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Geo-Spatial And Ahp-Based Analysis To Delineate The Untapped Ecotourism Potential Of District Swat, Pakistan

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Abstract.
This study's main goal is to evaluate and identify possible ecotourism locations in Pakistan's Swat district by combining the Analytical Hierarchy Process (AHP) approach with Geographic Information System (GIS). Using information from a comprehensive literature analysis and field work, we took into account a number of variables, such as landscapes and natural features, rainfall, temperature, wildlife distribution,[1] land use, elevation, slope, and proximity to historical and cultural places. We successfully used the AHP technique to classify sub-parameters from highly suitable to unsuitable classes Using ArcGIS 10.8, we determined the final weighting of these criteria to identify suitable ecotourism sites. Our analysis revealed significant chances for ecotourism throughout the designated area, with the central and northern portions showing higher promise than other places due to spectacular glacial lakes, lush vegetation, and picturesque sites. While the southern and some central parts are high and moderate suitable form ecotourism. Accessibility, a wealth of historical and archaeological sites, wildlife distribution, and existing infrastructure are all important elements in unlocking this potential. In contrast, some south eastern sites have lower ecotourism potential. We hope that our study's findings will be useful in identifying ecotourism opportunities in the Swat district, hence promoting socioeconomic development in the region.

Keywords: *Ecotourism, Geo-spatial, AHP, Socio-economic, Sustainability, GIS, Delineation.*

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1 Introduction

Ecotourism is an activity that encourages people to travel to undeveloped areas not only to appreciate the natural beauty and also to know about the customs, culture and traditions of the surrounding areas. (Oladi et al., 2010; Samal & Dash, 2022). Moreover, it helps the responsible use of biodiversity with least number of negative effects on the host society and natural environment. (Baloch et al., 2023; Ryngnga, 2008). The International Union for Conservation of Nature (IUCN) has defined ecotourism as "tourism to untouched natural environment with the aim of studying and admiring the natural diversity, ensuring conservation, the involvement of local community for their socioeconomic activities. Essentially, travelers come to enjoy and protect the natural environment and wildlife (Bunruankaew and Maryam, 2011).

Ecotourism has emerged as a vital component of sustainable tourism, aligning with the principles of sustainability to ensure economic viability, environmental conservation, and cultural appropriateness (Garrod & Fyall, 1998; Fennell, 2001; Rinzin et al., 2007; Wood, 2002; Elena & Thomas, 2018). Therefore, ecotourism, which has received academic interest from the mid-1980s, represents a nature-based tourism strategy that aims to protect the environment while delivering enriching experiences for guests and helping local people (Xu et al., 2023). Its multidimensional strategy includes long-term sustainable development goals such as education, resource conservation, income production, and social infrastructure improvements (Oladeji et al., 2022; Valdivieso et al., 2015).

Ecotourism, particularly in developing nations, is seen as a promising option for alleviating poverty and rural revenue generation (Snyman, 2017; Zhong & Liu, 2017). The tourist industry emerges as a crucial engine of global economic growth, because of its rapid growth (CREST, 2018; Kangai et al., 2024). Tourism makes a substantial contribution to economic development and poverty alleviation efforts. Furthermore, it generates significant foreign exchange profits, as governments frequently target tourists from locations with higher currency values (Lee & Chang, 2008). Locally, tourism generates job possibilities in a variety of industries, including tour guiding, hospitality, and transportation, as well as encouraging self-employment and industrial expansion (Ghani, 2020).

The quantitative assessment of tourism resources and their sustainable development necessitates modern scientific approaches and techniques (Ali & Maryam, 2014; Bunruamkaew & Murayama, 2011; Delavar et al., 2010; Kumari et al., 2010; Ullah & Hafz, 2014; Gourabi & Rad, 2013; Mahdavi & Niknejad, 2014). AHP, a widely used MCDA method, enables pairwise comparisons of criteria to assess their relative importance in identifying potential ecotourism sites (Saaty, 1980). Scholars have applied diverse thematic layers and criteria in AHP-GIS frameworks to evaluate ecotourism potential, considering factors such as wildlife, ecological value, attractiveness, resiliency, diversity, landscape, accessibility, community characteristics, climate, topography, geopedology, and socioeconomic characteristics (Bunruamkaew & Murayama, 2011; Gourabi & Rad, 2013; Ghamgosar, 2011; Mahdavi & Niknejad, 2014; Ullah & Hafz, 2014).

In 2019, there were 1.458 billion tourists around the world. Pakistan received a total of 1.225 million foreign tourists in 2017. Pakistan's share in the global tourist market in 2017 was only 0.08%, significantly lower than its potential, compared to India which attracted almost 10 million overseas tourists. According to the World Travel and Tourism Council (WTTC), tourism industry of Pakistan would generate $ 36.2 billion in revenue by 2030. The government of Pakistan also anticipates that by 2025, ecological tourism will bring in

Rs. 1 trillion in revenue. The Malakand Division's potential for ecotourism remains untapped, despite its well-known hospitality culture. Because of its stunning environment, diverse animals, and historical sites, it is a well-liked vacation spot.

This paper focuses on delineating ecotourism potential zones using the Analytical Hierarchy Process (AHP) among various Multiple Criteria Decision Analysis (MCDA) techniques, integrated with Geographic Information System (GIS) technology. GIS facilitates cost-effective and efficient mapping of ecotourism potential, handling large volumes of spatial data for accurate analysis (Jhariya et al., 2016). The aim of this study is to assess the capability of AHP and GIS techniques in mapping ecotourism potential, using Swat District, Khybaer Pakhtunkhwa, Pakistan, as a case study. This assessment serves as a valuable tool for decision-makers in identifying suitable locations for ecotourism site development, providing a pioneering blueprint for ecotourism planners in the region (Sahani, 2022).

2 Literature Review

All ecotourism activities contribute to poverty alleviation by increasing incomes, strengthening the influence of local societies, conserving culture, protecting threatened areas and protecting the environment. Ecotourism has been recognized as a nature-based tourism approach that aims to conserve the environment, support local communities, and provide enjoyable experiences for visitors (Ali et al., 2024a). It is therefore, important to identify supportable ecotourism resources to strengthen the socio-economic and cultural morals of the region (Fennell and Ebert 2004; Garrod et al., 2006 and Mondino and Beery, 2019). Therefore, the delineation of potential ecotourism destinations is important for tourism planning, guidance and promoting the development of the tourism industry. This can be achieved by applying a scientific method to the development and management of defensible tourism goods and activities (Hall, 2019; Swarbrooke, 1999). The literature on ecotourism planning and management has increasingly emphasized the integration of Geographic Information Systems (GIS) and Analytic Hierarchy Process (AHP) to achieve sustainable development objectives. Central to ecotourism is the goal of long-term sustainability, encompassing conservation, education, and socio-economic development (Whitelaw et al., 2014; TIES, 2015).

The Analytic Hierarchy Process (AHP), pioneered by Saaty (1980), provides a structured approach to assess it by pair wise comparison and rating. Its steps include defining hierarchical structures, weighting criteria and its sub-criteria, giving priority weight to alternatives and to determine final score (Duc, 2006). A review by Malczewski (2006) highlighted the widespread use of geographic information system (GIS) techniques in Multi Criteria Decision Analysis (MCDA) with more than 300 studies from various journals and applications. In particular, GIS and AHP are prominently used in ecotourism planning for site selection and management because they are effective in multi-criteria decision making (Bunruamkaew and Murayam, 2011).

Stem et al., (2003) see this as a potentially profitable way for long-term financial development. Wanyonyi et al., (2016) utilized an integrated scheme involving Analytical Hierarchy Process (AHP) and Geographical Information System (GIS) to analyze ecotourism opportunities in Kwale (Kenya). Bhaya and Chakrabarty (2016), Rehman (2010) used the Geographic Information Systems (GIS) to identify appropriate ecotourism destinations. Acharya et al., (2022), uses GIS and RS to study the feasibility and appropriateness of geo-ecotourism for a location in West Bengal, India. The study classifies

the study area into zones based on physiographic locations and LULC characteristics. Site suitability is evaluated using the Analytical Hierarchy Process (AHP) method. Bunruamkaew, and Murayama, (2012) demonstrated that the aim of this task is measure land use and natural assets using GIS in planning sustainable ecotourism destinations. The study prioritizes ecotourism-friendly destinations in Surat Thani province by combining information on land use and ecotourism suitability. Magige et al., (2020) believes that GIS is a computer-based system which can be used for decision making in ecological security, wildlife management and tourism marketing. Research shows that GIS and satellite remote sensing can detect ecosystem modifications, improve resource management and nature tourism. A growing volume of research emphasized the central role of sustainable ecotourism.

AHP-GIS technique has emerged as a valuable tool for spatial analysis and decision-making in ecotourism planning (Dang, 2023). By integrating geographical data on ecosystems, biodiversity, and visitor usage patterns, GIS enables planners to identify ecologically sensitive areas and design sustainable tourism routes (Ferreira et al., 2021). Furthermore, GIS facilitates the visualization of spatial relationships, allowing stakeholders to assess potential impacts on natural resources and wildlife habitats (Damm & Felderer, 2012). Through hierarchical decision-making, AHP assists in identifying suitable sites for ecotourism development while considering ecological integrity, cultural significance, and economic viability (Chan et al., 2020).

3 Objective of the Study

The Hospitality and tourism sector can play a significant role in stimulating the economic growth of a country. The tourism sector generated significant revenue for the majority of wealthy nations. The global tourism market is anticipated to grow from its 2022 valuation of US$ 10.5 trillion to US$ 17.1 trillion by 2032. Nonetheless, Pakistan's tourist industry contributes very little to the country's GDP—just 2.9% in 2017. There are several factors behind Pakistan's declining tourism industry. A contributing factor is ignorance; travelers who aspire to visit Pakistan are largely ignorant about the nation's tourist attractions. The District Swat offers exceptional opportunities for sustainable tourism and is endowed with affluent cultural history and heterogeneous natural environment, breathtaking scenery, waterfalls, Lakes, and valleys rich in wildlife. The Swat district's potential for sustainable ecotourism has not yet been thoroughly assessed.

4 Study area

Swat District, part of Khyber Pakhtunkhwa, Pakistan, borders Gilgit Baltistan to the northeast, Chitral to the north and Dir lies in the west, positioned at coordinates 34°32′30″ to 35°48′45″ North latitude and 72°08′00″ to 72°53′45″ East longitude. With a population of 1.26 million residents and covering a total area of 5,337 km2 making it the 15th largest district by area in the KP province. Swat lies within the temperate zone, experiencing a diverse climate influenced by factors such as elevation, latitude, summer monsoons, and western cyclonic currents (Bacha, et al., 2021). January marks the coldest month, while June is typically the hottest. The region receives an average annual rainfall of 1000-1200 mm.

As per the 2017 district census report, Swat boasts a population of 2,309,570. it is commonly referred to as the Valley of Swat due to its positioned within the naturally picturesque geographical region surrounding the Swat River. While traces of Bhudism

remained in the valley up to seventeenth century. Islam became the predominant faith thereafter. In ancient times, Swat flourished as a significant center of early Buddhism and Gandharan culture during the reign of the ancient kingdom of Gandhara. Throughout history, Swat has witnessed the rise and fall of various empires. Eventually, the British forces defeated the Sikhs in 1849, leading to Swat's establishment as a princely state under British rule as part of the British Raj (Naik, 2010). Among Swat's scenic attractions there are notable stunning lakes, including Daraal Lake, Mahudhand Lake, and Kandool Lake, Beshigram Lake, Daral Lake and Katora Lake etc (Abbas, 2014).

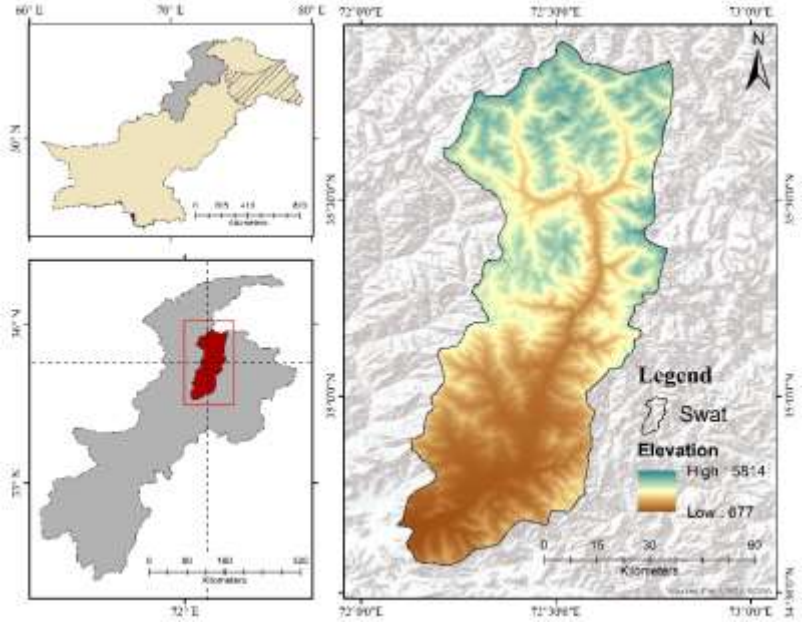


Fig. 1. Location Map of District Swat showing Elevation Ranges

5 Material and Methods

5.1 Data Collection

Data was gathered from primary and secondary sources to create fifteen criteria layers for an ecotourism suitability site study (Table 1). Interviews with experts in related sectors, including ecotourism specialists, environmentalists, literature reviewers, local knowledge, and academics, have helped identify the components and requirements for ecotourism in Swat. Following an in-depth review of the literature and expert comments, theme layers related to environmental, ecological, topographical, cultural, infrastructure, and ecological domains were chosen (Phua and Minowa 2005; Fung and Wong 2007). In addition, on a scale of 1 to 9, a total of 11 respondents were asked which criterion is more essential and how much. This approach assisted us in determining the weightage of each parameter concerning AHP priorities. The specialists were chosen based on their background knowledge and the number of years they spent in the tourism sector of the research area.

Table 1. Spatial datasets and sources for Ecotourism Suitability

S.No	Data	Description	Source
1	Land Use Land Cover (LULC)	10 m resolution	Sentinel-2
2	Elevation (El)	30 m resolution	ASTER GDEM
3	Slope		
4	View Shed	30 m resolution	ASTER GDEM/Wildlife habitat
5	Rainfall (Rf)	1Km resolution	https://worldclim.org.
6	Temperature (Tm)		
7	Road Connectivity (RC)	Digitized in Google Earth Pro as KML	Google Earth Pro 4.2
8	River Proximity		
9	Community Game Reserve (CG)	Point Data digitized from Maps provided by Wildlife department	Climate Change, Forestry, Environment & Wildlife department Government of Khyber Pakhtunkhwa.
10	Wildlife Distribution		
11	Wildlife Sanctuary		
12	Protected Areas (Pa)		
13	Lakes and Mountain Peaks (LMP)	Point map digitized from Google Maps	Google Maps/Literature
14	Historical and Cultural sites (HC)		
15	Adventure areas		
16	Hotel accessibility		

Remote Sensing Data. After pre-processing the open-source satellite imagery, the following parameters were generated

Digital Elevation Model (DEM). ASTERGDEM V3, with a 15m spatial resolution, was downloaded from NASA's LPDAAC (Land Processes Distribution Active Archive Centre). The updated ASTER GDEM V3 has more stereo pairs, better coverage, and less artefacts. The DEM was used to create elevation, slope, and view shed maps, which were then used to determine the ecotourism potential.

Geospatial Crowed Source Data. Secondary data were used to determine the location of lakes, mountain summits, historical sites, settlements, roads, and rivers. Protected areas were gathered from the Protected Planet database (https://www.protectedplanet.net/), while sites for adventurous activities such as game sanctuary and hunting, as well as animal distribution, were documented in the literature (W. Rashid et al., 2020).

Methodology for AHP Approach. The AHP Technique was used to score sub parameters such as appropriate, moderately suitable, and unsuitable. The final weight of the parameters

was determined in the ArcGIS 10.5.2 environment to evaluate ecotourism prospective sites. Figure 2 shows the process.

5.2 Methodology for AHP approach and integration

The Analytical Hierarchy Process (AHP) is based on the ideas of pairwise comparison and the ratio scale created by Saaty (1980). The AHP approach can compare each criterion independently. The comparison is based on their relative significance and ranking in terms of possible sites (Satty and Vargas 2001). The MCDA utilizing AHP involves determining the hierarchical structure, weighting criteria and sub-criteria, assigning preferred weights to each alternative choice, and lastly calculating normalized scores for each criterion (Duc 2006). Many studies have effectively combined GIS and AHP to identify potential ecotourism sites with the objectives of ecotourism planning, management, and sustainability (Bunruamkaew and Murayam 2011). The identification of potential ecotourism sites using AHP and GIS consists of four steps: geospatial database generation and criteria selection, normalization/standardization, application of AHP to determine weight for each criterion, and suitability assessment (Mansour et al. 2019; Sahani 2020) shown in **Figure 2.**

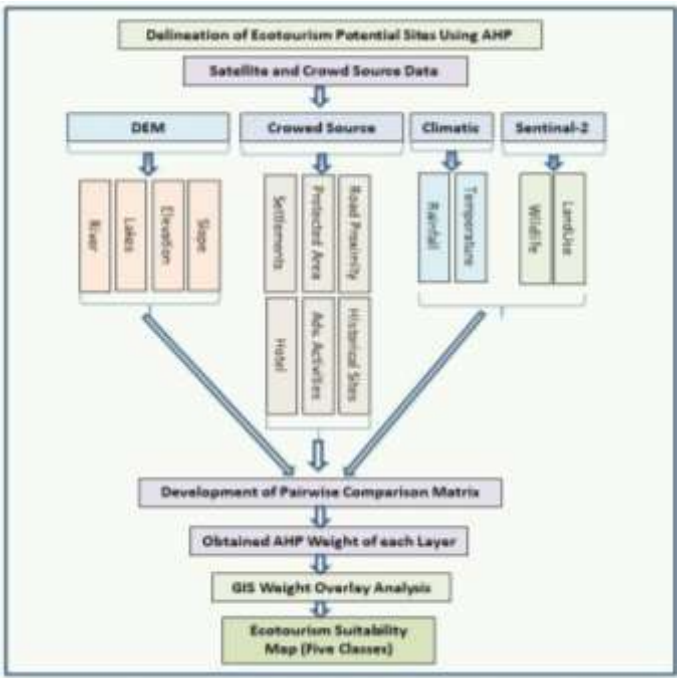


Fig. 1. Methodology of the Study for Delineation of Ecotourism Potentiality

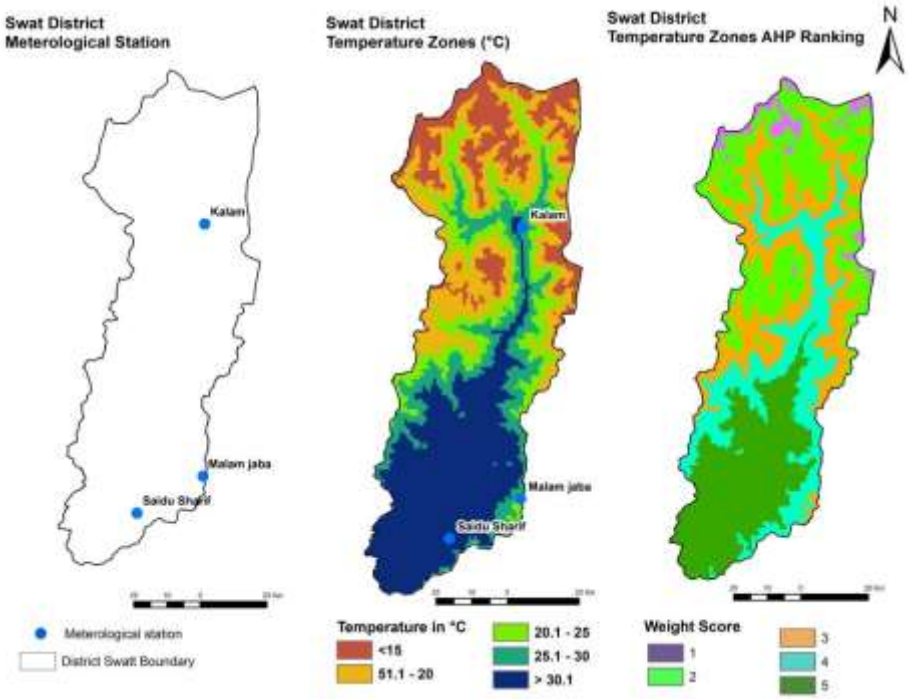
5.3 Generation of geospatial database and criteria selection

The identification of criteria or theme layers is the initial stage in this investigation (Kalogirou 2002; Malczewski 2004). Based on significance, a review of the literature, and local expertise, all the metrics and criteria were chosen. The following thematic layers have been considered for the identification of potential ecotourism sites: viewshed, historical and cultural sites, river proximity, road accessibility, wildlife distribution, community game

reserve, rainfall, landcover, lakes, mountain peaks, and elevation, slope, LULC, and wildlife sanctuary.

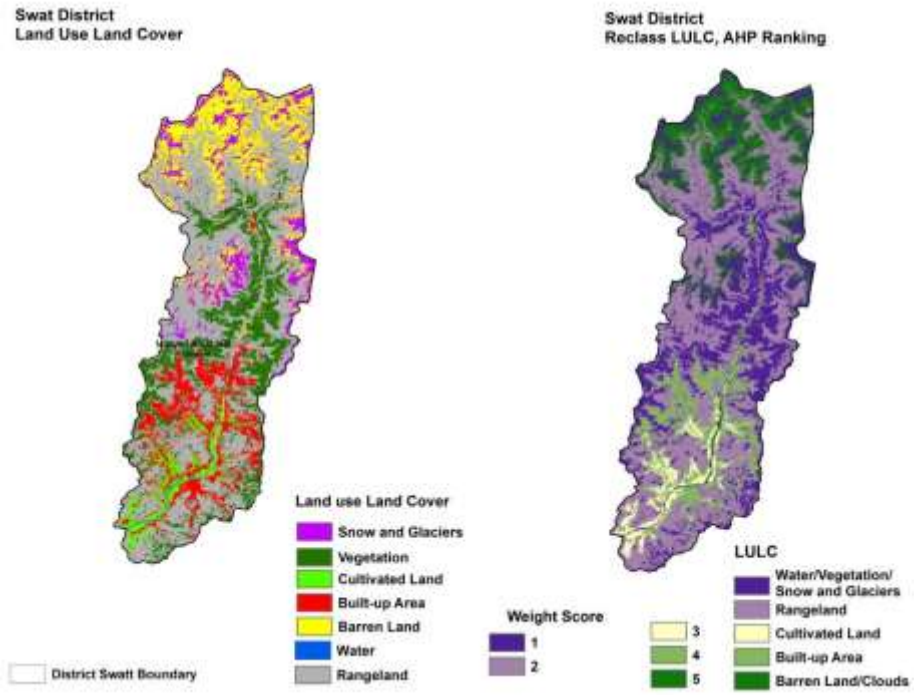
Temperature. The research region has a temperature range of -5.8°C to 39.8°C. The study region has been divided into five temperature zones, namely (-5.8 – 11.7) moderate, (11.8 – 18.2) high, (18.3 – 25) highly suitable, (25.1 – 31.9) low, and (> 32.0) unsuitable, for analytical purposes and to assess the temperature's suitability for ecotourism potentiality (Figure 3).

Fig. 2. Illustration of MET station, Temperature zones and AHP ranking of District Swat



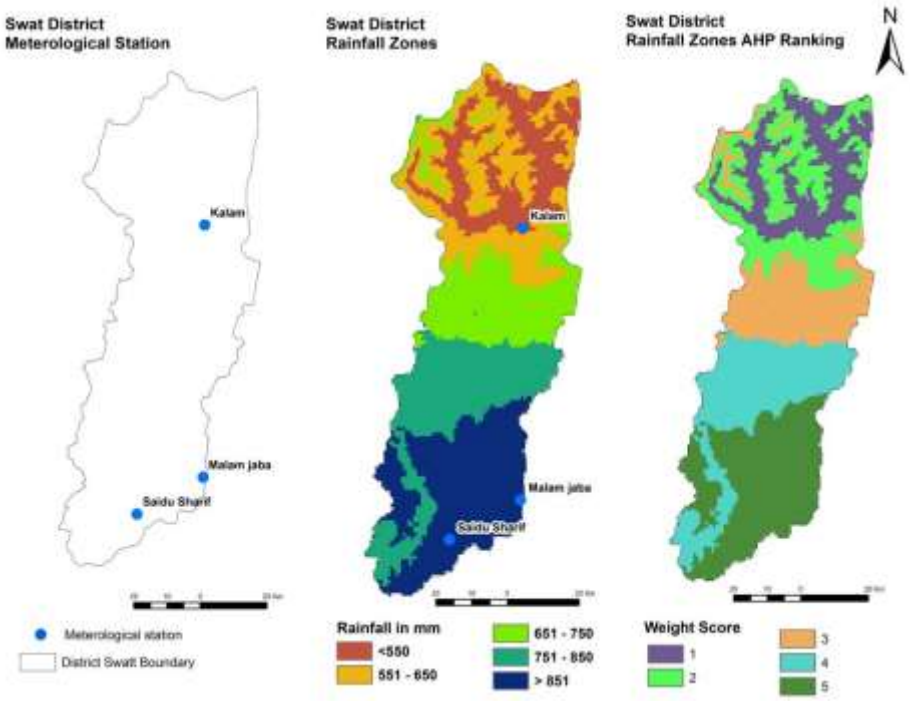
LULC. Understanding the surface's general characteristics is aided by the type of landcover. The research area is mostly made up of arid country with a significant amount of hard rock, ice, and glacier area (Qamer et al. 2016; Ali et al. 2019). Seven landcover types were identified from the study locations: barren land, water, vegetation, cultivated ground, built-up areas, snow and glaciers, and rangeland (Figure 4). The landcover type was classified into five classes: High, Moderate, high, Low, and Unsuitable. The best class for ecotourism was found to be forests (Figure 4).

Fig. 3. Showing the LULC and AHP ranking of District Swat



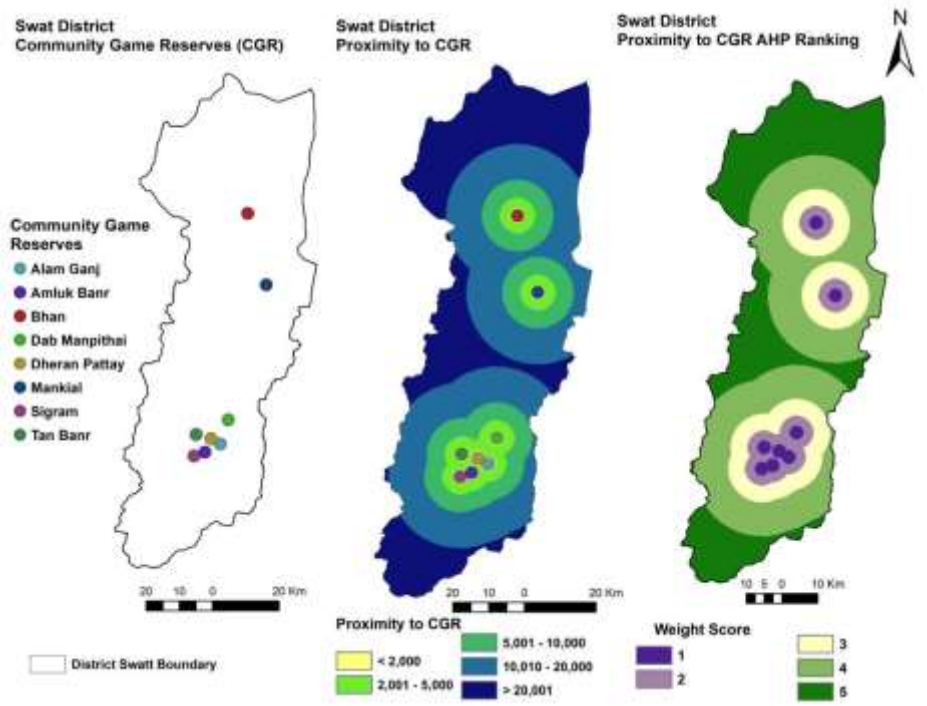
Rainfall. Rainstorms and landslides can be brought on by precipitation (Calligaris et al. 2013; Ali et al. 2019). For the purpose of protecting visitors in mountainous areas, the ecotourism site needs a minimal amount of precipitation. Five levels of suitability were identified based on the amount of precipitation (millimeters): extremely suitable (<371), high (372-571), moderate (572-742), low (743-932), and inappropriate (>933) (Figure 5).

Fig. 4. Illustration of Meteorological stations, Rainfall zones and AHP ranking of the study area



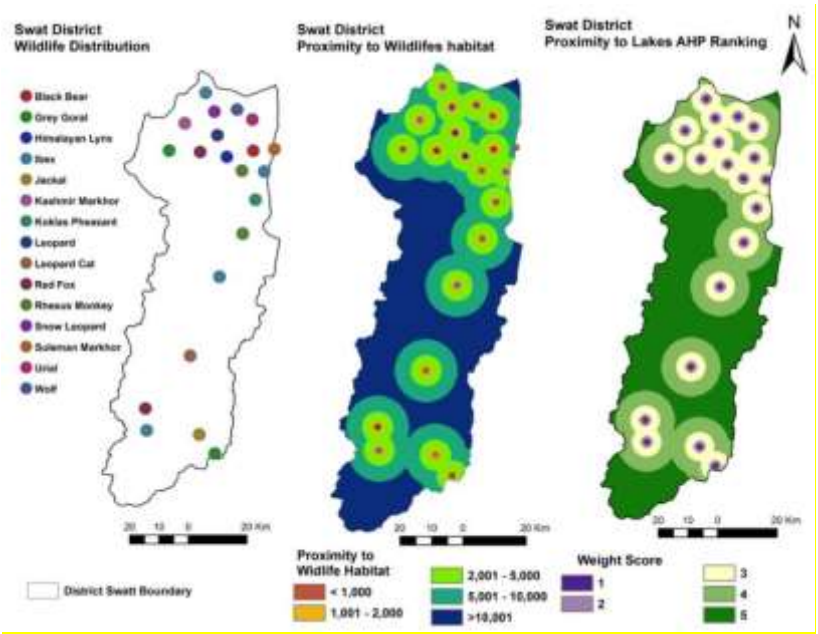
Community Game Reserves. Community game reserves are managed and monitored by the local community, serving as protected areas for the preservation of wildlife and natural environments. These reserves are typically established in regions where populations of animals are threatened by poaching, habitat destruction, or other human activity. Community game reserves are primarily intended to assist in the preservation of biodiversity while concurrently providing economic benefits and employment opportunities for nearby people. The Community Game Reserve is divided into different zones based on distance. The distance range of 0–2000 meters have the biggest influence on the growth of ecotourism. The zone that includes distance between 2001-5000m has a moderate impact on ecotourism. With the lowest weight >20,000m, the zones with (5001-10000m) and (10001-20000m) have moderate to low potential shown in (Figure 6).

Fig. 5. Showing different community game reserves, proximity and its AHP ranking



Game Reserve. A game reserve is an area set aside for the conservation and preservation of wildlife and their habitats. Typically, governments design and manage them with the main objective of safeguarding biodiversity and offering an appropriate environment for animals to thrive. There are five categories based on the distance (in meter) from Game Reserve (Figure 7). They are as follows: 0-2000 (very suitable), 2001-5000 (high), 5001-10000 (moderate), 10001-20000 (low), and >20000 (not suitable).

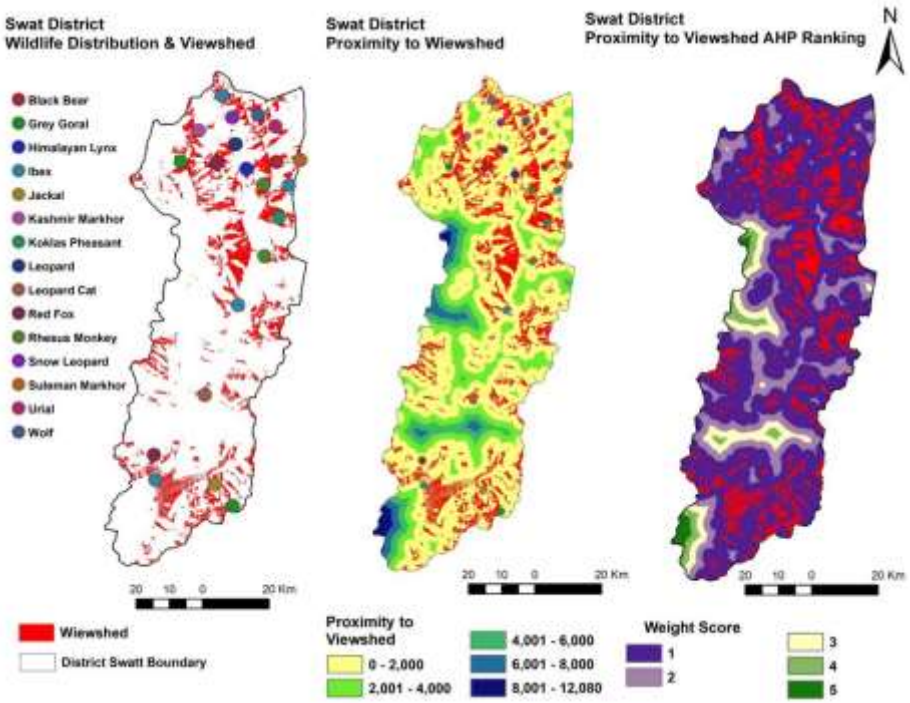
Fig. 6. Illustrated wildlife habitat, its proximity to lakes and AHP ranks



Viewshed. The wildlife viewshed refers to the areas from which various animal species can be seen; it is an important factor in determining an area's potential for ecotourism. Ecotourists are typically drawn to regions with plenty of view sheds that allow for animal sightings because they provide an unrivalled opportunity to connect with a diverse range of creatures. It has been divided into five categories: 0-1,000m (very suited), 1,001-2,000m (high), 2,001-5,000m (moderate), 5,001-10,000m (low), and >10,000m (unsuitable).

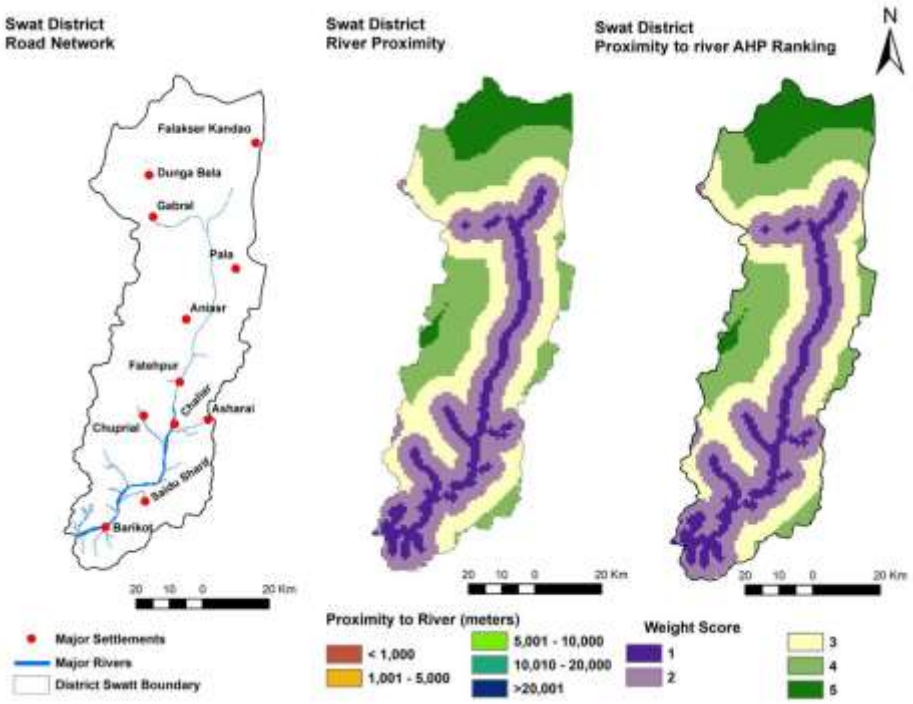
Wildlife Sanctuary. A wildlife sanctuary is a designated area of land where different animal species and their natural habitats are preserved and conserved. While game reserves typically allow hunting and other consumptive uses of wildlife, wildlife sanctuaries place a higher priority on offering a safe haven where animals can live and breed without interference from humans (Figure 8). One of the elements that determines whether an area is suitable for ecotourism is a wildlife sanctuary (Chaudhary et al., 2022). 2000–2000m (very suitable), 2001–5000m (high), 5001–10000m (moderate), 10001-20000m (low), and >20000m (unsuitable) are the five groups.

Fig. 7. Showing important wildlife species, view shed from maximum wildlife can seen and AHP ranking of District Swat



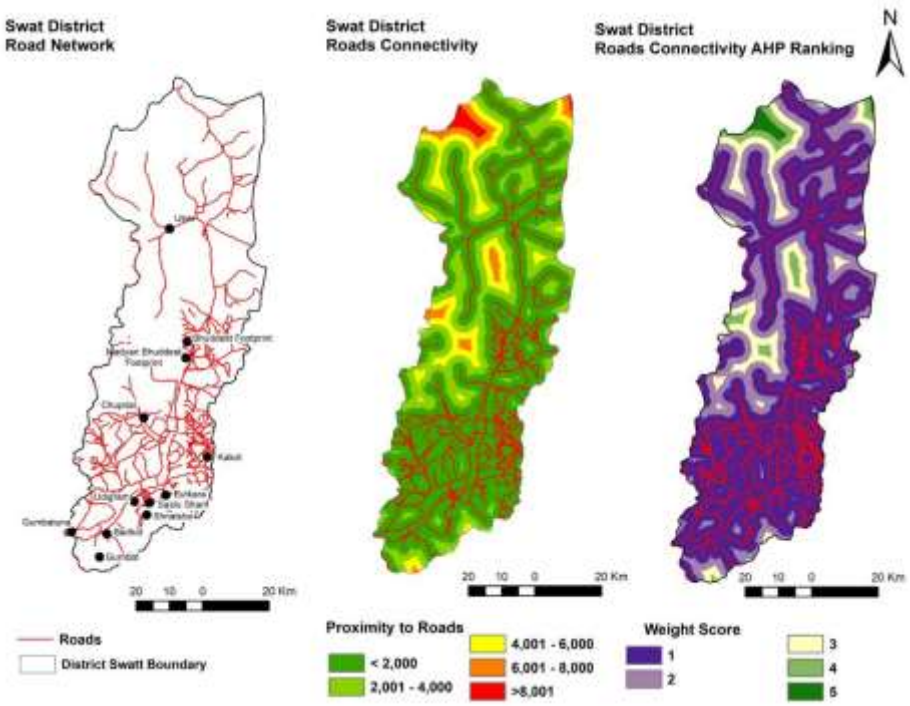
River Proximity. Rivers are vital to the tourism industry because they attract a wide range of animals with their vital water supplies and offer breathtaking scenery to tourists (Figure 9). Furthermore, the research region categorized road closeness into five groups: extremely appropriate (0–1,000 meters), quite appropriate (1,001–2,000 meters), somewhat appropriate (2,001–4,000 meters), poorly appropriate (4,001–8,000 meters), and inappropriate (more than 8,001 meters).

Fig. 8. Important river, its proximity and AHP ranks



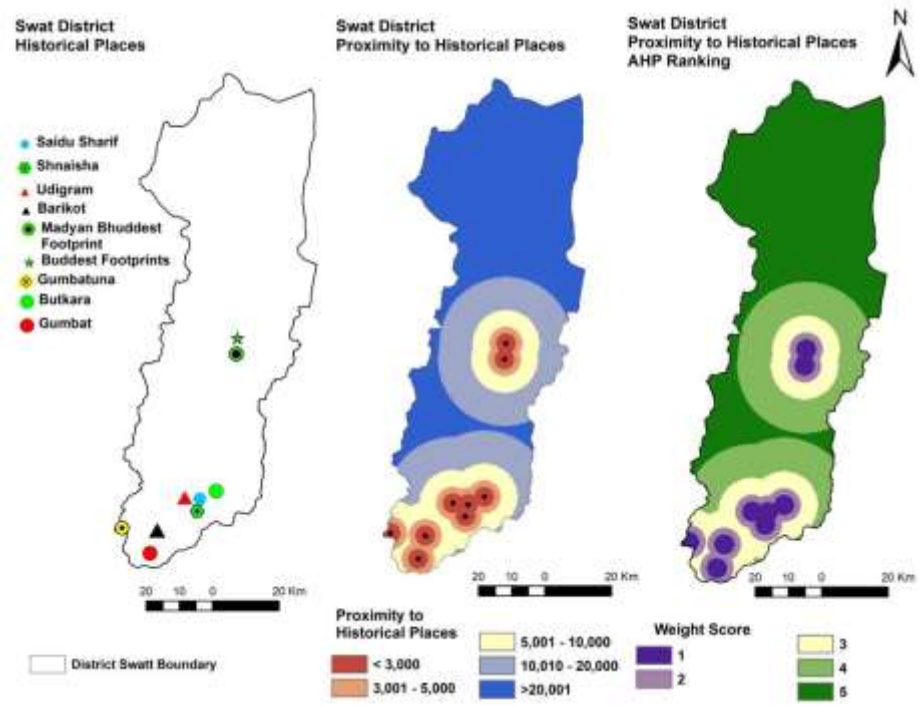
Road Connectivity. Road connectivity is an important aspect in defining tourism infrastructure and competitiveness in any region, as tourists favour regions with strong transportation networks. Road connection has a significant impact on other infrastructure and the competitiveness of the tourism business in any location (Chaudhary, 2022; Kim et al., 2015; Sahani, 2020). The road connectivity in the study area (Figure 10) was divided into five classes: 0-1,000 metres (very suitable). 1,001-2,000m (high), 2001-4,000m (mid), 4,001-8,000m (low), and more than 8,001m (unsuitable).

Fig. 9. Road networks and AHP ranking of District Swat



Cultural And Historical Sites. Cultural tourism, one of the first forms of tourism, continues to draw huge populations to numerous destinations across the world (Richards & Munsters, 2010). As a result, cultural and historical landmarks have a significant impact on the global travel sector. The cultural and historical sites in the study region were divided into five categories. 0-3,000 m (very suitable) 3,001-5,000m (high), 5,001-10,000m (moderate), 10,001-20,000m (low), and more than 20,000m (unsuitable) (Figure 11).

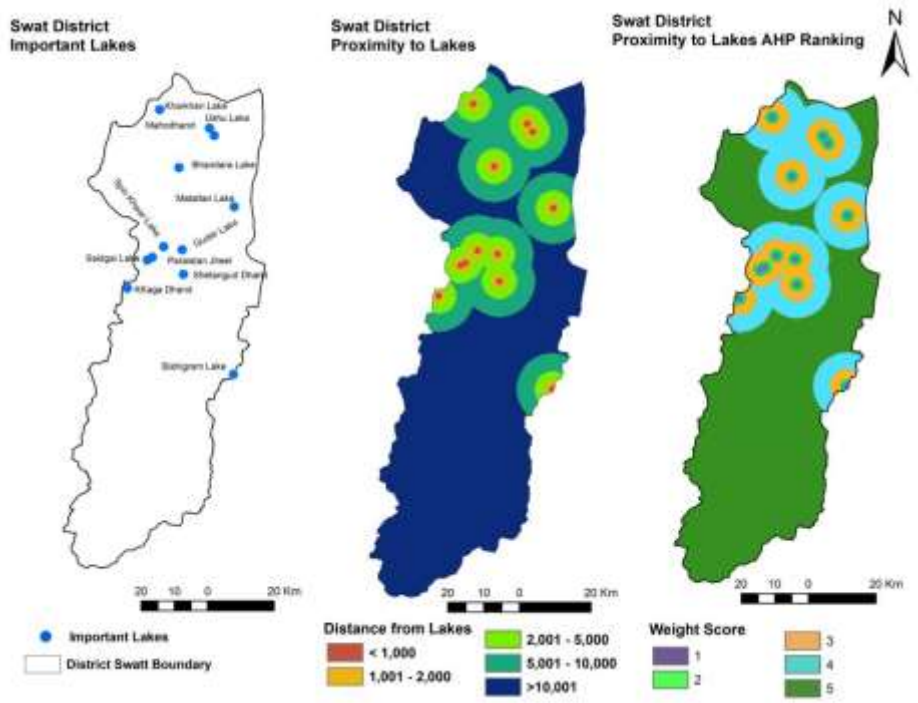
Fig. 10. Cultural and Historical sites of District Swat



Wildlife Distribution. Wildlife is one of the most appealing aspects of ecotourism. Visitors usually seek out spots where they may observe and photograph a wide range of animal species in their natural habitats. The presence of famous or endangered wildlife species can significantly improve an ecotourism destination's appeal and attract tourists from all over the world. It has been categorized into five groups, namely 0-2000m (very suited). 2,001-3,000m (high). 3,001-5,000m (moderate). 5,001-10,000m (low); >10,000m (unsuitable).

Lake, Scenic Areas, and Peaks. The vicinity of each lake, picturesque areas, and key peaks are considered significant for ecotourism development. As a result, the distance zone between lakes, scenic areas, and major peaks is regarded as a high-potential zone for ecotourism development (Amin et al., 2022; Arshad et al., 2018). As the distance from lakes, attractive locations, and key peaks increases, the importance of ecotourism potentiality reduces, and so the distance zone >10,000m is the least significant for ecotourism development (Figure 12). Mountain peaks give attractive views for tourists as well as opportunities for adventurous activities such as climbing and summiting the world's highest mountains, as the study region contains a long list of the world's highest peaks and mountains. The proximity layer was divided into five distance-based classifications. As a result of the improved visibility, areas around these mountain peaks have a higher possibility of attracting ecotourism, and conversely.

Fig. 11. Showing the important lakes, its proximity and it AHP value



Elevation. Elevation is a significant aspect in the development of ecotourism and in identifying viable sites (Bunruamkaew & Murayam 2011; Kumari et al., 2010; Ahmadi et al. 2015). Increasing elevation signifies a decrease in oxygen levels and a lower chance of human survival. Thus, an appropriate elevation range suggests more potential for ecotourism site development, and vice versa (Navale & Bhagat 2021). The study region has been classified into five categories based on elevation: 339-1,000m (very suitable), 1,001-2,000m (high), 2,001-3,000m (moderate), 3,001-4000m (low), and greater than 4,001m above sea level (unsuitable) for ecotourism.

Slope. The slope is also a significant factor in identifying suitable ecotourism places (Kumari et al. 2010; Bunruamkaew and Murayam 2011; Dashti et al. 2013). Steeper slopes indicate areas unsuitable for future ecotourism sites, and vice versa. The study area's slope was divided into five categories: 0-100 (very suitable), 10.1-200 (high), 20.1-300 (moderate), 30.1-400 (low), and > 40.01 (unsuitable) (Amin et al., 20212; Laurin & Ongaro, 2006).

5.4 Standardization

The selected criteria consist of environmental, topographical, ecological, natural, and anthropological areas with varying measurement scales, necessitating standardization for comparability. As a result, all vector layers were converted to raster format, then reclassification was used to standardize all rasters on the same scale of 1-9 and assign values to each parameter based on their importance (Figure 3). The justification for assessing each sub-criterion is based on its value, usefulness, and appropriateness rate for

creating an ecotourism potential map. As a result, priority scores and rankings for the sub-criteria were determined based on their importance (Table 2) and suitability for ecotourism.

Table 2. Saaty' Scale of relative Importance (Saaty, 2008)

Variables	Preferences expressed
1	Equal importance
3	Moderate Importance
5	Strong Importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values between adjacent scale value

All of the criteria in the decision-making process are given weights, which results in the ranking of the parameters in a hierarchical structure. By constructing a pairwise comparison matrix of all criteria using Saaty's 1–9 scale (Table 2), where a score of 1 indicates equal importance and a score of 9 indicates high importance of themes relative to other indicators, the weight of each indicator represents its significance (Saaty 1980). Afterwards, using Saaty's scale (Table 3), a pair-wise comparison matrix was created with the assistance of experts to identify possible ecotourism locations.

Table 3. Pair wise comparison of all Parameters Derived by AHP for Suitability

Thematic Layers	Lc	W	Gr	Lu	Rf	St	T	Ha	Rc	Hc	Ac	Rp	LP
Ls	1	2	2	3	4	6	4	5	5	2	2	2	1/3
W	1/2	1	1	1/2	2	5	2	2	3	1/3	1/4	1/3	1/8
Gr	1/2	1	1	1/2	2	3	2	3	3	1/2	1/5	1/2	1/5
Lu	1/3	2	4	1	1	1	3	5	3	1/3	1/4	1/4	1/7
Rf	1/4	1/2	1/2	1	1	3	2	2	1	1/4	1/5	1/6	1/7
St	1/6	1/5	1/3	1	1/3	1	1	1	1/5	1/5	1/7	1/8	1/9
T	1/4	1/2	1/2	1/3	1/2	1	1	3	1	1/5	1/6	1/6	1/8
Ha	1/5	1/2	1/3	1/5	1/2	1	1/3	1	1	1/6	1/7	1/7	1/8
Rc	1/5	1/3	1/3	1/3	1	5	1	1	1	1/6	1/6	1/6	1/8
Hc	1/2	3	2	3	4	5	5	6	6	1	1/3	1	1/5
Ac	1/2	4	5	4	5	7	6	7	6	3	1	3	1/4
Rp	1/2	3	2	4	6	8	6	7	6	1	1/3	1	1/3
LP	3	8	5	7	7	9	8	8	8	5	4	3	1

Table 4. Normalization all Parameters Derived by AHP for Suitability

NORMALIZED															
Thematic Layers	Lc	W	Gr	Lu	Rf	St	T	Ha	Rc	Hc	Ac	Rp	LP	AHP Weight	%
Ls	0.1266	0.0768	0.0833	0.1160	0.1165	0.1091	0.0968	0.0980	0.1131	0.1413	0.2177	0.1688	0.1037	0.1206	12.06%
W	0.0633	0.0384	0.0417	0.0193	0.0583	0.0909	0.0484	0.0392	0.0679	0.0236	0.0272	0.0281	0.0389	0.0450	4.50%
Gr	0.0633	0.0384	0.0417	0.0193	0.0583	0.0545	0.0484	0.0588	0.0679	0.0353	0.0218	0.0422	0.0622	0.0471	4.71%
Lu	0.0422	0.0768	0.1667	0.0387	0.0291	0.0182	0.0726	0.0980	0.0679	0.0236	0.0272	0.0211	0.0445	0.0559	5.59%
Rf	0.0316	0.0192	0.0208	0.0387	0.0291	0.0545	0.0484	0.0392	0.0226	0.0177	0.0218	0.0141	0.0445	0.0309	3.09%
St	0.0211	0.0077	0.0139	0.0387	0.0097	0.0182	0.0242	0.0196	0.0045	0.0141	0.0156	0.0105	0.0346	0.0179	1.79%
T	0.0316	0.0192	0.0208	0.0129	0.0146	0.0182	0.0242	0.0588	0.0226	0.0141	0.0181	0.0141	0.0389	0.0237	2.37%
Ha	0.0253	0.0192	0.0139	0.0077	0.0146	0.0182	0.0081	0.0196	0.0226	0.0118	0.0156	0.0121	0.0389	0.0175	1.75%
Rc	0.0253	0.0128	0.0139	0.0129	0.0291	0.0909	0.0242	0.0196	0.0226	0.0118	0.0181	0.0141	0.0389	0.0257	2.57%
Hc	0.0633	0.1152	0.0833	0.1160	0.1165	0.0909	0.1210	0.1176	0.1357	0.0707	0.0363	0.0844	0.0622	0.0933	9.33%
Ac	0.0633	0.1536	0.2083	0.1546	0.1456	0.1273	0.1452	0.1373	0.1357	0.2120	0.1089	0.2531	0.0778	0.1479	14.79%
Rp	0.0633	0.1152	0.0833	0.1546	0.1748	0.1455	0.1452	0.1373	0.1357	0.0707	0.0363	0.0844	0.1037	0.1115	11.15%
LP	0.3797	0.3073	0.2083	0.2706	0.2039	0.1636	0.1935	0.1569	0.1810	0.3534	0.4355	0.2531	0.3112	0.2629	26.29%

5.5 Determination of weights using AHP

All indicators and criteria were compared pairwise using the AHP multi criteria decision-making technique, which Saaty (1980) introduced (Figure 4) (Saaty 2008; Sahani 2020). After conducting a thorough literature research, consulting with experts, and drawing on local experience, the relative relevance of each theme was determined (Table 4). The relative weights of thematic layers were the outcome of the AHP approach, which used a comparison of each pair as input. Equation (1) was utilized to determine consistency ratio (CR), which is a measure of how well pairwise comparisons performed.

$$\textbf{Consistency Ratio (CR)} = \frac{\textbf{Ci}}{\textbf{RI}} \quad (1)$$

Here, RI is the Random Index which shows the means of resulting consistency index while, CI, is based on the order of matrix also given by (Malczewski, 2004)

$$\textbf{Consistency Index (CI)} = \mathbf{K_{max}}\frac{\mathbf{n}}{\mathbf{n-1}} \quad (2)$$

Equation (2) is used to determine CI, where n is the number of themes in each layer for ecotourism potentiality and k is the matrix's biggest eigenvalue. A value of less than 10% is advised to show general uniformity and adequate consistency among each parameter of the pairwise comparison matrix and derived weighting value (Ok et al., 2011; Saaty 2008). The consistency of weights in the model generated by the AHP is indicated by the CR.

Table 5. Parameters, Suitability, weight generated by AHP showing highly suitable, high, low and unsuitable classes

S/N	Major Parameters	Category class (m)	Suitability	Weight
1	Rainfall (mm)	<371	Very Highly	0.501
		372-571	Highly	
		572-742	Moderately	
		743-932	Low	
		>933	Unsuitable	
2	Community Game Reserve (m)	0-2000	Very Highly	0.262
		2001-5000	Highly	
		5001-10000	Moderately	
		10001-20000	Low	
		>20000	Unsuitable	
3	Distance from Lakes And Scenic Place (m)	0-1,000	Very Highly	0.493
		1,001-2,000	Highly	
		2,001-5,000	Moderately	
		5,001-10,000	Low	
		> 10,001	Unsuitable	
4	Elevation (m)	339-1,000	Low	0.377
		1,001-2,000	Very High	
		2,001-3,000	Moderately	
		3,001-4000	High	
		> 4,001	Unsuitable	
5	Distance from Wildlife Habitats (m)	0-2000	Very Highly	0.502
		2,001-3,000	Highly	
		3,001-5,000	Moderately	
		5,001-10,000	Low	
		> 10,001	Unsuitable	
6	Game Reserves (m)	0-2,000	Very Highly	0.5028
		2,001-5,000	Highly	
		5,001-10,000	Moderately	
		10,001-20,000	Low	
		>20,000	Unsuitable	
7	Slope (degree)	0-10	Very Highly	0.414
		10.1-20.0	Highly	
		20.1-30.0	Moderately	
		30.1-40.0	Low	
		> 40.1	Unsuitable	

S/N	Major Parameters	Category class (m)	Suitability	Weight
8	Historical and cultural sites (m)	0-3,000	Very Highly	0.5136
		3,001-5,000	Highly	
		5,001-10,000	Moderately	
		10,001-20,000	Low	
		> 20,001	Unsuitable	
9	Road Connectivity	0-1000	Very Highly	0.3639
		1001-2000	Highly	
		2001-4000	Moderately	
		4001-8000	Low	
		>8001	Unsuitable	
10	Viewshed (m)	0-1,000	Very Highly	0.506
		1,001-2,000	Highly	
		2,001-5,000	Moderately	
		5,001-10,000	Low	
		> 10,001	Unsuitable	
11	River proximity (m)	0-500	Very Highly	0.4782
		501-1500	Highly	
		1501-3000	Moderately	
		3001-6000	Low	
		>6001	Unsuitable	
12	LULC (m)	Water	Very Highly	0.245 0.232
		Vegetation	Very Highly	
		Cultivated land	Highly	
		Built up area	Moderately	
		Barren land	Low	
		Snow, glacier	Very Highly	
		Rangeland	Highly	
13	Wildlife Sanctuary (m)	0-2000	Very Highly	0.5028
		2001-5000	Highly	
		5001-10000	Moderately	
		10001-20000	Low	
		>20000	Unsuitable	
14	Temperature °C	-0.4964	Unsuitable	0.4964
		11.8 - 18.2	Moderately	
		18.3 - 25	Very Highly	
		25.1 - 31.9	Low	
		>32	Unsuitable	

5.6 Suitability Assessment

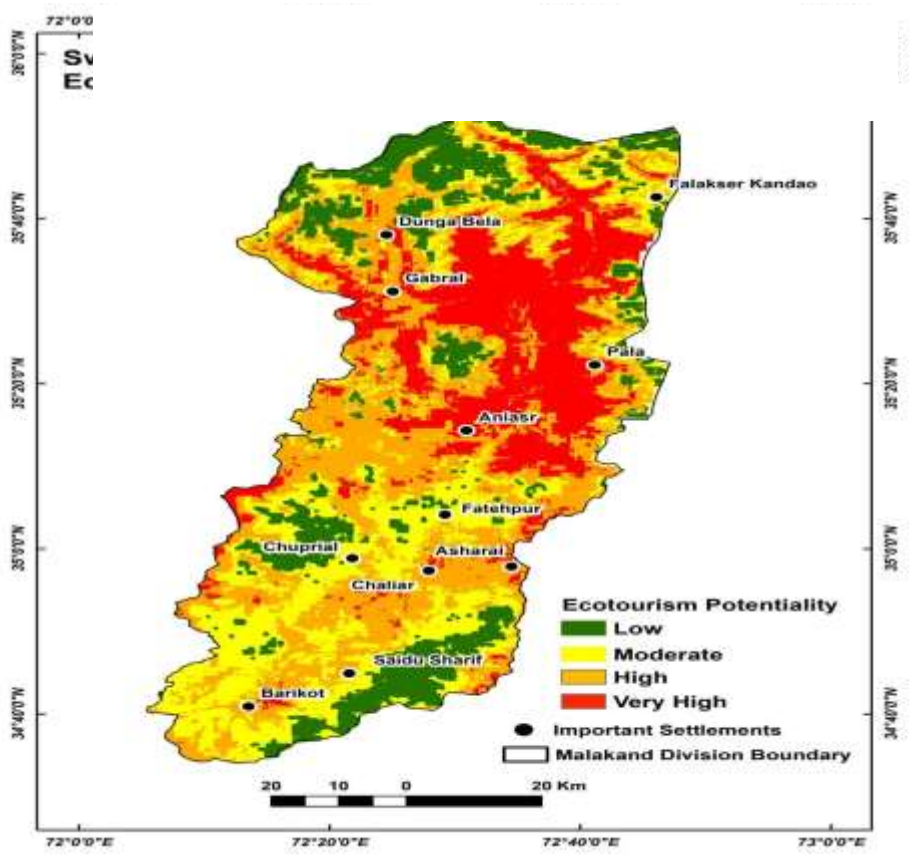
During suitability assessment, a multi-factor analysis is employed to integrate suitability scores, resulting in a final suitability map. After combining components using a weighted linear combination methodology, this map integrates all factor maps by applying a weighted overlay method. Table 5 lists all the characteristics, along with their respective AHP weights and overall weights, that were employed in this study to identify the best location for ecotourism development. A multi-factor analysis is performed to identify

suitable locations for ecotourism by considering the overall appropriateness ratings of all the categories, as indicated in table 5

A weighted linear combination approach is used to construct a final suitability map using raster-formatted AHP weight different factor maps with pixel-based values. To achieve this, a weighted overlay method that takes into account the AHP results is used to combine all factor maps onto a single scale of measurement (Rashid et al. 2020).

Criteria maps, which are each multiplied by an AHP weighting value, are used to represent the fifteen parameters. The final step is to superimpose all of the raster data layers and their classes to create the final suitability map. The weighted overlay results are finally divided into five suitability zones (Very High, High, Moderate, Low, and Very Low), as illustrated in Figure 4.34, with the suitability scores standardized from 1 (lowest suitability) to 5 (highest suitability) (Ahmadi et al. 2015; Amin et al., 2021; Us Saqib et al. 2019).

Fig. 12. Delineated Ecotourism Potential classes through AHP based weighted overlay analysis.



6 Results

6.1 Suitability analysis for ecotourism in Swat

Consistency ratio (CR) of 8.5% was discovered during AHP analysis, which is less than the recommended threshold of <10 or 0.1 (Malczewski 1999; Dalalah et al. 2010). The CR number indicates that the expert's view was consistent, that the pairwise comparison had a respectable degree of consistency, and that the disagreement was acceptable. The AHP model assigned a priority of 15% to elevation among the 15 thematic layers that were identified, and a lowest value of >1% to historical sites. The findings indicate that the research area's potential ecotourism site development areas are unevenly dispersed. District Swat has the most potential for ecotourism in the study area. District Swat has 1299.23 km³ of very high ecotourism potential sites (32.65% of the Malakand division's total very high potential area), and 1930.16 km³ of high potential sites (21.27% of the Malakand division's high potential area). The northern and northeastern regions have significant potential because to the presence of important lakes such as Mohudand Lake and Kandol lakes but a lack of road access and basic infrastructure is a major impediment to exploration. Mahodand Lake is a serene alpine lake surrounded by snow-capped mountains, accessible via a thrilling jeep journey from Kalam. The breathtaking natural splendor of the region provides the ideal setting for camping, boating, and fishing. While the southern and southeastern sections of the research region have identified prospective ecotourism locations due to hotels, historical sites, connecting roads, and infrastructure availability, the remaining areas in the southwestern and central regions have demonstrated minimal suitability for ecotourism.

A few of the factors that make a region highly ideal are that it is located in the highest appropriate elevation class, has beautiful natural landscapes and characteristics, including lakes, wetlands/rangelands, protected areas, communities, and adventurous and historical tourist attractions. Beautiful lakes such as Daraal Lake, Mahudhand Lake, Kandool Lake, Beshigram Lake, Katora Lake, etc. are the main draws of the Swat district (Ali et al., 2024b). Malam Jabba is surrounded by the striking Karakoram Range and dark mountains, providing tourists with a breathtaking view. An adventurer's and nature lover come to Kalam Valley. There are hiking, camping, and trout fishing opportunities available, in addition to the stunning scenery, verdant forests, and gentle rivers. Among the ancient Buddhist archaeological sites in the Swat valley are the Butkara Stupa, the Jahanabad Buddha, and the Shingardar Stupa. These ruins provide insight into the area's rich Buddhist past. The Swat Museum, located near the Butkara Stupa archaeological site, has an extensive collection of Gandharan antiquities on exhibit, including sculptures, coins, ceramics, and relics from the Buddhist era. Highlights of Ushu Forest, near Kalam, include extensive pine trees, hiking trails, and alpine meadows. It's the ideal location for picnics, outdoor excursions, and bird viewing.

7 Discussion

The discovery and restoration of historical places, the introduction of new adventurous activities and initiatives, and the improvement of the road network can all lead to a rise in the potential for ecotourism. It is proposed that increasing these variables will also raise the potential for ecotourism as a whole. Swat boasts well-known ecotourism destinations where visitors come to take in the scenery and spend their holidays, boosting the earnings of small and medium-sized businesses. Examining Swat's untapped ecotourism potential was made possible by the construction of the current Swat Express Motorway.

There is a suggestion that a significant amount of the nation's economy may come from the tourism sector. As per the World Travel and Tourism Council report (2017), Pakistan's economy gained approximately 893.8 million USD (3.6% of total exports) in 2016. It is anticipated that approximately 2.173 million international tourists will visit Pakistan, resulting in a 7.7% annual growth in the tourism industry's income, which will reach USD 1942.8 million (2.8% of total) in 2027 (Arshad et al. 2018).

One of the key elements in the creation of new ecotourism destinations is landcover. According to reports, Pakistan's tourism sector contributed 7% of the country's GDP (Amin et al., 2023). Pakistan was rated 125th in 2015 and 124th out of 136 countries in 2017. Pakistan might increase its revenue by developing new tourist destinations. It is believed that because ecotourism locations require less infrastructure, they should not be developed in areas with an urban land cover. The potential for the development of ecotourism sites will be reduced by these changes in land cover type. It follows that in the near future, it is recommended that ecologically vulnerable regions within the research region not be utilized for urban expansion. To boost ecotourism, however, we can create new national parks or protected areas, which will have favorable effects on the ecology and the economy (Crotti and Misrahi 2015; Naeem Abbas 2015; Us Saqib et al. 2019; Pablo-Cea et al., 2020; Rashid et al. 2020).

8 Conclusion

In order to identify ecotourism potential zones using a multi criteria decision model, the current study uses an integrated strategy that combines AHP and GIS techniques. The study effectively divides the Swat region into five ecotourism suitability zones using remote sensing and data gathered from crowd sourcing. Because of their accessibility, wealth of historical monuments, and wildlife reserves, the southern regions have a lot of potential for ecotourism. Visitors can enjoy historical and natural wonders year-round because to well-established infrastructure supporting these attractions. An excellent road network, historical sites, game reserves, a wide variety of species, protected regions, and regular rainfall are all important components of the region's ecotourism potential.

On the other hand, the northern regions of the Swat district provide excellent ecotourism locations, but a lack of infrastructure, services, and promotion has left much of it undiscovered. However, locations with beautiful mountain scenery and hiking paths, such as Bashigram Lake and Daral Lake, in the district's western and central sections, show promise. There are prospects to increase local revenue as a result of the region's tremendous potential for sustainable ecotourism expansion. The foundation for identifying ecotourism zones in comparable mountainous places is laid by this pioneering study. Regular updates to ecotourism suitability evaluations are advised in order to take into consideration the constantly changing nature of the tourism industry and its infrastructure, as well as activities like investment projects, capacity building, the creation of protected areas, site marketing, and human resource development.

Disclosure statement

No potential conflict of interest was reported by the authors.

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