Assessing potential areas of ecotourism through a case study in Chokie Mountain Watersheds in northwest highlands of Ethiopia based on the application of remote sensing techniques

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Abstract

Environmental sensitivity refers to ecosystem reflection on human activity and the natural changes in the environment. It provides users of math and computer simulations developed by ecologists at different resolution scales to appreciate model dependence on input parameters and to investigate the importance of each input parameter in determining their output model.

The study area is a part of the Upper Blue Nile River Basin, with varying parameters of natural and cultural ecotourism by considering landscape variables such as potential ecotourism, historical and cultural phenomena, vegetation cover, climate conditions, and topographical structure. In environmental protection, it is a fantastic source of international revenue and a source of income for the community.

Ecotourism preparation and future assessment were carried out by integrating remote sensing techniques with ARC GIS software as a method for assessing and tracking the Chokie Mountain Watersheds environmental sensitivity index.

The model includes Remote sensing techniques used to evaluate potential ecotourism areas requiring land use land cover, visibility, reservation protection, species diversity, proximity to cultural values, elevation, slope, distance from a road, and settlement sites for potential ecotourism targets using weighted overlay techniques.

An appropriate area for evaluating the potential for ecotourism has been assessed for each cell size. The outcome may be divided into the very sensitive, the sensitive, the sub-sensitive, and the insensitive according to the similar interval reclassification process in the GIS.

Keywords: Chokie Mountain watersheds, Ecotourism, Potential Assessment, Remote sensing techniques

1. Introduction

The recent study aims to establish an ecotourism plan based on the objective of preserving the natural and cultural ecotourism values of an area [1]–[3] by considering landscape variables such as the number of possible ecotourism, vegetation cover, cultural values, and topographical structure.

The recent study aims to establish an ecotourism plan based on the objective of preserving the natural and cultural ecotourism values of an area [1]–[3] by considering landscape variables such as the number of possible ecotourism, vegetation cover, cultural values, and topographical structure.

Accurate assessment for ecotourism planning is necessary to protect and sustain the area's ecological diversity as well as the local people's economic upliftment [4]. It provides the ability to foster principles in protected areas and finance stakeholders relevant to it. The evaluation of possible areas of ecotourism in this respect is a sensible approach to the sustainable development of nature-based tourism areas [4]. Arc GIs is used as the geographic information system to determine the variables of ecotourism and the region of the study was obtained via land survey, questionnaires, and mapping.

The region has a highly variable topographic structure, i.e. in terms of surface shapes it has a rich structure and there is visible landscape quality. This surface variety also makes the region rich in vegetation cover and climate values; the location benefit can be called this richness. It has allowed rich flora and therefore a variety of fauna to be created. While in this area the summers are hot and the winters are wet, in both seasons the region receives enough rainfall.

2. Materials and methods

2.1. Chokie Mountain Watersheds

Chokie Mountain watershed is the water tower of the upper Blue Nile River Basins in most highland portions of Ethiopia. The watershed located between 37º50´ – 37 º 53´ N and 10 º 41´ – 10 º 44´ E. The altitude of the area ranges from 900 m above sea level around Blue Nile George to 4100 m top of Chokie Mountain watersheds [5], [7].

Choke Mountain Watershed has natural tourism opportunities and several geological features such as land types, water flow, gorges, cliffs, native biodiversity, and other stunning viewpoints. The beautiful landscape is a great natural resource, and atmospheric conditions such as rainfall, wind, temperature, and humidity. Other potential tourism opportunities are forests of Aba Jime, AratMekerakir, Molalit cave, and Lake BahireGiyorgies in line with specific biodiversity resources that include species of plants, animals, and birds.

3. Data and Methods

3.1. Input data

Remote sensing techniques were used to analyze potential ecotourism area that requires land use land cover, visibility, reservation protection, diversity of species, proximity to cultural values, elevation, slope, distance from road and settlement sites.

The input values were collected using digital elevation and satellite image data using ground-based land surveys, questionnaires, and mapping. The analysis describes the above-nine variables as markers of Chokie Mountain Watershed's ecosystem potential.

Table 1:factors and criteria for ecotourism potential assessment [1], [3]

factor	Criteria	Unit	Factor suitability rating			
Landscap Naturalness	Land use land ver	Class	High	Moderate	Marginal	Not Suit
	Visibility	Range	Near range	Middle range	Far range	Not sible
Wildlife	Reservation	Protected eas class	High	Moderate	Marginal	Not
	Species Diversity	% corded ecies	>30%	20%_30%	5_20	<5
Topograp	Elevation	meter	300-400	100-300	>400	0-100
	slope	Degree	0-5	5-25	25-50	>50
Accessibi y	Proximity to ltural values	Kilomete	0-15	15-30	30-45	>45
	Distance from	Kilomete	Outside of any	within 2km	In 5km	Area

	ɔad		ffer zone	ffer zone	ffer zone	thin 10km
Communi ıaCharacter ics	Settlement Site	Populatio ıize	Absence of rmanent tlement	Communities ·1000)	Semi- ɔan 1000- 000	Urban tlement (>10000)

3.2. Determination of factors and Classification of Criteria

3.2.1. land cover

The practice of land use management in the study area has serious impacts on natural resources including water, soil productivity, vegetation, and animals [3]. The shift in land use is due to human activities, and natural changes in the climate are deciding land cover and changes in the green area linked to the urban area and its immediate environment. Land cover is one of the most important data that is used to demonstrate the effects of changes in land use, especially human activities.

The improvements in urban growth and green area over time were measured by the use of land cover maps. At the same time, the relationship was explored between changes in the land cover over time and changes in the urban population.

3.2.2. Visibility

It specifies the positions of the raster surface visible to a collection of observer features or defines which observer points are visible from each position of the raster surface. It is the number of species living in the study field, and the abundance of each species.

This factor was generated from a digital elevation model integrated with natural uniqueness location by viewing shed analysis on the visible or not visible basis [1].

3.2.3. Protection / reservation

Landscape planning for protected areas means making decisions about the future of urban land and it predicts how the land has changed over time and the effects of natural factors and human activities on the land. Successful and lasting landscape planning studies can be achieved in this way. Since [1] wildlife sanctuary findings and no hunting area are classified as high, national park areas are classified as medium, and non-reserve areas are classified as medium and non-forest reserve areas as moderate. Areas outside the protected area are categorized as non-reservation /

protection factors by the form of protected areas appropriate for residents for habitat, endangered species, and newly discovered species.

3.2.4. Species diversity

It is the number of species and abundance of each species that lives in the study area. To consider the abundance of wildlife populations in the region, this factor was counted from the number of species recorded [1]. Landscape resource is an important index for measuring ecological processes in the ecosystem influencing species distribution, persistence, and abundance[8]. The size and distribution patterns of the vegetation patches that have become wildlife habitats and, in particular, the quality of the connectivity between these patches are important factors to be considered in the assessment of potential ecotourism [9]. Landscape connectivity is an important factor in protecting biodiversity and maintaining ecosystem integrity and stability [7], [10]. Landscape pattern characteristics can be computed based on different models. The Shannon diversity index divides the maximum possible diversity within a given abundance of landscapes, which is the maximum distribution of each patch type in Table 2. SHIE can reflect the degree to which the landscape is dominated by one or more superior types of plaques and is a powerful way of comparing the diversity of different landscapes in different periods [10]. SHEI can determine community composition (number of vegetation species) and the commonness of species in a community.

$$SHEI = \frac{-\sum_{k=1}^{m} Pk * ln(Pk)}{ln(m)} \qquad \textit{Equation 1}$$

Where, p_k represents the area occupied by each patch type, and m represents the total numbers of landscape patch types.

Table 2: Vegetation diversity & density of patches

No.	Land type	Area of patch	Ln(p	patch*ln(pk)	area/T.area	pi*lnPk	sum *lnpk	I/ln(8)
10	Cultivat land	9735.405	9.19	89468.37195	0.006126612	0.056303565	13.24756	6.37073313
20	Forest	904957.84	13.72	12416021.61	0.569501283	7.813557597		
30	Grasslan	181297.26	12.11	2195509.843	0.114092633	1.381661788		

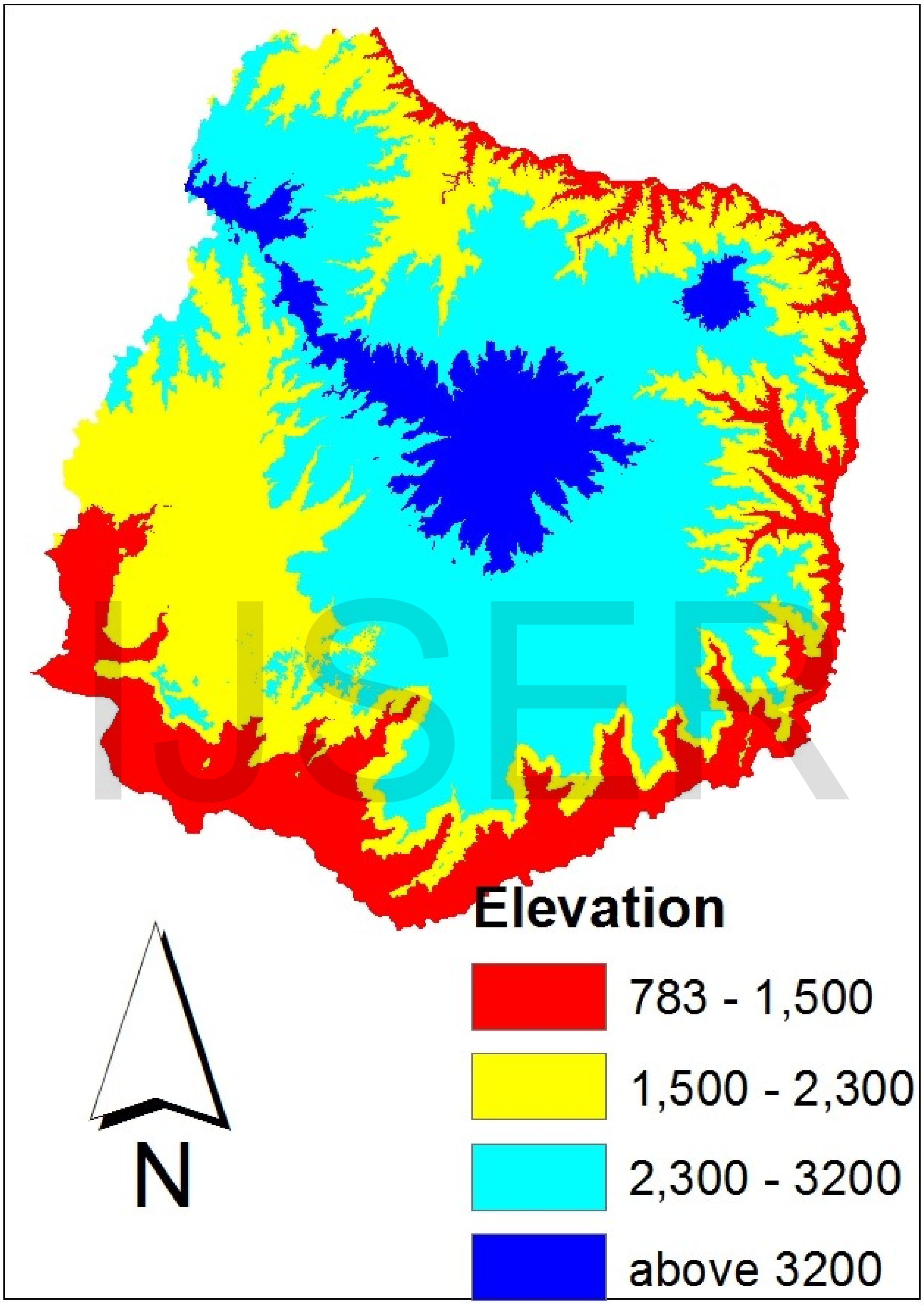
40	Shrub ıd	471523.01	13.06	6158090.511	0.296735324	3.875363334		
50	Wetland	13188.207	9.49	125156.0844	0.008299504	0.078762288		
60	Water dies	2019.645	7.61	15369.49845	0.001270988	0.009672217		
80	Artificia ırface	2143.463	7.67	16440.36121	0.001348908	0.010346125		
90	Bare ıd	4170.819	8.34	34784.63046	0.002624749	0.021890403		
		1589035.6	14.28					ln(8)=2.079

3.2.5. Elevation

The elevation map of the study area extracted from DEM data was reclassified based on the difference in altitude using the agro-ecological classification zone to rank the region's suitability for staying in the area *Table 3*. The layer was reclassified into four classes and new values were allocated to each class and values of 500 – 1500, 1500 – 2300, 2300 – 3200, and above 3200 m above sea level were provided based on this classification 4, 1, 2 and 3 respectively.

Table 3: Elevation Difference

Climatic Zone	Climate	Altitude	Avg. annual Temperature	Avg. ann. Rainfall
Kola	Warm semi-arid	500-1500	27.5-20	200 – 800
Woina Daga	Cool sub humid	1500-2300	20-17.5/16	800 – 1200
Dega	Cool and humid	2300-3200	17.5/16-11.5	1200 - 2200


Elevation
783 - 1,500
1,500 - 2,300
2,300 - 3200
above 3200
N

3.2.6. Slope

The slope of the surface of the ground can be described by degree or percentage for slope adjustment. Terrain properties such as convexity and concavity produce slope profile undulation which appears to be visually appealing to observers across a wider geographic region. The slope of the study area was reclassified according to its degree in four classes for the spectacular eco-tourism potential mapping. As shown in Figure 5 below the topography level, there are four types of slope: flat slope (< 8 °), slow slope (8 ° -25 °), mid-slope (25 ° -45 °), and steep slope (> 45 °). Rank 4 was given to the flat areas which are less attraction value and rating 1 was given for mountain area (> 45 percent).

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Proximity to cultural and ecotourism sites

Table 4:GPS points for cultural sites and ecotourism locations

OID	Easting	Northing	Elevation	Name
0	372235	1175794	3761	አባ ጅሜ ደን
1	373016	1177190	4005	
2	373421	1184115	4087	ፍልፈል ሜዳ
3	3364901	1175269	3518	እናት አምባ
4	364702	1174843	3486	
5	364848	1175197	3583	እናት አምባ
6	369580	1171487	3450	ከረቡዕ ገበያ ጮቄ መግቢያ
7	368436	1186047	3516	ዋብር መንደር
8	362008	1199064	2845	ድጎ ፅዮን
9	365500	1186796	3444	ሞላላ ዋሻ
10	367381	1186219	3649	እናት ዋብር
11	363473	1190224	3394	ከድጎ ፅዮን የፈረስ ቤት መገንጠያ
12	354627	1192308	3200	በረቅ ደን
13	347886	1199439	3011	ፈረስ ቤት ከተማ
14	346518	1199825	3026	ፈረስ ቤት ከተማ
15	367788	1137418	2426	ቁይ መገንጠያ
16	378674	1154589	2600	የበቅላ
17	389621	1161041	2649	ቁይ ከተማ
18	387153	1166104	2628	ወደብ ኢየሱስ ቤ/ን
19	380775	1176430	2904	ገልባጤ መንደር
20	381643	1179286	3414	ጩማ
21	384450	1182134	3935	በቅሎ መስበሪያ
22	412181	1154957	2541	ቢቸና ከተማ
23	407764	1171834	2531	ዲማ መገንጠያ/ጠልማ
24	414572	1165955	2352	ዲማ ጊዮርጊ
25	396454	1181861	2959	ዋሻ ጊዮርጊስ ቤ/ን
26	409104	1178375	2517	ደብረወርቅ ማርያም ቤ/ን
27	400124	1207596	2663	ጉንደወይን town
28	406995	1213053	2611	ባህረ ጊዮርጊስ
29	387369	1212594	2516	ቁራንዮ መድኀኔዓለም ከተማ
30	378190	1224643	2433	ሞጣ ከተማ
31	391036	1212042	2496	ሸጌ መገንጠያ ወደ ሰላም አበበ ቀበሌ
32	380307	1192798	3460	ሰማይላስ መድኀኔዓለም ቤ/ን
33	380239	1192964	3487	ሙሽሪት ገደል እናት
34	367618	1225060	2059	ሞጣ ቢቡኝ መገንጠያ
35	366148	1223443	1790	አበያ ወንዝ
36	387647	1213178	2478	ቁራንዮ መድኀኔዓለም ቤ/ን
37	376803	1224635	2460	ሞጣ ጊዮርጊስ ቤ/ን

1 (0 out of 44 Selected)

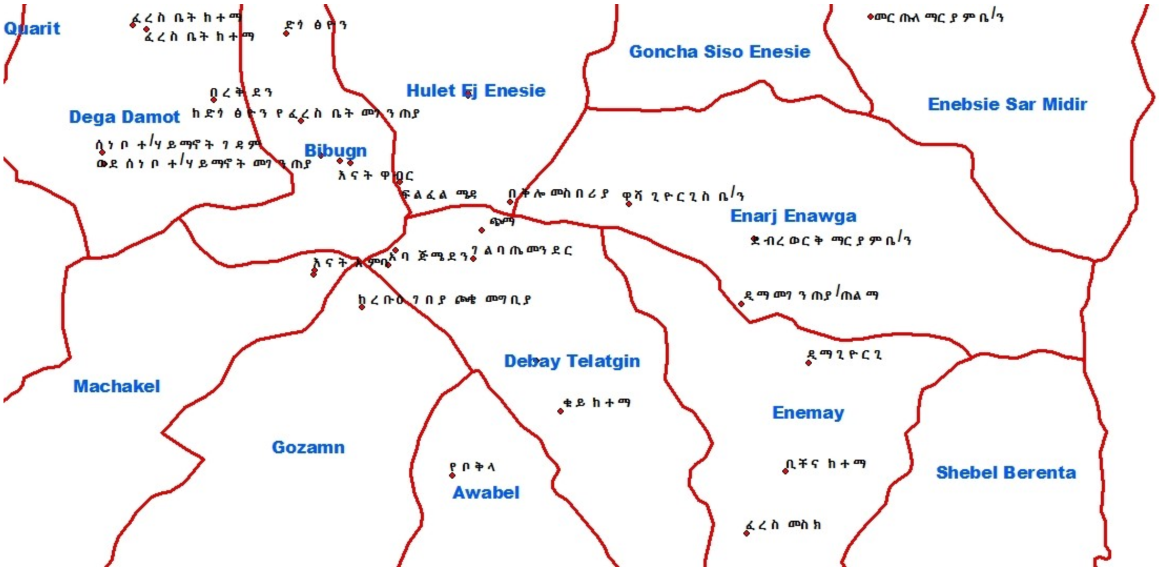

Figure 1: Spatial location of ecotourism spots

3.2.7. Distance from road

Distance from the factor of the roads depends on the condition of transport by the form of access and distance from the types of roads. Sometimes, ecotourism occurs in natural areas, cultural or historical resources, and traditional culture. The important factor for ecotourism is the accessibility to cultural sites, historical sites, the traditional and local community including distance from the street. This criterion has been listed based on the state of transport using access and distance from the type of road where the remote areas are the best fit for attractions and growth of ecotourism. Areas outside of any buffers around all roads are classified as high potential for the development of ecotourism; areas within 2 km buffer around the third main roads are classified as moderate, areas within 5 km buffer around second main roads are classified as marginal, and areas within 10 km buffer around major roads are classified as not suitable for the development of ecotourism.

3.2.8. Settlement sites

The settlement size factor was classified by population size.

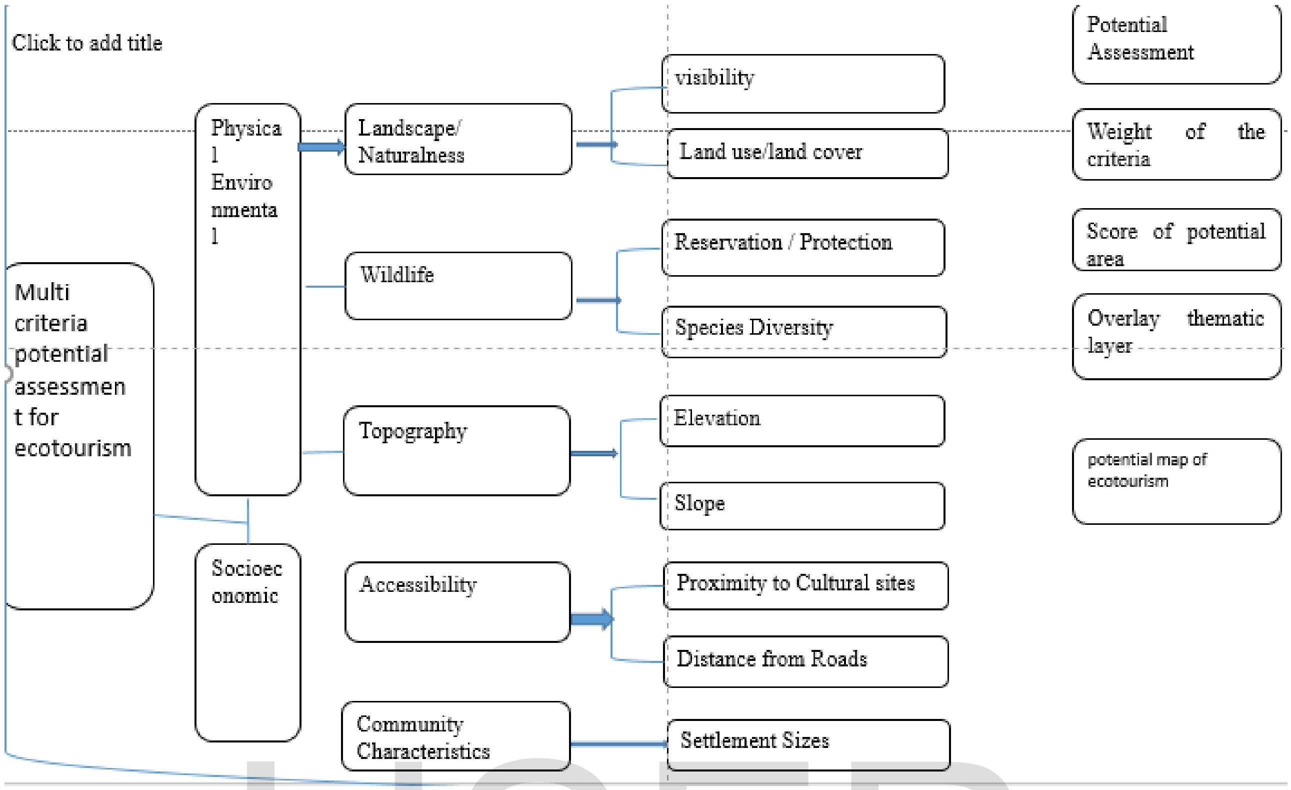

Figure 2: Workflow for Eco-tourism potential assessment [1], [3]

3.3. Determining the Weight of Factors

In AHP finding appropriate factors and criteria to be used in the analysis were chosen based on experience, opinions of experts, and information from different sources. The development of information has been accomplished through discussions with experts in relevant fields of research study, the collection of authenticated kinds of literature, and historical data analysis. The overall significance or contribution assigned for each parameter can be given using the result of the pair-wise comparison matrix [4], [12], [13]. Ultimately, weighted sum analysis is carried out using free online AHP software and analytical hierarchical process principles to score the degree of importance of each parameter compared to each other, calculating the standardized matrix for weighted sum analysis. As (Saaty L., 1990; Alexander, 2012, Zahedi & Fatemeh, 1986) findings the scale of priorities for pair-wise comparisons between two parameters varies from the maximum value 9 to 1/9. The AHP Scale was described as 1- Equal Importance, 3- Moderate Importance, 5- Strong Importance, 7- Strong Importance, 9- Extreme Importance (2,4,6,8 values in between).

Table 5: Fundamental analytic hierarchy process (AHP) scale

Degree of portance (scale)	Definition	Explanation
1	Equal Importance	Two factors contribute equally to the objective
3	Moderate portance	Experience and judgment moderately favor one activity er another
5	Strong importance	Experience and judgment strongly favor one activity er another
7	Very strong portance	Activity is strongly favored and its dominance monstrated in practice
9	Extreme portance	The evidence of favoring one activity over another is of highest possible order of affirmation
2,4,6,8	values in-between	Compromise is needed
Reciprocals	If activity i has one of the above numbers assigned to it when compared with ivity j, then j has the reciprocal value when compared with i	

Comparative matrixes are usually considered consistent if the Consistency Ratio value is less than 0.1 (Saaty L., 1990; Alexander, 2012, Zahedi & Fatemeh, 1986). (Saaty L., 1990; Zahedi & Fatemeh, 1986; Alexander, 2012). Consistency Index (CI) = 0.0818, Consistency Ratio (CR) =

6.5 percent = 0.0065 < 10 percent, Comparison Number = 15. As shown in Table 3, the consistency ratio value is 6.5 percent, which is less than 10 percent, and the incoherence is appropriate.

Factors	Weight	Criteria	weight	Total suitability ore	Rating
Landscape	0.44	Land use/cover	0.47		
		Visibility	0.53		
Wildlife	0.11	Reserved area	0.54		
		Species Diversity	0.46		

Topography	0.31	Slope	0.53
		Elevation	0.47
Accessibility	0.06	Proximity to cultural sites	0.53
		nce from Road	0.47
Community ıaracteristics	0.08	Settlement size	1

3.4. Ecotourism potential assessment

The land suitability map for ecotourism was generated based on a linear combination of the suitability score of each used factor as shown in Equation (2). The AHP approach was used to assess the relative significance of all of the variables selected. For each land unit, the total suitability score "Si" was determined from the linear combination of suitability score obtained for each factor and criteria concerned. Using the normalized values of each element, the weighted summation analysis using ARC GIS spatial analysis tool determined the comprehensive index for the entire study field.

$$E = \sum_{i=1}^{n} wi * pi \qquad \textit{Equation 2}$$

Where E is representing the desired comprehensive index, Wi represents the multiplication of all associated weights in the ith factor hierarchy, Pi represents the ith assessment index and n represents the number of the assessment index. In Multi-Criteria Evaluation (MCE) using a weighted linear combination, for each given category the assigned weights must be summed up to 1. However, each element in the last layer has been categorized into 4 suitability classes (S1, S2, S3, N), and their suitability scores have been presented in a standardized format ranging from 0 (least suitable) to 1 (most suitable).

4. Results

4.1. Estimation of ecotourism parameters

Chokie Mountain Watershed land use covers can be categorized as water bodies, wetlands, barren ground, grassland, forest, agricultural land, built-up area, and woodland. Due to its strong and diverse ecology, it is considered the highest suitable for ecotourism growth because it carries potential forest and dense forest land cover of the study region. Therefore, forest cover was given the highest rank, water bodies were given the rank of two, wetland rank three, woodland rank four, grassland rank five, farmland rank six, area rank seven was built up and the least suitability eight ranks was given for Bare land.

Visibility was the second possible parameter for landscape ecotourism to delineate the visibility of the earth's surface from one known point or geospatial polyline. The region can be graded as extremely visible, moderately visible, and not visible to four key groups and differing in the value of each parameter.

4.2. Ecotourism Sensitivity Evaluation

The potential area for ecotourism has been categorized based on four suitability classes, namely extremely suitable (0.8-1.0), moderately suitable (0.4-0.8), slightly suitable (0.2-0.4), and not suitable (0.0-0.2) [1], under the food and agricultural organization framework research for land assessment.

The findings are based on ranking various sites according to the set criteria and thus identify those with the better ecotourism potential. Particularly in ecotourism study, data on the potential sites for ecotourism, the results of the survey to examine existing tourism facilities, the current tourism situation, future ecotourism opportunities, the ecotourism requirement, and the main ecotourism development policy in the area are considered.

5. Conclusion

Chokie mountain watershed is to be one of the northwest highlands of Ethiopia's most popular ecotourism destinations. It has fascinating and beautiful mountain landscapes, the spring water supply of income, diversity of fauna and flora, a variety of people, cultures, and historic sites. Effective production of nature-based tourism protects the climate and supports the local community for ecosystem preservation.

The analytical hierarchical process approach for the study of ecotourism vulnerability was carried out using three key criteria and about seven sub-criteria to define the most important region for sustainable ecotourism. The evaluation of ecotourism planning was done in arc GIS software by multiplying each parameter's impact to define the possible ecotourism region.

The major factors for investigating the research were landscape patterns such as vegetation density, the potential for ecotourism, agricultural resources, cultural resources, and topographic features of the study area. The percentage of the possible ecotourism planning area for the entire watersheds can vary greatly.

The outcome may be divided into the very sensitive, the sensitive, the sub-sensitive, and the insensitive according to the similarly interval reclassification process in the Geographic information systems. Government and planners should be paying more attention to extremely vulnerable and highly sensitive areas for the growth of ecotourism during the protection and restoration of the watershed.

REFERENCE

[1] K. Bunruamkaew and Y. Murayama, "Site Suitability Evaluation for Ecotourism Using GIS & AHP : A Case Study of Surat Thani Province, Thailand," vol. 21, pp. 269–278, 2011.

[2] H. M. Mosammam, M. Sarrafi, J. T. Nia, and S. Heidari, "Typology of the ecotourism development approach and an evaluation from the sustainability view: The case of Mazandaran Province, Iran," *Tour. Manag. Perspect.*, vol. 18, pp. 168–178, 2016.

[3] K. Bunruamkaew and Y. Murayama, "Land Use and Natural Resources Planning for Sustainable Ecotourism Using GIS in Surat Thani, Thailand," pp. 412–429, 2012.

[4] G. Hai-ling and W. Liang-qiang, "Procedia Engineering A GIS-based approach for information management in ecotourism region," vol. 15, no. 200904003, pp. 1988–1992, 2011.

[5] B. Robe and A. Ababa, "Development of Community-Based Ecotourism , A Case of Choke Mountain and Its Environs , Ethiopia : Challenges and Opportunities," vol. 16, pp. 14–21, 2016.

[6] J. T. Hospit and S. A. Aseres, "Tourism & Hospitality Assessment of the Potentials Tourism Resources of Choke Mountain and," vol. 4, no. 3, 2015.

[7] B. Simane, B. F. Zaitchik, and M. Ozdogan, "Agroecosystem analysis of the choke mountain watersheds, Ethiopia," *Sustain.*, vol. 5, no. 2, pp. 592–616, 2013.

[8] P. S. Roy, "Application of Landscape Ecology and Remote Sensing for Assessment, Application of Landscape Ecology and Remote Sensing for Assessment, Monitoring and Conservation of Biodiversity," no. October 2010.

[9] K. Mochizuki, “Evaluation of Vegetation Patch Connectivity,” vol. XXXIII, pp. 146–151.

[10] Y. Lin, W. J. Li, J. Yu, and C. Z. Wu, “Ecological Sensitivity Evaluation of Tourist Region Based on Remote Sensing Image — Taking Chaohu Lake Area as a Case Study,” vol. XLII, pp. 7–10, 2018.

[11] S. Huang and L. Nan, “Urban Ecological Sensitivity Evaluation of Anshun , China,” vol. 8, no. 9, pp. 630–634, 2017.

[12] P. Sd-, “Decision-Making using the Analytic Hierarchy Process (AHP) and SAS / IML ® Melvin Alexander , Social Security Administration , Baltimore , MD ABSTRACT,” pp. 1–12, 2012.

[13] I. Dhami, J. Deng, R. C. Burns, and C. Pierskalla, “Identifying and mapping forest-based ecotourism areas in West Virginia - Incorporating visitors’ preferences,” *Tour. Manag.*, vol. 42, pp. 165–176, 2014.

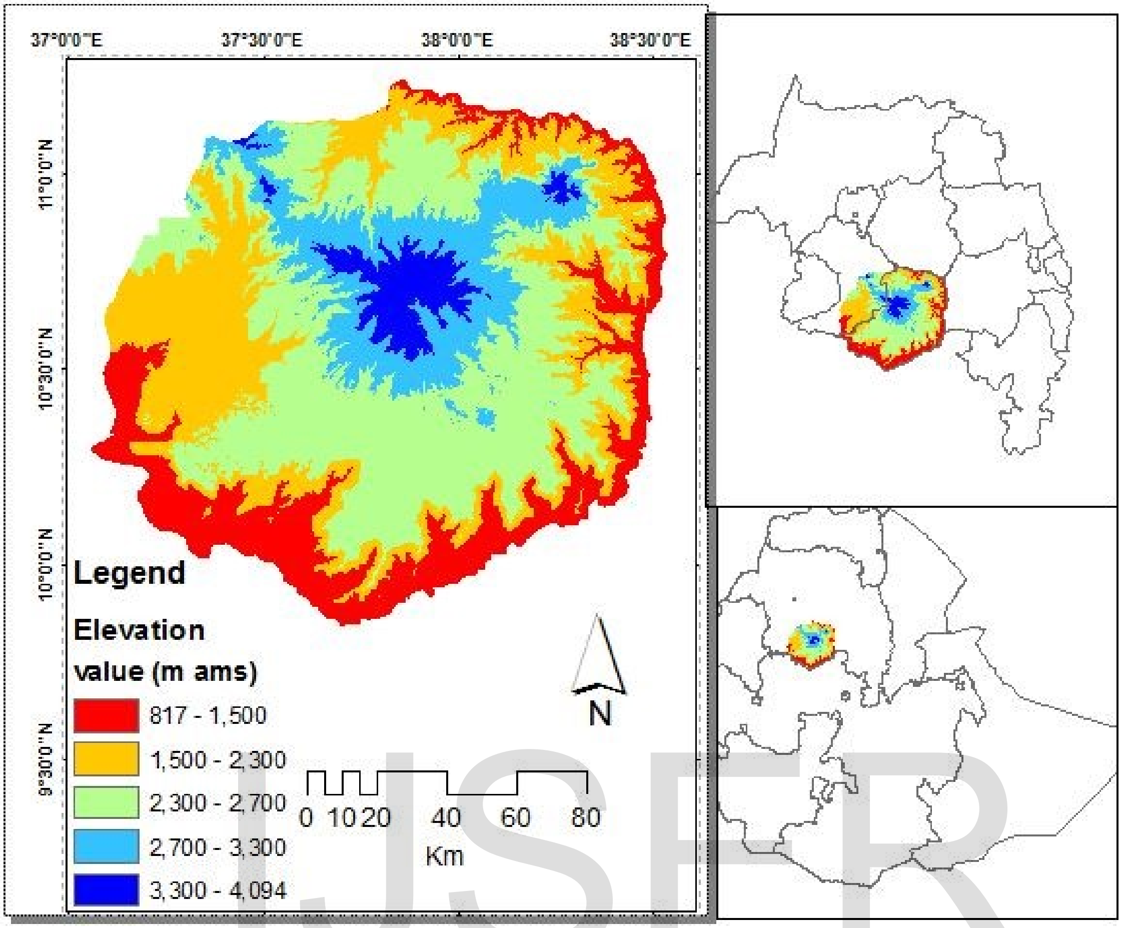

Figure 3: Chokie Mountain Watershed

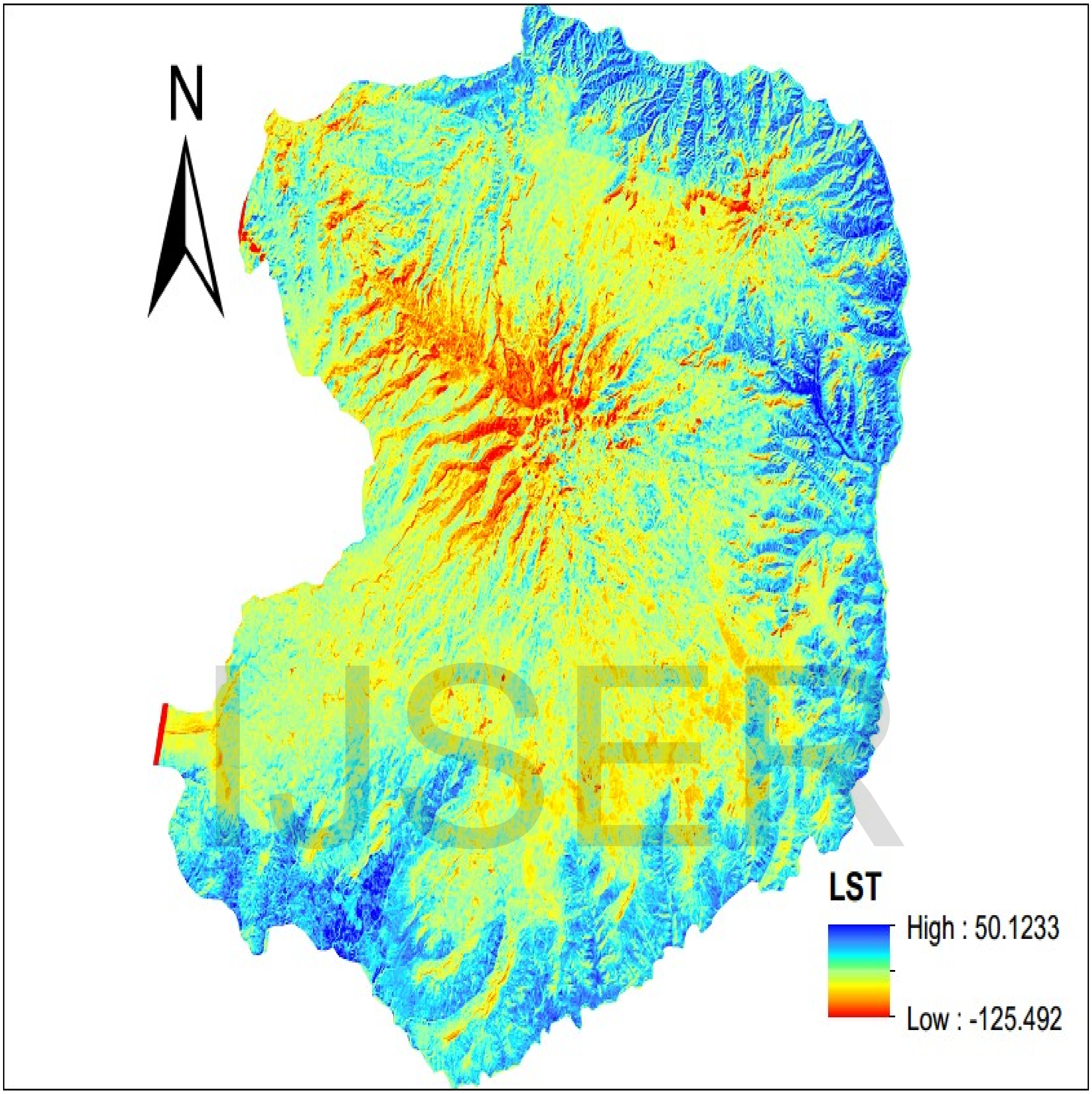

Figure 4: Land Surface Temperature

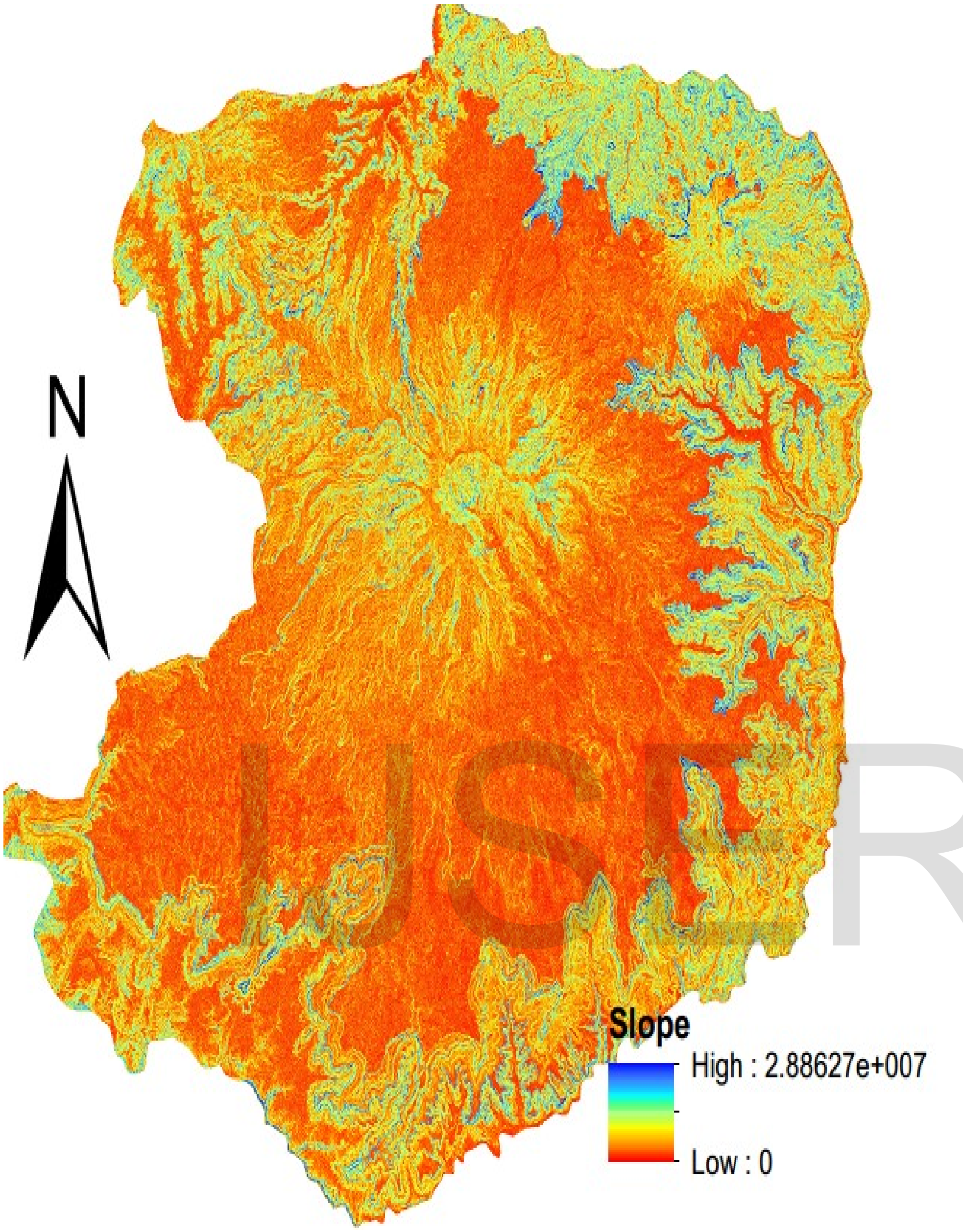

Figure 5: Slope Map

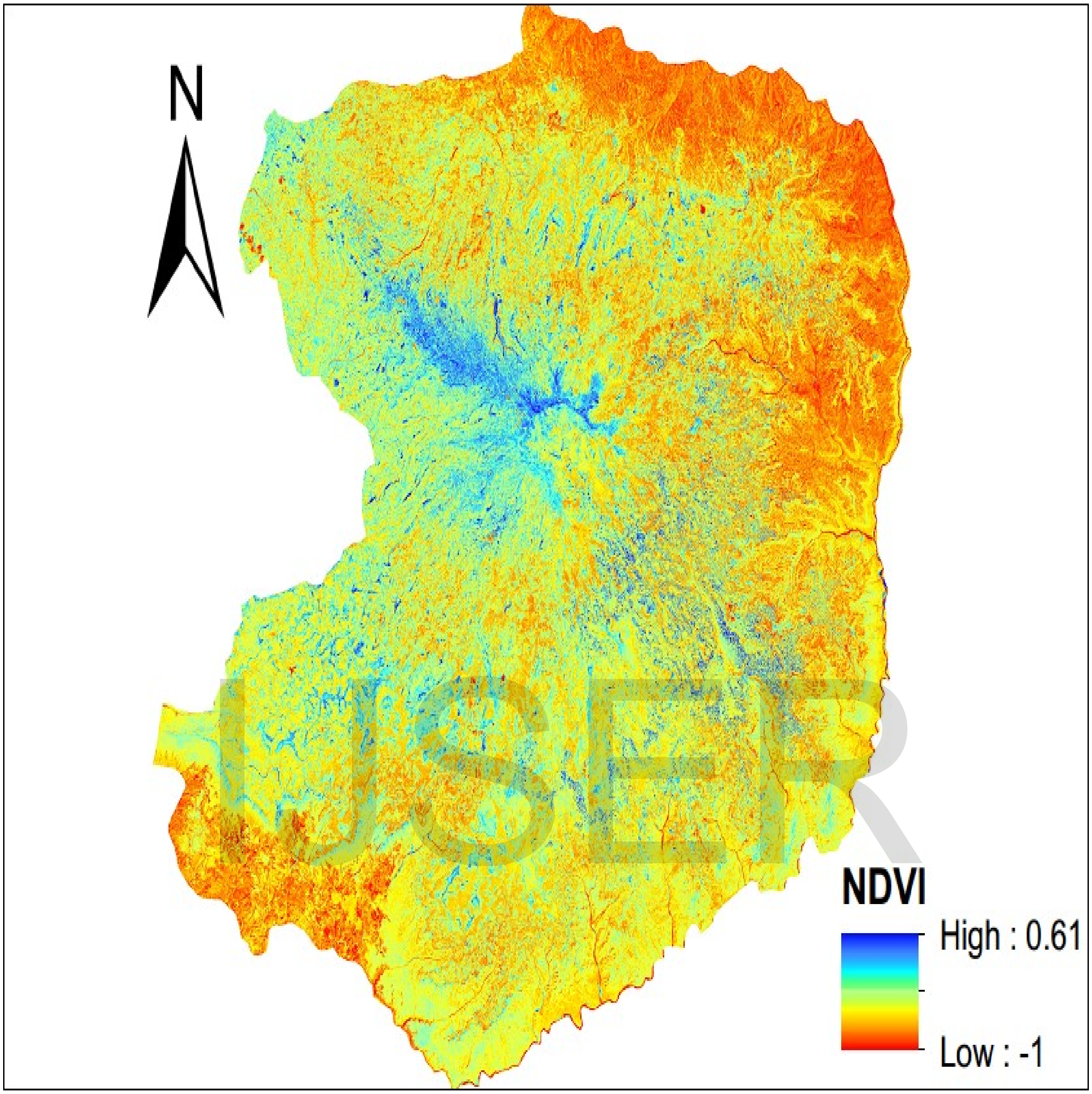

Figure 6: Natural Difference Vegetation Index

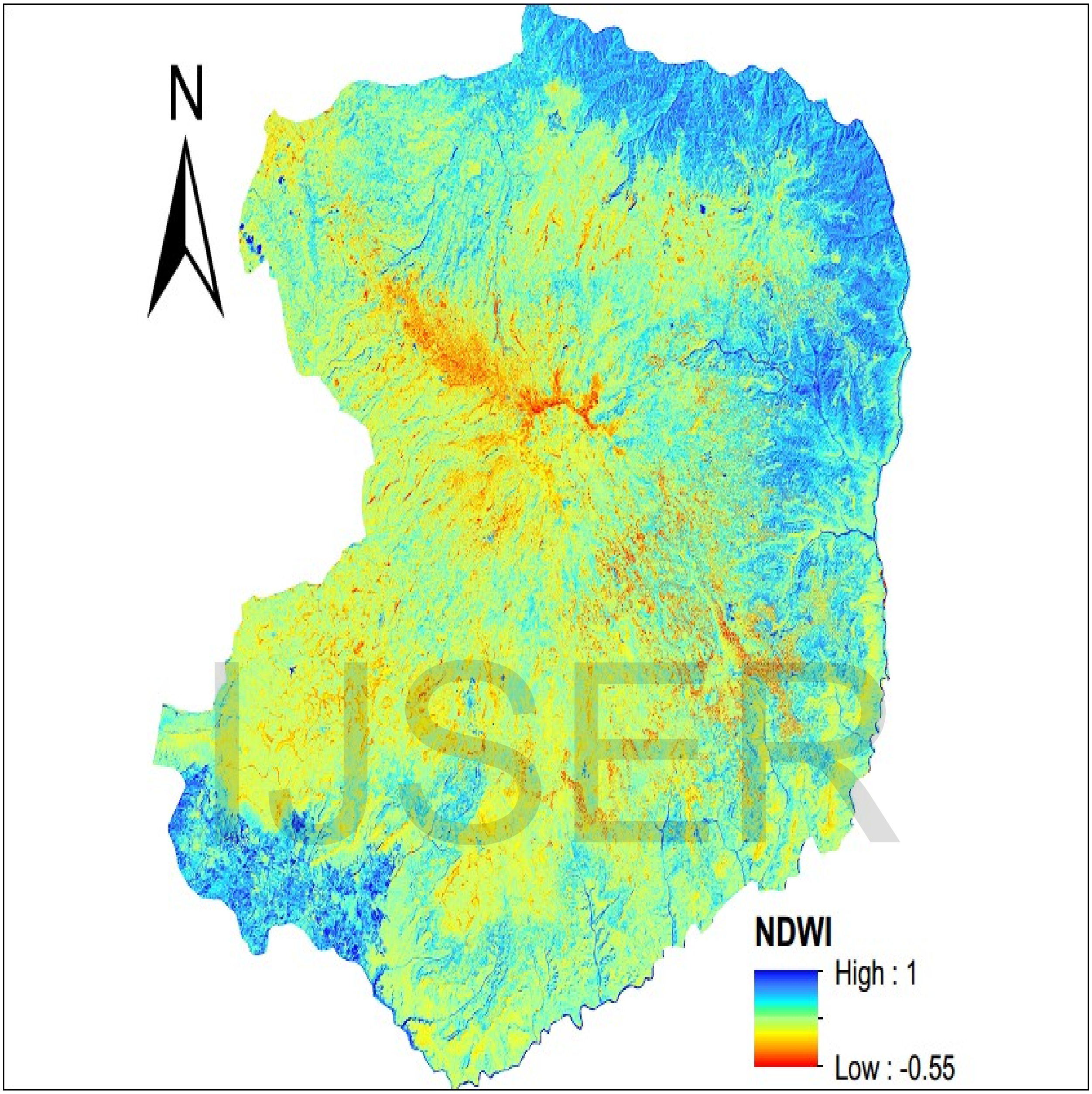

Figure 7:Natural Difference Water Index

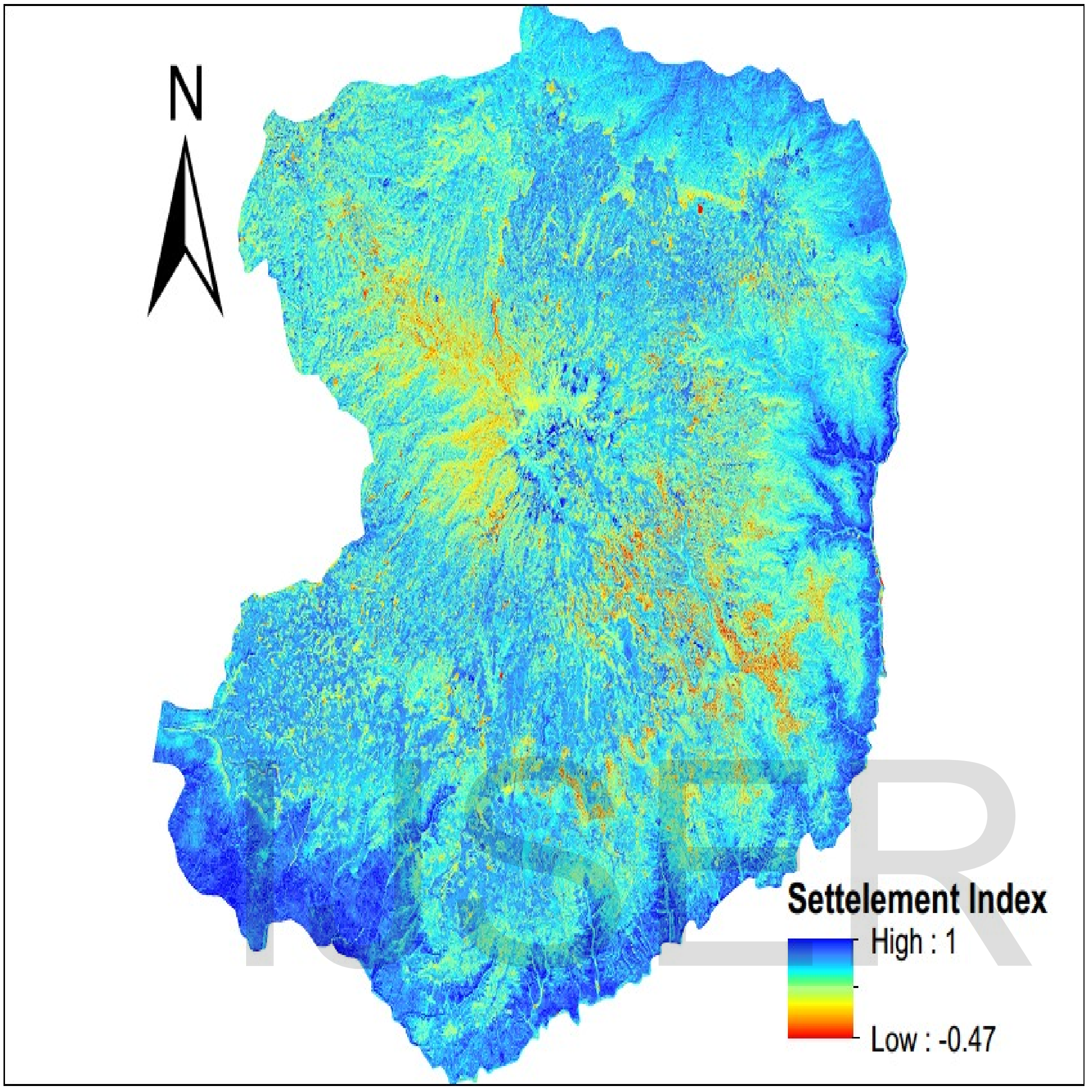

Figure 8: Natural Difference Settlement Index