Knowledge-based Engineering and Sciences (2023), **4**, (1), 1–18
doi:10.51526/kbes.2023.4.1.1-18

RESEARCH PAPER

Agricultural potential zone mapping with surface water resource management using geo-spatial tools for Jhargram district, West Bengal, India

Jatisankar Bandyopadhyay,[*,1] SK Habibul Rahaman,[1] and Chandan Karan[2]

[1]Department of Remote Sensing and GIS, Vidyasagar University, Midnapore 721102, India
[2]Faculty of Geography, Seva Bharati Mahavidyalay
[*]Corresponding author. Email: jatib@mail.vidyasagar.ac.in

(Received 08 December 2022; revised 16 March 2023; accepted 25 March 2023; first published online 30 April 2023)

Abstract

Regional development is an effort to improve the people's standard of living and Socio-economic development by the fight of hard efforts against the extreme adversities of Nature. This pattern is especially noticeable among the residents of the Lateritic zone of Jhargram district in the Jungle Mahal region. The Jhargram Jungle Mahal region is composed mainly the tertiary gravel ferrous materials and older alluviums of South Western margin of West Bengal. About 40% peoples are directly engaged to agriculture system, where 30% of area depend on Monocrop production system due to the water crisis, pedogenic unevenness and not implemented of proper scientific methods for agriculture development; as a result more than 50% and ancient host people are suffering from food insecurity or scarcity also and malnutrition. Therefore proper agricultural zone identification is more essential for this region. This investigation is applied AHP with multi-criteria decision analysis (MCDA) methods for calculating the agricultural potential zone mapping (APZM). Thus, the good potential zone is covered 166032.5 hectare in the Jhargram district and this areas percentage is 54.05%. Then the moderate area is 20857.2 hectare area and of this area's percentage is 6.79%. And the last categories area is covered at last 8628.021 hectare area and the percentage are 2.81%. That APZM proposed method will be used for agricultural planning and assessment purpose for regional development of the Lateritic upland area of Jhargram district.

Keywords: Agriculture Potential Zone Mapping; water crisis; Geo-spatial Techniques; Analytical Hierarchy Process (AHP); Regional development.

1. Introduction

The geological formation of the Jhargram district is mainly lateritic, which occupies the central in addition to the southern parts of this area, whereas the eastern part gradually gives way to the alluvium of the Lower Ganga plain. That lateritic zone of Jungle Mahal area has paedogenic unevenness of the soil geomorphology, which consists of around 5.5 to 6.5 pH level and poor in calcium, organic matter, and available phosphates concentrated with little water holding capacity zone. Some portions of the district red graveled and sandy soils appear with few patches of older alluvium. In the lateritic tracts of Jhargram district are mostly loam and sandy loam soils cover and same part is alluvial zone [1], [2].

The land use and land cover (LULC) pattern of an area was an outcome of the natural and socio-economic parameter and applied by the man in time and space [3]. In terms of land use, agriculture and bare land with/without scrub contributed mass majority to total soil losses and are reasonably stumpy in dense forest area of Jhargram district [4], [5]. So, LULC this study is extremely significant for understanding the connections and interactions between anthropogenic activities and ecological occurrences for better decision-making and land use management [6], [7]. Land use in Jhargram from its origin is dominated by agricultural activities is under-developed and in a state of static condition. Aus, Aman and Boro paddy are the principal agricultural crops produced in the district. Apart from these many other different crops are grown in the district such as wheat, sugarcane, pulses, oil seeds as, mustard, groundnut, vegetables as potato, tomato, cabbage, cauliflower, brinjal, cucurbits, onions etc.

Using the Geo-spatial remote sensing (RS) and geographic information system (GIS) data with intensive field verification, more than 60% of the land area is under the Lateritic Zone with forest cover and also 40% of area is dominated by the Lateritic upland; which is infertile soil and less agriculture area due to scarcity of water. The annual rainfall is occurring about 157 cm to 185 cm (yearly). But the slope of lateritic upland is steep to moderate; as result the surface water in rainy season is quickly flowing down [8].; that's way that the area is comes under the draught phone area. Jhargram district constant is eight block these are Jhargram, Binpur-I, Binpur-II, Jamboni, Gopiballavpur-I, Gopiballavpur-II, Nayagram and Sankrail. About 40% of peoples are directly engaged to agriculture system, where 30% of area depends on Monocrop production system due to the water crisis, paedogenic unevenness [9]. As a result, more than 70% and ancient host people are suffering from food insecurity also and malnutrition. It is right time to think to find out the Agriculture Potential Zone Mapping (APZM) and Surface Water Management (SWRM) and for innovating Idea and techniques. For the potential zone mapping AHP with MCDA methods are widely applied in various parts of the earth's surface like rice potential zones, hospital side suitability [10], groundwater potential zone [11], [12], residential area identification and many more [13]–[15]. This method is more useful for the decision making, policy assessment and future planning purpose, therefore many agencies, government bodies and others stakeholders are applied this method for sustainable planning purpose.

Some researchers noted and mentions that, how to deal with the problem of soil erosion in a specific geographical area [4]. It is hoped that this article will make it easier to manage land use overall. Researchers are mentions how to deal with the problem of soil erosion in a specific geographical area. This article is expected to make it easier to manage land use overall. This article also discusses the extent of soil erosion and how to solve the various problems of the people in that area. This article also shows how people are changing the way they use land in the forest environment. Some study in the case of Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times [16], [17]. Timely and accurate change detection of Earth's surface features provides the foundation for a better understanding of the relationships and interactions between human and natural phenomena in order to better manage and use resources. Another investigation noted and mentions the objective groundwater vulnerability Assessment to delineate that are more susceptible to contamination from anthropogenic source has become an important element for sensible natural resource management and land use and land cover planning of Janghalmohal area [8]. The main objective of this study is to find out the agricultural potential zone of Jhargram district with the help of AHP and MCDA methods for sustainable agricultural production. The district models have considered seven permanents viz. Depth to water level, net recharge, aquifer material soil material topography: impact of vadose zone and conducted. The main objective of this research is to find out the agricultural potential zone mapping and sustainable development over the Jhargram district using AHP methods to identifying the variation of agricultural sustainability.

2. Study Area

The Jhargram District of West Bengal in India lies between $86°34'0''E$ - $87°20'0''E$ longitude and $22°52'0''N$ - $22°48'0'N$ latitude on the globe. The district lies between the Kangsabati River in the north and the Subarnarekha in the south. The study area is experiencing a southwest monsoon climatic zone. Temperature hovers around 32°C and at night it feels like 25°C. In September, the annual rainfall is occurring about 140 cm to 160 cm. The hydrology condition is quite suitable for agriculture practice (Fig 1). The supplementary surface water source for agricultural use is rivers, channels, wells and pond. Jhargram district covers an area of 3037.64 Km^2. Out of which 268249 hectares is agricultural land and 59497 hectares is under forest coverage. The district is a part of Chota Nagpur Plateau which gradually slopes down towards east, hilly terrain occurs in the north-western part of the district. Agricultural production in this district is more vulnerable and mainly fruit, vegetable, and some crop productions are there, but climatic conditions and high humidity destroyed the local agricultural production. Therefore agricultural zone mapping over the study area is essential for sustainable agricultural production. Therefore this study is useful for the identification of agricultural zone over the study area.

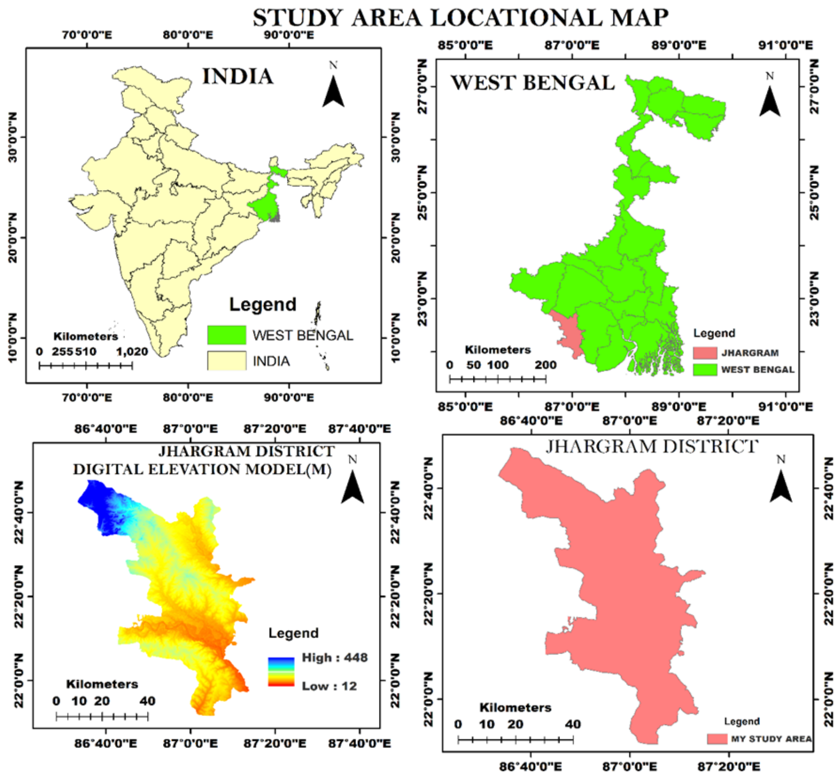

Figure 1: *Location Map of the Jhargram District.*

3. Materials and Methods

3.1 Data Used

From the perspective of Agriculture Potential Zone Mapping with water resource management using Geospatial Techniques of Jhargram District in Janghalmohal geographical area are consistently carried out both primary and secondary data. That Method will be pioneer steeps for the construction of research proposal as well as research report. Primary data will be collected through intensive field investigation with Image processing and GIS software using Landsat 8 OLI/TIRS satellite images using Geo-spatial techniques. Study of the physical condition of the soil, chemical condition of the soil, surface water and drainage network system access to the pixel value of the original images supervised classification And Secondary data will be collected land use land cover through various Govt. officials (West Bengal Block Land and Land Reforms office, Local Panchayats etc.) Local NGO's and others literatures for preparing of land use land cover classes, Agricultural diversity cropping pattern of Jhargram district in Janghalmohal geographical area (Table 1).

Table 1: *Details about data used.*

Parameters	Data	Sources	Others Information
NDBI	Landsat 8	https://earthexplorer.usgs.gov/	Date 15/03/2021
NDVI	Landsat 8	https://earthexplorer.usgs.gov/	Path/Row 139
LULC	Landsat 8	https://earthexplorer.usgs.gov/	and 044/049
Surface Water	Landsat 8	https://earthexplorer.usgs.gov/	with cloud cover <5%
SOIL	Secondary	SoilGrids250m2.0	
Geology		https://bhukosh.gsi.gov.in/Bhukosh/Public	
Geomorphology		https://bhukosh.gsi.gov.in/Bhukosh/Public	
Drainage	SRTM DEM	https://earthexplorer.usgs.gov/	Date23/09/2014 Coordinate
Slope	SRTM DEM	https://earthexplorer.usgs.gov/	21,86; 21,87;
Rainfall		https://crudata.uea.ac.uk/cru/data/hrg/	22,86; and 22,87
Population Density	Census 2011	Economics and Statistics Department	

Gradually we have special need to collect the primary data on the conservation of surface water as well as the selection of suitable sites for agricultural practices as a particularly fundamental problem in the Jhargram geographical area. Primary data related to various types of soil samples and various land use related to agricultural data have to be surveyed for accurate land survey and information has been collected in different places with the help of RS-GIS method. As a suitable place to collect primary data, GPS points have been made at different places in each block of the entire Jhargram district to collect information on soil pH, Nitrogen, Organic carbon, etc. Tested data has also been collected on what types of crops have been cultivated which is expected to facilitate potential positive planning.

3.2 Prepare the criteria

The present study is done mainly with the help of the Primary and Secondary datasets. Mainly physical condition and chemical condition of the soil, Surface water and drainage network system, Agricultural map and LULC of the study area has been analyzed in the laboratory, different techniques were performed with the help of Image processing and GIS software using Landsat 8 OLI/TIRS data. All the images were mosaicking and subset to the boundary of Jhargram District. Image processing was completed using ERDAS imagine software v2014 environment. It has been adjusted by suitable color balancing and data scaling technique. Land use/ land cover map was prepared based on the visual interpretation technique on Landsat 8 OLI/TIRS data and verified with spectral signatures for each class, District Planning map, topographic maps and ground truth points. Jhargram district is classified into seven LULC classes which are water body, vegetation cover, flooded vegetation, agriculture, build-up area/settlement area, sand and bare land. The drainage lines were mapped through this 5.8meter resolution imagery and topographic maps and DEM data will help to check the accuracy. The lineaments are extracted from the drainage pattern of this study area. In that hard rock topography, the drainage pattern helps to identify the lineament structure (Fig 2).

Geo-referenced ASTER GLOBAL elevation data from a 30-meter tiles (1 arc second) digital elevation model of the study sites were collected from USGS Earth Explorer (http://earthexplorer.usgs.gov/) and the data were overlaid throughout the model. Advanced Space-borne Thermal Emission and Reflection (ASTER) elevation data was used to generate the slope map, flow accumulation map and stream ordering. The different types of DEM analysis and processes for generating different types of thematic maps are done on ArcGIS 10.8 environment. The thematic layers (drainage density, soil, geology, geomorphology, land use/land cover, etc.) were prepared with the help of ArcGIS 10.8 environment. After reclassifying, the criteria have been merged through assigning weighted values for each and every class of the layers. Finally, the Agricultural potential zones were identified using overlay analysis method.

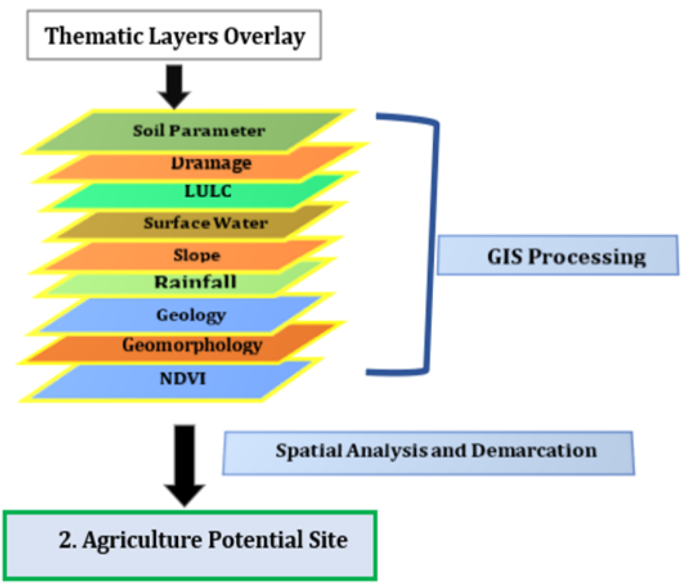

Figure 2: *Geo-processing for weighted calculation.*

3.2.1 Soil pH

The pH of the soil is most important for plant growth. The pH value represents the amount of free or active acidity and not the total quantity of potential or combined acidity. In other words, it represents the intense acidity of a solution. Depending upon the preponderance of hydrogen or hydroxyl ions, soils may be acidic, alkaline or neutral in reaction. Those having pH less than 7.0 are acidic soils, and those greater than 7.0 are alkaline. For practical purpose, soils having pH ranging from 6.5 to 7.5 are considered neutral though they are very slightly acidic or alkaline as indicated by this range it is of no consequence as far as crop growth is concerned. Soils having pH between 6.0 and 5.0 are considered moderately acidic, those between 5.0 and 4.0 are strongly acidic, while those having pH less than 4.0 are extremely acidic. Such soils are usually barren as no plant is able to tolerate such high acidity. In the soil report, it is shown that high pH area is the Gopiballavpur-I, II, Nayagram, Sankrail (Figs 3 and 4).

3.2.2 Organic Carbon

The soil carbon improves the physical properties of soil. It increases the cation exchange capacity (CEC) and water holding capacity of sandy soil and it contributes to the structural stability of clay soils by helping the particles bind into aggregates. Soil organic matter, of which carbon is a major part, holds a great proportion of nutrients, cation and trace elements that are of importance to plant growth. It prevents nutrient leaching and is integral to the organic acids that make minerals available to plants. It also buffers soil from strong changes in pH. It is widely accepted that the carbon content of the soil is a major factor in its overall health. In the soil report, it is shown that the high organic carbon area value is 0.28%. The high concentration of organic carbon is suitable for paddy and vegetable cultivation.

3.2.3 Nitrogen

The availability of nitrogen is controlled mainly by microbial activity. One of the principal objectives for including a legume in farming rotation is to improve the reserves of nitrogen (N) in the soil. Once soil N levels have been raised, the stored N can be utilized by a period of cropping. In the soil report, it can be shown that the high-nitrogen area is the North- Western part of Binpur-I and south part of Jhargram and the western part of Jamboni Block, the value is 210 kg/ha. The high concentration of nitrogen is suitable for paddy, potato, and vegetable cultivation.

3.2.4 Drainage system

The study area has a good network of the drainage system. The drainage map of the study area. The study area is situated in Kangsabati, Subarnarekha, Dulung and Tarafaeni river basins, where a few of the canals are the most important for agriculture purpose.

3.2.5 LULC

In this study essential step was LULC. Land Use Land Cover map help to delineate the several fracture of the study area. There was Seven Classes for classification, Water Body, Vegetations Cover, Flooded Vegetation, Agriculture Land, Build-up/Settlement area, Sand and Bare land. It's classified by supervised classification by maximum likelihood in ERDAS imagine software. It can help to specify the several pixel values.

3.2.6 Surface water

Surface Water supply in this study area is Moderate. In this District most blocks of Agriculture are dependent on Surface Water. There are Different types of Surface Water in this area. Permanent Surface Waters are present year-round, and includes lakes, rivers wetlands. New Permanent Surface Water are located channels, dammed artificial lakes and ponds. Ephemeral Permanent Surface Water refers to bodies of water that are only present of the year include channels such as some ponds, creeks, lagoons and waterholes. Seasonal Surface water is usually seen in Rivers, channels and some ponds during monsoons.

3.2.7 Slope

The district part of Chota Nagpur Plateau which gradually slopes down towards East, hilly terrain occurs in the north–western part of the district. Slope map has been prepared from DEM data. Slope map is prepared using ArcGIS slope tool. The district slope layer is divided by four classes, 0–3.4 range of slope indicate Very Low, 3.4–8.6 indicate Low, 8.6–20.3 indicate High and 20.3–87.7 range of slope indicate Very High. Kakrajhore area is having the highest altitude of about 300mts, Nayagram, Gopiballavpur-1 and 2 blocks are having the altitude of about 65mts and Jhargram town altitude is around 80mts.

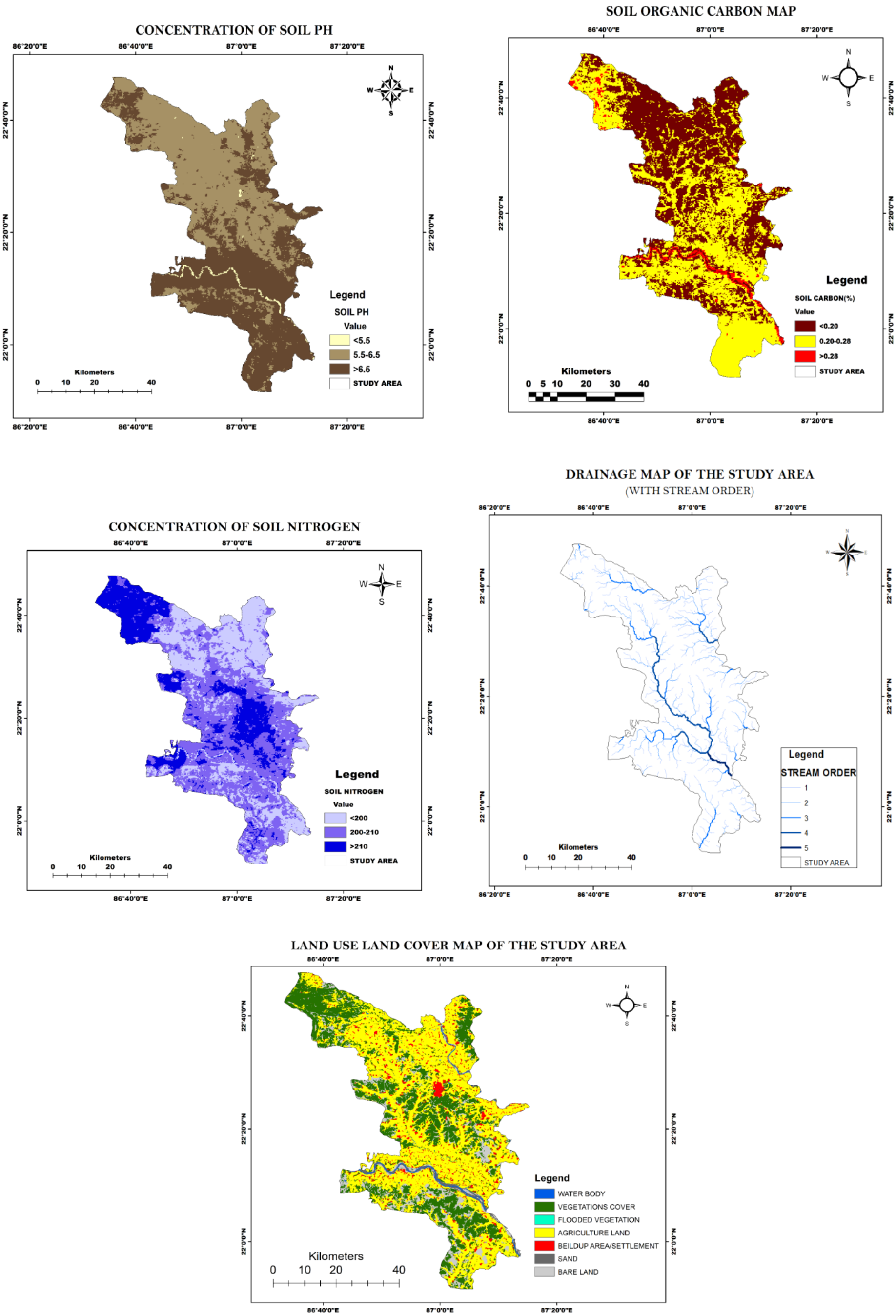

Figure 3: *Criteria maps of the study area.*

3.2.8 Rainfall

Rainfall map has been prepared from Rainfall CRU (Climatic Research Unit) data 2021. Total Jhargram district area is divided into five classes, like 161 – 168mm, 169 – 175 mm, 176 – 181 mm, 182 – 188mm, and 189 – 195 mm.

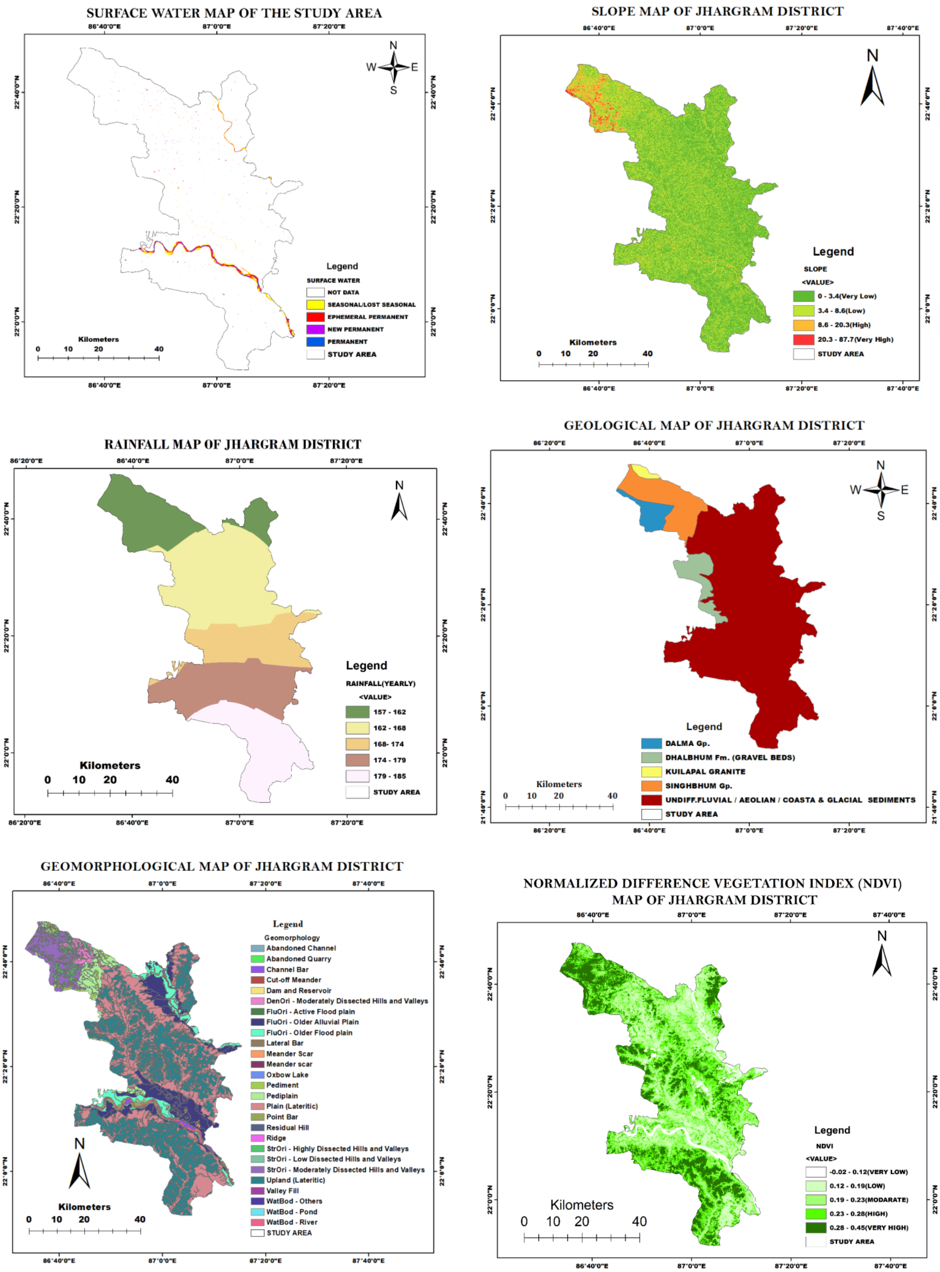

Figure 4: *Criteria maps of the study area.*

3.2.9 Geology

Jhargram district covers an area of 3037.64 sq/km. Out of the which 268249 hectare is Agriculture land and 59497 hectare is under forest coverage. The district is part of chota Nagpur Plateau, which gradually slopes down towards east, hilly terrain occurs in the north-western part of the district. This area is covered with unfertile hard laterite soil/rocks and alluvial soil. 90% cultivated area has lateritic soil and 10% area has alluvial soil. Quartzite, Genesis, Metamorphic, Schist, Limestone, conglomerate are common rocks and minerals found here in the Jhargram district. The Geology map was prepared using satellite data of 2021 and Bhukosh website the geological features digitized from the satellite image. Identified in the study area included Dalma gp, Dhalbhum fm(gravel beds), Kuilapal granite, Singbhum gp, Undiff-flivial/Aeolian/Coastal and Sediments.

3.2.10 Geomorphology

Geomorphological maps help to identify various geomorphic units, surface and groundwater occurrence in each unit. Satellite data is the most useful tool to understand the Geomorphological setting of this area. The secondary data collected from GSI map of Jhargram district. It helps to verify the Geographical feature massed up with the interpretation of the satellite image. The Geological map was prepared using satellite data from 2021 and Bhukosh website the Geomorphological features digitized from the satellite image. The landforms identified in the study area included Active flood plain, Older Alluvial plain, older flood plain, Upland and Plain (lateritic), Pediment, Pediplain, Channel bar, Meander scar, Abandoned channel and quarry, Residual hill, Water body Rivers, pond. Jhargram district other Geomorphological landforms–Cut off meander, Dam and reservoir, Lateral bar, Point bar, Oxbow Lake, Ridge, valley fill, High Low moderate dissected hills and valleys etc.

3.2.11 NDVI

The Normalized Difference Vegetation Index (NDVI) is the basic index for measuring the greenness of the earth surface. The above map shows the distribution of vegetation. NDVI map has been prepared from Landsat 8 data. The Normalized Difference Vegetation Index (NDVI) is a calculation, based on several spectral bands, of the photosynthetic output (amount of green stuff) in a pixel in a satellite image. It measures, in effect, the amount of green vegetation in an area. NDVI calculations are based on the principle that actively growing green vegetation strongly absorb radiation in the visible region of the spectrum while strongly reflecting radiation in the near Infrared region. Total Jhargram district area are divided into five classes, these are, (-0.02 – 0.12Very Low, 0.12 – 0.19Low, 0.19 – 0.23 Moderate, 0.23 – 0.28High, 0.28 – 0.45Very High).

3.3 Reclasssficaiton of the selected criteria

Reclassification was applied to simplify or change the explanation of raster data by changing a single value to a new value [11]. Each criteria source map was reclassified by their dominating suitability Agriculture potential zone site selection. The classification their suitability such as Good, Very Good, Moderate, Poor suitable. Station data converted into raster layers and then calculate in ArcGIS software v10.8. Those criteria were classified as integer raster, represented by different site suitability levels based on their threshold values [18]. Calculate the suitability levels of the agriculture potential zone sites for their chosen weighted score. The suitability analysis requires all criterion maps in a common standard unit. All criteria were placed on the same scale and same unit's for calculating the final site suitability map. In this methodological study, we applied a good, very good, moderate, poor suitable site for Agriculture Potential site selection.

3.4 AHP-based weighted calculation

Analytical hierarchy process is the most acceptable multi-criteria decision-making technique [19]. This process is used for each criterion or sub-criteria to estimate a hierarchical structure by providing the weight value of each criterion or sub-criteria for the decision-making process [20]. In the decision-making process, analytical methods were delivered strong structural stages for quantifying the design criteria and elements in pairwise technique [21]. Using the pairwise comparison matrix, the AHP process identifies the individual weighted score for each criterion and normalizes the sum of the factors to unity [13], [22], [23]. AHP was used in this study to calculate weights score for the reclassifed and established criteria, by developing a pairwise comparison matrix based on Saaty [22]. The pairwise comparison matrix was calculated using 1–9 score [24], [25] (Table 2 and 3), where 9 indicates highly significant and indicates equal significance [22]. The comparison matrix is the criterion that is mathematically delivered as:n=(n-1)/2 for n numbers of site selection criteria in the pairwise comparison matrix [14], [22], [26]. After calculating the pairwise matrix, weights are calculated using the Saaty method [22]. Analytical hierarchy process is estimated by the consistency ratio (CR) which is measured by Eq. (1). This equation helps to identify the corrected logical contradiction of the pairwise comparison matrix established based on experience or expert judgement.

$$CR = \left(\frac{CI}{RI}\right) \tag{1}$$

where CI indicates the consistency index and RI indicates random index.

$$CI = \frac{(\lambda_{\max} - n)}{(n-1)} \tag{2}$$

Equation (2) indicates the consistency index (CI) when $\lambda_{\max}$ is the highest eigenvector of the computed matrix and n denotes the number of criteria. Random index (RI) is the mean value of the consistency index depending on the matrix order given by Saaty [22]. The RI value for the 9 criteria is 1.45 (Table 4). The CR value is 0.10, and then the weight value of the AHP method may not give the proper results. In this study calculated CR is 0.0801, which is under acceptable limits, and calculated weighted values are usable for Agriculture potential site selection.

Table 2: *Development the pair-wise Comparison Matrix.*

Factor	Development the pair-wise Comparison Matrix								
	Soil Parameter	Drainage	LULC	Surface Water	Slope	Rainfall	Geology	Geomorphology	NDVI
Soil Parameter	1	2	3	2	1	3	3	5	3
Drainage	0.5	1	3	3	4	4	2	5	4
LULC	0.33	0.33	1	3	2	1	3	3	4
Surface Water	0.5	0.33	0.33	1	2	3	3	3	4
Slope	1	0.25	0.5	0.5	1	2	3	4	1
Rainfall	0.33	0.25	1	0.33	0.5	1	1	1	3
Geology	0.33	0.5	0.33	0.5	1	1	1	2	1
Geomorphology	0.2	0.2	0.33	0.33	0.25	1	0.5	1	2
NDVI	0.33	0.25	0.25	0.17	0.25	0.33	1	0.5	1
Total	9.07	10.23	19.5	21.67	24	32.67	35	49	46

Table 3: *Computation of Criterion Weight.*

Factor	Computation of Criterion Weight									
	Soil Parameter	Drainage	LULC	Surface Water	Slope	Rainfall	Geology	Geomo rphology	NDVI	Criteria Weight (Rounded)
Soil Parameter	0.11	0.2	0.15	0.09	0.04	0.09	0.09	0.1	0.07	26
Drainage	0.06	0.1	0.15	0.14	0.17	0.12	0.06	0.1	0.09	21
LULC	0.04	0.03	0.05	0.14	0.08	0.03	0.09	0.06	0.09	16
Surface Water	0.06	0.03	0.02	0.05	0.08	0.09	0.09	0.06	0.09	11
Slope	0.11	0.02	0.03	0.02	0.04	0.06	0.09	0.08	0.02	9
Rainfall	0.04	0.02	0.05	0.02	0.02	0.03	0.03	0.02	0.07	7
Geology	0.04	0.05	0.02	0.02	0.04	0.03	0.03	0.04	0.02	5
Geomo rphology	0.02	0.02	0.02	0.02	0.01	0.03	0.01	0.02	0.04	3
NDVI	0.04	0.02	0.01	0.01	0.01	0.01	0.03	0.01	0.02	2
TOTAL	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	50

Table 4: *Random index for criteria.*

No of Observation	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.51	0.88	1.11	1.25	1.35	1.40	1.45	1.51

3.5 Weighted overlay analysis

The weighted overlay analysis is one of the suitable methods for the site selection of any kind of area (Table 5 and 6). Analytic hierarchy process is used to identify the prominent factors using weighted overlay analysis [27]. Thematic layers were combined in the GIS technique to apply the WOA [28]. In ArcGIS, weighted overlay method needs that all raster must be integer unit for suitable result. The weighted overlay analysis tool measures the suitability index for a pixel by multiplying the site suitability score and the weight for every pixel; the summation of the results yields a suitability map using this formula shown in Eq. (3) [29]–[31].

$$s = \sum w_i X_i \tag{3}$$

where s is the total suitability score, w_i is the weight of the selected site suitability factor i, and X_i is the assigned criterion score of site suitability factor i.

4. Results and discussion

Agriculture potential zone is actually the measure of potential productivity per unit area at an instant lime with specified management inputs which, for a given crop type and level of management, is largely determined by the interaction climate, soil, and terrain. From the Landsat 8 OLI/TIRS data of the year (2021) in this study the agriculture potential zone is shown in these study areas (Fig 5).

In the total geographical area of Jhargram District was classified by the several colour which elaborate the poor to very good various classes. In this study green colour is identify very good potential zone and yellow is identified good in nature and the orange and red colour identify moderate and poor potential zone. In this study the potential zone which is very good that area is covered

Table 5: *Determination of Consistency ratio.*

Factor	STEP-1	STEP-2		
Soil Parameter	1.057615	10.144	Estimation of Lambda	9.929711
Drainage	1.135818	10.426		
LULC	0.696643	10.33	CI	0.1162
Surface Water	0.609834	9.8	CR	0.0801
Slope	0.514773	9.745		
Rainfall	0.31708	9.723		
Geology	0.321429	10.003		
Geomorphology	0.205408	9.565		
NDVI	0.17426	9.631		

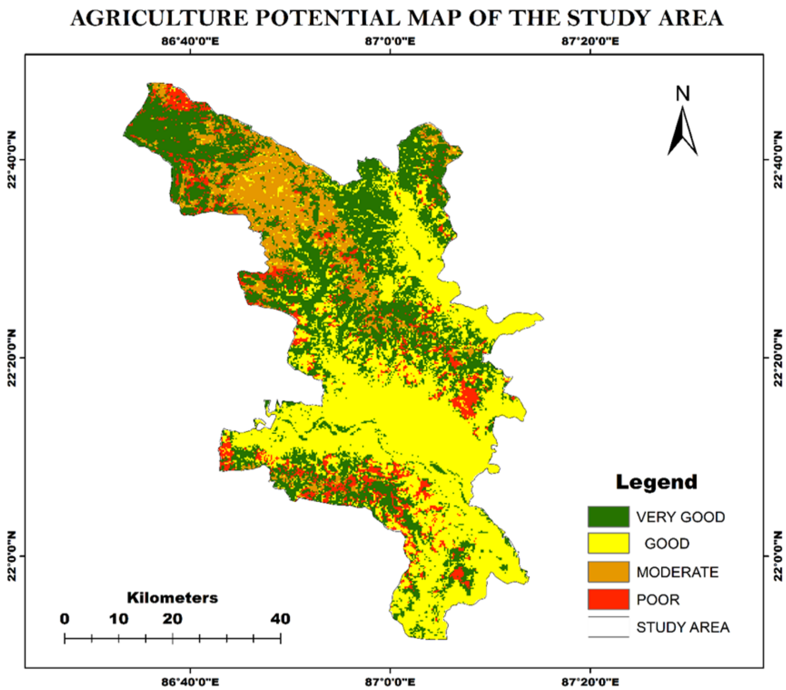

Figure 5: *APZM of the Jhargram district.*

111665.3 (ha) In the total Jhargram District and the percentage of area of this zone is 36.35%. Thus, the good potential zone is covered 166032.5 hectare in the Jhargraandm District and this areas percentage is 54.05%. Then the moderate area is 20857.2 hectare area and of this area's percentage is 6.79%. And the last categories area is covered at last 8628.021 hectare area and the percentage are 2.81% (Table 7).

Where the very good area is covered the total Jhargram District area is 111665.3 hectare here it is seen that there climatic factors are ideal of this area and on this are the water supply is available by the surface or ground water sources. In this area the soil quality is much ideal rather than other categorise

Table 6: *Weights of every criteria.*

Sl. No.	Criteria	Weighted	Influences (%)	Sub-criteria	Suitability Level
1	Soil Parameter	26	0.26	Soil pH	High/ Moderate/ Low
				Soil Organic Carbon	High/ Moderate/ Low
				Soil Nitrogen	High/ Moderate/ Low
2	Drainage System	21	0.21	5	Very High
				4	High suitable
				3	Moderate
				2	Low
				1	Suitable
3	LULC	16	0.16	Water Body/ Sand/Agricultural Land	Not Suitable
				Flooded Vegetation/ Built-up area	Suitable
				Vegetation	Low Suitable
				Bare Land	High Suitable
4	Surface Water	11	0.11	Seasonal/ Lost Seasonal	High Suitable
				Ephemeral Permanent	Moderate Suitable
				New Permanent	Low Suitable
				Permanent	Suitable
5	Slope	9	0.09	0 - 3.4	High Suitable
				3.4 - 8.6	Moderate Suitable
				8.6 - 20.3	Low Suitable
				20.3 - 87.7	Suitable
6	Rainfall	7	0.07	157 -162	Low Suitable
				162 - 174	Moderate Suitable
				174 - 179	High Suitable
				179 - 185	Very High Suitable
7	Geology	5	0.05	Dalma Group	Very High Suitable
				Dhalbhum	High Suitable
				Kuilapal Granite	Moderate Suitable
				Singbhum Group	Low Suitable
				Aeolian	Suitable
8	Geomorphology	3	0.03	Abandoned/Alluvial plain/ Dam and Reservoir/Pediment/Pediplain	Very High Suitable
				Flood plain/ Chanel bar	High Suitable
				Lateritic plain, Upland/	Moderate Suitable
				Cut of meander/ meander scar/ridge/valley fill	Low Suitable
				Waterbody/point bar	Suitable
9	NDVI	2	0.02	Very Low / Low	Very High Suitable
				Moderate	High Suitable
				High	Low Suitable
				Very High	Not suitable

of potential zone. The salinity of soil, moisture of soil is very much ideal in these places. This amount was arrived through all the possible thematic outcomes irrespective of, but all such areas may not be possible for conversion to Agriculture purposes. For example, areas that cannot be radically altered are forest land and cultural land. The detailed study has covered the possibility of conjunctive use of surface water in areas where actual irrigation and agriculture could be undertaken. Irrigation is a way to supply water to soil for cropping and it is mandatory to distribute the water properly towards the comparatively dry cropland area due to un-uniformed rainfall for growing perennial crop. The study explored the possible use of GIS in the area of irrigation water management. In our country, 83% of total water is used in agricultural irrigation sector. It will likely decrease by 10–20% by 2025 to fulfill the requirement of domestic and industrial needs. So, there should be a proper management and utilization of water resource to produce the sufficient crop for food security. The present study to decrease the rainwater during sum- mar season and rainy season surface runoff increase the consumption of water to the soil to decrease the runoff water. To avoid the surface runoff, the policy of planting maximum number of vegetation cover and checking dams to slow down the surface runoff should be followed. Some related studies are also analysis the variation of the different sector, mainly the potential zone identification is more essential for planning and future food scarcity related problems analysis. Some previous studies are established different aspect of AHP methods and applied different sector [30], [32]–[34].

Table 7: *Percentile Suitable area of Agriculture Potential area.*

SL No	Suitability class	Suitable area of Agriculture Potential area	
		Area in hectare(ha)	Area of Percentage (%)
1	Very Good	111665.3	36.35
2	Good	166032.5	54.05
3	Moderate	20857.2	6.79
4	Poor	8628.021	2.81

The main problem of the region in laterite soils is the low fertility and water-holding capacity. Therefore, maintaining the agriculture and Surface Water conservation of the people in this region is very challenging. Different solutions can be made by conducting direct and in-depth field surveys. It is described below-

• The forested abandoned and fallow land should be utilized and deep reservoirs should be constructed on the forested and abandoned land.

• One method that can be used to retain water in those reservoirs permanently is to collect the leaves of trees such as sal, palash, kendu etc. From the forest below the reservoir which falls during winter without setting fire to the forest with the help of local people and collect those leaves one foot below the reservoir. It should be spread wide, then the lining of that leaf should be slightly filled with earth and stones. Then during the monsoon, those leaves will rot a lot and create humic substances. As a result, the water in the reservoir will be prevented from seeping down and water can be permanently stored in the reservoir and can also be supplied to the agriculture lands.

• After constructing the reservoir, the adjacent part of the reservoir cannot be kept open. The tree cover must be increased on the banks of the water reservoir and different kinds of vegetables must be cultivated on the banks of the water bodies, as a result of which the income of the local people will also be maintained and the livelihood of the local people will be widened by cultivating some fish in the water bodies.

• Since laterite soils have very low soil water availability, agriculture land in that region must be cultivated with vegetables that can be grown with less water, such as pulses, soybeans, sesame, peas etc.

5. Limitataions and recommendation

This agricultural zone mapping is more essential for the planning and future food scarcity management purpose, therefore scientists, researchers and planners needs more accurate and cost-effective plan for APZM of earth's surface. Some techniques are established for this area identification, while AHP and MCDA methods are widely applied. The limitation of this study, soil and rainfall-related data acquisition, perfect and spatial distributional datasets have more costly and time taking. LULC classification is more essential therefore field validation of each classes is necessary, Landsat 8 is 30 meter resolution, heterogenus areas are there, so high resolution satellite datasets is needed. Some future planning for this area is groundwater potential zone, drought prone area identification, agricultural area change, forest land change, and soil chemical parameter mesurement.

6. Conclusion

According to the intensive field study with data collection and helps of remote sensing techniques, overall that research project helps to proper understanding of Potential Agriculture Zone identification and side by side surface water resource management in JhangalMohal Geographical area. This study focuses on how the scope of agricultural process in face of everyday human beings is in crisis and the specific outline of surface with subsurface water crisis. This project is to continuous monitoring of changing nature of groundwater level and place-to-place character in various season with the help of Digital Weather Station and measuring instrument by the field work. Regular monitoring the soil health with moisture level is another perspective of that project work. The prepare the sustain guideline about surface water conservation and proper utilization of agricultural practices is vital concluding aspect.

According to District Statistical Handbook report, Medinipur (1996-97) with LISS-IV multispectral satellite data,2010 representing the only 2.71% is water body, 30.1% forest cover, 29 .86% Agricultural paddy land and also 31. 58 % Agricultural fallow land. That is the sign of potential perspectives of Agricultural development in that region. A few covers (2.71%) of water body are the very determinate of continuous practices of Agricultural sectors. The study of land use pattern and analyzing land use patterns of the year 1996-97 and 2010-11 of Jhargram Subdivision reveals the fact that the net sown area has decreased to a very large extent in the study area. According to the block level data the highest amount of decrease of net sown area is seen in Jamboni, Sankrail, Nayagram blocks; moderate amount of decrease is seen at Gopiballavpur-I and Gopiballavpur-II; small amount of decrease can be observed at Jhargram and Binpur-II. The decreasing net sown area of Jamboni has been in tune with the increase of forest area in the block. Also, a large amount of land has been under current fallow in case of Jamboni block. The decrease of net sown area and a considerable amount of area under land other than agricultural uses indicates that cropping land is getting reduced to make way to settled area, transport lines etc. in Sankrail. In case of Nayagram the decreasing net sown area is directly related to increasing forest area in the block. Binpur-I is the only block in Jhargram Subdivision which shows an increase in net sown area over the period of fourteen years. Binpur-I has undergone a moderate reduction of forest area. Thus, although in 201011 the land use pattern is still inclined towards net sown area but the regional variations over a period of fourteen years revels that the use of land as cropping activity is getting replaced either by forest area or by fallow land or by non-agricultural activities. The drought proneness and lack of proper irrigational facilities might have played a role in this departure. So that result concluding by primarily selecting pocket area of Rain and Surface water conservation site and Sustain use of water, secondly prepare the Agricultural potential Zone Mapping and suitable guide line about agricultural sustainability with human development for lateritic fringe people of Jangal Mohal geographical area.

Acknowledgments: The authors thankful to the Vidyasagar University for this research opportunity and truly thankful for local government body for field survey and data collection.

Funding: This research has not received any funding from any source.
Conflicts of Interest: The authors declare no competing interests.

References

[1] N. Kayet et al., “Spatiotemporal LULC change impacts on groundwater table in Jhargram, West Bengal, India,” Sustain. Water Resour. Manag., vol. 5, no. 3, pp. 1189–1200, 2019.
[2] P. K. Shit, A. S. Nandi, and G. S. Bhunia, “Soil erosion risk mapping using RUSLE model on Jhargram sub-division at West Bengal in India,” Model. Earth Syst. Environ., vol. 1, no. 3, pp. 1–12, 2015.
[3] B. Halder, J. Bandyopadhyay, and P. Banik, “Monitoring the effect of urban development on urban heat island based on remote sensing and geo-spatial approach in Kolkata and adjacent areas, India,” Sustain. Cities Soc., vol. 74, Nov. 2021, doi: 10.1016/j.scs.2021.103186.
[4] P. K. Shit, R. Paira, G. Bhunia, and R. Maiti, “Modeling of potential gully erosion hazard using geo-spatial technology at Garbheta block, West Bengal in India,” Model. Earth Syst. Environ., vol. 1, no. 1–2, 2015, doi: 10.1007/s40808-015-0001-x.
[5] M. Mandal and N. Das Chatterjee, “Forest landscape and its ecological quality: A stepwise spatiotemporal evaluation through patch-matrix model in Jhargram District, West Bengal State, India,” Reg. Sustain., vol. 2, no. 2, pp. 164–176, 2021.
[6] Q. Weng, D. Lu, and J. Schubring, “Estimation of land surface temperature–vegetation abundance relationship for urban heat island studies,” Remote Sens. Environ., vol. 89, no. 4, pp. 467–483, 2004, doi: 10.1016/j.rse.2003.11.005.
[7] B. Halder and J. Bandyopadhyay, “Delineation of geospatial indices based water bodies’ and vegetation change mapping using Sentinel-2 imagery in Canning blocks of south 24 parganas district, India,” Remote Sens. Appl. Soc. Environ., vol. 25, 2022, doi: 10.1016/j.rsase.2021.100688.
[8] K. Bera and J. Bandyopadhyay, “Drought Analysis for Agricultural Impact Through Geoinformatic Based Indices, A Case Study of Bankur District, West Bengal, India,” J. Remote Sens. & GIS, vol. 06, no. 03, 2017, doi: 10.4172/2469-4134.1000209.
[9] A. Mukhopadhyay, S. Hazra, D. Mitra, C. Hutton, A. Chanda, and S. Mukherjee, “Characterizing the multi-risk with respect to plausible natural hazards in the Balasore coast, Odisha, India: a multi-criteria analysis (MCA) appraisal,” Nat. Hazards, vol. 80, no. 3, pp. 1495–1513, 2015, doi: 10.1007/s11069-015-2035-9.
[10] B. Halder, J. Bandyopadhyay, and P. Banik, “Assessment of hospital sites’ suitability by spatial information technologies using AHP and GIS-based multi-criteria approach of Rajpur–Sonarpur Municipality,” Model. Earth Syst. Environ., vol. 6, no. 4, pp. 2581–2596, 2020, doi: 10.1007/s40808-020-00852-4.
[11] B. Halder and J. Bandyopadhyay, “Potential sites’ selection of groundwater zones using AHP and GIS-based multi-criteria approach of Kolkata Municipal Corporation,” Int. J. Energy Water Resour., pp. 1–18, 2022.
[12] R. Thapa, S. Gupta, S. Guin, and H. Kaur, “Assessment of groundwater potential zones using multi-influencing factor (MIF) and GIS: a case study from Birbhum district, West Bengal,” Appl. Water Sci., vol. 7, no. 7, pp. 4117–4131, 2017, doi: 10.1007/s13201-017-0571-z.
[13] B. Feizizadeh, P. Jankowski, and T. Blaschke, “A GIS based spatially-explicit sensitivity and uncertainty analysis approach for multi-criteria decision analysis,” Comput. Geosci., vol. 64, pp. 81–95, Mar. 2014, doi: 10.1016/j.cageo.2013.11.009.
[14] A. Dughairi et al., “Citation: Investigation for Solar Power Plant Using GIS, AHP and Multi-Criteria Decision Approach: A Case of Land Suitability Investigation for Solar Power Plant Using GIS, AHP and Multi-Criteria Decision Approach: A Case of Megacity Kolkata, West Bengal, India,” 2022, doi: 10.3390/su141811276.
[15] Y. Ouma and R. Tateishi, “Urban Flood Vulnerability and Risk Mapping Using Integrated

Multi-Parametric AHP and GIS: Methodological Overview and Case Study Assessment," Water, vol. 6, no. 6, pp. 1515–1545, 2014, doi: 10.3390/w6061515.
[16] B. B. Ghute, M. B. Shaikh, and • Bijay Halder, "Modeling Earth Systems and Environment Impact assessment of natural and anthropogenic activities using remote sensing and GIS techniques in the Upper Purna River basin, Maharashtra, India," vol. 1, p. 3, doi: 10.1007/s40808-022-01576-3.
[17] D. Tewabe and T. Fentahun, "Assessing land use and land cover change detection using remote sensing in the Lake Tana Basin, Northwest Ethiopia," Cogent Environ. Sci., vol. 6, no. 1, p. 1778998, Jan. 2020, doi: 10.1080/23311843.2020.1778998.
[18] K. Tienwong, S. Dasananda, and C. Navanugraha, "No Title," ScienceAsia, vol. 35, no. 2, p. 170, 2009, doi: 10.2306/scienceasia1513-1874.2009.35.170.
[19] M. A. Al-Shalabi, S. Bin Mansor, N. Bin Ahmed, and R. Shiriff, "GIS based multicriteria approaches to housing site suitability assessment," in XXIII FIG congress, shaping the change, Munich, Germany, October, 2006, pp. 8–13.
[20] G. A. Kiker, T. S. Bridges, A. Varghese, T. P. Seager, and I. Linkov, "Application of Multicriteria Decision Analysis in Environmental Decision Making," Integr. Environ. Assess. Manag., vol. 1, no. 2, p. 95, 2005, doi: 10.1897/ieam_2004a-015.1.
[21] W. Miller, M. G. Collins, F. R. Steiner, and E. Cook, "An approach for greenway suitability analysis," Landsc. Urban Plan., vol. 42, no. 2–4, pp. 91–105, 1998, doi: 10.1016/s0169-2046(98)00080-2.
[22] T. L. Saaty, "A scaling method for priorities in hierarchical structures," J. Math. Psychol., vol. 15, no. 3, pp. 234–281, 1977, doi: 10.1016/0022-2496(77)90033-5.
[23] J. Malczewski, "GIS-based land-use suitability analysis: a critical overview," Prog. Plann., vol. 62, no. 1, pp. 3–65, 2004, doi: 10.1016/j.progress.2003.09.002.
[24] T. L. Saaty, "Decision making with the analytic hierarchy process," Int. J. Serv. Sci., vol. 1, no. 1, p. 83, 2008, doi: 10.1504/ijssci.2008.017590.
[25] T. L. Saaty, Theory and applications of the analytic network process: decision making with benefits, opportunities, costs, and risks. RWS publications, 2005.
[26] B. Halder, J. Bandyopadhyay, and P. Banik, "Assessment of hospital sites' suitability by spatial information technologies using AHP and GIS-based multi-criteria approach of Rajpur–Sonarpur Municipality," Model. Earth Syst. Environ., vol. 6, no. 4, 2020, doi: 10.1007/s40808-020-00852-4.
[27] M. Parimala and D. Lopez, "Decision making in agriculture based on land suitability–spatial data analysis approach 1," 2012.
[28] M. S. Girvan, J. Bullimore, J. N. Pretty, A. M. Osborn, and A. S. Ball, "Soil type is the primary determinant of the composition of the total and active bacterial communities in arable soils," Appl. Environ. Microbiol., vol. 69, no. 3, pp. 1800–1809, Mar. 2003, doi: 10.1128/AEM.69.3.1800-1809.2003.
[29] T. Cengiz and C. Akbulak, "Application of analytical hierarchy process and geographic information systems in land-use suitability evaluation: a case study of Dümrek village (Çanakkale, Turkey)," Int. J. Sustain. Dev. & World Ecol., vol. 16, no. 4, pp. 286–294, 2009, doi: 10.1080/13504500903106634.
[30] S. G. Yalew, A. van Griensven, M. L. Mul, and P. van der Zaag, "Land suitability analysis for agriculture in the Abbay basin using remote sensing, GIS and AHP techniques," Model. Earth Syst. Environ., vol. 2, no. 2, 2016, doi: 10.1007/s40808-016-0167-x.
[31] B. Halder et al., "Land Suitability Investigation for Solar Power Plant Using GIS, AHP and Multi-Criteria Decision Approach: A Case of Megacity Kolkata, West Bengal, India," Sustainability, vol. 14, no. 18, p. 11276, 2022.
[32] B. B. Ghute and S. Md. Babar, "An Approach to Mapping Groundwater Recharge Potential

Zones using Geospatial Techniques in Kayadhu River Basin, Maharashtra," Indian J. Agric. Res., vol. 55, no. 1, pp. 23-32., May 2020, doi: 10.18805/IJARe.A-5477.
[33] A. Aydi, T. Abichou, I. H. Nasr, M. Louati, and M. Zairi, "Assessment of land suitability for olive mill wastewater disposal site selection by integrating fuzzy logic, AHP, and WLC in a GIS," Environ. Monit. Assess., vol. 188, no. 1, 2015, doi: 10.1007/s10661-015-5076-3.
[34] M. K. Pramanik, "Site suitability analysis for agricultural land use of Darjeeling district using AHP and GIS techniques," Model. Earth Syst. Environ., vol. 2, no. 2, 2016, doi: 10.1007/s40808-016-0116-8.