



Original Research Paper

A STUDY ON RICE CROP SUITABILITY IN BARPETA AND NAGAON DISTRICTS OF ASSAM THROUGH A MULTICRITERIA DECISION-MAKING APPROACH

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ABSTRACT

Land evaluation provides the crucial diagnostic framework that is the bedrock of contemporary sustainable rice farming practices. Through combining geospatial modeling that takes into account factors like edaphology, soil physical properties, topography, hydrology, and climatic risk, suitability testing helps identify the environment parameters that will ensure closing of yield gaps, maximizing fertilizer and water use efficiency, and protecting ecologically sensitive regions from unsustainable agriculture conversion. This paper focuses on the complex process of land evaluation and rice suitability testing, exploring the nexus between geospatial analysis, edaphic assessment, and remote sensing. In this analysis, the agricultural lands have been classified into Highly Suitable (S1), Moderately Suitable (S2), Marginally Suitable (S3), and Not Suitable (N). The findings reveal that Barpeta is mostly made up of areas which are moderately suitable (63%) and marginally suitable (32%), while there is only around 1% of area considered highly suitable in Barpeta. On the other hand, Nagaon has far more agricultural potential in which 50% areas are moderately suitable and over 15% are highly suitable. Marginal and unsuitable lands make up the rest of the areas in these districts. It is clear from the above analysis that both the regions have high agriculture potentials, which can further be converted to highly suitable lands.

Keywords: *Rice Crop Suitability, Analytic Hierarchy Process, Land Evaluation, Geospatial Analysis.*

INTRODUCTION

Rice (*Oryza sativa* L.), which continues to provide the bedrock of global food security [1, 2], is the staple diet for more than 3.5 billion people worldwide. Considering the global estimates predicting a rise in the world population nearing 10 billion by mid-century, there is a need to raise rice production by at least 25% on limited land bases [3]. Such an effort will be complicated by growing industrialization, urban sprawl, poor land conditions, and the impacts of global climate change [4]. For many years, efforts to increase the productivity of rice farming have been through agricultural extensification and intensification of production through heavy use of inputs as was the case during the Green Revolution [3]. These conventional methods have been responsible for some of the negative effects on the environment such as groundwater depletion, soil salinization, emission of greenhouse gases, and overall ecological fatigue. The current approach in agronomy needs to move away from uncoupled input intensification to precision land management and sustainable intensification. The realization of efficient production in light of the current situation requires scientific assessment of natural resource endowments before planting. The concept of land evaluation and suitability

tests has become very important in the systematic assessment of the physical, chemical, and climatic potentials of land for allocation of suitable areas for rice cultivation [5, 6, 7]. Sustainable land-use planning should account for the ecological consequences of agricultural intensification, including pesticide contamination and associated impacts on agroecosystems [39].

The evaluation of land is considered the method by which the potentiality of the land for alternate types of use is assessed through the analysis of its physical, chemical, biological, and socio-economic characteristics [3]. In applying this methodology to the testing of rice suitability, such approach systematically examines the ecological and physiological needs of the crop in question in comparison to the different characteristics of the landscape in question. The methodology was developed by the Food and Agriculture Organization (FAO), creating the orders, classes, and subclasses by which one can identify whether the specific piece of land is Highly Suitable (S1), Moderately Suitable (S2), Marginally Suitable (S3), or Not Suitable (N) for the specific type of cropping [8, 9, 10]. The significance of this test cannot be understated because the improper allocation of agricultural lands contributes significantly

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to yield gap creation, increases variable operational expenses, facilitates topsoil erosion, and increases the likelihood of total crop failure [11]. On the contrary, such testing is important in providing spatial intelligence to guide proper allocation of resources [12].

The need for land evaluation in rice production lies in the fact that the crop has its own distinctive bio-physical attributes which need to be met. Unlike upland cereals, rice production in wetlands and lowlands requires certain unique edaphic, hydrological and topographic conditions. First of all, regarding edaphic conditions, the physical structure of the soil determines its capacity to retain water, nutrients and roots. For successful growth, rice thrives in soils with fine or moderately fine textures like clay, silt clay, clay loam which have low hydraulic conductivity and high bulk density to prevent excessive downward movement of standing water [12, 13]. Sandy soils, on the other hand, tend to have high infiltration rates causing fast water losses, mobile anion leaching and moisture deficiency. From the point of view of chemical attributes, the plant needs a balanced soil profile with sufficient organic carbon content, good cation exchange capacity and neutral soil reaction (between pH 5.5–7.0). Severe changes in soil chemistry may cause toxic effects (like aluminum/iron toxicity in hyper acidic soils) or create micro-nutrient lockouts (like zinc deficiency in calcareous or saline systems). Comprehensive land evaluation maps the spatial variability of macronutrients (nitrogen, phosphorus and potassium) and trace elements in the soils [14, 15, 38].

METHODOLOGY AND STUDY AREA

The classical, static soil survey methodologies of the previous century have been replaced with more sophisticated computing technologies that utilize Geographic Information Systems (GIS), Remote Sensing

(RS), and Multi-Criteria Decision Analysis (MCDA). Of these, the Analytic Hierarchy Process (AHP) and the variations on this theme (Fuzzy AHP) are used as standard methodologies for synthesizing ecological parameters into suitable suitability indices [9, 15]. Through the development of criteria hierarchies, and weight assignments using rigorous mathematical procedures, AHP ensures that subjective biases are minimized when assessing the complex problems of land use suitability [16, 17]. Most recently, the availability of supervised GIS algorithms such as random forests, support vector machines, and artificial neural networks have raised the bar even higher through the identification of non-linear relations between different variables on a regional level that is beyond the scale of agricultural policies and field-level farm management [11].

Barpeta is an administrative district that falls within the Brahmaputra valley of the western part of Assam, bounded by Bhutan in the north. The district lies geographically within the active alluvial flood plains formed by the Brahmaputra River and the northern tributaries such as the Manas, Beki, and Puhumara rivers. Its climate is characterized by humid subtropical conditions with high monsoon rains which cause flooding of its water bodies and formation of wetlands.

Nagaon district lies in the middle part of the middle Brahmaputra valley of Assam and is situated on the south bank of the river Brahmaputra. Nagaon is known for its fertile and flat alluvial lands, broken by various rivers such as Kolong and Kopili rivers along with many oxbow lakes or beels. The region experiences a humid sub-tropical climate with high levels of rainfall throughout the year, thus making the region the most productive area in terms of agriculture in Assam.

Table 1: Data Collection Sources and Details

SI No.	Factors of LSA	Source/ Details	Year	Data type/ Resolution
1	Type of Soil	North Eastern District Resources Plan (NEDRP), NESAC (https://nedrp.gov.in/)	2023	Raster, 30m
2	Elevation	SRTM, USGS Earth Explorer (https://earthexplorer.usgs.gov/)	2023	Raster, 30m
3	Slope	SRTM, USGS Earth Explorer (https://earthexplorer.usgs.gov/)	2023	Raster, 30m
4	Precipitation	NASA POWER 10 m gridded precipitation data (https://power.larc.nasa.gov/), CRU Dataset on annual rainfall (https://crudata.uea.ac.uk/cru/data/hrg/)	2023	Raster, 10m
5	Groundwater	North Eastern District Resources Plan (NEDRP), NESAC (https://nedrp.gov.in/)	2023	Raster, 43.5m
6	Temperature	Landsat 8 OLI, May 2023 (https://earthexplorer.usgs.gov/)	July 2023	Raster, 30m
7	Irrigation	North Eastern District Resources Plan (NEDRP), NESAC (https://nedrp.gov.in/)	2023	Raster, 43.5m
8	LULC	Landsat 8 OLI, May 2023 (https://earthexplorer.usgs.gov/)	2023	Raster, 30m
9	NDVI	Landsat 8 OLI, May 2023 (https://earthexplorer.usgs.gov/)	2023	Raster, 30m

10	Flood Impact	Landsat 8 OLI, July 2023 (https://earthexplorer.usgs.gov/)	2023	Raster, 30m
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Multi-Criteria Analytical Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is developed by a mathematician Thomas L. Saaty is a methodology that helps analyze and rank multi-criteria decisions in 1970s [3]. This technique works through a hierarchical approach in which a decision problem is broken down into layers such that there is an overarching goal at the top level, criteria for evaluation in the middle level, and alternative choices at the bottom level. The basic process of AHP revolves around pairwise comparisons of criteria and options according to a scale of 1 to 9 to measure the relative importance between two options. Such

assessments create reciprocal comparison matrices, which are later normalized using column sums in order to obtain average row ratings as priority weights of the elements. In order to avoid inconsistencies in human decision-making, a consistency index (CI) and ratio (CR) is obtained, and if it is less than 10%, i.e., ($CR < 0.10$), then the assessments are consistent mathematically. Lastly, the priority weights of the alternatives are multiplied with the weights of the criterion and summed up to obtain a composite rating score for each choice [3, 18, 19, 20].

Table 2: Suitability Ratings According to the Importance [3, 18, 19, 20].

Intensity of Importance	Meaning
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2, 4, 6, 8	Intermediate Values

$$CI = \frac{\lambda_{\max} - n}{n - 1} [10]$$

$$CR = \frac{CI}{RI} [11]$$

Where, n = total number of items

$\lambda_{\max}$ = Largest Eigen Value

RI = Random Consistency Index

RI = 1.49 for this study as per the scale given in the table no.3

Table 3: Random Consistency Index According to the Matrix Value [3, 18, 19, 20].

Matrix Value (n)	1	2	3	4	5	6	7	8	9	10
Random Index (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

RESULTS AND DISCUSSION

Soil type is very critical in rice cultivation due to its control of water retention capability, anchorage of roots, and availability of nutrients. Clay and clay-loam soils are the best soils for lowland wetland rice (paddy) due to their heavy textures and small particle sizes that lead to formation of an impermeable subsoil layer following puddling. This results in minimum percolation of water below ground surface and maintenance of continuous water layer for anaerobic conditions, weed elimination, and healthy root growth [21]. Furthermore, clay and alluvial soils have high Cation Exchange Capacity (CEC) and organic content, which keeps the nutrients including nitrogen, potassium, and phosphorous from leaching and therefore ensures continuous nutrition of plants during the vegetative and grain formation periods. Soil pH values of 5.5 to 6.5 ensure maximum nutrient solubility without iron and aluminum poisoning [22].

Topographic and climatic factors form the other important component of rice suitability analyses. The topographic features include slope and elevation and affect the flow of water on the surface, the feasibility of mechanized agriculture and construction of field bunds

[23]. Lowland rice cultivation needs practically flat ground (less than 3° slopes) for achieving similar ponding depth, effective puddling and avoiding drought-stressed patches in the field [24]. Besides making land preparation and terracing expensive and increasing runoff rates, thus resulting in soil erosion, steeply sloping lands also make irrigation difficult [25, 26, 27]. Climatically, rice is very sensitive to thermal boundaries and rainfall. Suitability analyses consider features like seasonal temperature patterns, growing degree days, relative humidity and reference evaporation [28, 29]. Analyzing such features helps in ensuring that crucial stages of rice plant development like panicle formation and flower opening do not synchronize with deadly heat waves or chills that render the plant infertile. In addition to this, global warming impacts the natural hydrology of the region; incorporating multi-temporal radar data from remote sensing allows identification of flood zones for the farmers.

Groundwater acts as a consistent and buffer-proof water source that is necessary for ensuring maximum efficiency in rice cultivation, especially in dry seasons such as Boro rice production or monsoon spells that may be irregular [3, 30]. Whereas rain-fed agriculture will suffer from dry

spells, shallow to medium aquifers will ensure a continuous water supply when the plant goes through crucial developmental phases such as tillering, panicle initiation, and flowering where any water shortage will significantly affect grain production. The use of tube and bore wells will help the farmers retain the important 2–5 cm water layer that is necessary to inhibit weed growth, control soil temperatures, and facilitate nutrient dissolution through anaerobic conditions (nitrogen and phosphorus) [3].

The selection of irrigation technique ultimately determines the water use efficiency, root development and potential yield for rice crops [27]. Whereas conventional flood irrigation technique helps control weed growth and enhance nutrient movement, modern irrigation methods such as alternate wetting and drying (AWD) and surface irrigation through canals ensure proper plant physiology. AWD irrigation technique involves deliberate introduction of non-flooded periods which help enhance soil aeration, encourage deep rooting and avoid sulfide build-up without affecting the water consumption rate that may reduce up to 30 percent and does not affect grain yield in any way [25]. Modern techniques used in upland rice or non-puddled rice involve drip irrigation and micro-sprinkler irrigation that help in application of water along with dissolved fertilizers (fertigation) to root zones.

LULC analysis plays an important role in enhancing the productivity of rice through optimization of suitable agricultural parcels and avoiding conflicting land uses

[31]. Through mapping land cover in the region, LULC identifies the active agricultural land, low-lying flood plains, and wetlands separate from the urban land use, abandoned lands, and the sloping land areas. The intelligence derived from LULC analysis ensures that paddy fields are located in low-lying basin areas with drainage characteristics and near water bodies instead of dry areas or soil erosion areas. In addition, the temporal LULC analysis maps the process of crop rotation, fallow cycle, and change in cropping intensity like the practice of growing double-crop of Sali and Boro rice. Through the identification of buffer zones around river channels and forest margins, LULC analysis protects agricultural high-productive land from urbanization and industrial fragmentation [32].

NDVI is an important technology which helps improve rice production by helping monitor the condition of the crops through real-time and non-destructive methods. NDVI uses multispectral reflectance of satellite or drone in which it measures the ratio of near-infrared and red light. NDVI follows the process of the crops from vegetative tillering to heading and grain maturity. High NDVI readings mean that there is plenty of chlorophyll in the plants, but low NDVI means there are stress factors for the plants, such as nitrogen deficiency, lack of water, weed presence, or pest infestation even before it could be visually detected. It can help in site-specific precision agriculture by performing top-dressing fertilization with variable rate application as well as specific pest management [33, 34].

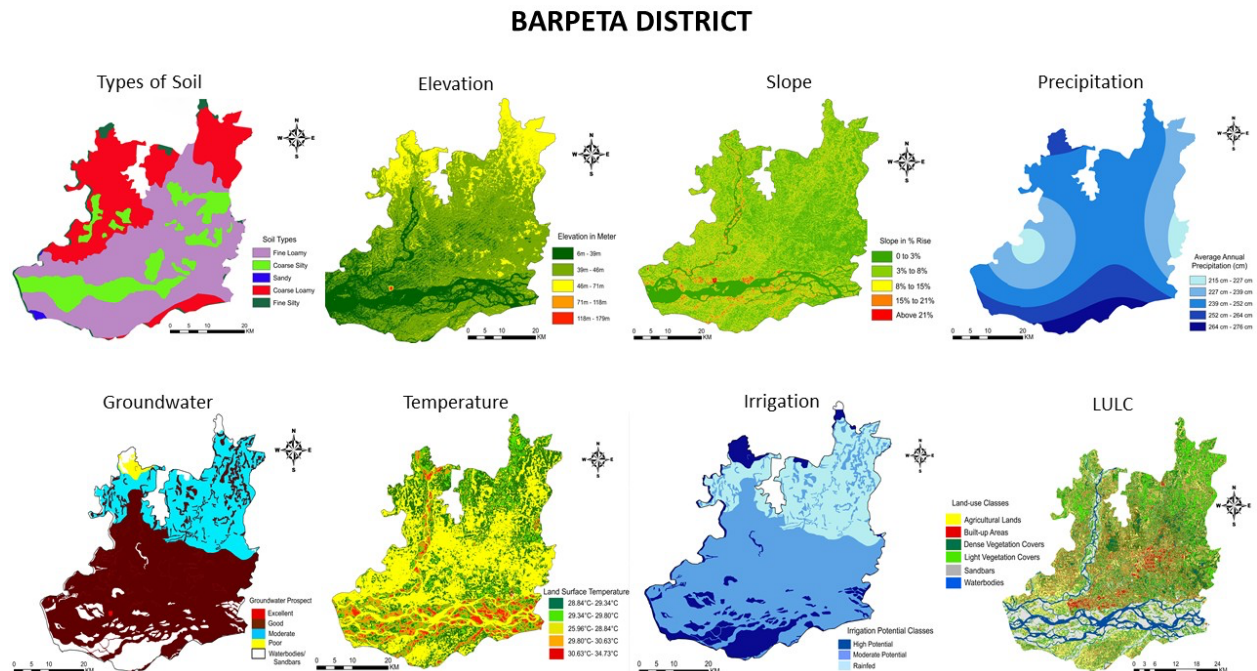
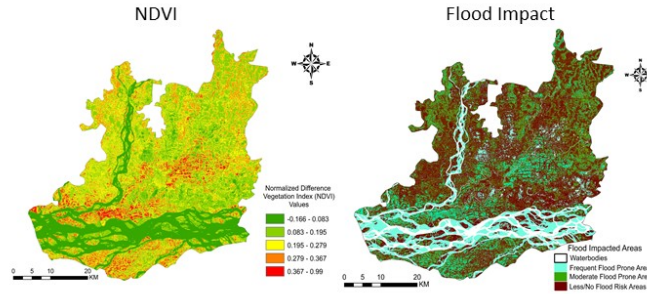
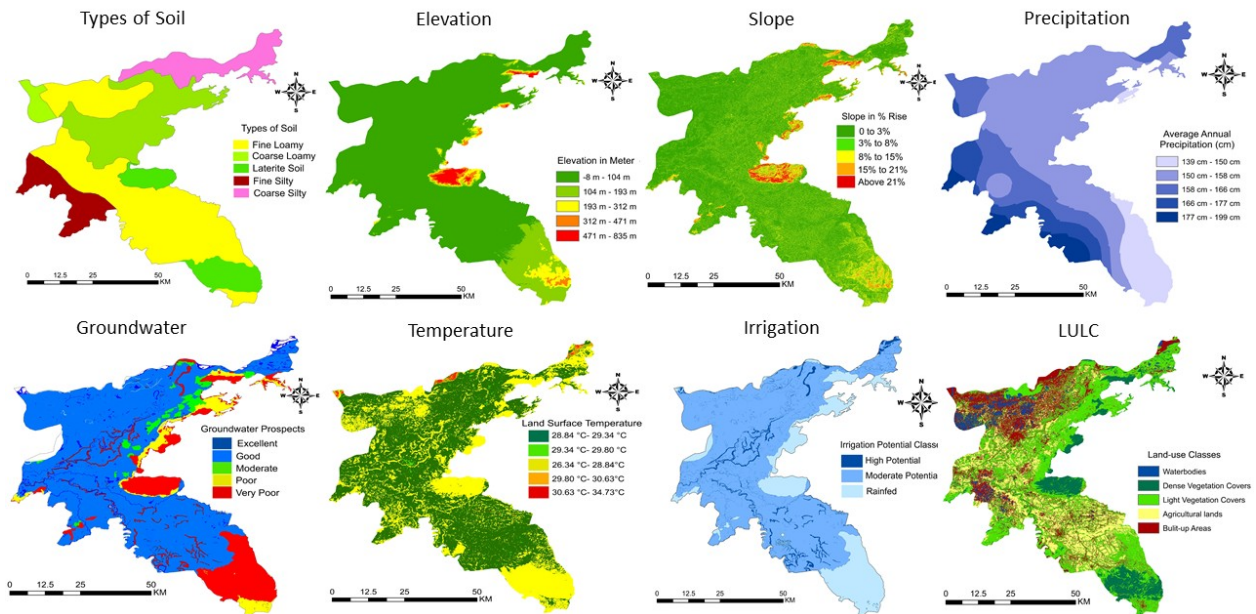
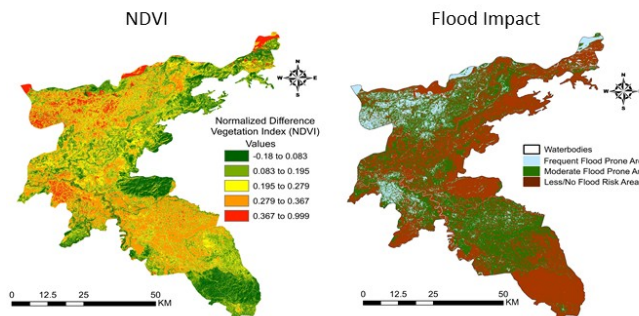


Figure 1: Rice crop conditioning factors of Barpeta District of Assam.

BARPETA DISTRICT**Figure 2:** Rice crop conditioning factors of Barpeta District of Assam.**NAGAON DISTRICT****Figure 3:** Rice crop conditioning factors of Nagaon District of Assam.**NAGAON DISTRICT****Figure 4:** Rice crop conditioning factors of Nagaon District of Assam.

Seasonal controlled flooding increases rice crop suitability and the productivity of the soil through alluvial silt formation over floodplains. The natural process of sediment deposition increases the fertility of the topsoil through nutrient-rich deposits of alluvium. Seasonal flooding ensures the enrichment of the topsoil

with essential macro and micro-nutrients such as phosphorus, potassium, and organic nutrients, thus decreasing the dependence on artificial fertilizer use in future crops. Seasonal flooding helps to control weeds and pests through waterlogging of weed seeds, soil insects, nematodes, and fungi spores [35, 36, 37].

Moreover, the monsoon rains help recharge the aquifer of the soil and increase its moisture content to ensure proper moisture availability in the high-productive dry season (Boro) crop. Rice varieties such as deepwater or floating (Aman or Bao varieties) have the unique characteristic of elongated internode and grow well under conditions of moderate flooding.

The threat posed by such flooding is a catastrophe on the growth of rice, as it can cause total crop losses, physical destruction, and decreased land productivity. The prolonged immersions beyond the limits that can be tolerated by the usual seedlings result in cessation of photosynthesis, cellular anoxia, rapid rotting and eventual crop failure [35, 36, 37]. The high speed of floodwaters can lead to the erosion of the soil, uprooting of the crops, and extensive lodging; also, they leave sand splays that sterilize the fertile topsoil for many years. Stagnation of waters after floods causes a toxic anoxic environment that increases the concentration of iron toxins and sulfur, and development of fungus diseases, such as sheath blight and bacterial leaf blight. Additionally, the sudden flooding may delay the agricultural schedule, destroy matikor, and damage the dykes, irrigation canals, and transportation facilities.

The below mentioned table 4, AHP evaluation scheme helps to effectively prioritize physical, climatic, and hydrological parameters which determine the

productivity of wetland rice (paddy). In terms of their significance at the macro level, the following indicators rank first: edaphic (soil type 13.8%) and climatic (precipitation 12.6%, NDVI 12.2%, temperature 11.0%) parameters. Such an order of importance of the criteria is a true reflection of biological reality. It should be noted that rice cultivation requires warm and fertile moist alluvial soils like Aeric Fluvaquents (Rating 5) for root fixation and maintenance of the anaerobic puddled state; also, an optimum range of temperature 28.84°C-29.34°C.

The suitable rainfall (185 cm to 192 cm/year) to guarantee photosynthesis activity and fertility of the grains without causing any diseases or cold temperature spikelet sterility. From the geographical and hydrological perspective, the model shows extreme preference for relatively flat and low-lying alluvial basins with assured water supply. The areas which have low elevation (49–96m), nearly flat slopes (<1 to 3%), high irrigation suitability along with shallow water tables (<0.86 m) are awarded the highest suitability rating (Rating 5) as these regions have natural conditions to maintain the necessary standing water layer without any costs of pumping or water loss through runoff erosion. Also, awarding the highest rating to the regions that are under cultivation or are affected by floods suggests that the model was designed for floodplain agro-ecosystems rich in nutrients due to regular flooding for Boro and Sali Rice.

Table 4: Weighting of Parameters

Sl. No	Factors	Unit	Class	Suitability Class Rating	Weight (%)
1	Type of Soil	Type	Aeric Fluvaquents	5	13.8
			Typic Dystrochrepts	4	
			Aquic Udifluvents	3	
			Aeric Haplaquents	2	
			Typic Paleudalfs	1	
2	Elevation	Meter	49-96	5	9.7
			96-110	4	
			110-134	3	
			134-190	2	
			190-330	1	
3	Slope	Percentage	<1% to 3%	5	8.7
			3% to 8%	4	
			8% to 15%	3	
			15% to 21%	2	
			Above 21%	1	
4	Precipitation	cm/year	185-192	5	12.6
			192-197	4	
			197-200	3	
			200-205	2	
			205-214	1	
5	Groundwater	Meter below ground level	Below 0.86 m	5	5.3
			0.86-1.28 m	4	
			1.28-1.70 m	3	
			1.70-2.13 m	2	

			Above 2.13 m	1	
6	Temperature	Degree Kelvin	28.84°C-29.34°C	5	11
			29.34°C-29.80°C	4	
			27.32°C-28.84°C	3	
			29.80°C-30.63°C	2	
			30.63°C-32.63°C	1	
7	Irrigation	Level	High potential	5	9.7
			Moderate potential	3	
			No irrigation/ Rainfed	1	
8	LULC	Level	Agricultural lands	5	8.6
			Light vegetation covers	4	
			Dense vegetation covers	3	
			Waterbodies	2	
			Sandbars	1	12.2
9	NDVI	Level	0.193-0.273	5	
			0.083-0.193	4	
			0.279-0.367	3	
			-0.18-0.083	2	
			0.367-0.999	1	
10	Flood Impact	Level	Frequent impact	5	8.4
			Moderated impact	3	
			Less impact/ No impact	1	

Table 5: Pair-wise Comparison Matrix

Matrix	Type of Soil	Elevation	Slope	Precipitation	Groundwater	Temperature	Irrigation	LULC	NDVI	Flood Impact
Type of Soil	1	1	1	1	3	3	1	3	1	1
Elevation	1	1	1	1	2	1	1	1	1	1
Slope	1	1	1	1	1	1	0.5	1	1	1
Precipitation	1	1	1	1	3	1	2	1	1	3
Groundwater	0.33	0.5	1	0.33	1	1	0.33	0.33	0.33	1
Temperature	0.33	1	1	1	1	1	3	3	0.33	1
Irrigation	1	1	2	0.5	3	0.33	1	1	1	1
LULC	0.33	1	1	1	3	0.33	1	1	1	1
NDVI	1	1	1	1	3	3	1	1	1	1
Flood Impact	1	1	1	0.33	1	1	1	1	1	1
Sum	8	9.5	11	8.17	21	12.67	11.83	13.33	8.67	12

Table 6: Normalized Pair-wise Comparison Matrix

Matrix	Type of Soil	Elevation	Slope	Precipitation	Groundwater	Temperature	Irrigation	LULC	NDVI	Flood Impact
Type of Soil	0.125	0.105	0.091	0.122	0.143	0.237	0.085	0.225	0.115	0.083
Elevation	0.125	0.105	0.091	0.122	0.095	0.079	0.085	0.075	0.115	0.083
Slope	0.125	0.105	0.091	0.122	0.048	0.079	0.042	0.075	0.115	0.083
Precipitation	0.125	0.105	0.091	0.122	0.143	0.079	0.169	0.075	0.115	0.250
Groundwater	0.042	0.053	0.091	0.041	0.048	0.079	0.028	0.025	0.038	0.083
Temperature	0.042	0.105	0.091	0.122	0.048	0.079	0.254	0.225	0.038	0.083
Irrigation	0.125	0.105	0.18	0.061	0.143	0.026	0.085	0.075	0.115	0.083

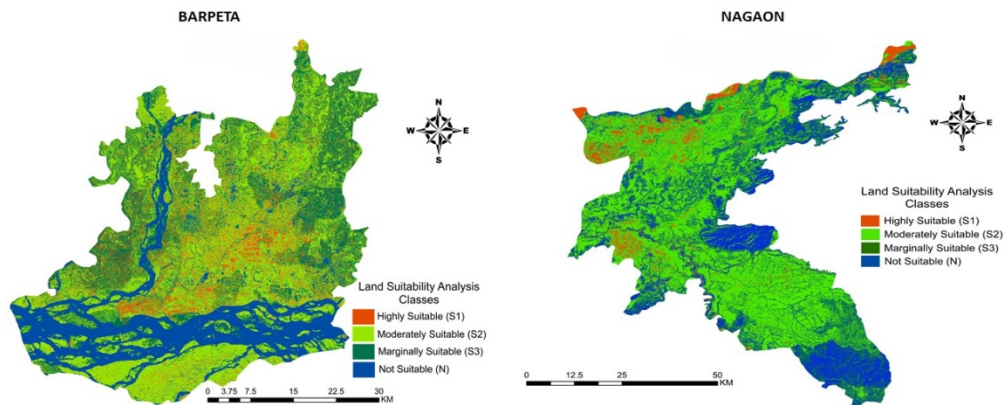
			2							
LULC	0.042	0.105	0.091	0.122	0.143	0.026	0.085	0.075	0.115	0.083
NDVI	0.125	0.105	0.091	0.122	0.143	0.237	0.085	0.075	0.115	0.083
Flood Impact	0.125	0.105	0.091	0.041	0.048	0.079	0.085	0.075	0.115	0.083

Table 7: Calculation of CR

Factors	Vp	Cp	D	E
Type of Soil	1.39	0.135	1.472	10.915
Elevation	1.07	0.104	1.052	10.119
Slope	0.933	0.091	0.951	10.511
Precipitation	1.34	0.130	1.375	10.618
Groundwater	0.539	0.052	0.568	10.877
Temperature	1	0.097	1.197	12.341
Irrigation	1	0.097	1.066	10.983
LULC	0.896	0.087	0.950	10.927
NDVI	1.25	0.121	1.299	10.744
Flood Impact	0.896	0.087	0.914	10.510
Sum	10.31			108.544
$\lambda \text{ max} = 108.544/10 = 10.85$		CI = 0.0949	CR = CI/RI = 0.0637	

These calculated values are for a mathematically valid and acceptable in Analytic Hierarchy Process (AHP) Pairwise Comparison Matrix. Since there are $n = 10$ rows and columns in the matrix, the largest eigenvalue is $\lambda \text{ max} = 108.544/10 = 10.85$, satisfying the mathematical condition of $\lambda \text{ max}$ is larger or equal than number of variables. This results in an accurate Consistency Index

value of (CI) = $(\lambda \text{ max} - n) / (n - 1) = (10.8544 - 10) / 9$ approx. 0.0949. In using the consistency index and comparing it to the random index of Saaty for a 10 X 10 matrix (RI) = 1.49, the computed Consistency Ratio (CR) = $0.0949 / 1.49$ approx. 0.0637 or 6.37%. Since this ratio is way below 10% (CR) 0.10, then the judgments are logically consistent and reliable [3, 18, 19, 20].

LAND SUITABILITY ANALYSIS (LSA)**Figure 5:** Land Suitability Analysis for Barpeta and Nagaon District of Assam.**Table 8:** Land Suitability Assessment Classes.

Sl. No.	Suitability Classes of LSA	Barpeta		Nagaon	
		Area (Km ²)	Area (%)	Area (Km ²)	Area (%)
1	S1- Highly Suitable	13	0.81	616.567	15.51
2	S2 -Moderately Suitable	1008	63.04	1998.9018	50.31
3	S3 -Marginally Suitable	516	32.27	1127.2734	28.37
4	N -Not Suitable	62	3.88	230.2578	5.75
	Total Area	1599	100	3973	100

Barpeta district, which consists of a total analyzed area of 1599 sq. km, is mostly composed of moderately suitable (S2) land occupying 1008 sq. km or 63.04% of the total geographical area. It means that the conditions for rice production in this region are favorable due to the existence of the alluvial plains. The second largest type of the land is the marginally suitable (S3) land, occupying 516 sq. km (32.27%) due to environmental constraints such as waterlogging, floods or sandy riverside lands. There is very little amount of highly suitable (S1) land (13 sq. km) which constitutes 0.81% of the total land. The least of all types is the not suitable (N) land which is constituted of 62 sq. km or 3.88% of the total geographical area.

The area covered by Nagaon district is relatively larger in terms of geographical area at 3973 sq. km, having a considerably greater amount of high-quality agricultural lands as compared to Barpeta. The main class is moderately suitable (S2) lands occupying an area of 1998.90 sq. km (50.31%) used extensively for paddy cultivation in the central plains. It is noteworthy that highly suitable (S1) lands cover an area of 616.57 sq. km (15.51%). This indicates fertile soils, right slopes, and advanced irrigation system in the district. As for the marginally suitable (S3) lands, they cover an area of 1127.27 sq. km (28.37%), usually occurring on the borders of lowlands, floodplains, and undulating areas near the border of Karbi Anglong. Finally, not suitable (N) class comprises 230.26 sq. km (5.75%) and includes such elements as rivers, oxbow lakes, and rocky areas.

CONCLUSION

The distribution of land suitability in Barpeta and Nagaon indicates that there is much scope for improvement in agriculture in the area. Though there are huge extents of moderately suitable (S2) and marginally suitable (S3) lands at present, these lands can be improved with proper efforts and intervention from the farmers. By adopting appropriate land reclamations, control measures, and advanced agricultural techniques, many of the marginally suitable lands can be converted into moderately suitable lands, and the rest of the moderately suitable lands into highly suitable (S1) lands. Marginally suitable (S3) lands can be improved by overcoming physical and hydrological limitations such as water logging, drainage, and acidic/infertile topsoil. Properly planned controlled drainage system, building of embankments, and contour bunding would solve the problem of flash flood destruction and crop submergence. Soil improvement by the means of liming, green manuring, and addition of organic silt would increase cation exchange capacity and improve water holding capacity.

In the same way, transition from moderately suitable (S2) to highly suitable (S1) category is also reliant on precise irrigation and technological innovations in agriculture. The switch from dependence on rainfall to assured micro-irrigation and shallow tube wells, as well as

Alternate Wetting and Drying (AWD) method, provides for continuous moisture supply during the most crucial tillering and flowering stages, especially for Boro paddy. Climate resilient, flood resistant (for example, Sub1 gene varieties) and drought tolerant seeds reduce yield variability. In addition, the application of variable rate fertilizers using NDVI remote sensing and site-specific nutrient management (SSNM). Thus, through combination of structural management of water with technological innovations in agricultural sector, a strategic route can be identified to counteract the inherent disadvantages of natural environment. Such an upgrading of land suitability categories will lead to optimal yield and sustainable land utilization.

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