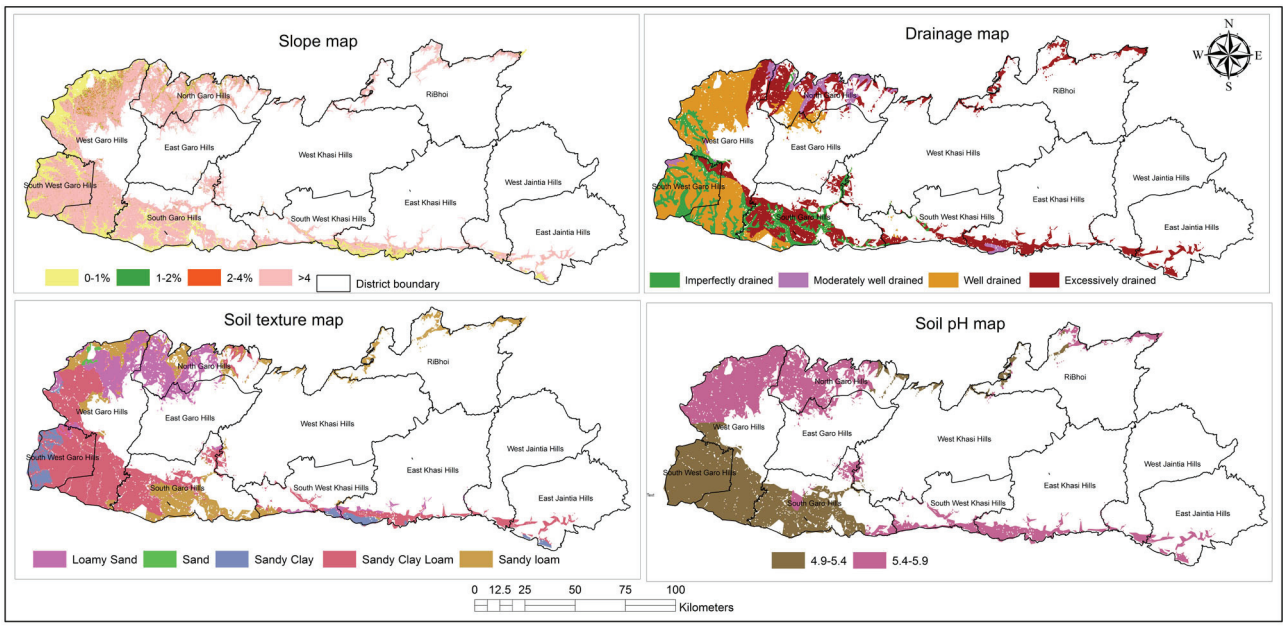

Figure 3. Different thematic maps of the study area.

prerequisite for land-use planning and development. Moreover, during soil site suitability analysis, the main limiting factors for agricultural production are identified. This enables decision makers, viz. land-use planners, land users and agricultural support services to develop a crop management plan so that such constraints can be overcome and productivity can be increased. Lands are categorized into different suitability classes and sub-classes based on the terrain characteristics, soil properties like depth, texture, drainage, soil pH, etc. and by analysing existing land use[9].

The existing soil map prepared by National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) at 1 : 250,000 scale was updated to 1 : 50,000 scale by studying additional soil profiles based on physiography base map prepared from Resourcesat-2 LISS III images

Table 3. District wise suitable areas for expansion of boro rice (in ha)

District	Highly suitable (S1)	Moderately suitable (S2)	Marginally suitable (S3)	Total	Area (%)
West Khasi hills	–	0.5	70.9	71.4	0.1
South West Khasi hills	–	11.1	126.6	137.7	0.2
East Garo hills	–	–	150.5	150.5	0.2
East Khasi hills	–	1,189.9	97.4	1,287.3	1.6
North Garo hills	–	664.2	4,514	5,178.1	6.4
South Garo hills	–	3,720.6	4,390.3	8,110.9	10
South West Garo hills	–	7,805.2	9,547.2	17,352.4	21.5
West Garo hills	635.2	8,516	39,277.1	48,428.3	60
Total	635.2	21,907.4	58,174.2	80,716.7	100.0

of 2016–17. Different thematic maps like soil drainage, soil texture, soil depth, flooding and gravel/stoniness were derived from the updated soil map. Land-use map of 1 : 50 K scale prepared by NESAC was used to extract the study area which includes all land use classes except forest, built up and barren rocky area. Cartosat DEM generated at NESAC was used to prepare slope and elevation maps. The slope map was reclassified into four classes, viz. 0–1%, 1–2%, 2–4% and >4% and considered as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N) respectively. The elevation map was reclassified into four classes, viz. 0–60 m, 60–120 m, 120–200 m and >200 m and considered as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N) respectively. The range of slope percentage and elevation for suitability of boro rice cultivation was decided in consultation with officials from Research Office, Directorate of Agriculture, Government of Meghalaya, Shillong. Composite surface soil samples were collected from 121 locations representing various physiography, slope and land use. Soil samples were analysed for available N, P, K, organic carbon, pH and other micronutrients. Various fertility maps were generated by using interpolation tool of ArcToolbox (ArcGIS software). All thematic maps were overlaid in GIS environment (ArcMap) and by using overlay function of analysis tools of ArcGIS software, a composite layer was prepared. The composite layer with attributes of all input layers was used to compare the requirements of boro rice 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[10]. Suitability classes of land were assigned according to the number and intensity of limitations and classified as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N) (see Table 1).

Results and discussion

From the study it was observed that out of 4903 sq. km study area only 807 sq. km (16.5%) is suitable for boro rice cultivation in the state. Though 16.5% area is suitable for boro rice, only 0.8% (635 ha) area is highly suitable, which is found in West Garo hills district. It was observed that 581.74 sq. km area is marginally suitable whereas 219.07 sq. km area is moderately suitable (Table 2 and Figure 2).

It was observed that suitable areas are distributed in 20 blocks of 8 districts of the state. More than 50% of suitable areas are found in West Garo hills that cover 484.3 sq. km, whereas only 0.7 sq. km area which is the lowest area is found in West Khasi hills district (Table 3). It was also observed that highly suitable areas are found in Selsella and Dadenggre block of West Garo Hills district followed by Betasing block of South West Garo hills. The lowest area is found in Nongstoin block of West Khasi hills district (Table 4).

Based on problems of soil and topography which cause various degrees of limitations for growing of boro rice, suitability classes were divided into 20 sub-classes (Table 5). It was observed that slope, soil texture, soil fertility (acidity) and soil drainage are the major limiting factors/problems, because of which maximum areas are found marginally and moderately suitable for boro rice expansion (Figure 3). Based on problems/limitations of the land, land users and planners can decide on crop management strategies to increase crop productivity.

Soil samples were collected from 121 locations and analysed in the soil testing laboratory of the research office, Shillong. It was observed that the soil textures of the study area vary from sandy loam, loamy sand, sand, sandy clay and sandy clay loam. Various studies showed that for paddy cultivation, light texture soils like sandy soils are not suitable whereas heavy texture soils like clay and sandy clay soils are suitable. It was observed that 0.5% of area has sandy soil which poses severe limitations; therefore, these areas are not suitable for boro rice cultivation. The soils with sandy loam and loamy sand textures cover 43.4% of area which is marginally suitable for boro rice cultivation. Sandy clay loam soils that cover 50.1% of area are moderately suitable for boro rice cultivation. It was observed that only 6% of area of the study area have a sandy clay soil texture which is highly

Table 4. Block-wise area under different suitability sub-classes

Blocks	S1	S2f	S2s	S2sf	S2sw	S2swf	S2tf	S2ts	S2tsf	S2tsw	S2tw	S2twf
Nongstoin												
Mawshynrut									0.5			
Rongjeng												
Songsak												
Rongram				20.5					6.7	0.2		0.0
Ranikor				7.9					3.2			
Rongara				149.9					0.7			
Kharkutta					29.3	8.2				15.6		1.9
Mawsynram					48.7	107.2				5.7	13.4	1.1
Gambegre				542.3					18.6			
Baghmara				558.4					34.1			
Chokpot			3.9	1176					29.1			
Resubelpara					441	132.8				35.3		
Gasuapara				1741.9					26.6			
Dalu				3438.5					11.5			
Zikzak		465.2		2253.7			15.3		34.6			
Tikrikilla												
Betasing		259.7		3373.9		514.8	8.2		10.5	0		35.4
Dadenggre												
Selsella	635.2	11.2	3768.7	661.9		8.1		6.6	20.9	0		0.3
Total	635.2	736.2	3772.7	13924.8	519.1	771.1	23.5	6.6	196.9	56.8	13.4	38.8

Blocks	S2w	S2wf	S3s	S3sw	S3t	S3ts	S3tsw	S3tw	S3w	Total	Area (%)
Nongstoin					14.6					14.6	0.0
Mawshynrut			0.2		49.2	7				56.8	0.1
Rongjeng			9.9			16	31.5			57.4	0.1
Songsak			0.7	11.5		0.3	80.7			93.1	0.1
Rongram			0.0		44.0	30.0	0.0			101.3	0.1
Ranikor			46.8	0	53.1	0.6	0.7	25.5		137.7	0.2
Rongara			342.4			15.2				508.1	0.6
Kharkutta			539.7		133.1	369.8	0.8			1098.5	1.4
Mawsynram	487.9	525.8	96.6		0.8					1287.3	1.6
Gambegre					126.6			459.8	326.1	1473.4	1.8
Baghmara			721.9		148.2	31.4				1494	1.9
Chokpot			368.6		55.8	14.6				1648	2.0
Resubelpara			1870.3	250	120.7	853.4	376.2			4079.6	5.1
Gasuapara			849.7	1023.8	38.4	14.5	8.7	48.2	709	4460.8	5.5
Dalu			763.6	81.2	261.7	9.9	1.8	485.1	2064.9	7118.2	8.8
Zikzak			0.5		619.3			810.4	3239.6	7438.6	9.2
Tikrikilla			790.2	5652.7		181.9	1320.1			7945	9.8
Betasing		833.8	600.7	699.8	375.4	5.3	12	437.2	2746.9	9913.8	12.3
Dadenggre				3359.8			3654.7	2082.7	1829.2	10926.3	13.5
Selsella			2165.6	7079.2	233.1	5.4	132.9	991.3	5143.6	20864	25.8
Total	487.9	1359.6	9167.4	18157.9	2274.1	1555.2	5620.1	5340.2	16059.3	80716.7	100.0

Table 5. Different suitability sub-classes and limitations/problems of the soil site

Suitability class	Suitability sub-class	Area (ha)	Area (%)	Limitation/problems
S1	S1	635.2	0.8	No limitation
S2	S2f	736.5	0.9	Soil fertility
	S2s	3,772.7	4.7	Soil texture
	S2sf	13,933.9	17.2	Soil texture and soil fertility
	S2sw	520.2	0.6	Soil texture and soil drainage
	S2swf	771.3	1.0	Soil texture, soil drainage and soil fertility
	S2tf	23.5	0.0	Slope and soil fertility
	S2ts	6.6	0.0	Slope and soil texture
	S2tsf	196.9	0.2	Slope, soil texture and soil fertility
	S2tsw	57.3	0.1	Slope, soil texture and soil drainage
	S2tw	13.5	0.0	Slope and soil drainage
	S2twf	38.8	0.0	Slope, soil drainage and soil fertility
	S2w	490.3	0.6	Soil drainage
	S2wf	1,360.0	1.7	Soil drainage and soil fertility
S3	S3s	9,211.2	11.4	Soil texture
	S3sw	18,195.3	22.5	Soil texture and soil drainage
	S3t	2,274.3	2.8	Slope
	S3ts	1,555.4	1.9	Slope and soil texture
	S3tsw	5,620.1	7.0	Slope, soil texture and soil drainage
	S3tw	5,340.7	6.6	Slope and soil drainage
	S3w	16,069.8	19.9	Soil drainage
Total		79,465	100	

suitable for boro rice cultivation (Figure 3). The soil analysis results show that soil pH of the study area varies from 4.9 to 5.9 which are moderately and highly suitable for boro rice cultivation respectively (Figure 3).

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