The University of Tehran Press

Pollution

Print ISSN: 2383-451X
Online ISSN: 2383-4501

https://jpoll.ut.ac.ir/

Comprehensive Analysis of Tourism Ecosystem Health Assessment (Case Study: Western basin of the Hyrcanian forests)

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Article Info

Article type:
Research Article

Article history:
Received: 30 December 2024
Revised: 01 February 2025
Accepted: 16 July 2025

Keywords:
Assessment
Tourism Ecosystem Health
Coastal City
Human Disturbances
Mazandaran province of Iran

ABSTRACT

Human activities are increasingly impacting landscapes, creating significant social, economic, and environmental challenges that threaten sustainable development in both urban and rural areas. Ecosystem health, fundamental to sustainable development, directly and indirectly influences human well-being. The rapid expansion of tourism in Mazandaran Province, northern Iran, exemplifies this challenge. While tourism is often considered relatively environmentally friendly, its complex interactions within the tourism ecosystem necessitate comprehensive assessment. This 2023 study utilized the VORSH model, a robust framework encompassing productive capacity, structural integrity, resilience, ecosystem service functionality, and socio-economic indicators, to evaluate the health of Mazandaran's tourism ecosystems. Analysis of the health score of the study area showed a value between 0.2 and 0.8. Although 54% of the region has good health and 24% has moderate health, 22% has a worrying level. Coastal areas displayed the most severe impacts, with degradation escalating from west to east. This trend, if left unchecked, will likely result in irreversible environmental damage. The findings emphasize the urgent need for proactive, sustainable tourism management strategies to protect Mazandaran's valuable ecosystems and ensure long-term socio-economic well-being. Further research should focus on targeted interventions to mitigate identified vulnerabilities.

Cite this article: Jadidi, J., Amiri, M. J., & Faryadi, Sh. (2025). Comprehensive Analysis of Tourism Ecosystem Health Assessment (Case Study: Western basin of the Hyrcanian forests). *Pollution*, 11(3), 973-985.
https://doi.org/10.22059/poll.2025.387850.2715

DOI: https://doi.org/10.22059/poll.2025.387850.2715

INTRODUCTION

In general, there is a reciprocal relationship between population growth and economic development. Neglecting this relationship may lead to an overestimation of the role of population growth in economic development (Zhang & Xie, 2019). The expansion of human activities in various landscapes creates numerous social, economic, and environmental issues, posing a threat to the sustainable development of urban and rural areas. Developed countries prioritize environmentally based advancements in their planning processes, incorporating them into every aspect and phase of their economic and social development programs. Studies indicate that despite the establishment of ambitious sustainable development goals, no country currently exists that meets the basic needs of its population while simultaneously utilizing resources sustainably (O'Neill et al., 2018). Therefore, conventional business practices fail to provide a sustainable socio-ecological system, necessitating alternative strategies to enhance the balance between social needs and environmental requirements. Long-term sustainability depends on goals that balance the relationship between people and nature (Henderson &

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Loreau, 2023). As the foundation of sustainable ecosystem development, ecosystem health is primarily used to demonstrate an ecosystem's ability to meet the reasonable demands of human development, and its health directly or indirectly impacts human well-being (Huang et al., 2022). The health of an ecosystem is crucial because human survival depends on its goods and services. Hence, continuous monitoring of ecosystem health is essential for human welfare and for identifying options to improve natural systems (Padua et al., 2023). Given that urban environments have undergone significant changes in appearance and function, many countries have made substantial progress in improving environmental quality and reducing the negative impacts of human activities through their persistent efforts. In this context, the concept of ecosystem health links human health, human activities, and ecosystem changes. The health status of an ecosystem is closely related to sustainable human development (Wolf et al., 2013). When disturbances reduce the system's self-regulating capacity or exceed its threshold, the ecosystem also limits the sustainable growth of human well-being by providing low-quality ecosystem services (Villns et al., 2013). Maintaining ecosystem health is a key factor in achieving sustainable socio-economic development. Quantitative monitoring of environmental health status in a region and identifying improvement strategies are crucial for maintaining the sustainable development of cities and villages (Hader et al., 2020). Ecosystem health assessment provides a scientific basis for managers to improve scientific management, which is beneficial for achieving sustainable livelihoods. Therefore, quantitatively assessing ecosystem health levels and analyzing the underlying reasons for ecological management are of great importance (Shen et al., 2020).

With the rapid growth of tourism and the introduction of new destinations to visitors in large and small urban and rural areas, issues related to ecosystem health have become increasingly apparent (Banarsyadhimi, 2022). Phenomena such as overconsumption of resources, soil erosion, habitat degradation, loss of biodiversity, increased waste production, and subsequent environmental pollution constrain the development of sustainable tourism (Liu et al., 2022). The tourism ecosystem is a composite system consisting of a tourism system, an economic system, a social system, and a natural system, making its definition and health assessment highly challenging due to its complexity and comprehensiveness. It is also important to consider that a tourism ecosystem is dynamic, open, interactive, and subject to change (Luo et al., 2022). Planners identify the primary problem of tourism ecosystems as the lack of balance between resource extraction and consumption with the environment's capacity and carrying capacity of attractions. Therefore, finding solutions to maintain the integrity of the interaction between environmental protection and tourism development, and maintaining the health of the tourism ecosystem (TEH), has always been a focus for planners. The environmental carrying capacity of composite system resources includes resources, environment, economy, and society. Tourism development is one of the human socio-economic activities related to the carrying capacity of resources and the environmental carrying capacity, supported by the development of tourism resources and environmental conditions. Tourism resources refer to elements that can be developed and utilized by tourism, including natural and cultural landscapes. Compared to other polluting industries, tourism is considered a relatively environmentally friendly industry. Given the high potential of tourism to create prosperity for society and its low level of pollution, it has attracted attention in many regions (Weng et al., 2018). Ignoring the carrying capacity of tourist areas, lack of awareness and understanding of tourists regarding the environmental importance of destinations, and the inability to counteract the potential impacts that tourists may have on the environment have caused significant damage to tourism ecosystems (Qin and Cheng, 2019). Meanwhile, tourism is an industry highly dependent on natural resources, ecological environment, and climate change, and a decline in ecosystem health will not be beneficial for the sustainable development of tourist cities (Li and Shen, 2021). A tourism ecosystem is considered healthy when it can maintain its self-regulating properties under external pressures and driving forces, while meeting the material and spiritual needs of the local population and responding to the needs of tourists (Mei and Han, 2022; Hillebrand, 2022).

Assessing and monitoring ecosystem health involves continuously evaluating the overall system performance, including monitoring the status of stability, sustainability of structures and functions, and the resilience capacity after disturbances and stresses. For evaluating ecosystem health, quantitative indicators can be developed, and their changes can be monitored and analyzed over time (Abbaszadeh Tehrani, 2015). An ecosystem provides the sites, resources, and services required for the development of other systems and stimulates the formation of forces and functions of ecological services. On the one hand, economic development and tourism activities disrupt an ecosystem, while on the other hand, they provide a budget for investing in environmental protection and pollution control, leading to rapid efforts to restore the ecosystem, which contributes to the resilience of the tourism ecosystem health. Tourism development offers significant economic, social, and ecological benefits. It elevates the position of the tourism economy in the national economy, thereby contributing to the improvement of the economic structure. According to the World Tourism Organization, this industry is considered one of the strongest drivers of economic growth (UNWTO, 2019). Additionally, it offers potential opportunities for creating different types of economic benefits and attracting more attention (Monterrubio et al., 2020; Gabdrakhmanov et al., 2016). From a social perspective, tourism creates job opportunities that lead to the adjustment of the social employment structure. Moreover, it enhances the urbanization process and contributes to optimizing the urban and rural population structures. The ecological benefits arising from eco-friendly tourism development increase green coverage, leading to self-purification of the environment and environmental beautification, along with improving natural structures, which consequently helps in building the organizational structure of tourism ecosystem health. Economic development can enhance livelihoods, such as investing in strengthening medical and educational facilities and services, which improves the health conditions and scientific and cultural literacy of citizens, thereby contributing to the health aspects of the tourism ecosystem related to residents' health and education levels. In summary, complex multidimensional interactions occur between tourism, ecological, economic, and social systems, resulting in five dimensions of tourism ecosystem health (Run Luo et al., 2022). Therefore, research on TEH, with a special focus on analyzing structure and function, as well as driving factors, is crucial for improving sustainable development, high-quality transformation, and promoting regional tourism in the country. When disturbances occur, the first to change are the structural features closely associated with function. If disturbances persist, functions also change (Smith et al., 2023). Studies indicate that structural diversity is a good predictor of key ecosystem functions such as productivity, energy, and nutrient dynamics. The response to disturbances is carried out by structural components, and structural diversity may impact ecosystem resilience and resistance by reducing or enhancing the effects of disturbances. Therefore, structural diversity can act as both a limiting factor and a catalyst for disturbances (Burton et al., 2020).

The counties of Ramsar, Tonekabon, and Abbasabad are among the most visited tourist areas in West of Mazandaran Province, but their health has not yet been assessed. These counties, with their diverse landscapes and suitable size, host many domestic and foreign tourists, which has led to the destruction of their ecosystems in recent years. The accumulation of waste in forest areas is a serious problem in these areas. Also, the discharge of household sewage and service complexes into rivers and the sea has led to soil and water pollution and has endangered the lives of many animals and humans.

In recent years, researchers have examined ecosystem health and tourism impacts. Bahari Meymandi et al. (2018) investigated the role of tourism in the sustainable development of Ramsar using the TOPSIS method, declaring this area highly significant and investable due to its abundant natural landscapes and scenery. Aleyasin et al. (2021) also assessed the ecosystem health of the Miqan wetland in Arak, demonstrating that wetland contamination with heavy metals resulted from the activities of the sodium sulfate factory in the northern region of the wetland. Jahadi and Hezbavi (2023) assessed forest ecosystem health at the watershed scale, using a combination of six indices: NDVI, EVI, SAVI, NDWI, ARI1, and CRI1, finding that the NDVI index, with an R2 value of 0.77, had the greatest impact on forest health levels. Liu et al. (2020) conducted a study to improve wetland ecosystem health, aiming to combat widespread wetland degradation, showing that conservation and restoration policies increased the comprehensive index of wetland ecosystem health. Sari and Nazli (2021) examined the effects of tourism overgrowth on public health and ecosystem health using the MAXQDA software, attempting to link tourism overgrowth to the social exchange theory, in terms of the exchange of key resources in tourist destinations. Luo and colleagues (2022) developed the VORSH framework to explore the spatial and temporal evolution and driving forces of tourism ecosystem health in the Yangtze River Economic Belt of China. Lu and colleagues (2023) examined the dynamic evolutionary characteristics and driving factors of ecosystem health in tourism within China, utilizing the DPSIR model and an ecosystem health assessment index system. They discovered that regulations on tourism practices and the enhancement of information technology significantly positively influence ecosystem health in tourism. Bi et al. (2024) also investigated deep learning-based ecosystem health in a mountain basin system in the arid regions of Central Asia, China, with the aim of preserving the environment and improving economic growth in a mountainous area with suitable pastures, using the VORS model and a deep learning innovation method. They found that the highest quality of pastures was related to summer pastures and the lowest health value was related to winter pastures. Based on their findings, they recommended reduced grazing intensity for high-altitude summer pastures, along with implementing rotational grazing strategies and prohibiting grazing in winter pastures in the central and southern parts of the study area, as well as for spring and autumn pastures. Additionally, they advised the planting of high-quality, high-yield forage grasses along the Irtysh and Ulungur rivers.

The aim of this research is to comprehensively analyze the health assessment of the tourism ecosystem in the northern regions of Iran in Mazandaran province using the VORSH[1] model in 2023, which is the most complete framework and the dimensions of production capacity, structure, resilience, performance of ecological services and the level of health and It includes the education of residents. The existing model has been improved by strengthening, changing, and creating new indicators, analyzing the factors driving the health of the tourism ecosystem in the studied tourism region, and determining the damage that tourism has caused to the region's ecosystem. Strategies to improve the health of the ecosystem of the region in question have also been presented, which can serve as a reference for formulating precise regional environmental management policies.

MATERIALS AND METHODS

Study Area

The coastal province of Mazandaran, encompassing the Hyrcanian forests, has more attractive cities than other provinces in Iran, which has led to a boom in tourism. Ramsar, Tonekabon, and Abbasabad are among the western counties of this province, which welcome many tourists every year in all seasons. The Caspian Sea catchment basin is one of the open basins of Iran, which is considered the main basin in the division of Iranian basins. The area of this basin is 174,618 square kilometers and is divided into 7 sub-basins. This basin includes waterways that lead to the Caspian Sea, most of which flow entirely within Iran before entering the sea

1- Vigor- Organizational Structure- Resilience- Ecological service function- Residents' health and education level

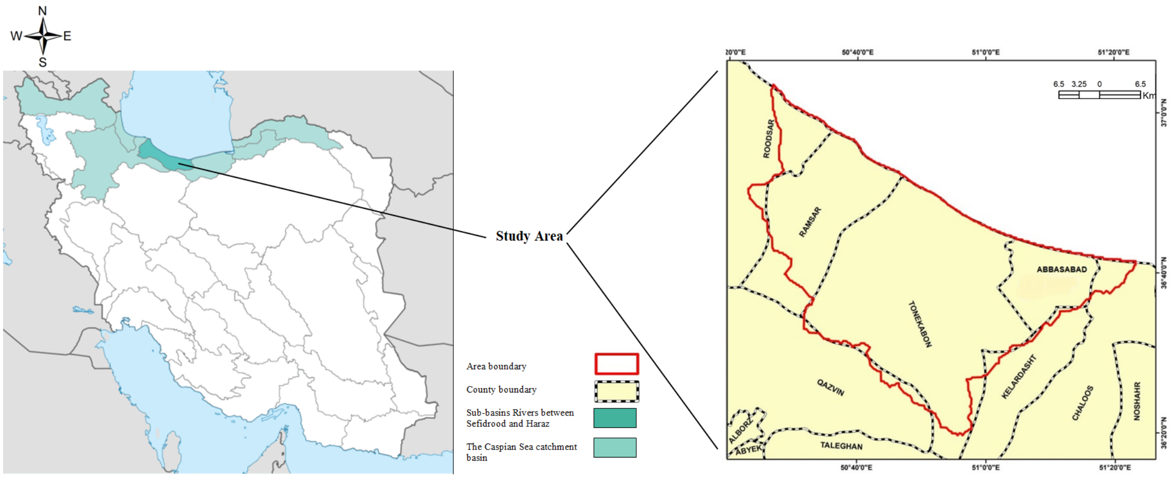

Fig. 1. Location of the study area including the catchment basin, sub-basins, and counties

(Iranian Water Resources Management Company, 2017). The sub-basin of the rivers between Sefid-Rooz and Haraz or Lahijan-Nur is 10,905 square kilometers and includes the rivers of the eastern half of Gilan and the western half of Mazandaran. This basin is located in the area between the Sefid-Rooz and Haraz rivers and includes several coastal rivers that originate in the central Alborz Mountains. The geographical location of the sub-basin of the rivers between Sefid-Rooz and Haraz in the Caspian Sea catchment basin and the studied sub-basins, which coincide with the borders of the selected counties, is shown in Figure 1.

These areas are hot and humid in summer and temperate in winter. Also, due to the proximity to the Caspian Sea, the Alborz mountain wall, and the short distance between the mountain and the sea, it has moderate temperatures and high humidity, so that the annual rainfall reaches 1300 mm and the seasonal distribution of rain is proportional and the dry period is very short.

A large part of this area, which has diverse natural landscapes such as beautiful beaches, conical mountains, roaring rivers, eye-catching waterfalls and summer meadows, is made up of dense deciduous forests. Moving southwest, the altitude increases and country villages are visible. Ramsar is known as the bride of Mazandaran and has attractions such as hot springs, a coastal amusement park, Javaherdeh country villages, a cable car, the old Mir Abdolbaqi Mosque, and an anthropological museum. Moving southwest, the altitude increases and country villages are visible. Ramsar is known as the bride of Mazandaran and has attractions such as hot springs, a coastal amusement park, Javaherdeh country villages, a cable car, the old Mir Abdolbaqhi Mosque, and an anthropological museum. Markoo Castle, Chaldarreh Forest Park, Daryasar Plain, dreamy Kohsar waterfalls, and Dohezar and Sehezar forests are among the most well-known tourist attractions in Tonekabon. Abbasabad is also well-known for its Dehchal Cave, Behesht Gorge, Mazichal summer village, beautiful beaches, Khoshkedaran forest and wildlife museum.

Research Method

Due to the existence of complex social relationships in tourism areas and their connection with other parts of the combined system of this industry, a mixed method was chosen for this study. First, using qualitative methods, the underlying categories of the phenomenon under study were identified, and then, in a quantitative phase, a model was designed based on the identified categories.

To assess the health of the tourism ecosystem, after determining the boundaries of the study area on topographic maps, the required information layers were prepared based on the selected model for each indicator through ArcGIS10.8 software. In this study, the VORSH model was used to construct an indicator system, which is the most comprehensive model available in this field. Indicators are objective, identifiable and measurable signs for qualitative concepts. Given that some indicators had multiple dimensions, to achieve them, they were first decomposed into more detailed components, and then standardized using fuzzy logic mapping. The fuzzy ANP method was used to weight the indicators, and the weight of each was multiplied by the generated layers. The required information layers were prepared by preparing a land use map and identifying the study area through RS and GIS-based software. Then, Landsat satellite images were used to extract land use classes and land cover in the study area, and Envi software was used to achieve this.

A wide range of ecosystem health indicators are available in previous research, but depending on the questions examined in the research, existing indicators were combined and localized, and some indicators were added after studying various aspects of tourism. Another important point in selecting indicators is the availability of data to quantify the relevant indicators at appropriate spatial and temporal scales. The quality of the selected and produced indicators is more important than their quantity, and ultimately all indicators are multiplied together; this means that an indicator may be moved among the existing dimensions, based on the researchers' perspective; therefore, the nature of the model used and its considered dimensions are very important.

After determining the indicators, the required data was obtained through correspondence with the Deputy of Northern Forest Affairs, the National Mapping Organization, the National Geological and Mineral Exploration Organization, the National Meteorological Organization, the Agricultural Jihad Organization of Mazandaran Province and the Agricultural Jihad Department of the studied counties, the Natural Resources Department of Ramsar, Tonekabon, and Abbasabad counties, the General Directorate of Statistics and Information of the Ministry of Agriculture, the General Directorate of Cultural Heritage, Tourism, and Handicrafts of Mazandaran Province and the studied counties, the Statistical Center of Iran, and the National Soil and Water Research Institute.

RESULTS AND DISCUSSION

In this study, Residents' health and education level (H) dimension in the VORSH model was placed in the Organizational structure (O) and formed the health and educational infrastructure indicators. Table 1 shows 33 the health assessment indicators of the tourism ecosystem in the study area.

A comprehensive analysis of the selected indicators is as follows:

From an ecological perspective, vigor as the first dimension in this model, reflects the metabolic capacity and primary productivity of an ecological system. In this coupled human-natural system, vigor is primarily manifested as the socio-economic development of tourism. Sub-dimensions of economic capacity include indicators such as tourism revenue and inbound tourist numbers; resource capacity encompasses water footprint; and natural capacity includes Net Primary Productivity and the presence of natural, cultural, and historical attractions. Tourism revenue is assessed by defining upper and lower limits and evaluating its impact on socical health. The impact of inbound tourist numbers is determined by comparing them to the region's carrying capacity, aligning with the objective of assessing system health. The water footprint, encompassing consumption, access, and other factors, is calculated per tourist and categorized by water source (springs, wells, rivers, etc.), spatially analyzed by mapping their distribution and linkages to settlements. NPP is assessed using the Normalized Difference Vegetation Index, a normalized index derived from the reflectance of electromagnetic radiation by vegetation. NDVI provides information on vegetation health and is strongly correlated with

Table 1. Tourism ecosystem health assessment indicators (source: Authors, 2025)

Dimension	Sub-dimension	indicators	Weight
Vigor (V)	Economic	Income from tourism	0/034
		Number of incoming tourists	0/033
	Source	Water footprint	0/021
	Natural	NPP (Net Primary Production)	0/03
		Existence of attractions (natural, cultural, historical)	0/04
Organizational Structure (O)	Access to public infrastructure	Drinking water distribution network	0/031
		Main power transmission line	0/023
		Main gas transmission line	0/019
		Internet access	0/031
	Access to the tourist area	Distance	0/03
		Roads	0/031
	Population structure	Tourism-related employment rate	0/04
		The ratio of hotels to the number of tourists available to travelers	0/024
		Population density	0/0315
	Wastewater and waste treatment	Waste generation (annual)	0/029
		Wastewater treatment rate	0/026
	Natural	NDVI (Natural to Human-Planted Green Cover Ratio)	0/034
		The rate of land use change from ecological to non-ecological	0/0325
		LER (Lanscape Ecologycal Risk)	0/031
	Health infrastructure	Health per capita	0/026
	Educational infrastructure	Per capita education	0/027
Resilience (R)	Sustainability	Resistance	0/03
		Resiliance	0/029
	Protective	Protected area	0/035
		Land with vegetation cover above 60 percent	0/031
	Carbon	Carbon footprint	0/028
Ecological service function (S)	Regulating	Air quality	0/024
		Flood control	0/029
		Soil erosion control	0/03
		Carbon sequestration	0/028
	Supporting	Preserving biodiversity (conserving habitat, endemic and iconic species)	0/031
	Cultural	Preservation of cultural values (spiritual, artistic and historical)	0/034
		Aesthetic	0/038
Total			**1**

primary productivity, making it a widely used indicator of ecosystem capacity. The presence of natural, cultural, and historical attractions is determined through a site-specific assessment of the study area, evaluating its tourism potential.

Organizational structure is related to biodiversity and the relationship between system elements. In this dimension, sub-dimensions of access to public infrastructure including drinking water distribution network, power transmission line, internet access, access to tourist area including distance, roads, population structure including direct and indirect employment related to tourism, ratio of hotels to number of tourists according to statistics provided by the Cultural Heritage Organization of the studied area and population density, wastewater and waste treatment including annual waste generation, wastewater treatment rate, natural green cover rate to human planting, ecological to non-ecological land use change rate and landscape ecological risk (LER) which includes all landscape metrics and ultimately shows the level of human manipulation of nature, and health and education infrastructure which includes per capita these items are considered. While the rate of access to public infrastructure such as access to drinking water in a tourism ecosystem may reach 100%, its importance necessitates its inclusion in the model. This dimension acts as an organizing factor for the ecosystem and determines its structural stability.

Resilience refers to the capacity of an ecosystem to maintain its structure and function in the face of external disturbances. Resilience is manifested in two key aspects: (1) the ability to resist external interference (such as natural disasters or human activities) through self-regulation to prevent degradation, maintain species stability, and sustain productivity; and (2) the ability to recover to its initial state after a serious ecosystem disturbance (Li et al., 2014). In the resilience dimension, the following dimensions are considered: sustainability, including resistance coefficient and reversibility coefficient, protection, including protected areas and lands with vegetation cover greater than 60%, and carbon sequestration, including carbon footprint. In general, the weight of Resist and Resil should be determined according to whether the external disturbance exceeds the ability of the systematic self-regulation. Ecological service functions refer to the provision of tourism products and services, and within this dimension, there are regulatory, supporting, and cultural sub-dimensions. Regulatory services include air quality, flood control, and soil erosion control, which can be calculated based on different models. In the support sub-dimension, there is a need to calculate carbon storage and maintain biodiversity in the ecosystem in question. Also, in cultural services, the preservation of cultural, spiritual, artistic, historical and aesthetic values is of interest.

After collecting the required data, 33 information layers were prepared in ArcGIS 10.8 software and the weight of the generated layers was multiplied by each pixel of the layers using the following formula and finally they were superimposed.

$$TEHi = \sum_{i=1}^{n} Wi * Ii \tag{1}$$

Then the health of the studied tourism area was calculated and normalized, which can be seen in Figure 2.

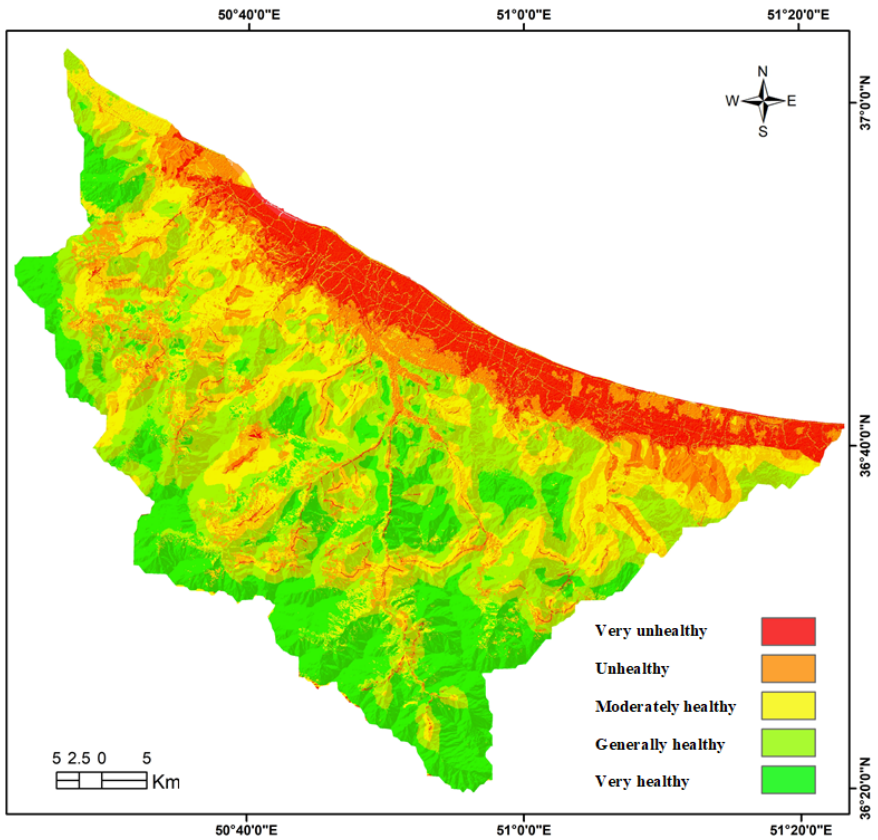

Fig. 2. Tourism Ecosystem Health grades of western Mazandaran Province in 2023

Table 2. Tourism ecosystem health level

Health state	Very unhealthy	unhealthy	moderately healthy	Generally healthy	Very healthy
Health value	[0,0.2]	(0.2, 0.4]	(0.4, 0.6]	(0.6, 0.8]	(0.8, 1]

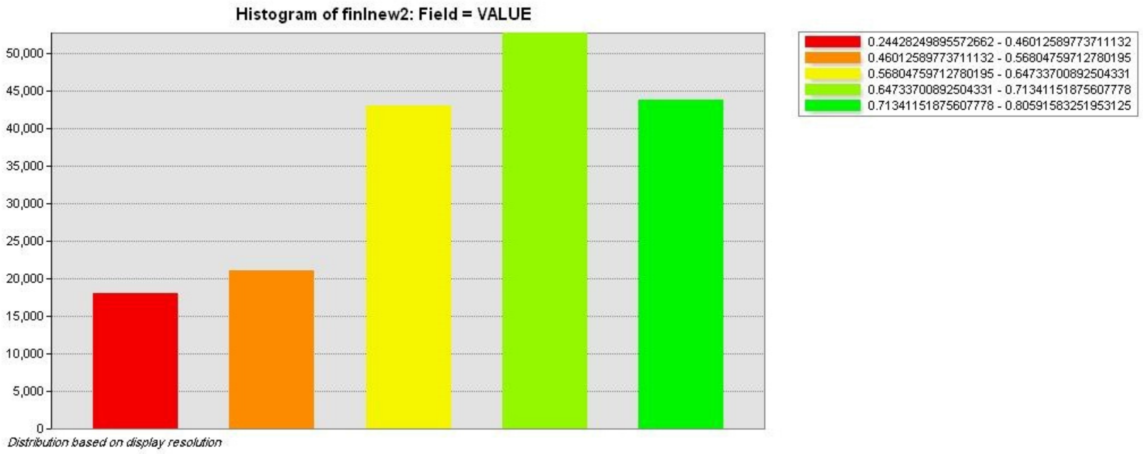

Chart 1. Histogram of the health levels of the tourism ecosystem of the western basin of the Hyrcanian forests in Mazandaran province

Five grades for TEH were created using the equipartition method, which is derived from Integrating previous research in this field (Lu et al., 2023, Luo et al, 2022, Weng et al., 2019, Xu et al., 2017).

The health level of the tourism ecosystem of the studied cities is indicated in a fuzzy form in Figure 2 based on the five degrees mentioned in Table 2. The lowest health level is 0.2 and the highest health level is 0.8. The coastline has the most damage, and this trend is more intense from west to east.

According to the histogram above, 10% of the area is at the very unhealthy level, 12% is unhealthy, 24% is average, 30% is moderately healthy, and 24% is very healthy.

CONCLUSION

This study examined the health status of the tourism ecosystem of Iran's tourism hub using the index system construction method in the VORSH model. This model, the most comprehensive in the field of tourism, comprehensively captures ecosystem integrity and sustainability, its self-organizing and self-recovery capacity under pressure, and its capacity to provide ecosystem services. Human activities, including tourism, impact the structure and functional integrity of ecosystems and the supply of ecosystem services. These impacts occur through alterations in land cover, pollutant discharge, interference with the growth and reproduction of flora and fauna, and modification of the cycling of matter and energy within biological chains (Li and Shen, 2021). A local perspective reveals a positive correlation between tourism activity and employment levels across numerous regions. However, the continued provision of this economic benefit is contingent upon the preservation of the environment. The study demonstrates a significant negative correlation between the intensity of tourism activities and ecosystem health in the study area. The eastern coastal region, including Nashtarud and Motel-Ghoo beaches, suffered the most severe damage. This is due to the spatial concentration of numerous tourism destinations and the resulting mass tourism experience. The concentration of tourism in the western cities of Mazandaran province (Abbasabad, Tonekabon, and Ramsar)

- the main tourist destinations - poses a significant waste management challenge. The fertile agricultural lands and high groundwater levels in the region severely limit access to suitable landfill sites, leading to capacity saturation in existing facilities. The urgent challenge facing the tourism industry in Mazandaran Province is the unsustainable disposal of waste in forests and watersheds. The resulting toxic gas emissions and leachate contaminate soil and water. While the current ecosystem health assessment indicates that 54% is in good health, 24% is in moderate health, and 22% is unhealthy, without immediate action, irreversible environmental damage is imminent. Key findings of this research emphasize the necessity of maintaining the carrying capacity of tourist destinations, considering whether they are concentrated or dispersed. The influx of tourists must remain within the bounds of the environment's assimilative capacity. Furthermore, the preservation of the quality and quantity of natural, cultural, and historical attractions facilitates a more even distribution of tourist pressure, thereby mitigating its impact on the ecosystem. Consciously creating an attraction such as a handicraft market based on the values in the past customs of the studied area and the needs of tourists is one way that can cause tourist distribution; because it leads to the formation of positive feelings in people and has had a positive impact on the development of sustainable tourism from the past to the present. The uneven distribution of tourists among different regions indicates shortcomings in the tourism industry in developing countries that need to be strengthened through extensive education and advertising to strengthen tourism infrastructure and culture.

Factors affecting the development of tourism in a region include natural, economic and social potential, as well as the availability of infrastructure and facilities. The presence of wildlife and pristine forest areas is another factor determining the natural potential of a region, which refers to the preservation of biodiversity. This issue is so important that in developed countries, tourists' interest in nature and animals has led to the formation of a special type of tourism called wildlife tourism. The establishment of four classes of protected areas under the Department of Environment's jurisdiction—national parks, national natural landmarks, wildlife refuges, and protected areas—presents a potential nexus between tourism development and environmental conservation. The presence of wildlife refuges and protected areas within the study area highlights the inherent vulnerability of these ecosystems to unsustainable tourism practices. Effective management strategies are therefore imperative to prevent irreversible ecological degradation, necessitating a comprehensive approach that cultivates a sense of environmental stewardship among tourists. This study examines a region containing several areas of high tourism significance: the Do Hezar and Se Hezar hunting prohibition zones, the Beles Kuh protected area and Khoshke Daran National Park in Tonekabon. The aesthetic value of the landscape, a critical component of ecosystem services, is a key focus. The diverse landscapes—forests, coastal areas, villages, rivers, lakes, and waterfalls—contribute significantly to the region's aesthetic appeal, a vital ecosystem service requiring careful management and preservation.

The restoration of ecological integrity within the Mazandaran tourism ecosystem is a complex, long-term process. The existing tourism infrastructure is demonstrably insufficient to accommodate the current high volume of visitors, necessitating significant infrastructural development. The adoption of advanced waste management technologies, such as incineration, in conjunction with comprehensive civic education programs aimed at both residents and tourists, is crucial for addressing prevalent environmental issues. Furthermore, the integration of a comprehensive waste recycling program offers a viable strategy for generating sustainable revenue streams for local authorities, thereby promoting economic development, enhancing community livelihoods, and fostering entrepreneurial activities.

Ultimately, the health of Mazandaran's tourism ecosystem is inextricably linked to the economic prosperity and environmental well-being of its residents; a sustainable approach is essential for both.

GRANT SUPPORT DETAILS

The present research did not receive any financial support.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

DATA AVAILABILITY

All data are provided in the manuscript.

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