Plant Archives Vol. 25, No. 1, 2025 pp. 1078-1082 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.1.161

LAND IRRIGABILITY CLASSIFICATION OF RIVERINE SOILS IN LOWER BRAHMAPUTRA VALLEY ZONE OF ASSAM INDIA

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(Date of Receiving-04-01-2025; Date of Acceptance-15-03-2025)

ABSTRACT

Land irrigability classification involves the systematic grouping of soils based on their intrinsic properties, external landscape features and prevailing climatic conditions. The present study was conducted to assess land irrigability of riverine soils in Nalbari district located in the Lower Brahmaputra Valley Zone of Assam. Soils samples were collected from 84 different locations of the study area and were analysed for various properties. Based on soil hydro-physical properties, chemical properties, groundwater table depth and topographic characteristics the land irrigation suitability was assessed. The study showed that 69.57% soils of the studied riverine areas was moderately suitable (B) and 30.42 % of the area was highly suitable (A) for irrigation. Soil erosion, soil structure, soil texture, hydraulic conductivity and available water content were found to be the limiting factors for irrigation.

***Key words*:** Riverine areas**,** Brahmaputra valley**,** Land irrigability, GIS Technology.

Introduction

Optimal use of water resources is a serious concern in several parts of India. In the state of Assam, majority of the rainfall occurs during summer (June - September) (Gogoi and Rao, 2022). Heavy rain during this period causes the problem of flooding, especially in the riverine areas. Consequently, in such areas crops are mostly grown during winter season, where, crops need to be irrigated through artificial source (Deka *et al.*, 2024). Irrigation is the process of artificially supplying water to the soil to ensure adequate moisture for plant growth. The process of determining whether the soil is suitable for irrigation based on soil properties related to irrigation is known as soil irrigation suitability assessment (Bhusan and Roy, 2018). Land irrigability classification deals with evaluation of soils for their suitability to irrigation based on quantitative limits of soil characteristics pertinent to irrigation. This classification provides a scientific framework for assessing soil suitability for various land uses, particularly in relation to agricultural productivity and irrigation potential (Gurumurthy, 2019).

Evaluating a piece of land's suitability for irrigation is crucial for making effective use of the scarce resources (Kebede and Ademe, 2016). The suitability of soils for sustainable irrigation use is determined by key characteristics such as available moisture-holding capacity, effective rooting depth, and water intake properties (Chaudhary, 2020). Sultan (2013) evaluated land suitability for irrigation of the Fogera catchment using GIS in South Gondar. Based on the calculated parameters, about 28% of the study area is moderately suitable (S2), 43% is marginally suitable (S3) and 28% of the area is unsuitable (N).

For increasing crop yield as well as to bring food security at national as well as household level, there is a need for improvement and expansion of irrigated agriculture must. However, investigation on estimating irrigation potentiality based on land and water resources are very limited in Assam. As such the present investigation was undertaken to assess the land irrigability classes of soils of the riverine areas of Nalbari district of Assam to propose optimal land use plans for sustainable agricultural production.

Table 1: Weightage of different soil parameters and soil classes for land irrigation suitability (Deka *et al.*, 2024).

Soil Characteristics	Weightage	Soil classes				
		S1 (5)	S2(4)	S3(3)	N1(2)	N2(1)
Surface texture	5	SiL, CL, L	C, SiC, SC	SL	LS	S, Si
Soil Structure	3	Crumb, Granular	Angular Sub-Angular blocky	Platy	Columnar, Prismatic	Massive, Single Grained
pH	2	6.6-7.3	5.6-6.5	4.6-5.5	4-4.5	<4
EC (ds m^{-1})	1	<1	1-1.5	1.51-2.50	2.51-3	>3
ESP (%)	1	<15	15-35	20-30	30-40	>40
$CaCO_3$(%)	2	<0.3	0.3-10	10-25	25-50	>50
Saturated hydraulic conductivity (cm/hr)	4	6-2	2-0.5	12.5-6	25-12.5 or 0.5-0.25	>25 or <0.25
Available water capacity in effective profile depth (cm)	5	>21	21-14	14-7	7-2	<2
Drainage	2	Well	Moderately well	Imperfect	Poor	Very poor
Slope (%)	3	0-2 Level	2-5 Nearly Level	5-8Very gentle	8-15 Gentle	>15 Strong
Soil erosion	3	Slight	Moderate	Severe	Very severe	Extremely severe
Soil stoniness (% gravels by volume)	2	<15	15-35	35-55	55-70	>70
Soil depth	5	>100 Deep	75-100 Moderately deep	50-75 Slightly deep	25-50 shallow	25 very shallow
Ground water table depth (m)	2	>5	3-5	1.5-3.0	0-1.5	-
Total	40					

Materials and Methods

The study was conducted in riverine areas of Nalbari district located in the Lower Brahmaputra Valley Zone of Assam, India (Fig. 1). The study area lies between 26.15^0 N to 26.26^0 N latitude and 91.22^0 E to 91.46^0 E longitude, with elevation ranging from 58 m to 71 m above the mean sea level. The study area is mainly located in the south side of the district along the bank of the river occupying 140 square km of the district. Geocoded FCC of LANDSAT-9 data were visually interpreted with the survey of India toposheets (1:50,000) for demarcating the Brahmaputra riverine areas of Nalbari district. Based on visual image interpretation, 84 sampling sites were identified and both bulk and core samples were collectedfor research purpose.

The collected surface samples were air dried, grounded using hammer and sieved through a 2 mm mesh sieve then stored. The samples were further analyzed for various soil physico-chemical properties. Soil reaction (pH) and electrical conductivity (EC) were determined by adopting procedure outlined by Jackson (1973). Calcium carbonate content of soil samples was determined by rapid titration method of Puri (1930). Exchangeable sodium was determined by extracting the soil with neutral normal ammonium acetate solution (Jackson, 1973). Hydraulic conductivity was estimated by constant head method (Klute, 1986). Available water content was determined from field capacity and permanent wilting point by using pressure plate technique (USSL Staff, 1954). Soil erosion was calculated by using Morgan–Morgan–Finney model (Morgan, 2001).

Land Irrigation suitability was determined using the procedure outlined by Palaskar and Varde (1985), Sehgal

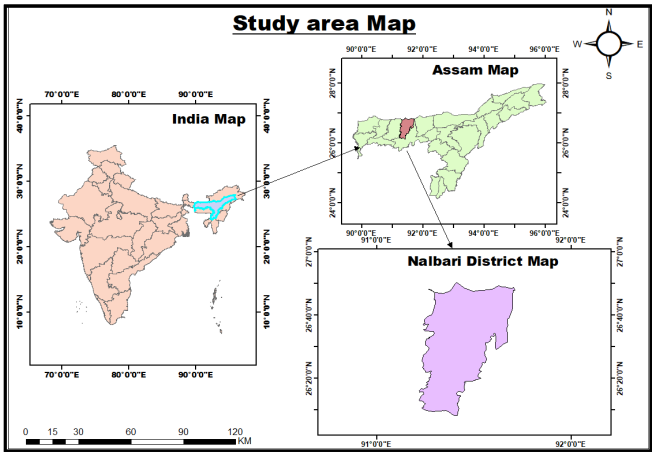

Fig. 1: Location map of riverine areas of Nalbari district of Assam.

Table 2: Land irrigation suitability classes and index.

Land Irrigability Classes	Land Irrigability Index	Interpretation
A (Highly suitable)	5-4	None to slight soil limitation for sustain use under irrigation
B (Moderately suitable)	4-3	Moderate soil limitation for sustain use under irrigation
C (Moderately suitable)	3-2	Severe soil limitation for sustain use under irrigation
D(Currently not suitable)	2-1	Very severe soil limitation for sustain use under irrigation
E Currently not suitable)	<1	Unsuitable for irrigation

et al., (1996) and modified by Deka *et al.*, (2024). A total of 14 parameters were selected and each parameter was allotted a weightage based on their relative significance in the predominant area. Based on both laboratory and field observations of each parameter's value, each soil sample were given a unique rating between 1 and 5 (Table 1). The scores for each parameter were multiplied by the weightage, which were then integrated. The land irrigability index was calculated by dividing the integrated score by the entire maximum weightage. The land irrigability classes were determined using the rating system (Table 2) proposed by Bhushan and Roy (2022)

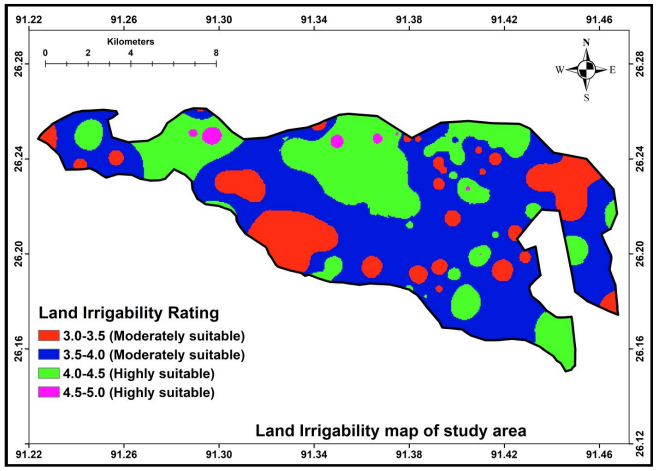

Fig. 2: Land irrigability index map of riverine areas of Nalbari district of Assam.

based on the computed Land Irrigability Index. The GIS based land irrigability map was prepared under Arc GIS environment using the calculated land irrigability index values. Interpolation for the unsampled location was carried out using Inverse Distance Weighted (IDW) function and the interpolated maps were reclassified to get the map units and legends.

Results and Discussion

The estimated values of various soil physico-chemical properties, topographic features and ground water table position used in land irrigability classification of the riverine areas of Nalbari district are presented in Table 3.

Physical properties

The texture of the studied soils varied from loamy sand to clay loam. Loamy sand soils predominated in the investigated area. The majority of the soils in the riverine area were single-grained, followed by sub-angular blocky and massive in structure. The studied soils were assigned

Table 3: Range values of various soil properties and Land irrigability scores for land irrigability classification.

Soil Characteristics	Range of soil properties	Land irrigability scores
Surface texture	Loamy sand to Clay loam	10-25
Soil Structure	Single grain to Sub- angular blocky	3-12
pH	5.20- 7.72	6-10
EC (ds m^{-1})	0.02-0.19	5
ESP (%)	0.90- 6.77	5
$CaCO_3$(%)	1.00- 4.80	8
Saturated hydraulic conductivity (cm/hr)	0.83-12.03	12-20
Available water capacity in effective profile depth (cm)	2.50-23.94	10-25
Drainage	Moderate to well drained	8-10
Slope (%)	2-5	12-15
Soil erosion	5.28- 147.75	3-15
Soil stoniness (% gravels by volume)	<15	10
Soil depth	Moderately deep to deep	20-25
Ground water table depth (m)	4-5	8
Land irrigability Index	-	3.14- 4.70

scores of 10 to 25 for texture and 3 to 12 for land irrigability.

Chemical properties

The soil pH of the study area ranged from 5.20 to 7.72, with a mean value of 6.95. The electrical conductivity (EC) of the soils of riverine areas varied from 0.02 dS/m to 0.19 dS/m, with a mean value of 0.07 dS/m. The calcium carbonate was in the range of 1.00% to 4.80%, with a mean value of 3.02% of the study area. The exchangeable sodium percentage of the study area ranged from 0.90% to 6.77%, with the mean value being 3.14%. Based on soils pH, the soils were assigned irrigability scores ranging from 6 to 10. The land irrigability scores for electrical conductivity, calcium carbonate and exchangeable sodium percentage were 5, 8, and 5, respectively for all the sampling sites.

Hydraulic properties

The hydraulic conductivity of the studied area was found to fall under the range of 0.83 cm/hr to 12.03 cm/hr, with a mean value of 5.90 cm/hr. Based on their hydraulic conductivity the scores for irrigability of soils varied from 12 to 20. The available water content (AWC) in the soil ranged from 2.50% to 23.94%, with a mean value showing 11.44%. Based on the available water content the scores for irrigability of the soils were estimated to be in the range of 12 to 20. The studied soils were moderately to well drained and, thereby, the irrigability scores were found to be ranging from 8 to 10.

Slope and Soil erosion

The riverine region of Nalbari district was predominantly level to nearly level, with a slope ranging from 2% to 5%. The land irrigability scores for slope were found to be in the range of 12-15. The calculated annual soil loss in the study area varied from slight (5.28 t/ha/yr) to extremely severe (147.75 t/ha/yr), with a mean value of 41.41 t/ha/yr (very severe). Based on soil loss value the land irrigability scores were ranging from 3-15 for the study area.

Soil stoniness

Soil stoniness refers to percentage of gravel/stone content within the top productive soil depth. Soil stoniness reduces infiltration capacity in soil and germination capacity of crops. Also it reduces surface area of land suitable for irrigation and as such stoniness is considered as not suitable for agronomic practices. In all the soil samples of the study area gravels were found to be less than 15%. Thus the land irrigability scores for stoniness were assigned as 10.

Soil depth and Ground water table depth

The soil depths at all sampling points in the riverine area of Nalbari district were assessed based on auger-hole observations and soil profile descriptions. The results indicated that soil depth ranged from moderately deep to deep, and accordingly, the studied soils were assigned land irrigability scores ranging from 20 to 25. The groundwater table depth in the study area ranged from 4 m to 5 m, and a land irrigability score of 8 was assigned to all sampling sites.

Assessment of land irrigability

Based on calculated land irrigability index values, the studied soils were classified into different classes. There are five land irrigability classes recognized for evaluation of soils for flow irrigation and arable cropping which varies from A to E (Table 2). The study area varied from highly suitable (Irrigability class A) with a maximum aggregate index of 4.70 to moderately suitable (Irrigability class B) with a minimum aggregate index of 3.14. The mean value of aggregate index of irrigability was 3.84. According to the land irrigability map, 69.57% (97.41 Sq. km) land of the study area was moderately suitable and 30.42 % (42.59 Sq. km) land was highly suitable for irrigation (Fig. 2). Similar findings were also reported by Yadav and Patil (2024) in the Ganjigatti sub-watershed area of the Dharwad district and by Gurara (2020) in the Katar River watershed in the Rift Valley Basin in Ethiopia. The main limiting factors for land irrigability were identified as soil erosion, soil structure, soil texture, hydraulic conductivity and available water content. Similar limitations like soil texture, hydraulic conductivity, soil structure was also observed by Deka *et al.*, (2024) in Simen River Basin of Northern Brahmaputra Valley of Assam.

Conclusion

The study was conducted to evaluate the suitability of land for irrigation of riverine areas of Nalbari district of Assam using physico-chemical parameters of soil, ground water table position and external landscape features. The study revealed that 69.57% land of the study area was moderately suitable and 30.42 % land was highly suitable for irrigation. The primary constraints for land irrigability were identified as soil erosion, soil structure, soil texture, hydraulic conductivity and available water content.

Acknowledgements

Authors are grateful to Govt. of Assam for providing the financial support to carry out this research work at Assam Agricultural University, Jorhat, Assam through the project “GIS mapping of Char areas of Assam using geospatial techniques for planning strategies of crop management and improving liabilities security project”.

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