INDONESIAN JOURNAL ON GEOSCIENCE
Geological Agency
Ministry of Energy and Mineral Resources

Journal homepage: https://ijog.geologi.esdm.go.id
ISSN 2355-9314, e-ISSN 2355-9306

A GIS Framework to Identify The Suitability Map to Utilize Sand Deposited Land in Dibru River Basin: Using AHP Method and MCDM

Gulap Sonowal[1], Gitika Thakuriah[2], and Palash Moni Saikia[3]

[1]Assistant Professor, P.G. Department of Geography, Darrang College (Autonomous), affiliated under (Gauhati University) Tezpur-784001, Assam, India
[2]Assistant Professor, Department of Geography, Cotton University, Guwahati-781001, India
[3]Principal, Darrang College (Autonomous), Tezpur, India

Corresponding author: gulapsonowal15@gmail.com; gthakuriah@yahoo.in
Manuscript received: August, 12, 2025; revised: October, 27, 2025;
approved: January, 29, 2026; available online: May, 19, 2026

Abstract - The site suitability for utilizing sand deposited land is an important step towards sustainable development by adopting conservative measures. Soil is the most crucial for maintaining an environment and ecosystem which is helpful to sustaining all forms of life. The increasing action of sand deposition day to day has been one of the common issues all over the world, especially the country with high magnitude flood. The present study aim is to identify the sensitive area of the sand deposition within The Dibru River Basin. Multicriteria evaluation is carried out using Geographic Information System (GIS) techniques to help the choice makers in identifying the suitable site of sand deposition. Different layers which were considered for multicriteria evaluation are: sand deposition, geomorphology, soil capability, soil texture, and slope for identifying the vulnerable zone of sand deposition. Analytical Hierarchy Processes (AHP) are used for weighted sum to find the sensitive area of the sand deposition for land management using selected criteria. The site suitability map was classified into low, moderate, and high deposition zones. This paper will help policy makers for implementing the preventive measures to use the siltation zone into sustainable agriculture practise within The Dibru River Basin.

Keywords: sand deposition, AHP, remote sensing, GIS, sustainable agriculture

How to cite this article:
Sonowal, G., Thakuriah, G., and Saika, P.M., 2026. A GIS Framework to Identify The Suitability Map to Utilize Sand Deposited Land in Dibru River Basin: Using AHP Method and MCDM. *Indonesian Journal on Geoscience*, 13 (2), p.171-187. DOI: 10.17014/ijog.13.2.171-187

Introduction

Sustainable agriculture is a critical global issue for supplying the essential requirements for sustainable production and food security and for addressing challenges such as population growth, climate change, and land degradation (FAO, 2017; Lal, 2009; Lal, 2012).Soil is an important natural resource for the agricultural and industrial development of anynation, and one of the prime life-supporting ecosystem (Manral *et al*., 2023). To feed the world population, which is continuously growing, agricultural expansion and intensificationare necessary. Unsustainable cultivation practices have been considered the mainly responsible for losses in soil biodiversity and fertility (Bisht *et al*., 2023; Kopittke *et al*., 2019). Major factors for soil deterioration include salinization, erosion, depletion of nutrients,exhaustive agricultural practices, and contamination with toxic heavy metals (Usman*et al*., 2020). Therefore, adopting sustainable agriculture practices to preserve soil quality and to provide safe and healthy foods is the most promising alternative to preserve the soil environment and guarantee crop yield for animal consumption (Tahat *et al*., 2020). These practices integrate biological, physical, and chemical principles for developing new ways for agricultural production that are not harmful to the environment, which act as suppressing pathogens, sustaining biological activities, decomposing organic matter, inactivating toxicmaterials, and recycling nutrients, energy, and water (Sahu *et al*., 2017). Physical and chemical properties of soils vary according to topography, climate, weathering processes, vegetation cover, microbial activities, and several other biotic and abiotic factors (Manral *et al*., 2022; Pandey *et al*., 2023). Weathering process that rocks are subjected in the most superficial layers of the earth crust give origin to different types of soil (Stoops and Schaefer, 2018). The main soil classes include clayey, sandy, silty, humic, and karstic soil (Kufmann, 2003). Co-variations of some soil traits change soil texture and indirectly affect organic matter mineralization (Li *et al*., 2022). The soil biota and micro- biotahave direct and indirect effects on plant growth and food quality, controlling pests, disease incidence, soil nutrient cycling, and water transfer. They can also induce resistance and resilience in agro ecosystems against biotic and abiotic stresses (Roger-Estrade *et al*., 2010).

The use of sandy soil areas for agricultural practices is critical to achieving the world demand for food production. However, this soil type is very fragile, and degradation quickly emerges when not scientifically managed. Considering the Scopus database, 15,018 original articles and book chapters were published in the last ten years reporting the soil types and their degradation. Works that studied sandy soils account for around 55% of the total publications. This representativeness highlights the importance of research regarding sustainable agricultural practices in the most fragile soils.

In Dibru River Basin, the significant impact on natural landscapes and cultural landscapes are mainly affected by the action of the river processes, like widening its channel, process of erosion, and sand deposition, high discharge, and a heavy pour of precipitation.

The region is fond of cash crops like tea cultivation, paddy cultivation, betel nut cultivation, and orange cultivation. Because of the erosion, deposition, and flood, many hectares of tea garden, betel nut, paddy field, orange cultivation are lost. The lower course of LohitRiver is widening its channel, making many villages, cultivation fields, *etc.* be washed away.It is observed in some places where government and community had taken steps to minimize the bank erosion by following techniques like installing porcupine and geotextile tube or bag.

During flood period, people shifted where there is high land or embankment, and took shelter there. Villagers like in Kaliapani gaon, Hati ghuli, Gohai gaon, Buka bill, Balunala NC, Garo NC, took shelter in nearby villages called Minalpurgaon. Diverse communities have been found here, like Assamese, Bengali, Baishya, Sarkar, Adibasis people, and migratedones from the above villages to Minalpurgaon and to Na Bormura. People lost their agriculture land, tea garden, household property, fruits, cattle,*etc*. In this region people mainly depended on agriculture, but due to increase in siltation in agricultural land, people shifted their economic activities to fishing and services.

So, modelling of suitability to utilize sand deposited land management is crucial for the management of natural resources and sustainable development of this region. This can be achieved by integrating various parameters and modelling the index using advanced techniques like remote sensing (RS) and geographic information systems (GIS) and analytical hierarchy process (AHP). Therefore, this research paper aims to study the use of sandy soils and the main challenges necessary to achieve sustainable and efficient production in this soil type.

Objective

1. To find the sensitive area of sand deposition in The Dibru River Basin
2. To formulate a strategy to use the siltation land into alternative sustainable agriculture.

Studied Area

The Dibru River is a left-bank tributary of The Brahmaputra River. The basin drains into the plain region of Assam, experiencing the tremendous sub-Himalayan terrain and bounded by rivers The Brahmaputra and The Lohit in the north, NoaDihing River in the eastern, and some tributaries of The BurhiDihing River in the south and western borders of the basin. Geographically its latitude and longitudinal extension are 27º 25'30″ N-27º46'30″N and 95º6'0″ E-95º58'30″ E covering about 1779 km^2 area of Tinsukia, Dibrugarh, Dhemaji District of Assam and part of Arunachal Pradesh (Figure 1). The basin slope varies from gently sloping to base level slope (0°-5º).

The Dibru River origin at an altitude of about 155 m above mean sea level and runs up to 132.95 km, where the channel gradient is 0.35 m/km (Table 1).

A significant portion of the studied area is a plain region. The population concentration is very high in the southern part of the basin. The Dibru River Basin consists of four revenue circles: Chabua, Doom Dooma, Margherita, and Tinsukia (Sonowal*et al.*, 2022).

Methodology

The analysis uses the different years of satellite images at ten-year intervals to show the temporal changes in sand deposition in The Dibru River Basin. Multitemporal Land-sat satellite data and Sentinel-2 data for 1977, 1987, 1997, and 2020 were used to identify spatio-temporal sand deposition in the studied area (Table 2). GPS points were collected for

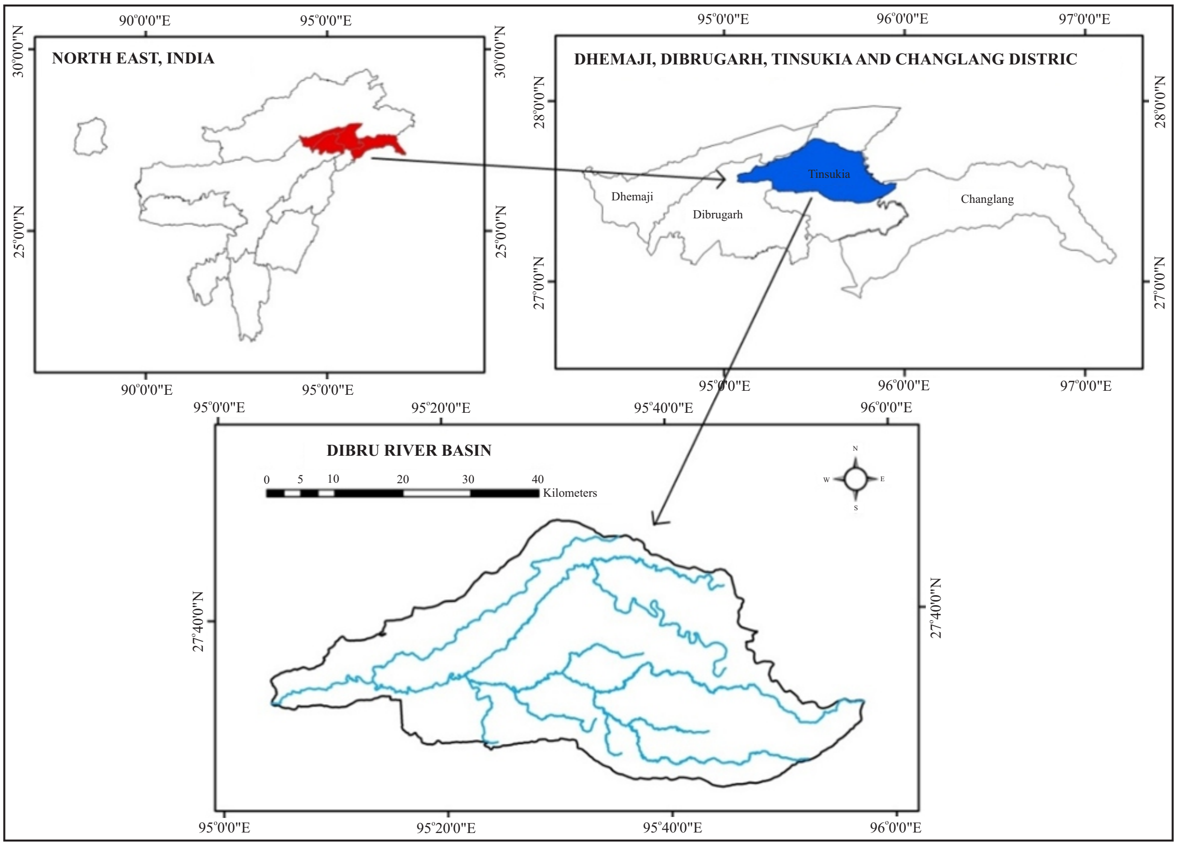

Figure 1.Location map of the studied area.

Table 1. Details of The Database

Data Types	Details of Database	Sources of Database
Toposheet (Slope and River distance)	83M/2, 83M/5, 83M/6, 83M/7, 83M/9, 83M/10, 83M/11, 83M/13, 83M/14, and 83M/15	Survey of India
Thematic Map	**Soil**: texture, capability	National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) Regional Centre, Jorhat, Assam, India, Digital Soil Map of the World
	Geomorphology	Geological Survey of India
GPS Ground truth	Location of sand deposition site	GPS

Table 2. Detail of Satellite Imagery for Sand Deposition

Sensor	Date of acquisition	Bands used	Resolution
Sentinel-2	31 Dec. 2020	8,4,3	10 m
Sensor	**Date of acquisition**	**Bands used**	**Resolution**
Landsat M.S.S.	6 February 1977	MTL	60 m
Landsat M.S.S.	22 March 1987	2,3,4	30 m
Landsat M.S.S.	16 February 1997	2,3,4	30 m
O.L.I. and TIRS	22 December 2020	3,4,5	30 m

ground truth verification, and a high resolution satellite image was also used for validation of sand deposition.

Multicriteria decision analysis using AHP is the most common and well-known GIS-based method for delineating siltation map. This method helps in integrating all the thematic layers into single features. These five thematic layers are supposed to control the factor of utilization sand deposited land in the area. The associations of these influencing factors are weighted according to their reaction in converting agricultural land to siltation land. A parameter with a high weight illustrates a layer with high impact, and a parameter with a low weight illustrates a low impact on sand deposited in a given area. The weights of each parameter were assigned according to Saaty's scale (1–9) of relative importance value.

Further, the weights were assigned considering the review of past studies and field experience. The Saaty's scale of relative importance value reveals that the value of 9 indicates extreme importance, 8 very very strong, 7 very extreme importance, 6 strong plus, 5 strong importance, 4 moderate plus, 3 moderate importance, 2 weak, and 1equal importance. As per the classification, weights are assigned to the thematic layers based on their importance and siltation capacity in a given region. Accordingly, all the thematic layers have been compared in a pairwise comparison matrix.The subclasses of thematic layers were reclassified using the natural-break-classification method in the GIS platform for assigning weight. Each thematic layer was ranked on a scale of 1 to 5, based on its relative influence on the sand deposited in the studied area. Table 3 illustrates the assigned rank and weights of thematic layers. For calculating the consistency ratio (CR), the following steps were adopted: (1) Principal Eigenvalue (λ) was computed by the Eigenvector technique (Table 4), and (2) Consistency Index (CI) was calculated from Equivalent 1(Saaty, 2008)given below:

Table 3. Rank And Weightage of Suitability Map to Utilize Sand Deposited Land Using The Weighted Overlay Method

SL No	Contributing Factors	Classes	Rank	Weight (%)
1	Sand deposited area	Siltation	5	26
2	Geomorphological	Water bodies-River	1	16
		Braid Bar	1	
		Channel Island	4	
		FluOri-Active Flood plain	4	
		Meander Scar	2	
		Abandoned Channel	2	
		DenOri-Pediment-Pediplain Complex	1	
		3FluOri-Older Flood plain	4	
		Pediment	1	
		Palaeochannel	2	
		Lateral Bar	2	
		Channel Bar	1	
		Point bar	1	
		FluOri-Younger Alluvial Plain	5	
		Crevasse Splay	1	
		Back Swamp	1	
		Water bodies-Pond	1	
3	Soil texture	Fine clayey	1	10
		Fine silty	2	
		Fine loamy	2	
		Coarse loamy	3	
		Sandy	4	
4	Land capability	II w	5	19
		III es	4	
		III w	3	
		IV es	1	
5	Slope (%)	0-0.5	5	29
		0.5-1.0	2	
		>1.0	1	

Table 4. Saaty's Ratio Index for Different Values of N

Order of The Matrix												
N	1	2	3	4	**5**	6	7	8	9	10	11	12
RCI Value	0.00	0.00	0.85	0.90	**1.12**	1.24	1.3	1.41	1.45	1.49	1.51	1.48

⅄max=25/05=5
CI=⅄max-N/N-1 ....(Equivalent 1)

where n is the number of factors used in the analysis.

CI= (05-05)/ (05-1) = 0 ....(Equivalent 2**)**

Consistency Ratio is defined as CR= CI/RCI, where RCI= Random consistency Index value, which values were obtained from Saaty's standard Table 3.

CR =0/1.12=0 ....(Equivalent 3)

Saaty has opined that a CR of 0.10 or less is acceptable to continue the analysis. If the consistency value is more significant than 0.10, then the judgment needs to be revised to locate the causes of inconsistency, and to correct it accordingly. If the CR value is 0, there is a perfect level of consistency in the pairwise comparison. The threshold value is not exceeding 0.1, which means the judgment matrix is reasonably consistent. Five thematic layers were integrated with the weighted overlay analysis method in the GIS platform to generate sand deposition map in The Dibru River Basin.

Results

Suitability Map to Utilize Sand Deposited Land

Thesuitability map to utilize sand deposition land is prepared with the AHP model using Saaty's scale. The methodology part is already explained in the methodology part.

After computing the comparison matrix using Saaty's rating scale with the help of AHP in Arc GIS, the consistency ratio is 0, which is a good sign of judgment among all the given parameters (Table 5).

The contributing factors are selected based on the characteristics of the region, from physical to socio-economic, and a literature review of the relevant area. The sand deposition map, sand deposited area, slope, and land capabilities are assigned with the most influencing factors in the basin (Figure 2).

Usually, sand is deposited on a low-gradient slope. The river carries the sediments from the high slope, and deposits where they find the equilibrium level and a low gradient. As the region is plain, the sediment is deposited near the bank of the river and also on the cropland area. The sand deposition map is prepared from satellite imagery and assigned the area with the highest rank value because of high sand deposition (Figure 3).

Geomorphology and soil texture play the next important factor in contributing to sand deposition area. Under geomorphology, active flood plain, old flood plain, river islands, and younger flood plain are the important features contributing to sand deposition, and are assigned the highest rank value. Active flood plains and younger flood plain are more vulnerable to the sand deposition, because silt and sand are usually found under these two groups of features and areas near the river bank. River Island is also responsible for the sand deposition zone. DibruSaikhowa National Park is a riverine island, and this island is formed from the erosion and deposition action of The Lohit, Dibang, and Dihang Rivers. Otherfeatures have less impact on sand deposition.

Cohesiveness and noncohesiveness of soil is an important characteristic in a sand deposition. Clay indicates less resistance to erosion, and coarse loam and sand are more resistance to erosion. Sediments with more erosion resistance are more vulnerable to sand deposition in floodplain regions as they are easily eroded by the actions of the river, and can transport to longer distances.

The capability classification provides three major categories of soil groupings. The first category, capability unit, is a grouping of soils with about the same responses to systems of management of commonly cultivated crops and pasture plants. Soils in any one capability unit are adapted to the same kinds of common cultivated and pasture

Table 5. Pairwise Comparison Matrix of The Five Most Contributing Thematic Layers for Utilizing The Sand-Deposited Land

Sl. No	Contributing Factors	Weight	Siltation	Soil Texture	Geomorphology	Soil Capability	Slope	Normalized Weight
1	**Sand deposition**	9	1	1.8	1.2	1.5	1	1.3
2	**Soil texture**	5	0.55	1	0.71	0.83	0.55	0.72
3	**Geomorphology**	7	0.77	1.4	1	1.16	0.77	1.02
4	**Soil capability**	6	0.66	1.2	0.85	1	0.66	0.87
5	**Slope**	9	1	1.8	1.28	1.5	1	1.31
	Consistency Ratio = 0							

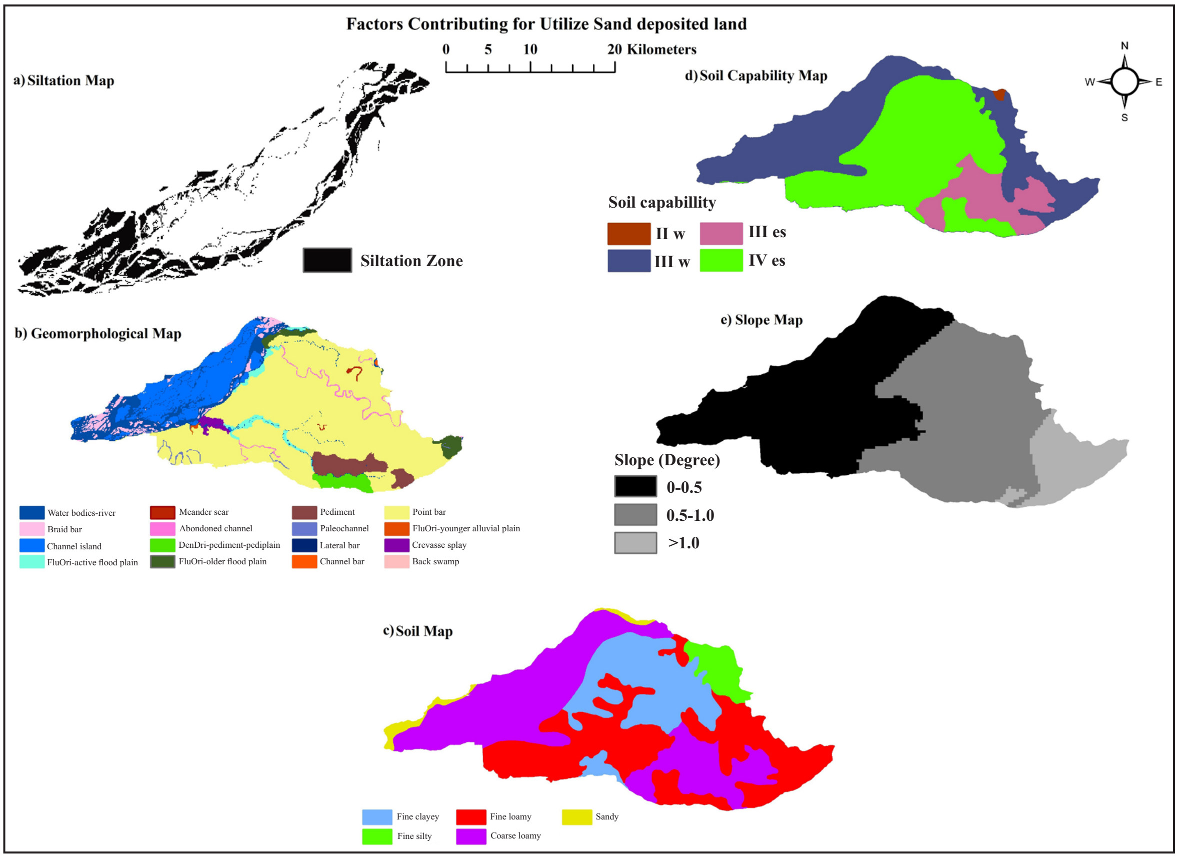

Figure 2.Factors contributing to utilizing sand-deposited land.

plants, and require similar alternative systems of management for these crops. Longtime estimated yields of adapted crops for individual soils within the unit under comparable management are at most about 25 %. The second category, the subclass, is a grouping of capability units with similar limitations and hazards. Four general limitations or hazards are recognized: 1. Erosion, 2. Wetness, 3. Rooting zone, and 4. Climate.The third category, capability classification, places all the soils in eight capability classes. Class I–IV are good management classes of soils. Classes V, VI, and VII are suited to adapt native plants. Classes VIII does not return on-site benefits for management inputs for crops, grasses, or trees without major reclamations.

Soils in class II have some limitations that reduce the choice of plants or require moderate conservation practices. The soil in this category requires careful soil management, including conservation practices, prevents deterioration, or to improve air and water relations when the soils are cultivated. The limitations of this soil are that generally, it is found in gentle slopes and has moderate susceptibility to wind, water erosion, and moderate past erosion. The depth of the soil is less than ideal, and the soil structure is unfavourable.

Soils in class III have severe limitations that reduce the choice of plants, require special conservation practices, or both. This class of soil has more restrictions than class II. The limitations of this soil class are that it is generally found in moderately steep slopes with high susceptibility to water and wind erosion. There is a shallow depth to bedrock and very slow permeability.

Soils in class IV have severe limitations that restrict the choice of plants and require very careful management or both. This class of soil has more restrictions than class III soil. The limitations of this soil are that it is generally found on steep slopes, and has severe susceptibility to water or wind erosion. The depth of the soil is shallow, and the holding capacity of moisture is low. More

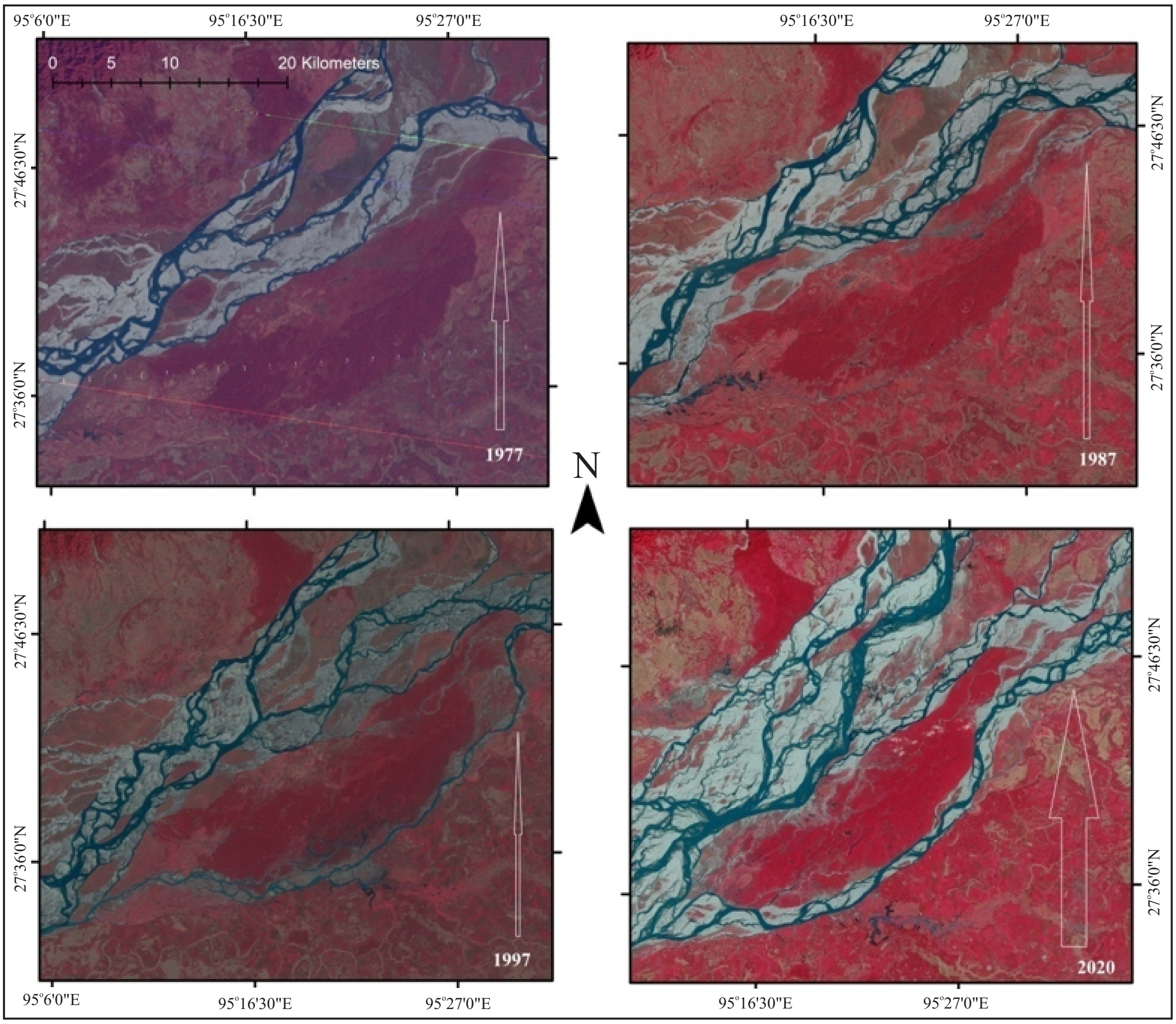

Figure 3.Temporal changes in the sand deposition (1977–2020).

careful management and conservation practices are applied when these soils are cultivated.

Subclass (e) erosion is made up of soils where the susceptibility to erosion is the dominant hazard. Erosion susceptibility and past erosion damage are the major soil factors for placing soils in this subclass.

Subclass (w) excess water is made up of soils where water is the dominant hazard. Poor soil drainage, wetness, high water table, and overflow are the criteria for determining this subclass.

Subclass (s)soil limitations within the rooting zone include shallowness of rooting zones, low moisture-holding capacity, and low fertility. Land capability classes IIw and IIIes give more weightage to delineating suitable areas for utilizing sand-deposited land.

The slope factor also plays an important role in sand deposition. As the region falls in the plain region, there is a gentle slope where water holds for a longer time and flows steadily. The lower degree of slope is assigned with the highest rank, and so on (Table 3).

The weight and rank of each parameter in influencing sand deposition are shown inTable5.

To check the validation of the map, 09 GPS points had been collected from the studied area for ground truth, after collecting the point; it was verified with the map. It looks that out of the 09 GPS points, 08 GPS points falls according to the map. The accuracy is almost 88%.

Taking all these parameters gives a suitable map to utilize sand deposition land for alternative cultivation. Table 6 shows that high and moderate

Table 6.Details of The Suitability Zone for Utilizing Sand-Deposited Land

Sl. No	Suitability Zone	Area (km^2)	Area (in %)
1	Low	89.69	5.04
2	Moderate	35.13	1.97
3	High	0.02	0.001
4	Unsuitable zone	1654.16	92.98
5	**Total area**	**1779**	

sand deposition zone covers an area of 0.02 $km^2$and 35.16 km^2 like Minalpur Village, Notungaon, and DighalTarang T.E. The recommendation to use the sand deposition land is given in Table 7.

Action Plan for Sustainable Development

The optimum land action plan is a long-term vision of altering the land use based on potential natural resources and socio-economic conditions for sustainable land and water resource development. It can provide a more balanced distribution of activities and population, mitigating conflicting interests and the best possible way of livelihood. The proposed land action plan is formulated based on the careful observation of hydro-geomorphology, soil, land use-land cover, socio-economic conditions, geo-environmental problems like flood and bank erosion, and sand deposits of the studied area, and integrated them using geospatial techniques for sustainable development of land and water resources. Table 7 illustrates the integration of critical factors of the optimum land action plan. Figure 4 displays the proposed most suitable area for a land action plan to mitigate geo-environmental problems and create better means of livelihood.

For utilizing sand-deposited land, the most suitable areas are suggested in cropland and settlement areas at a level to the gentle slope (0^o−0.5^o), fine loamy soil with the capability of land III w and IV es zones, and flood plain areas. 0.02 km^2 and 35.13 km^2 area of the basin were identified as a high siltation zone and moderate siltation zone for utilizing the sand deposited land for cultivation (Figure 4). The primary occupation of Minalpur Village and Notungaon was agriculture. Most of the agricultural land had been converted to sedimentation due to the action of the river (Figure 5). The villages of Notun Gaon and Minalpur have undergone significant transformation, gradually turning into areas affected by siltation (Figure 6 & 7). Because of the geo-environmental issues, there is a shift in activities from paddy cultivation to fodder crops, fishing, and services. People of these regions mainly engaged in the cultivation of fodder for animals and fishing. The soil around The Minalpur Village is sandy coated with silt, which is suitable for cultivating winter crops, such as mustard, potatoes, papaya, chilly, maize, *etc*. (Govt. Assam, Dhemaji District). As these crops are suitable for cultivation in the sand-deposited land. The sedimentation land can be used for alternative cultivation in the coming days to prevent the scarcity of food production as a means of sustainable development.

Table 7. Action Plan for Sustainable Formulation

Sl. no	Action	Physiography	Soil	Slope	Pop. Distribution	Drainage den	LULC	Soil Capability	Rainfall (cm)	Area (km^2)	Impact
1	Fodder crops and vegetable like (potatoes, papaya, chilly, maize, *etc.*)	Flood plain (Active and Old Flood plain zone)	fine loamy	0°-0.5°	Low-Moderate density	Moderate to high	Cropland, settlement	III w − IV es	<180.93 180.93−203.33 >203.33	Moderate siltation Zone (35.13 km^2) High siltation Zone (0.02 km^2)	Sand deposits

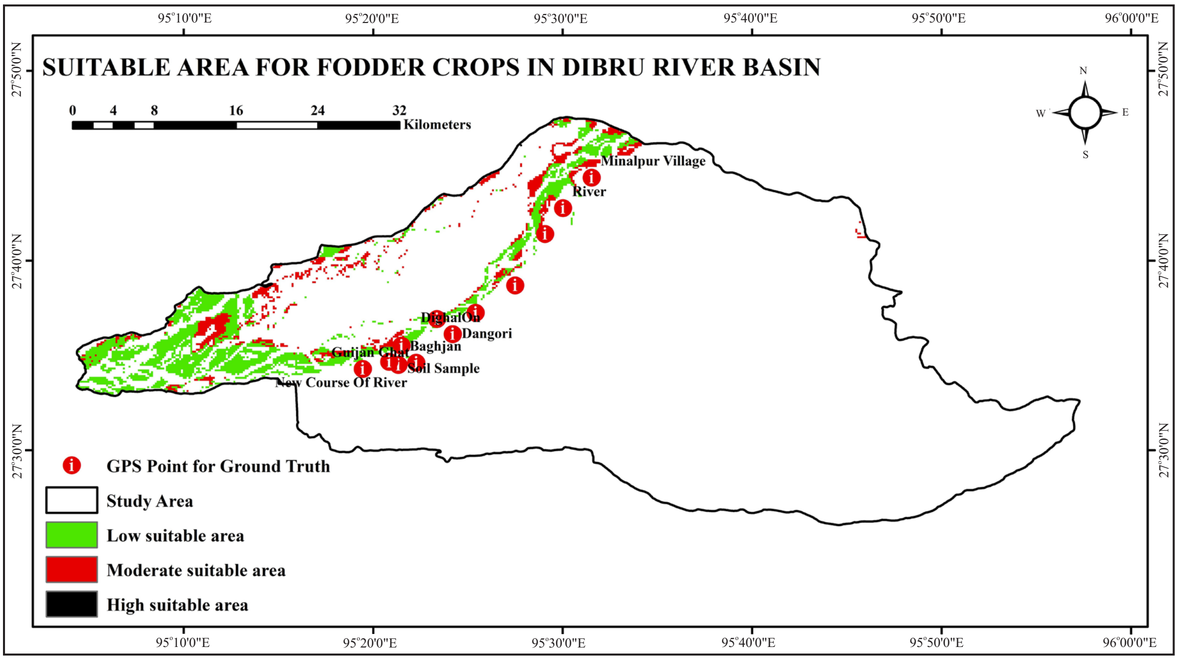

Figure 4.Suitable area for fodder crops with GPS point.

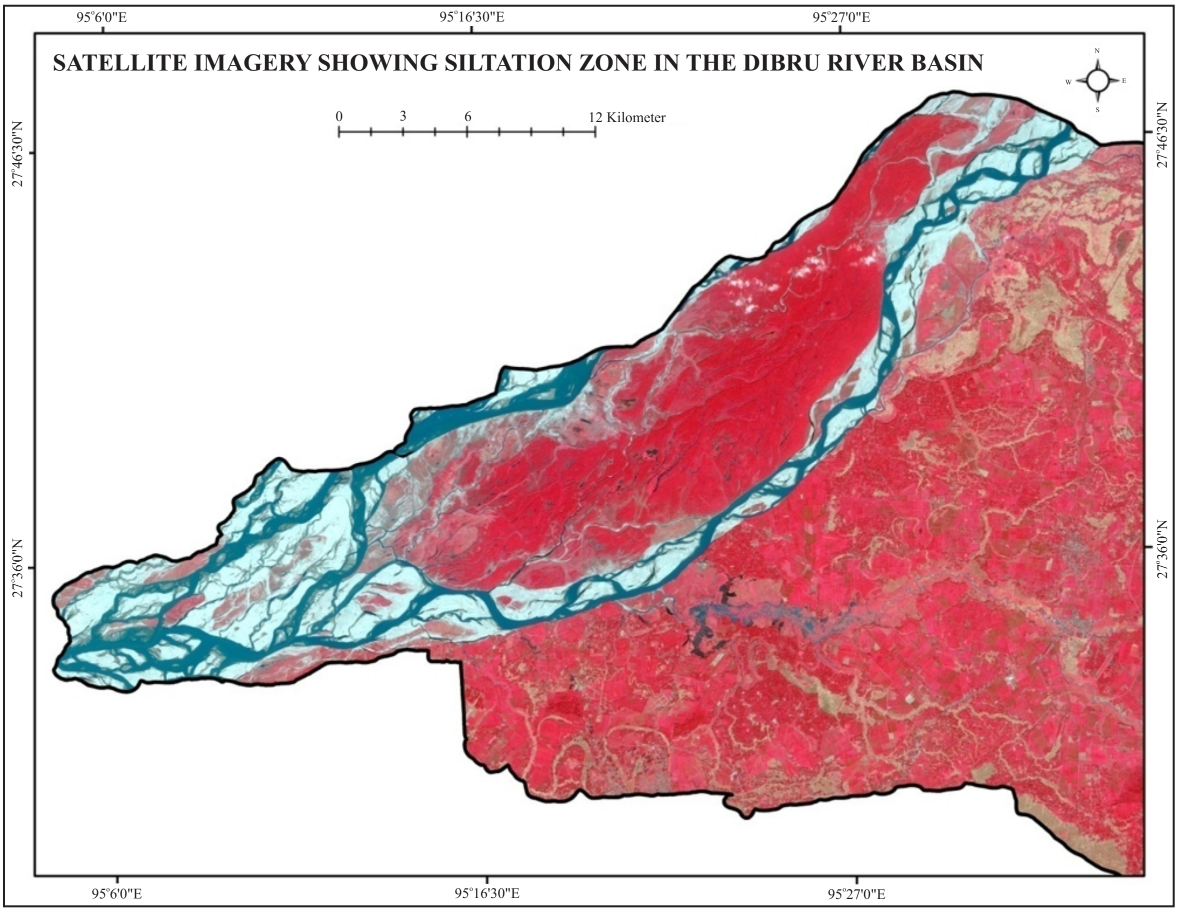

Figure 5.Validation of map showing the siltation zone in The Dibru River Basin (Sentinel image, 2020).

Figure 6. Sand deposition of Notun Village.

Figure 7. Sand deposition of MinalpurVillage

Discussion

Over the past few decades, continuous agriculturalland-use without considering land evaluation assessments has led to significant land degradation. Land evaluation assessment involves the systematic process of determining the suitability of a piece of land for various uses, such as agriculture, forestry, urban development, conservation, or recreational purposes. In order to prevent further damage, it is essential to establish land suitability classification methods. These methods should consider water accessibility, soil management practices, and

plant adaptability (Ziadat and Al-Bakri, 2006). The soil condition plays a pivotal role in determining the efficiency of agricultural machinery (Abdel and Elzain, 2007; Ohu *et al*., 1987).

Land suitability assessment is a process that evaluates andclassifies different areas of land based on its appropriateness for a particular purpose (Lee andYeh,2009; Martin andSaha2009; YigeltuandAlemu,2022). This process plays an essential role in understanding the relationship between the characteristics of a land parcel and its potential usage (Beek,1980). Performing land suitability assessments can lead to improved land use planning, decrease soil degradation, and foster the design of land-use structures that minimize environmental challenges by separating conflicting land uses,like land-use zoning and land-use segregation (Ziadat,2007). It also reveals existing constraints that may hinder land-use, providing a comprehensive overview of the land potential and limitations (Ziadat and Al-Bakri, 2015; Ziadatand Sultan, 2011). Therefore, land suitability assessment is a critical tool for utilizing land resources effectively. By understanding the land strengths and limitations, land managers can plan its use more wisely, mitigate potential environmental issues, and optimize its value for a specific purpose.

Land suitability evaluations have utilized a wide variety of factors, including slope, soil type, land use, land cover, drainage, soil texture, soil depth, soil electrical conductivity, calcium content, organic matter, and climate (Moller *et al*., 2021; Radocaj *et al*., 2020; Radocaj *et al*., 2021; Sultan,2013; Taghizadeh-Mehrjardi *et al.,* 2020; Yigeltu and Alemu, 2022).

Moreover, numerous analytical methodologies have been employed by researchers to determine the most suitable landfor agricultural machinery (Al-Taani *et al*.,2021; Mazahreh*et al*., 2019). Several techniques, such as spatial assessment, qualitative description, and advanced practices like hierarchical analytic procedures, dynamic system models, and other multicriterion analysis techniques, have been used for land suitability assessments (Morales and de Vries, 2021; Pilevar *et al*., 2020; SeyedMohammadi *et al*., 2019). However, traditional land suitability assessments often utilize limiting factors typically established by experts drawingon historical research and experience (Ziadat, 2007). This conventional method, while thorough, often necessitates extensive computations and considerable time to produce reliable results (Mokarram *et al*., 2015). To overcome these limitations, some researchers have turned to machine learning algorithms.

Bangladesh needs more land suitability analyses, specifically for agricultural machinery (BinteMostafiz*et al*., 2021; Haque *et al*., 2022; Hossen *et al*., 2021; Perveen*et al*., 2005). A key strategy for enhancing mechanization and consequently boosting agricultural production involves identifying well-suited lands for such machinery (Yang *et al*., 2023). Utilizing data on agricultural machinery usage, combined with spatial soil physical attributes, could provide information for such assessments.

In this context,the primary aim of this study is to develop a suitable land classification map for the operation of combine harvesters at the Kalikoir, Gazipur, and Bangladesh. Ultimately, this approach should identify the most suitable rice fields for efficient harvesting operations using a combine harvester,and may result in substantial benefits, including reducing human drudgery and harvesting costs, saving time, and increasing crop productivity. Using this strategic approach to land suitability analysis, the effectiveness of mechanization in Bangladesh agriculture sector can be optimized, and significant strides toward enhancing national food security will be made. Many researchers had studied on the sustainable agriculture in siltation land.

Holanda, in his paper "Challenges for sustainable production in sandy soils:A review",aims to study sandy soils and themain challenges necessary to achieve sustainable and efficient production in this soil type.The increasing global pressure forland resources requires developing methodologies for the sustainable use of sandy soils foragricultural purposes aimed at sustaining the growth of the world population.

Silva in his paper "Biogenic and physicogenic" (Silva *et al*., 2023) aggregates as indicators of quality in soils with sandy texture in areas of organic agriculture", in the Rio de Janeiro lowlands.

Selmy wrote "Impact of Short-Term Cultivation on Some Selected Properties of Sandy Soil in an Arid Environment" (Selmy *et al*., 2022). In his paper, he continuously monitored the effects of diverse soil managementstrategies in the short term assists in the understanding of the on-going changes in soil physical andchemical characteristics, which is critical for maintaining satisfactory soil quality and sustainable soil-productivity in arid lands. So as per pervious work carried by some researcher on sandy soil, it uses a sustainable means of agriculture. In the researched area, the basin is a fond of flood and deposition. Due to deposition, the agricultural land is converted to a siltation zone. People lost their agricultural land, and had to shift their activities from agriculture to alternative source of livelihood like fishing, grazing,*etc*. Those unproductivity land can be used into productivity zone by cultivating crops which suit for the sandy soil or siltation land.

The suitability analysis for utilizing sand-deposited land in The Dibru River Basin, highlights the complex interaction between fluvio-geomorphic processes, soil characteristics, and land capability conditions in a highly dynamic riverine environment. The application of the Analytical Hierarchy Process (AHP) integrated with GIS-based weighted overlay analysis proved effective in identifying zones with varying degrees of suitability for alternative land-use practices on sand-deposited surfaces.

The consistency ratio (CR= 0) obtained from the pairwise comparison matrix indicates a high level of coherence and reliability in the weighting of thematic layers, reflecting sound expert judgment, and appropriate parameter selection. This strengthens the robustness of the suitability model and confirms the logical prioritization of sand deposition, slope, land capability, geomorphology, and soil texture as the most influential factors governing the utilization potential of sand-deposited land.

The results reveal that anonly a limited area - 0.02 km² classified as highly suitable and 35.13 km² as moderately suitable-was identified for potential utilization of sand-deposited land. These zones are predominantly located in gently sloping floodplain areas (0°-0.5°), characterized by fine loamy soils and land capability subclasses

IIIw and IVes. The dominance of low-gradient slopes facilitates sediment deposition by reducing flow velocity, while also by allowing water retention for short durations, which is beneficial for certain crop types. Similar geomorphic settings have been reported to support seasonal and alternative cropping systems in other alluvial floodplain regions.

Geomorphological units such as active floodplains, younger alluvial plains, channel islands, and riverine bars emerged as key contributors to sand deposition. These landforms are inherently dynamic, formed through continuous erosion–deposition processes driven by the Lohit, Dibang, and Dihang Rivers. The presence of Dibru Saikhowa National Park as a riverine island further illustrates the long-term role of sediment dynamics in shaping land surfaces suitable for selective utilization. However, older floodplains and abandoned channels showed comparatively lower suitability due to soil compaction, drainage issues, and reduced sediment replenishment.

Soil texture and land capability classes played a decisive role in differentiating suitability levels within sand-deposited areas. Fine loamy and coarse loamy soils exhibited higher suitability compared to fine clayey soils, owing to better drainage conditions and moderate moisture-holding capacity. Although sandy and coarse loamy soils are generally more resistant to erosion, their presence in floodplain environments makes them more prone to deposition due to repeated sediment influx during flood events. The prioritization of land capability classes IIw and IIIes reflects their moderate limitations, which can be managed through appropriate conservation and agronomic practices, thereby enhancing their potential for sustainable use.

Ground validation using GPS-based field verification demonstrated an overall accuracy of approximately 88%, indicating a strong correspondence between the modeled suitability zones and actual ground conditions. This level of accuracy supports the reliability of the geospatial framework adopted in the study, and confirms the applicability of AHP-based multi-criterion evaluation for land suitability assessment in data-scarce floodplain regions.

From a livelihood perspective, the suitability map provides important insights into adaptive land-use strategies in response to recurring sedimentation and flood hazards. In villages such as Minalpur and Notungaon, where agricultural land has been severely affected by sand deposition, traditional paddy cultivation has become increasingly unviable. As a result, households have shifted towards fodder cultivation, vegetable farming, fishing, and service-based livelihoods. The identification of moderately and highly suitable zones for alternative cultivation supports this transition and aligns with local practices already observed in the field.

Crops such as mustard, potato, maize, papaya, and chilli are particularly well-suited to sandy and silt-coated soils, especially during the winter season. These crops require relatively shorter growing periods, and can tolerate well-drained substrates, making them ideal for sand-deposited lands. The proposed action plan, therefore, emphasizes fodder crops and vegetables as viable alternatives, contributing to food security, income diversification, and resilience against flood-induced agricultural losses.

Overall, the study demonstrates that although the extent of suitable sand-deposited land is limited, targeted and informed land-use planning can transform these marginal landscapes into productive resources. The integration of hydro-geomorphological, soil, land capability, and socio-economic factors through geospatial techniques offers a comprehensive framework for sustainable land and water resource management. The findings emphasize the need for long-term, adaptive land action plans that balance environmental constraints with livelihood needs, thereby promoting sustainable development in flood-prone river basins.

Finding

From the suitability map, it came into sight that Minalpur Village, Notungaon, and Dighal-Tarang Tea Estates sites are highly covered with siltation.

The primary occupations of Minalpur Village and Notungaon were agriculture, but with phases of time, the activities shifted to fishing, grazing,*etc.*

Most of the agricultural land had been converted to sedimentation due to the action of the river.

Because of the geo-environmental issues, there is a shift in activities from paddy cultivation to fodder crops.

The optimum land use action plan had been prepared to mitigate the fluvio-geomorphic problem. A land management action plan to utilize sand deposited bare ground is suggested and implementation.35.13 km^{2}areasare suggested to be fodder crops and vegetables like potatoes, papaya, chilly, and maize.

Conclusion

The sustainable development of siltation soils has never received any serious attentionbefore era, but this can be used as an asset to sustain the world population growth with the productivity of other ecosystems. However, nowadays, there is constant pressure to expand the unproductivity land into productive by following traditional or scientific tools. Regarding agricultural management, sandy soils present several economic problems for sustaining the farmers. Therefore, the economic viability of agriculture on these soils is the challenge that becomes the next frontier to be crossed for agriculture development.

The degradation of agricultural land is the product of complex interactions among rainfall-regimes, soil characteristics, vegetation cover, and actions of water, erosion, deposition, land use, and management.

However, there is a consensus that human activities are accelerating the degradation process, affecting macroscopic life and microscopic organisms. Therefore, it is essential to develop effective soil conservation strategies to stop the degradation process and enable sustainable production of crops.

Acknowledgment

The authors express their sincere gratitude to their respected supervisor for valuable guidance, insightful suggestions, and continuous encouragement throughout the preparation of this research paper. They also extend heartfelt thanks to the Editor of the journal for professional support and cooperation during the publication process. Finally, sincere appreciation is conveyed to all individuals and institutions whose direct or indirect support made this work possible.

Author contributions

GS conceived the idea and designed the methodology. GS collected the data from the field and analysis. GS led to the writing of the manuscript, data analysis, and interpretation and contributed to the final drafting of this manuscript. GT act as the supervisor for this manuscript. PMS supported for carrying the research work in the institution

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare no conflict of interest in the completion of the work.

ORCID ID:

https://orcid.org/0000-0002-8859-6130 (Dr.GitikaThakuriah)

https://orcid.org/0000-0003-2896-7320 (GulapSonowal)

Social media Profile:

GulapSonowalandGitikaThakuriah(Linkedln)

Referrences

Abdel and Elzain, S., 2007. A tillage implements performance and their effects on two types of soil in Khartoum area (Doctoral dissertation, M.Sc. thesis. Faculty of Agriculture. University of Khartoum).

Al-Taani, A.A. Nazzal, Y. Howari, F.M., Iqbal, J., Bou Orm, N., Xavier, C.M., Barbulescu, A., Sharma, M., and Dumitriu, C-S. (2021). Contamination Assessment of Heavy Metals in Agricultural Soil, in the Liwa Area (UAE). *Toxics,* 9 (3), 53, p.1-13.

Beek, K.J., 1980. From soil survey interpretation to land evaluation. Land reclamation and water management 29 pp. http://www.alterra.wur.nl/Internet/webdocs/ilri-publicaties/publicaties/Pub27/pub27-h2. Pdf.

Binte Mostafiz, Rubaiya, Ryozo Noguchi, and Tofael Ahamed. 2021. Agricultural Land Suitability Assessment Using Satellite Remote Sensing-Derived Soil-Vegetation Indices. *Land,* 10 (2), p.1-26. DOI:10.3390/land10020223

Bisht, M., Natung, N.T., Singh, G.K., and Sangtam, S.L., 2023. Study on controlling of soil erosion by soil conservation techniques. *Journal of Environmental Engineering and Its Scope,* 6 (2), p.1-13.

F.A.O., 2017. *The Future of Food and Agriculture, Trends and Challenges*; FAO, Rome, Italy, ISBN 9789251095515.

Haque MN, Fatema K, Joy MAR. 2022. Crop suitability analysis by adopting geo-spatial algorithm: a case study of Sirajganj district (floodprone area) in Bangladesh. *Arab Gulf Journal of Scientific Research: Water, Energy, Food and Environment*, 40 (4), p.392-414. DOI:10. 1108/ AGJSR- 07- 2022- 0118

Kopittke, P.M., Menzies, N.W., Wang, P., McKenna, B.A., and Lombi, E., 2019.Soil and the intensification of agriculture for global food security. *Environmental International,* 132, 105078. DOI:10.1016/j.envint.105078.

Kufmann, C., 2003. *Soil types and eolian dust in high-mountainous karst of the Northern Calcareous Alps* (Zugspitzplatt, Wetterstein Mountains, Germany).

Lal, R.,2009.Soil degradation as a reason for inadequate human nutrition. *Food Secur,* 1, p.45-57 [CrossRef].

Lal, R.,2012.Climate Change and Soil Degradation Mitigation by Sustainable Management of Soils and Other Natural Resources. *Agricultural Research*, 1, p.199-212 [CrossRef].

Lee, T.M. and Yeh, H.C., 2009. Applying remote sensing techniques to monitor shifting wetland vegetation: a case study of Danshui River estuary mangrove communities Taiwan. *Ecological Engineering,* 35 (4), p.487-496. DOI:10.1016/j.ecoleng. 2008. 01. 007.

Liang H, Xian Y and Wang X. 2024. Preparation and application of single-atom nanozymes in oncology: a review. Front. Chem. 12:1442689. DOI: 10.3389/fchem.2024.1442689

Li, H., Bulcke, J. van den, Mendoza, O., Deroo, H., Haesaert, G., Dewitte, K., Neve, S. de, and Sleutel, S., 2022. Soil texture controls added organic matter mineralization by regulating soil moisture-evidence from a field experiment in a maritime climate. *Geoderma,* 410, 115690. DOI:0.1016/j.geoderma. 2021. 115690.

Manral, V., Bargali, K., Bargali, S.S., Jhariya, M.K., and Padalia, K., 2022.Relationships between soil and microbial biomass properties and annual flux of nutrients in Central Himalaya forests.*IndiaLand Degradation & Development,* 33 (12), p.2014-2025. DOI:10.1002/ldr. 4283.

Manral, V., Bargali, K., Bargali, S.S., Karki, H., and Chaturvedi, R.K., 2023.Seasonal dynamics of soil microbial biomass *C*, *N* and *P* along an altitudinal gradient in central Himalaya. *India Sustainability,*15 (2), p.1-11. DOI:10.3390/su150 21651.

Martin, D. and Saha, S.K., 2009. Land evaluation by integrating remote sensing and GIS for cropping system analysis in a watershed. *Current science*, p.569-575.

Mazahreh S, Bsoul M, Hamoor DA. 2019. GIS approach for assessment of land suitability for different land use alternatives in semiarid environment in Jordan: case study (Al Gadeer Alabyad-Mafraq). *Information Processing Agriculture,* 6 (1), p.91-108. DOI:10. 1016/j.inpa. 2018. 08. 004

Mokarram M, Roshan G, Negahban S. 2015. Landform classification using topography position index (case study: salt dome of Korsia- Darab plain, Iran). *Model Earth Syst Environ,* 1 (4), p.1-7. DOI:10. 1007/ s40808-015- 0055-9

Moller AB, Mulder VL, Heuvelink GB, Jacobsen NM, Greve MH. 2021. Can we use machine learning for agricultural landsuitability assessment?. *Agronomy*, 11 (4), 703. DOI:10.3390/ agron omy11 040703

Morales F, de Vries WT. 2021. Establishment of land use suitability mapping criteria using analytic hierarchy process (AHP) with practitioners and beneficiaries. *Land*, 10 (3), 235. DOI:10. 3390/ land1 00302 35.

Ohu, J.O., Ayotamuno, M.B., and Folorunso, O.A., 1987. Compaction characteristics ofprominent agricultural soils in Borno State of Nigeria. *Transactions of the American Society of Agricultural Engineers.* 30 (6), p.1575-1577. DOI:10.13031/2013.30604.

Pandey, R., Rawat, M., Singh, R., and Bala, N., 2023. Large scale spatial assessment, modelling and identification of drivers of soil respiration in the Western Himalayan temperate forest. *Ecological Indicators,* 146, 109927. DOI:10.1016/j.ecolind. 10992.

Perveen F, Nagasawa R, Uddin MI, Delowar HK. 2007. Crop land suitability analysis using a multicriteria evaluation and GIS approach. *In*: 5th International Symposium on Digital Earth, (ISDE5), 5 (9), p1-12.

Pilevar AR, Matinfar HR, Sohrabi A, Sarmadian F. 2020. Integrated fuzzy, AHP and GIS techniques for land suitability assessment in semi-arid regions for wheat and maize farming. Ecol Indic 110 (August 2019):105887. DOI:10. 1016/j. ecoli nd.2019. 105887.

Radočaj D, Jurišić M, Zebec V, Plaščak I. 2020. Delineation of soil texture suitability zones for soybean cultivation: a case study in Continental Croatia. *Agronomy,* 10 (6), 823. DOI:10. 3390/ agron omy10060823.

Radočaj D, Jurišić M, Gašparović M, Plaščak I, Antonić O. 2021. Cropland suitability assessment using satellite-based biophysical vegetation properties and machine learning. Agronomy, 11 (8), 1620. DOI:10. 3390/ agron omy11 081620

Rahman, M.M., Kamruzzaman, M., Shahid. 2023. A GIS Framework to Demarcate Suitable Lands for Combine Harvesters Using Satellite DEM and Physical Properties of Soil,*Journal of Geovisualization and Spatial Analysis,* 7 (27), p.1-18. DOI:10.1007/ s41651-023-00156-y.

Roger-Estrade, J., Anger, C., Bertrand, M., and Richard, G., 2010. Tillage and soil ecology: Partners for sustainable agriculture. *Soil Tillage Research,* 111 (1), p.33-40. DOI:10.1016/j.still.2010.08. 010.

Saaty, T., 2008. Decision-making with the analytic hierarchy process. *International Journal of Services Sciences,* 1, p.83-98. DOI:0.1504/ IJSSCI.2008.01759.

Sahu, N., Vasu, D., Sahu, A., Lal, N., and Singh, S.K., 2017. Strength of microbes in nutrient cycling: A key to soil health. In:Meena, V., Mishra, P., Bisht, J., and Pattanayak,A. (eds.), *Agriculturally importantmicrobes for sustainable agriculture.* Singapore: Springer.

Salvador Ferreira de Holanda, Luciano Kayser Vargas, Camille Eichelberger Granada. 2023. Challenges for sustainable production in sandy soils: A review Environment, Development and Sustainability.

Selmy, S.A.H., Abd Al-Aziz, S.H., Ibrahim, A.G., Jiménez-Ballesta, R.,2022. Impact of Short-Term Cultivation on Some Selected Properties of Sandy Soil in an Arid Environment. *Soil Systems,* 6 (4), 82. DOI:10.3390/ soilsystems6040082.

Seyedmohammadi J, Sarmadian F, Jafarzadeh AA, McDowell RW. 2019. Development of a model using matter element, AHP and GIS techniques to assess the suitability of land for agriculture. *Geoderma*, 352, p.80-95. DOI:10. 1016/j. geode rma. 2019. 05. 046.

Silva, T.P., Morais, I.S., Santos, G.L., Zonta, E., Pinto, L.A.S.R., Fagundes, H.S., Pereira, M.G., 2023. Biogenic and physicogenic aggregates as indicators of quality in soils with sandy texture in areas of organic agriculture. *Revista Brasileira de Ciencia do Solo,* 47, e0230007. DOI:10.36783/18069657rbcs20230007.

Sonowal, G, Thakuriah, G., and Hazarika, S., 2022. Role of Channel migration and influencing hydro-geomorphic attributes in Dibru River Basin using remote sensing and GIS. *Nature environment and pollution technology*, 21 (5), p.2035-2054.

Sonowal, G. and Thakuriah, G., 2023. Using Geospatial tools to detect the Flood hazards in Dibru River Basin, Assam (India). *Disaster Advances*, 16 (1), p.42-52.

Stoops, G. and Schaefer, C.E., 2018.*Pedoplasmation: formation of soil material*. In Interpretation of micromorphological features of soils and regoliths, Elsevier.

Taghizadeh-Mehrjardi, Ruhollah, Kamal Nabiollahi, Leila Rasoli, Ruth Kerry, and Thomas Scholten. 2020. "Land Suitability Assessment and Agricultural Production Sustainability Using Machine Learning Models". *Agronomy,* 10 4, 573. DOI:10.3390/agronomy10040573

Tahat, M.M., Alananbeh, K.M., Othman, Y.A., and Leskovar, D.I., 2020.Soil health and sustainable agriculture.*Sustainability,* 12, 4859. DOI:10. 3390/SU121 24859.

Usman, M., Farooq, M., Wakeel, A., Nawaz, A., Cheema, S.A., Rehman, H. Ur., Ashraf, I., and Sanaullah, M., 2020. Nanotechnology in agriculture: Current status, challenges and future opportunities. *Science ofthe Total Environment, Elsevier BV,* 721. DOI:10.1016/j.scitotenv.137778.

Yang H, Ma W, Liu T, Li W., 2023. Assessing farmland suitability for agricultural machinery in land consolidation schemes in hilly terrain in China: a machine learning approach. *Frontiers in Plant Science,* 14, 1084886. DOI:10. 3389/ fpls. 2023. 10848 86

Yigeltu, E. and Alemu, A., 2022. Land suitability evaluation for surface irrigation using ARC-GIS and analytical hierarchy process techniques in Bedessa River Basin, Gedio Zone, Ethiopia. *Abyssinia Jurnal of Science and Technology,* 7 (2), p.11-25. DOI:10.20372/ajst.7. 2. 764.

Zahidul Islam, S. M., Rashadul Islam, Faruk Hossen, Kazi Mahtab-ul-Islam, Md. Rakibul Hasan, and Rezaul Karim. 2021. Moringa oleifera is a Prominent Source of Nutrients with Potential Health Benefits. *Hindawi International Journal of Food Science*, Volume 2021, Article ID 6627265, 11pp. DOI:10.1155/2021/6627265

Ziadat, F. and Al-Bakri, J.T., 2006. Comparing existing and potential land use for sustainable land utilization. *Jordan Journal Agricultural Science,* 2 (4), p.372-386.

Ziadat, F., 2007. Land suitability classification using different sources of information: soil maps and predicted soil attributes in Jordan. *Geoderma,* 140(1-2), p.73-80. DOI:10.1016/j.geode rma.2007.03. 004.

Ziadat, F. and Sultan, K.A., 2011. Combining current land use and farmers' knowledge to design land-use requirements and improve land suitability evaluation. *Renewable Agriculture and Food System,* 26 (4), p.287-296. DOI:10.1017/S1742 1705110000 93.

Ziadat, F. and Al-Bakri, J.T., 2015. Comparing Existing and Potential Land Use for Sustainable Land Utilization Comparing Existing and Potential Land Use for Sustainable Land Utilization. *Jordan Journal of Agricultural Sciences,* 2.