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Land Suitability Analysis Based Management of Flood Affected Agricultural Land of Kahalgaon Subdivision of Bhagalpur District, Bihar

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ABSTRACT

Prolonged flood water poses to negative impact on the cropland. In this context, the present study was investigated to assess the site-specific flood impact on agricultural land using modern tools viz. remote sensing and geographical information systems. However, digital thematic maps of climatic conditions, topography, and soil physic-chemical properties were overlaid for the potential land suitability analysis of mustard. Hence, satellite imageries of Landsat 8, MODIS V5, and SRTM data were employed to assess the flood inundation in lowland topography. Results revealed that the lowland alluvial plains having gentle slopes were found to be 30 % flood-affected land in Kharifseason, but the same agricultural land in the Rabi season may be found to be marginally suitable (S3) for oilseeds, caused by ranged from 6.25 to 7.89 soil pH justify the slightly acidic to neutral in reaction, while the range of EC value found to be less than 1 dSm^{-1} that enable to justify safe for agricultural operation. Results also revealed that the precise decision about the best use of the land resources using land suitability analysis helped to overcome the constraints and increase the agricultural productivity in the Rabi season.

Keywords: *Agricultural land, Geographical Information System, Landsat 8, Land Suitability, Flood, and Remote Sensing.*

Introduction

The land is a vital natural asset crucial for sustaining life in all its facets. Various physical factors such as elevation, sediment, weather, vegetation, and hydrology intricately shape its potential uses [1]. Hence, land suitability analysis (LSA) involves evaluating the appropriateness of the land for specific purposes like agriculture, plantation, recreation, settlement, industry, and watershed management. It integrates social, physical, and economic factors such as slope, soil quality, relief, humidity, drainage, and rainfall [2]. Multi-criteria decision-making (MCDM) techniques alongside remote sensing and Geographic Information Systems (GIS) were used to evaluate the suitable area for diverse purposes like agriculture in the flood-affected agricultural land[3]. It was emphasized that incorporating remote sensing into a GIS database can lead to cost reduction, time savings, and enhanced acquisition of detailed information for soil surveying purposes[4].

However, the initial stage of agricultural land use planning involves conducting a land suitability assessment to determine the most appropriate type of land use for a specific location [5]. This assessment, a method of land evaluation, identifies the primary limiting factors for cultivating a particular crop [6 &7]. It encompasses both qualitative and quantitative evaluations. Qualitative assessments consider information such as climate, hydrology, topography, vegetation, and soil properties [8], while quantitative assessments provide more detailed results and estimate yields [9]. Hence, the FAO land evaluation framework and physical land evaluation methods are commonly employed for land suitability assessments [10][11].

Land suitability maps play a crucial role in aiding agricultural planners by providing essential information, ultimately contributing to the reduction of land degradation and facilitating assessments of sustainable land use. Within the framework of digital soil mapping, the MCDM model was employed to establish connections between soil observations and auxiliary variables, thereby elucidating spatial variations in soil classes and other soil properties toward land use planning [12]. Auxiliary variables necessary for these models can be sourced from digital elevation models (DEM), remotely sensed data (RS), and other geospatial data sources [13]. Soil resources were studied by using satellite data from IRS-P6, LISS-IV, Cartosat-1, and Cartosat-2 for their thematic mapping[14]. However, a GPS receiver was employed to collect soil samples from various locations together with their latitudes, longitudes, and other geospatial features to create soil fertility maps under the RS-GIS domain[15]. Inverse Distance Methods (IDW), variogram, kriging, and nugget algorithms were used for grid-based soil resource mapping and their database generation[16]. GIS-based soil fertility maps were prepared for the management of soil nutrients in the area of interest for sustainable crop production, and better management of soil resources [17]. Keeping these facts in mind the present study was carried out to trace the suitable lands in the flood inundated agricultural lands for the cultivation of mustard in the *rabi* season.

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2.1 Study area

The study area Kahalgaon subdivision of Bhagalpur district, Bihar comes under Agro-Climatic Zone III A (South-east part of Bihar) (Fig.1).

The geographical area of the study area is 683.90 km^2 having latitudes and longitudes extensions of 25.19551° N to 25.39942° N and 87.12213° E to 87.52806 ° E. The elevation varies from 25 to 61 m above mean sea falling in a part of the Gangetic plains just before an extension of Rajmahal hills near the border of Bihar and Jharkhand. The Ganges flow from west to east and fills various ponds, lakes, and oxbows among other water bodies, underlain by mostly younger alluvial deposits in a broadly flat plain.

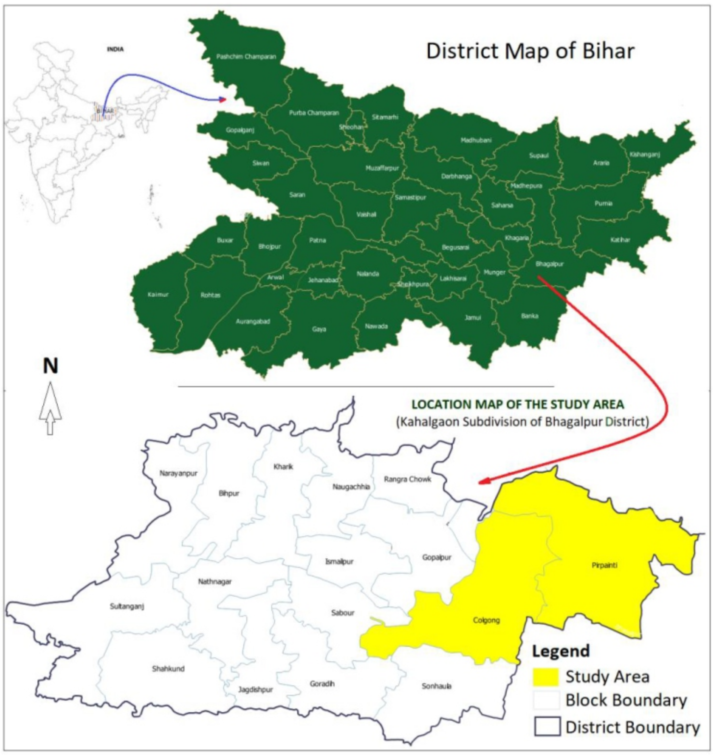

Fig 1: Location map of Kahalgaon subdivision.

Satellite images, hardware, and software used

The multi-spectral images of Landsat- 8, MODIS V5, and SRTM data were used to map the land use land cover pattern, elevation, slope, and waterlogging of the area of interest. However, the administrative boundaries of the area of interest were traced out using topographical sheets with scales of 1:250000 and 1:50000, and the GPS receiver was used for ground truthing. The computer system (HP Platinum 4 core processor) and QGIS software (Version 3.8.2) have been used for visual interpretation of satellite imagery, digitization, and mapping. In order to validate the derived data, soil survey reports, topographical maps, and auxiliary data were also used as references.

Methodology

Apart from satellite data, auxiliary data, GPS receiver, and computer system, an overlaying technique in the multi-criteria decision approach (MCDA) domain was used to trace out the potential land suitability for mustard cultivation in the *rabi* season. Hence, the methodology is summarized below for step-by-step processing of the data in the GIS domain (Fig.2).

Flowchart

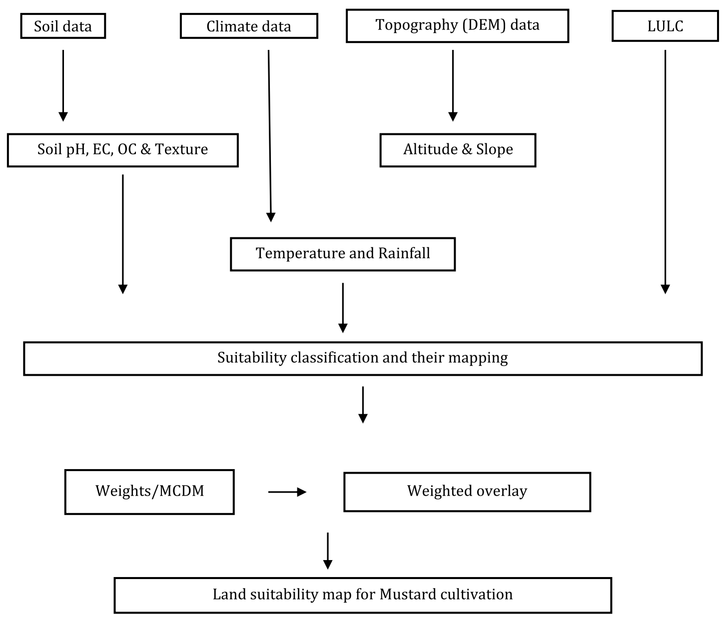

Fig. 2-Flow chart showing land suitability mapping for Mustard

Table 1: Land suitability criteria for Mustard

Sl. No.	Parameters	Highly suitable (S1)	Moderately suitable (S2)	Marginally suitable (S3)	Not Suitable (NS)
1.	Slope (%)	0-3 %	3-8 %	8-12 %	>12 %
2.	Elevation (m)	<700	700-800	800-1200	>1200
3.	Mean Temperature (^0C)	15-19	19-30	30-39	>39, <10
4.	Annual rainfall (mm)	725-1000	1000-1300	1300-1500	>1500
5.	Soil pH	6.5-7.3	7.3-8.4	5-6.5	<5
6.	EC (dS/m)	<1	1.3-4.4	4.4-7.6	>7.6
7.	OC (%)	>0.46	0.46-0.31	0.31-0.21	<0.21
8.	Soil Texture	Loam/ Loamy sand	Silty loam/ Coarse loam	Clayey	Sandy
9.	Land Use/ Land Cover	Agricultural Cropland	Fallow/ Barren Land	Forest land/plantation	Water bodies/ built up land

Source: Sarmah et al., 2017, Mustafa et al., 201

Results and Discussion

In terms of topography, climatic factors, and physico-chemical properties of soils, the pH range of the soils in the study area ranged from 6.2 to 7.8, indicating that soils were slightly acidic to alkaline in nature. However, EC was found to be low (non-saline), organic carbon low to medium, and loamy soil texture in the study area. In terms of elevation, the study area lies between 25-61 m from the above mean sea level, elevation continuously decreases towards the northeast from the south. However, the slope range was observed as 0-1.5 % (gentle or flat). The maximum elevated land was observed in the Pirpainti block having natural vegetation with medium upland. The mean temperature of the Kahalgaon sub-division was found to be in the range of 25°C and the temperature slightly decreases towards the eastern part. In terms of rainfall, the mean rainfall was observed in the range of 1600–1800 mm. The north-eastern area receives comparatively high rainfall.

Based on multi-criteria decision-making approach, the investigation revealed that out of the total geographical area (68390 ha), only 11133 ha (16.27%) of land was found to be highly suitable (S1) followed by 16802 ha (24.56%) which was moderately suitable (S2), 27866 ha (40.74%) was marginally suitable (S3) and 12499 ha (18.27%) of the total area was not suitable (NS) for the cultivation of mustard (Fig. 3). The middle part of the study area is moderately suitable, whereas western and eastern parts are marginally suitable due to constraint in soil texture (sandy), and very low OC.

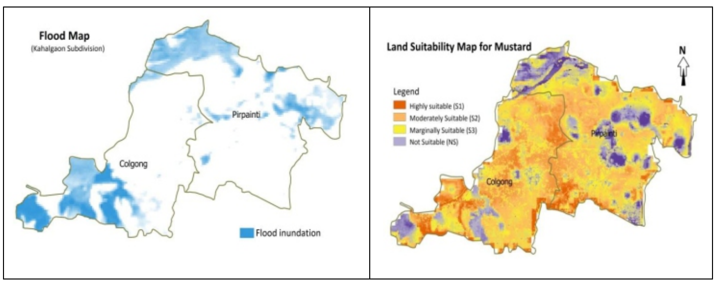

Fig 3: Potential Land Suitability Map of Mustard

Conclusion

The present study was conducted to analyze the suitable lands for mustard in flood-affected agricultural lands of the Kahalgaon subdivision using RS-GIS techniques. Soil characteristics, topographical features, and climatic factors indicated that 40.74 % of the land was found to be marginally suitable for Mustard cultivation. In order to help the local farmers engaged in wheat cultivation, site-specific spatial suitability analysis may be helpful to enhance the oilseeds production in rice fallow land in the lowland Ganges region of Kahalgaon subdivision. The findings of this study can be also used by policymakers to develop an appropriate plan for the promotion of Mustard, providing special agricultural incentive policies.

Future Scope of the Study

Research findings may be helpful in tracing out the flood-affected lands and their mitigation option through land suitability or land use planning. Outcomes will also be helpful to support to providing the supplementary data source for the initiation of the same type of research work in stressed land situations.

Conflict of Interest

The authors declare that they have no conflict of interest.

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