The impact of adopting artificial intelligence methodologies in enhancing the efficiency of tourism networks in rural areas in Tartous Governorate

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Abstract:

Tourism networks in rural areas are vital factors that significantly contribute to enhancing local economic interactions and attracting the attention of various stakeholders. Despite the richness of rural areas in natural and human resources, they still require a developmental strategy to revive and enhance their efficiency in achieving sustainable development. In this context, the role of artificial intelligence applications emerges as a modern, flexible, and

essential means to facilitate the func-tioning of these networks, which rely on fundamental factors encompassing continuously changing big data. Recent research has focused on integrating modern technological approaches into tourism development by using artificial intelligence techniques to combine big data technology, build network analysis models, and employ recommendation algorithms in comprehensive tourism analysis. This approach improves tourists' experiences and develops tourism services through its ability to analyze data and use computational intelligence in decision-making. It also aids in creating promotional platforms for large-scale tourist destinations, increasing the efficiency of re-source management, and planning for tourist destinations.

This contributes to the sustainable development of the tourism sector and enhances the attractiveness of tourist destinations. The re-search resulted in a matrix focusing on the importance of establishing a tourism network and the impact of artificial intelligence applications on it. It provided some outcomes that could help identify suitable locations for establishing the network and its hubs, influencing all critical criteria for forming developmental tourism networks. It also transitions to interactive maps that include new tourist products, distinctive industries, and improved resources, offering high-quality tourism services. These networks form a fundamental base for supporting the local economy

Keywords: Artificial Intelligence, Recommendation Algorithms, Broad Tourist Destinations, Rural Development, Tourism Networks.

أثر تبني منهجيات الذكاء الاصطناعي في تعزيز كفاءة الشبكات السياحية
في المناطق الريفية في محافظة طرطوس

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الملخص:

تعتبر الشبكات السياحية في المناطق الريفية من العوامل الحيوية التي تسهم بشكل كبير في تعزيز التفاعلات الاقتصادية المحلية وجذب انتباه الجهات المختلفة، فعلى الرغم من غنى المناطق الريفية بالموارد الطبيعة و البشرية ما زالت بحاجة لاستراتيجية تنموية لإعادة احياءها و الرفع من كفاءتها في تحقيق التنمية المستدامة وفي هذا السياق يأتي دور تطبيقات الذكاء الاصطناعي كوسيلة حديثة مرنة و هامة لتسهيل عمل هذه الشبكات بما ترتكز عليه من عوامل أساسية تحوي بيانات ضخمة متغيرة باستمرار ، حيث ظهرت العديد

استخدام تقنيات الذكاء الاصطناعي في الجمع بين تكنولوجيا البيانات الضخمة و بناء نماذج تحليل الشبكات و استخدامه في التحليل السياحي الشامل و خوارزميات التوصية مما يسهم في تحسين تجربة السياح وتطوير الخدمات السياحية من خلال قدرته على تحليل البيانات واستخدام الذكاء الحسابي في اتخاذ القرارات، وكذلك في إنشاء منصات ترويجية للوجهات السياحية واسعة النطاق، وزيادة كفاءة إدارة الموارد والتخطيط للوجهات السياحية، مما يسهم في تعزيز التنمية المستدامة للقطاع السياحي وزيادة جاذبية الوجهات السياحية ، ونتج عن البحث مصفوفة بحثية ترتكز على عوامل أهمية إنشاء الشبكة السياحية و مدى تأثير تدخلات تطبيقات الذكاء الاصطناعي فيها بتقديم بعض المخرجات التي من الممكن أن تعمل على تحديد المواقع المناسبة لعقد الشبكة و محاورها و التأثير في كل المعايير الهامة لتكوين الشبكات السياحية التنموية و الانتقال الى خرائط تفاعليه تتضمن منتجات سياحية جديدة وصناعات مميزة وتحسين الموارد وتوفير خدمات سياحية عالية الجودة تتعكس على هذه الشبكات لتشكل قاعدة أساسية لدعم اقتصاديات المكان.

الكلمات المفتاحية: الذكاء الاصطناعي ، خوارزميات التوصية، الوجهات السياحية العريضة، التنمية الريفية، الشبكات السياحية.

Introduction:

Tourism networks in villages and rural areas are among the key factors that significantly contribute to driving economic development and enhancing the living standards of local communities. Rural tourism, with its unique richness in breathtaking natural landscapes and tangible and intangible cultural heritage, represents a sustainable source for income improvement, job creation, and fostering cultural exchange between the local community and both domestic and international tourists. Rural areas possess immense potential for tourism development, making tourism a crucial tool for revitalizing local economies. Therefore, promoting tourism in these areas holds great importance as it enhances economic diversity, provides employment opportunities, and

subsequently improves the quality of life for rural communities   .

Furthermore, the development of tourism in rural areas helps preserve natural and cultural heritage and establishes dynamic interactive links between local residents and tourists. Globally, numerous studies have emerged addressing the role of tourism in economic development. According to the United Nations World Tourism Organization (UNWTO), international tourism revenues totaled approximately USD 1.7 trillion in 2019, representing a significant contribution to the global GDP. Statistics indicate that tourism directly provides over 320 million jobs, profoundly impacting human resource development and making it one of the largest sources of employment worldwide. In many countries, the tourism sector constitutes a substantial portion of GDP and significantly contributes to national revenues, infrastructure development, and cultural and social exchange. Studies suggest that for every dollar spent in the tourism sector, approximately three additional dollars are generated

in the overall economy, highlighting tourism's critical role as a driver of economic growth   .

In this context, and in recent years, the world has witnessed rapid advancements in technology. Among these developments, artificial intelligence (AI) has emerged as one of the most transformative innovations, reshaping how we think, interact, and engage with the world. Advanced AI technologies, including computational systems and electronic engineering techniques, enable the processing of vast datasets, ongoing training for analysis, and deriving decisions and recommendations in a manner analogous to human reasoning continuously and iteratively. This

opens the door to remarkable opportunities for advancing daily life and various sectors   .

AI has become a fundamental component of both the present and future, finding applications across a wide array of fields. These range from daily conveniences like Siri and Alexa to research methodologies, social media platforms, and medical diagnostic systems. As technology advances, AI applications continue to expand and diversify, becoming integral to sectors such as agriculture,

commerce, industry, medicine, and tourism   .

In the context of tourism development, AI has become a powerful tool for enhancing tourist experiences and improving tourism services and infrastructure. AI collects and analyzes data from various online platforms, as well as through surveys and inquiries, to identify tourists' preferences. This facilitates the development of tailored tourism offerings and strategic marketing initiatives.

Additionally, AI can optimize site management and tourism planning strategies, contributing to economic growth and sustainability in tourist destinations .

This study aims to demonstrate the impact of adopting AI methodologies on enhancing the efficiency of tourism networks and its importance in advancing tourism in rural areas, particularly in improving and developing these networks. Through technology, applications like virtual reality (VR) and augmented reality (AR) can provide virtual tours and interactive experiences of tourist sites, attracting large numbers of tourists and enriching their experiences. Such applications offer unique and customized tourism experiences in rural areas .

Moreover, technology and AI serve as powerful tools for improving resource management and tourism services in rural regions. This includes smart hotel and reservation management systems, which enhance booking processes, better understand tourist behaviors, and improve hospitality operations. AI-driven data analysis also refines the strategic planning and distribution of natural and human tourism resources to meet visitors' needs while preserving the local cultural identity .

To strengthen the research, theoretical literature on rural areas and tourism development will be reviewed, including studies and research that highlight the benefits of promoting rural tourism and its impact on the local economy and the quality of life for residents.

Research Problem:

With modern advancements, the diversity of leisure options, and rising local income levels, new spiritual needs have emerged among tourists, driving them to seek rural areas for relaxation, emotional growth, and a return to nature, away from the noise and bustle of urban environments. This has led to greater attention being paid to rural tourism, which has gained prominence alongside the continuous evolution of the tourism industry. Travelers' needs have become increasingly diverse, necessitating the provision of new, targeted services that cater to various travel preferences. Numerous studies have addressed the adoption of artificial intelligence (AI) in achieving higher levels of tourism development. For instance, researchers Yingying Pei and Yingchao Zhang (2021) emphasized the need to establish fundamental standards and requirements to ensure the sustainability of methodologies aimed at optimizing the allocation of tourism resources and providing high-quality services to consumers through data analysis and recommendation models. Other researchers have underscored the importance of devising a methodology that aligns tourists' desires with the local economy to achieve optimal investment in the spatial resources of rural areas. Despite their unique spatial advantages, rural regions often lack sufficient attention from responsible authorities.

This highlights the need to establish a working methodology that examines the fundamental criteria underpinning tourism networks in rural areas and explores how AI tools can be integrated to enhance and sustain these networks. Such a methodology is essential for facilitating continuous transformations and changes in the tourism sector.

Research Objectives:

The research aims to develop an operational framework for tourism networks to promote rural development and enhance it using AI tools to achieve economic, social, and environmental development in rural areas. This is pursued through two key strategies:

1. Identifying the fundamental criteria on which tourism networks are based.
2. Developing a working model for tourism networks that leverages AI tools.

First: Theoretical Literature Addressing Artificial Intelligence Concepts

The concept of artificial intelligence (AI) emerged in the 1950s and has since undergone significant development, especially with advances in technology and the growing use of computing. AI refers to the ability of electronic computer systems to perform tasks that require human intelligence, such as data collection and analysis, decision-making, problem-solving, and pattern recognition. One researcher defined AI as a human-created tool that perceives life as the processing of vast amounts of information at faster speeds. AI is a multidisciplinary field focusing on automating tasks that currently require human intelligence. It has been described as a transformative technology revolutionizing various aspects of life.

Others have defined AI as human-like intelligence exhibited by machines, such as computers or robots—machines capable of mimicking or performing human capabilities, including decision-making, problem-solving, recognizing people and objects, understanding, processing, and responding to language, and learning from past experiences or examples. In the context of regional planning, AI has a prominent role in decision-making, proposing strategies, and identifying opportunities by setting economic and social development goals, intervening in regional development, enhancing urban development strategies, and addressing economic challenges.

AI Strategies

In tourism, particularly rural tourism, AI strategies play a significant role in enhancing visitor experiences. Through machine learning, intelligent systems can analyze visitor data and provide personalized recommendations to improve hospitality services (Heaton, 2018). Another strategy, artificial neural networks, can contribute to rural tourism development by analyzing large visitor datasets and offering insights to improve services and experiences. For example, neural networks can analyze visitor preferences and predict tourism trends, aiding in planning activities and events that attract more visitors to rural areas. They can also improve marketing and advertising strategies for rural destinations more effectively (Hastie et al., 2009).

Pattern recognition helps understand visitor behavior and preferences, enabling more personalized tourism experiences by developing intelligent models capable of analyzing and interpreting data, discovering patterns, and identifying relationships. Such strategies include hierarchical clustering, principal component analysis, and random forest analysis (George J & Bo, 2008).

Fuzzy logic allows businesses to handle data ambiguity and imprecision, enabling more flexible decision-making. Lastly, optimization and research strategies enhance resource management

efficiency and support the sustainable development of tourism destinations by developing algorithms and methods for problem-solving and performance improvement. These include techniques such as local and global search algorithms, numerical analysis, statistical analysis, and heuristic algorithms (Russell & Norvig, 2016).

Advantages of Artificial Intelligence

In the context of tourism development, AI offers numerous advantages that contribute to improving services and experiences. AI enhances system performance, leading to higher operational efficiency and better outcomes. It facilitates integration and interaction between systems and their surrounding environments, ensuring seamless user experiences and effective communication.

Moreover, AI enables efficient processing and analysis of massive amounts of data, helping to identify precise patterns and trends useful for tourism planning. It ensures high accuracy in analysis and decision-making, reducing errors and improving the outcomes of plans. Lastly, AI fosters creativity and innovation by providing new solutions to technical challenges in the tourism sector (Khorasani, 2008).

Second: Theoretical Literature on Tourism Network Concepts

In one study, a network was defined as a group of stakeholders within a specific area working and collaborating to achieve common interests (Khorasani, 2008). Other researchers agreed with this perspective, emphasizing that networks represent collaborative relationships among parties with shared interests. They also noted that such networks reduce risks and enhance performance through trust, especially during crises affecting economic, commercial, and tourism projects (Holešinská & Bobková, 2015). Additionally, other studies described networks as models connecting tourism activities to understand lifestyles, organize regions, and classify them based on their economic and social activities (Chen, 2024).

Some planners suggested that these tourism networks could form a system capable of fulfilling the highest percentage of tourists' desires, thereby meeting all demands within a single destination. This approach ensures optimal utilization of the area and provides tourists with an exceptional experience.

Characteristics of Tourism Networks

Tourism networks are distinguished by their inclusiveness and focus on all dimensions and elements that may cause networks to differ based on spatial characteristics, such as the general distribution of links, local concentration, and relationships among activities. These factors include:

1. Cohesion: Grouping stakeholders based on strong mutual relationships.
2. Structural Equivalence: Clustering stakeholders based on similarities in their relationships with others.
3. Efficient Resource Utilization: Investing available resources in the best possible ways without wastage.

4. Tourist Attractions: Their types, diversity, and distinctiveness.
5. Community Participation: Involving the local community in planning and decision-making.
6. Enhancing Expertise: Focusing on the quality of expertise within the network and working to develop it.
7. Integration with Broader Plans: Aligning with local, regional, and global strategies (Holešinská & Bobková, 2015).

The following sections will review reference studies that have addressed tourism networks as a developmental strategy, particularly in rural areas, to identify the foundational criteria for such networks.
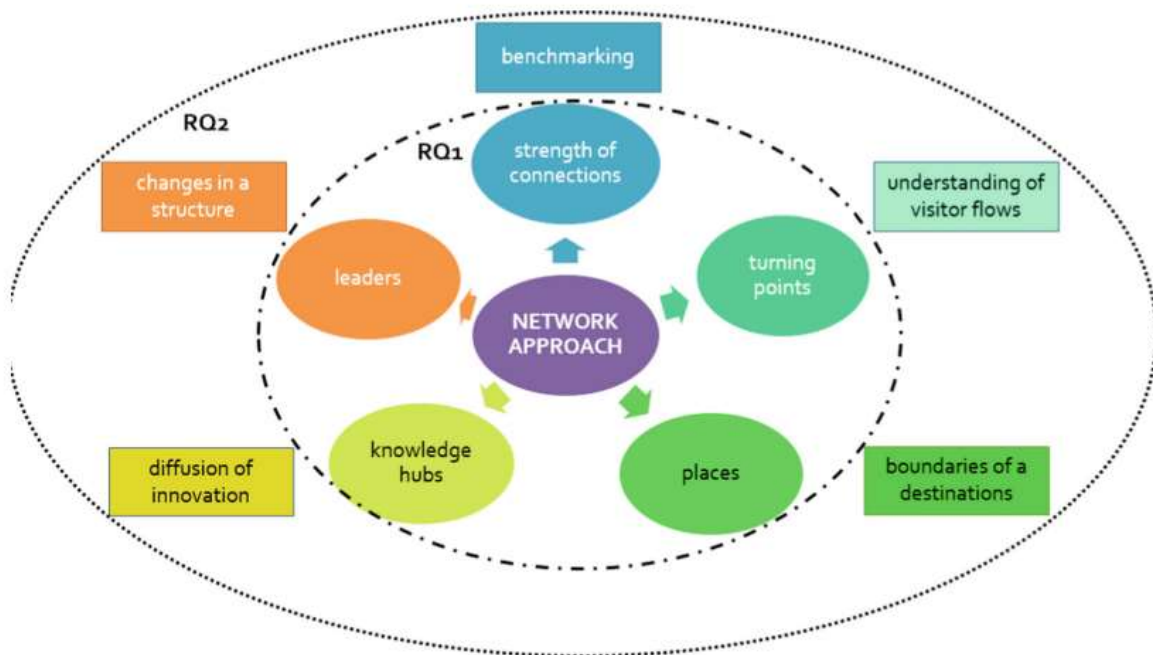

Figure 1: Contribution of network approach to tourism destination governance

Third: Reference Studies

Reference Studies on Tourism Networks in Rural Areas:
The first study focused on the structure of networks encompassing tourism flows and environmental characteristics in rural areas of China. It highlighted seasonal patterns, spatial planning, geographic influences, transportation structures, and tourism resources. Wang and colleagues utilized social network analysis and statistical analysis to examine the structural features of the network and factors influencing tourist flows based on online tourism data. Logistic regression and specialized social network analysis tools were employed. However, the study lacked an exploration of the impact of rural tourism resources, concentrating instead on tourist flows between rural and urban areas, governance approaches, rural tourism network management, and seasonal variations in tourist flows. Key findings included that tourist flows changed with seasonal and atmospheric variations, yet attractions remained constant due to their exclusion from the study. Other notable findings were low

tourism density and unequal distribution of primary and secondary nodes within the tourism network (Li et al., 2022).

Another study addressed development models for tourism flows and spatial structures. It tackled the regional imbalance in rural tourism resources and ways to enhance the development of rural tourism areas. The study examined spatial planning for rural tourism flows within networks by focusing on developing core nodes, main and secondary pathways, and clusters of tourism industries. The goal was to achieve optimal investment in spatial planning assets by leveraging tourist flows and spatial characteristics. The study used digital footprint data for tourists, spatial analysis of tourist destinations, and network analysis programs.

One study examined the social-functional relationships between tourism network operators in rural areas. It revealed that operators are influenced by network structures in rural Chinese destinations, affecting local community behaviors, and positively or negatively impacting destination effectiveness. These relationships were deemed vital for understanding tourism flows in rural areas. Key findings highlighted the development of social capital—a concept referring to the network of cultural, social, economic, and political relationships individuals and communities possess. These relationships foster collaboration, trust, and integration, serving as a significant resource for communities. Social capital contributes to regional economic and social development, promotes social equity, and supports positive societal change. Experimental and descriptive methods compared the effectiveness of two rural destinations using social network analysis programs (Ying et al., 2015).

Another study explored a multilayered model for improving tourism development between rural and urban areas, focusing on population movements and trends. Wang and colleagues analyzed high-resolution mobile signal data and geographic data from Yichang, China. They proposed holistic optimization measures for 92 towns and municipalities, including regional tourism facility development and maintaining spatial connectivity for urban and rural tourism networks. Results emphasized new approaches to regional tourism facility development and structural improvements in urban and rural areas (Liu et al., 2022).

A separate study highlighted rural tourism as a vital income source, emphasizing infrastructure, funding, legislation, and local resources in shaping rural tourism flows. Researchers proposed a sustainable rural environment development model through optimal use of local resources, rural youth settlement, reducing unemployment, women's participation in economic and social life, and enhancing traditional industries' contributions to GDP (Zorzoliu & Iatagan, 2009).

Finally, a study stressed the need for rural tourism networks to develop rural tourism while focusing on education quality, community participation, and sustainable development goals. It provided a broad definition of rural tourism and its key aspects (core criteria) for supporting rural area development. This included diversifying economies, revitalizing local social and economic life, preserving local exchanges, supporting agricultural initiatives, and developing infrastructure, drawing on various studies in the field for key insights (Bogdan, 2020).

These studies collectively highlighted fundamental criteria for building tourism networks in rural areas. Researchers employed secondary indicators calculated using various tools, including digital communication and mobile data, targeted surveys, geographic information systems (GIS), and specialized network analysis programs. Research outcomes were derived from diverse methodological approaches that can inform the development of a methodological matrix adaptable to varying social, economic, and geographic factors.

Some studies focused on economic aspects, others emphasized spatial dimensions for optimal rural resource investment, while others explored social factors and the functional relationships between network stakeholders.

After reviewing theoretical literature on tourism networks and artificial intelligence, a set of criteria emerged, including tourist numbers, governance methods, environmental protection, infrastructure, social networks, economic returns, and tangible and intangible cultural heritage. These align with sustainable development dimensions and could be enhanced through AI tools. Leveraging global experiences in this domain can help formulate a working methodology illustrating AI's role in each network criterion, supporting rural tourism development strategies.

Adopting Artificial Intelligence Strategies in Developing Tourism Networks in Rural Areas

First Study:
This study focuses on recommendation models and the importance of improving tourist services by integrating big data and other technologies to analyze tourist preferences. Such integration enables innovation in tourism products and services. Additionally, it facilitates the optimization of tourism resource allocation and the provision of high-quality tourist services based on technologies like Crawler and Hadoop, as illustrated in the following diagram:
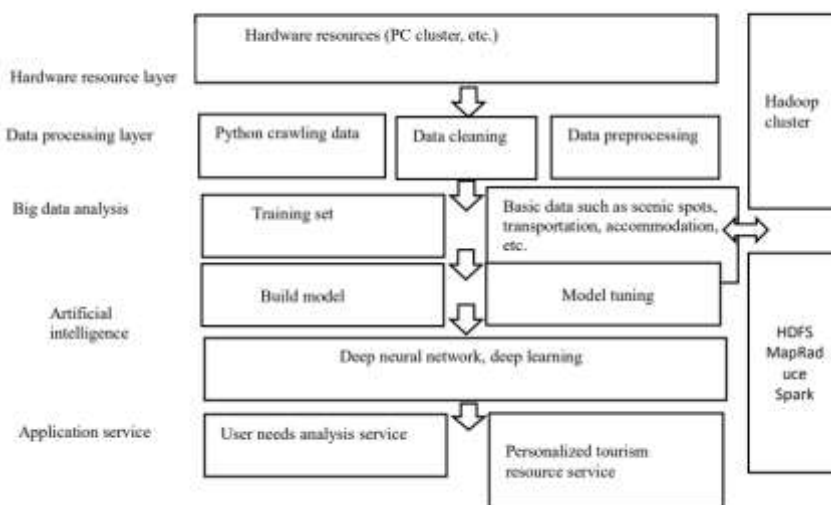

Figure 2: Big Data Analysis Model for Smart Tourism

The study examined tourists' cultural and historical preferences through a recommendation algorithm that can be utilized to achieve the highest visitation rates to neglected areas, despite their abundance of attractive natural resources. This algorithm collects tourists' data and preferences based on their desires via a survey, which presents them with locations matching their interests by referencing other tourists with similar preferences and their evaluations of these areas.

Mechanism of the Algorithm:

1. First, construct a "Tourist-Tourist Site" evaluation matrix. This tool is applied as illustrated in the diagram below:
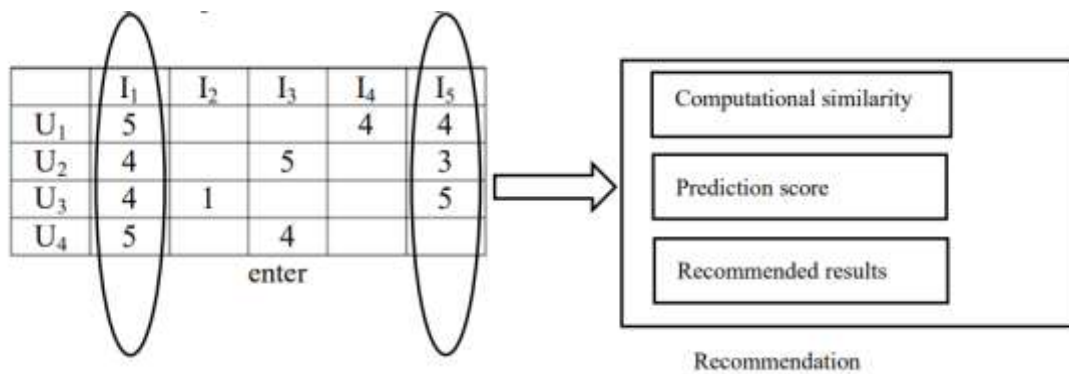

Figure 3: Schematic Diagram of the Item-Based Attraction Recommendation Algorithm

2. Similarity Calculation:
Calculate the similarity between each tourist site and the one not rated by the user. Select the top K sites based on the similarity ranking in descending order. The specific calculation formula is as follows:

$$sim(i, j) = \frac{\sum_{u \in U}(R_{u,i} - \overline{R_i})(R_{u,j} - \overline{R_j})}{\sqrt{\sum_{u \in U}(R_{u,i} - \overline{R_i})^2}\sqrt{\sum_{u \in U}(R_{u,j} - \overline{R_j})^2}}$$

Ru,iRu,j represent the tourists' ratings for areas i and j

Ri represents the average score

If the ratings of two scenic sites are identical during the calculation and the denominator equals zero, the similarity value is set to sim(i,j)=1\text{sim}(i, j) = 1sim(i,j)=1.
If the denominator equals zero due to there being only one tourist rating, the similarity value is set to sim(i,j)=0\text{sim}(i, j) = 0sim(i,j)=0.

3. Aggregating the Process:

Through this process, the expected rating value for the unrated tourist site can be calculated.

$$R_{u,i} = \frac{\sum\limits_{j \in N} sim(i, j) R_{u,j}}{\sum\limits_{j \in N} sim(i, j)}$$

Ru,i and Ru,jR_{u,j}Ru,j:

The predicted score for the tourist and the historical score for scenic sites iii and jjj.

sim(i,j)\text{sim}(i, j)sim(i,j):

Represents the similarity between the two corresponding scenic sites iii and jjj.

4. Providing Final Recommendation Results to Tourists:

In this study, data was used from **Ctrip.com**, a website that primarily offers travel services to consumers. These services include inquiries about tourist sites, ticket reservations, and evaluations of tourist attractions.

Based on the information available on this platform, the essential data required for evaluation can be obtained. Tourists are required to rate tourist sites based on indicators such as:

- The quality of the scenery.
- The efficiency of services provided.
- Their personal feelings towards the experience (rated between 1-5 points).

Using data mining techniques, evaluation data for tourist sites in the **Hainan** region was extracted. The data was then organized into a specific format: the first two columns contained the names of the tourist sites and the users' names, while the subsequent three columns corresponded to the ratings of the three indicators.

Study Results:

Traditional tourism services struggle to meet the increasing demand for tourism. Conventional methods cannot fulfill tourists' desires as they rely on a limited amount of data to design tourism products and services. Consequently, these methods fail to cater to tourists' needs regarding travel modes, tourist routes, and providing recommendations for attractions of interest.

Artificial intelligence (AI)-based recommendation systems have distinct advantages. They can process and analyze tourist preference information and provide customized tourism information and services that satisfy users.

In this context, a **smart tourism data analysis model** was developed and integrated with AI technology. This system can recommend information about attractions that align with tourists' interests, enabling users to enjoy a high-quality tourism experience.
(Pei & Zhang, 2021)

Second Study:

This research initially utilized **Kernel Density Estimation (KDE)**, **Geographic Clustering**, and the **Distance Decay Law** to extract tourism attribute factors. Secondly, it employed the **Random Forest Classification Algorithm** and the extracted tourism attribute factors to build a predictive model for preferred attractions.

Finally, the study investigated rural areas surrounding urban centers to explore modern rural tourism development and assist in the revitalization of rural regions.

Methodology:

Phase 1: Extracting Tourism Differentiation Factors

The extraction of tourism differentiation factors represents a fundamental aspect of enhancing the accuracy and personalization of tourism recommendations. Tourist data encompasses a wealth of personal and tourism-related information. This research aims to analyze such data to extract key tourism differentiation factors through studying information stored on cloud platforms. This comprehensive approach is effective in improving tourism recommendations and guiding visitors to their preferred attractions.

Node Density Index

According to the **First Law of Geography**, everything is related to spatial distribution, and the closer things are to each other, the stronger their connection. Thus, **Kernel Density Estimation (KDE)** can be employed to measure the strength of spatial connections between elements.

The **Kernel Density Analysis tool** in **ArcGIS 10.2** was utilized to analyze the distribution of central points within tourist attraction areas. This method helps create a **connection density map**, assigning different weights to the nodes within the study area.

As proximity to the central point increases, the weight rises, whereas it diminishes with distance from the network's central point. Consequently, this approach identifies peak zones in the point distribution, which represent the most attractive areas for tourists.

$$f_h(X) = \frac{1}{nh} \sum_{i=1}^{n} K\left(\frac{X - X_i}{h}\right)$$

- **k**: The kernel function
- **H**: Bandwidth
- **X-X**: The distance from the estimated destination to the sample
-

Geographic Concentration Index

Tourism is an activity characterized by distinct temporal features. Influenced by climatic conditions and the nature of tourism resources, tourist flows change regularly with the seasons, displaying clear seasonal characteristics. The **Geographic Concentration Index** is an important metric used to measure the degree of concentration of each tourism resource.

$$G = 100 \times \sqrt{\sum_{i=1}^{n} \left(\frac{x_i}{T}\right)^2}$$

Distance Decay Law: As the distance increases, the intensity of the effect decreases. Location, transportation, and information conditions are the primary influencing factors. In tourism, this law refers to the phenomenon where tourist flow to a destination decreases as the distance between the origin and the destination increases. It is an essential method for determining the radiation range of tourist attraction.

$$F = \frac{D}{r^2}$$

Phase Two: Prediction Methods and Models Using Random Forest Classification
The **Random Forest Classification Algorithm** was used to create a model for predicting preferred attractions. The application flows for the Random Forest model predicting preferred attractions are shown in Figure 3.
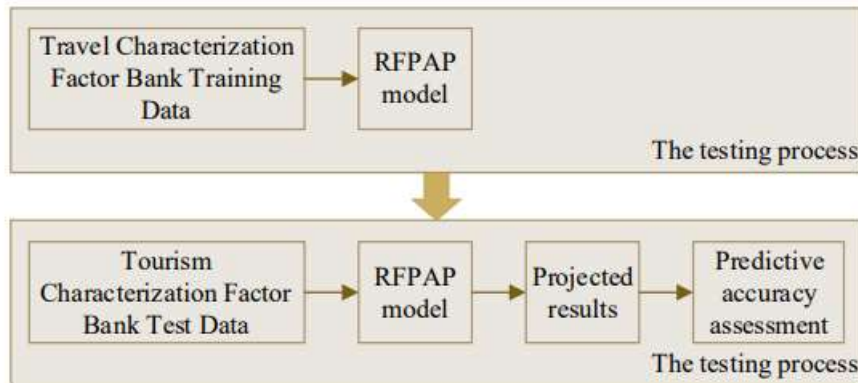

Figure 4: Flowchart of the RFPAP Model

Phase Three: Designing a Personalized Rural Tourism Recommendation Model

This model is based on three sub-models:

First: Designing a Recommendation Model Based on Tourist Attractions
The primary purpose of this model is to analyze the relationship between the target tourist and other

users based on preferences derived from their classifications, then provide personalized attraction recommendations to the target user. By analyzing the attraction patterns that users are interested in and comparing them with the target user, recommendations are made accordingly.

For example, if user A's preferences include "art and culture, historical landmarks, and nightscapes," user B's preferences include "art and culture, historical landmarks, and shopping," and user C's preferences include "natural landscapes, food and drink, and historical landmarks," we can calculate their similarities and recommend shopping-related attractions to target user A.

Second: Designing a Recommendation Model Based on Friend Relationships
Although this algorithm is relatively simple, its recommendation accuracy is not high. In social networks, the choice of friends often influences the user's selection. This paper proposes a recommendation model based on the user's friend relationships. The model only considers the user's friend list when selecting the most similar neighbors. While this approach slightly increases the algorithm's complexity, it effectively scales the system with the growing number of users and items.

In this paper, the proposed recommendation model based on friend relationships is classified into two types. In the first type, friend relationships on social networking sites are presented as mutual interests, where both parties are interested in each other. For example, if user uu is a friend of user vv and user vv is also a friend of user uu, this type of friendship is called a bidirectional friendship. In the second type, only one party follows the other. For instance, if user uu is a friend of user vv but user vv is not a friend of user uu, this type of friendship is called a unidirectional friendship.

Third: Developing a Rural Tourism Recommendation Model
All the aforementioned algorithms have their limitations. For instance, the geographic location algorithm can provide recommendations to all users who have evaluated the content; however, the accuracy of these recommendations is low, and their effects are generic, as the results rely solely on proximity to determine priority. On the other hand, the friend-based recommendation algorithm has a high degree of accuracy but is limited by the fact that not all tourists have friend relationships, making it rare to use recommendations based on such connections.

This research highlights the importance of developing a rural tourism recommendation model that combines the advantages of these three algorithms and compensates for their individual shortcomings, significantly improving the overall recommendation accuracy.

Experimental Analysis of the Role of Rural Tourism in Revitalizing Rural Areas:
To understand the role of rural tourism in rural revitalization, a targeted survey was conducted on a random sample between 2021 and 2022 at various locations, considering the diversity of tourists, travel conditions, and destinations visited. The survey included five criteria: *industrial prosperity, ecological livability, governance practices, a prosperous life, and rural civilization.* These dimensions encompassed secondary indicators, which are presented in Table (1).The table shows descriptive statistics and reliability tests for the rural tourism impact scale. The variable coefficients in the table are 0.835, 0.847, 0.853, 0.843, and 0.883, all of which exceed 0.7,

indicating that the reliability of the scale indicators is relatively high. The average value of each dimension is 3.001, 2.983, 2.998, 3.013, and 2.984, respectively. Thus, the ranking of the five dimensions is: *effective governance, prosperous industry, civilized rural culture, prosperous living, and ecological livability.* This indicates that the overall impact of rural tourism on rural revitalization is most evident in effective governance. It also demonstrates that the enhancement of the *prosperous industry* dimension is relatively better for rural revitalization.

Table 1: Descriptive Statistics and Reliability Test Results for the Rural Tourism Impact Scale

Dimension	Observation index	Sequence	Mean value	Variance	Cronbach's a
Inventory of total					0.874
industrial prosperity I	Increased local catering and service industries	B1	2.991	1.977	0.835
	Make the opening of the farm more	B2	2.995	2.003	
	Increase the local hotel and homestay business	B3	2.967	1.976	
	Make local produce more marketable	B4	3.051	2.057	
ecological livability II	To make villagers good autonomy and maintain environmental health	B5	3.001	2.056	0.847
	Facilitate the treatment of sewage treatment plants	B6	2.969	2.006	
	The forest natural ecological environment is protected	B7	2.985	2.007	
	Increase the vote to participate in the greening of the scenic area	B8	2.977	2.023	
rural civilization III	Improve the overall quality of the villagers	B9	3.035	1.970	0.853
	To make the practitioners honest business	B10	2.979	1.987	
	To promote education in the community tourism	B11	2.987	1.997	
	Increase the number of children in the rural areas that receive education	B12	2.991	1.975	
effective governance IV	Improve infrastructure	B13	2.997	1.997	0.843
	Increase the communication between the villagers and the outside world	B14	2.961	1.991	
	To train the villagers to participate in tourism service skills	B15	3.085	1.924	
	To enable more villagers to participate in local development and decision-making	B16	3.009	2.023	
affluent life V	Increase the income of the villagers	B17	2.979	2.011	0.883
	Increase the number of trips to the villagers	B18	3.003	1.981	
	Increase local living expenses	B19	2.971	1.978	
	Make the villagers more consumable	B20	2.983	2.007	

The study also addressed economic development, along with statistics on the number of social labor in rural tourism and the social labor gains between 2014 and 2022. Additionally, it explored the visitor experience, which included indicators of the tourism experience factors such as the environment and landscapes, infrastructure, tourism services, recreational activities, and cultural performances. Using SPSS 26.0 software, the mean and standard deviation were calculated to identify and classify the tourism experience factors according to their value size.

Table 2: Analysis of recognition of tourist experience factor indicators

Primary index	Secondary index	N	Mean value	Standard deviation	Mean ranking	Mean value
Environment and landscape	The environmental cleanliness of the scenic spot	390	4.293	0.961	3	4.291
	The beauty of the scenic spot	390	4.287	0.949	4	
	Safety of scenic spots	390	4.318	0.949	1	
	Comfort of scenic spot	390	4.305	0.956	2	
	The cultural landscape characteristics of the scenic spot	390	4.272	0.973	5	
	The natural landscape features of the scenic spot	390	4.271	1.008	6	
Infrastructure	The traffic situation of the scenic spot	390	4.236	0.995	18	4.250
	Wireless network signal of scenic spot	390	4.250	0.987	12	
	The accuracy of the signage in the scenic area	390	4.265	0.969	9	
	The number of public toilets in the scenic area	390	4.241	0.971	14	
	Public rest facilities in the scenic area	390	4.243	0.982	13	
	Parking lot design of scenic spot	390	4.268	0.997	7	
Travel service	Reception services in the scenic area	390	4.260	0.991	11	4.251
	Guided tour of the scenic area	390	4.267	0.992	8	
	Shopping service in scenic area	390	4.234	0.986	19	
	Dining service in the scenic area	390	4.233	0.998	20	
	Scenic accommodation services	390	4.261	0.962	10	
Recreational activity	There are many kinds of activities in the scenic area	390	4.239	0.966	16	4.234
	The activities in the scenic area are interesting	390	4.220	0.989	24	
	The characteristics of leisure and entertainment projects in scenic spots	390	4.237	0.988	17	
	The characteristics of the rural cultural experience project in the scenic spot	390	4.240	0.991	15	
Cultural display	The cultural connotation of the scenic spot	390	4.223	1.009	23	4.224
	Representative of local rural culture	390	4.230	1.002	21	
	The cultural inheritance of the scenic spot	390	4.216	0.991	25	
	Cultural performances in scenic spots	390	4.227	1.003	22	

As we can see from Table 2, the overall standard deviation is high, indicating some variations. However, the standard deviations for recognizing the aesthetics, safety, and comfort of the area are 0.949, 0.949, and 0.956, all of which are less than 0.96, indicating that the ratios are clear and balanced, not requiring significant intervention. The overall environment and landscapes in the city's

countryside are rated higher according to tourists' opinions. Meanwhile, the representation of local rural cultural characteristics, the performance of cultural programs at tourist sites, the landscapes of rural areas, and the cultural significance of the tourist sites all have standard deviations for recognition of 1.002, 1.003, 1.008, and 1.009, all of which are greater than 1, indicating that the evaluation scores for these factors are widely dispersed and vary significantly. In light of this, the overall cultural offerings in the city's countryside need improvement and enhancement, which will, in turn, increase tourist satisfaction. The main shortcoming of the study was enhancing the objective level of analysis in evaluating the performance of rural tourism to revitalize the countryside, analyzing measurable indicators such as the percentage of tourism income and the number of people received annually, and analyzing the quantitative weights for rural tourism development in various regions, ensuring that the indicators' weights are objective and relatively fair. Finally, a comprehensive system of dynamic indicator adjustments should be established, along with a mechanism for the dynamic deletion of indicators and dynamic adjustment of indicator weights to adjust evaluation indicators dynamically based on different development backgrounds and social needs in order to achieve dynamic performance evaluation for government assessments. (Gan, 2023)

Fourth: Research Findings:

Developing a Tourism Network Matrix Using Artificial Intelligence Tools:

Several key criteria for tourism networks were identified, and in turn, how to adopt artificial intelligence tools to enhance these criteria to ensure sustainability and continuous development and updating of the network in a technical manner. From this perspective, we will present the most important aspects where artificial intelligence intervenes:

1. Spatial Data Analysis: This involves machine learning and big data analysis to understand trends and patterns in the tourism industry. Data can be used to guide decisions made in the development of tourist areas and improve proposed programs and services.
2. Tourist Experience: This includes the use of technologies such as virtual reality (VR) and augmented reality (AR) to enhance the tourist experience, making it more interactive and personalized. Programs and services can be tailored based on tourists' preferences to offer unique experiences that better meet their needs. Recommendation algorithms discussed in previous research can also be mentioned here.
3. Regional Planning Decisions: Using AI systems to guide policies and plan the development of tourist areas more effectively.
4. Intelligent Guidance Systems: This relates to employing AI systems in guiding policies and making strategic decisions for the development of tourist areas. It can help in setting priorities, effectively allocating resources, and ensuring the sustainability of tourism development for the proposed networks.

Each of these aspects includes tools that can be used to achieve sustainable goals.

The following figure represents the intersection of tourism network criteria with sustainable development goals and how AI methodologies are incorporated to enhance the role of tourism networks, along with the tools used, as derived from previous studies:
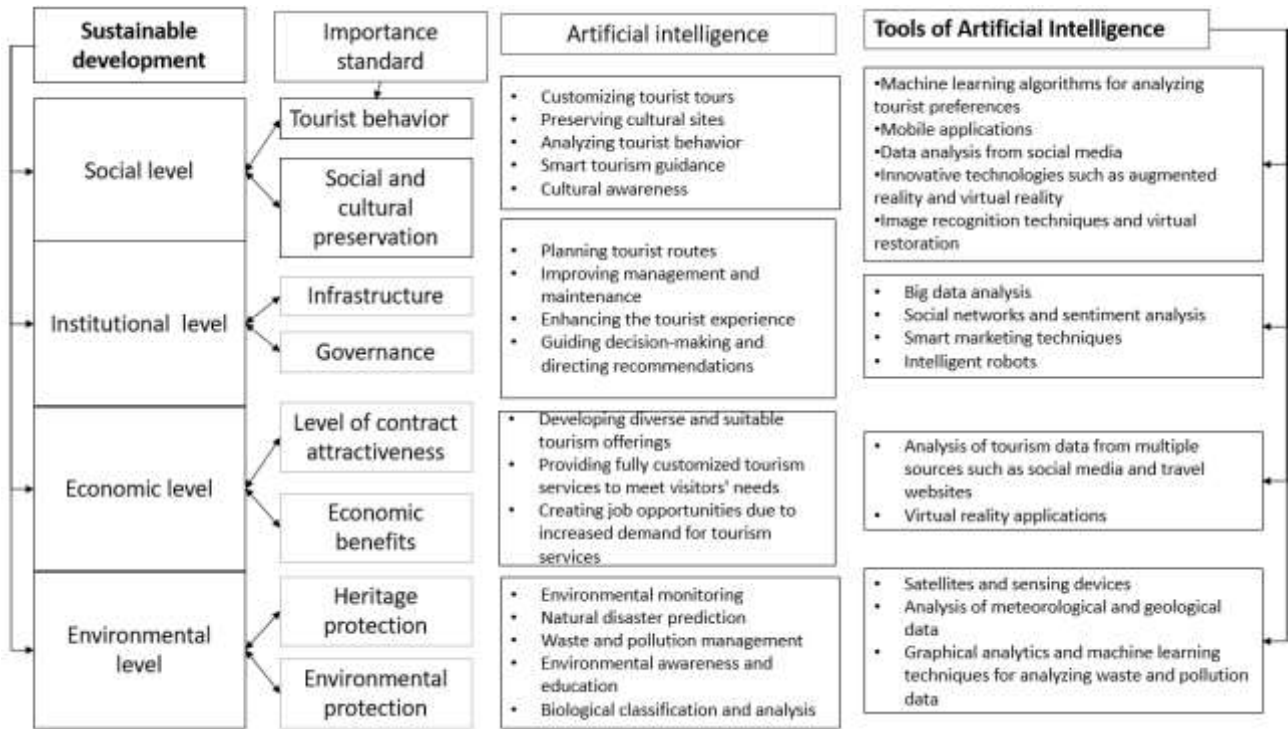

Figure 5: Matrix for adopting artificial intelligence methodologies in tourism networks - prepared by the researcher

Tourism Networks Using Artificial Intelligence Tools in the Study Area:

By applying the research matrix to the case study in the rural areas of Tartus Governorate, specifically in Safita and Dreibkish, the following results were obtained:

A questionnaire was distributed to a sample of experts to weigh the criteria for tourism networks in order to understand the weights on which the networks are based and how artificial intelligence can intervene to achieve the highest percentage for each of them. The following results were observed:

Table 3: Results of the questionnaire submitted to experts

Importance criterion	Criterion importance ratio
Tourist behavior	67%
Social and cultural preservation	80%
Infrastructure	79%
Governance	70%
Economic benefits	81%
attractiveness	80%
environmental protection	84%
Heritage protection	73%

From the following table, we can conclude the key criteria on which these networks are based, according to the opinions of the relevant experts. This highlights the importance of intervention in each of the criteria.

Another questionnaire was distributed to a sample of the local community and investors, which includes several secondary indicators that can be relied upon to develop the core criteria through artificial intelligence tools.

Table 4: Results of the questionnaire directed to investors and the local community - prepared by the researcher

Classification	Importance criterion	The Importance of Standards in Developing the Tourism Network	indicators	The Impact of Indicators on Developing Standards	Percentage of the indicator
Social level	Tourist behavior		Guest numbers	20%	39%
	Social and cultural preservation	67%	Nature and rivers	80%	98%
			Availability of services and public facilities		41%
			Open rural community		65%
			Presence of numerous landmarks and monuments		75%
			Existence of religious sites		74%
			Availability of recreational tourism components and projects		89%
Institutional level	Infrastructure	79%	Streets leading to tourist destinations	79%	47%
			Availability of safe and comfortable transportation		47%
			Availability of services and public facilities		48%
	Governance	73%	Archaeological areas and landmarks	44%	65%
			Tourism facilities and services		76%
			Hotels, restaurants, and tourist resorts		76%
			Traditional industries		65%
			Traditional markets		69%
			Hosting artistic and cultural festivals		80%
			Care for natural resources such as forests and reserves		71%
			Tourism promotion through audiovisual media		70%
			Qualified staff for tourism development and its weakness	56%	94%
			Tourism development plan		88%
			Tourism marketing		84%
			Economic benefits and low living standards		95%
			Tourism investment incentives		88%
			Coordination between regional planning authorities and local municipalities		93%
			Establishment of tourism projects in the area	53%	90%
			Development of traditional markets and industries		98%
			Attention to hosting artistic and cultural festivals		93%
			Securing services and public facilities in neglected areas		70%
Economic level	Economic benefits	81%	Tourism provides job opportunities	10%	24%
			Creating job opportunities by increasing the number of tourism establishments	37%	79%
			Providing loans and financial assistance for small agricultural projects		91%
			Providing loans and financial assistance for small commercial and industrial projects		80%
			Promoting rural tourism		98%
	Node attractiveness level	80%	Attention to training tourism personnel	66%	93%
			Diversifying tourism activities in rural areas		96%
			Attention to roads and services offered to tourists		90%
			Tourist guide	34%	68%
			Raising tourism awareness through educational seminars		59%
			Social media		81%
			Signage and road signs		71%
Environmental level	Heritage and environmental protection	84%	Efforts are being made in this regard	22%	4%
			Awareness seminars	78%	36%
			Tree planting and clean-up campaigns		43%
			Imposing fines on environmental polluters		34%
			Efforts are being made in this regard		71%

By reviewing the results that appeared, we conclude that cultural and social preservation receives significant attention from the relevant parties in the survey, and it has a fairly good percentage, along with the diversity of attraction nodes. On the other hand, the economic benefits resulting from tourism are very low according to the weight of the criterion given by the experts. Therefore, significant intervention can be made in this area to achieve the appropriate percentages in order to meet the goals of tourism networks in rural areas. As for tourism marketing, which has a very good weight, it is expected that intervention will be made to develop tourism marketing for tourist destinations in order to attract attention to the resources of neglected areas, despite their wealth in cultural and natural resources.

The matrix obtained in Figure (4) was applied, and results were achieved by applying it to the case study.
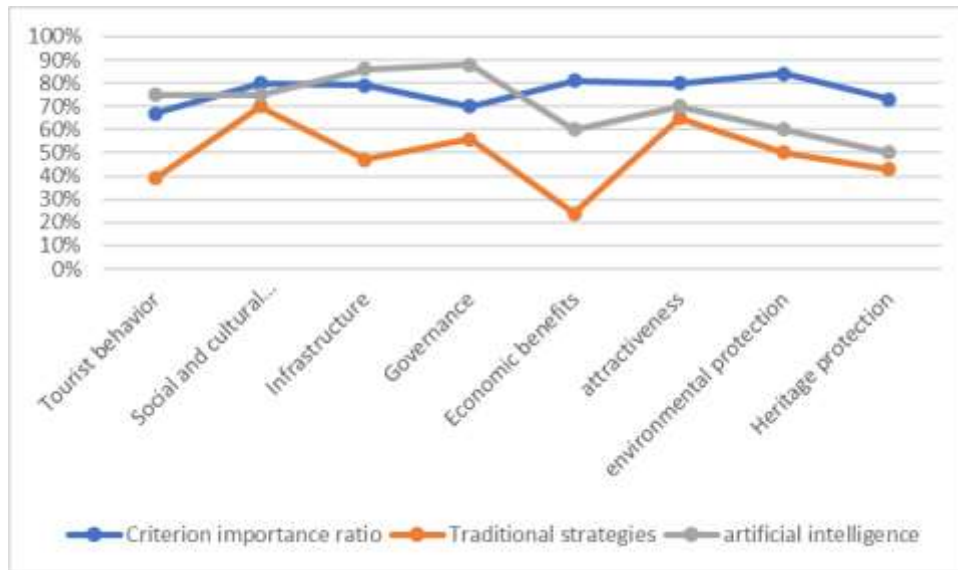
Figure 6: The relationship between traditional strategies and artificial intelligence methodologies in the basic criteria of tourism networks - prepared by the researcher

As shown in Figure (5), through the intervention of artificial intelligence methodologies, higher and more precise levels can be achieved in the basic criteria for building networks. We observe that its interventions are focused on government decisions and official entities with a range of (80-85%) due to their involvement in big data and its analysis, providing patterns, and identifying trends in the hospitality sector. Additionally, its interventions in enhancing tourist experiences through applications like ChatGPT, an automated chatbot interacting with travelers, have increased by about 30% compared to traditional patterns through the intervention of strategies analyzing tourist behavior by monitoring their browsing patterns online, their interactions with apps and websites, and analyzing their social media interactions to create personalized recommendation models that suggest tourism offers and recreational activities based on tourists' preferences and historical behavior, which is called personalized recommendations.

Voice and Image Analysis: Artificial intelligence can analyze images and videos of tourism to understand tourists' preferences by identifying the attractions they are interested in visiting or the activities they enjoy.

Opinion Analysis: AI can analyze survey data and assess tourists' preferences by understanding their responses to questions like the types of activities they prefer or the locations they wish to visit.

As for infrastructure, we also notice a significant improvement in its percentage, reaching 85%, due to AI interventions through the following strategies:

- **Natural Language Processing (NLP):** Used to understand and analyze natural language and interact with tourists in multiple languages. NLP (a machine learning technology that enables devices to interpret, process, and understand human language) can be used to analyze tourists' comments on social media and offer customized recommendations.

- **Machine Learning:** Used to predict tourist behavior and analyze big data to understand trends and needs. Machine learning techniques can help optimize tourist guidance and service customization.
- **Smart Robots:** Smart robots can be used in restaurants, hotels, and museums to provide services to tourists and offer interactive and engaging experiences.
- **Big Data Analytics:** Helps understand tourist behavior and analyze trends and needs using large amounts of data. It can be used to guide tourists and improve their experiences.
- **Augmented Reality (AR):** Allows for interactive and enjoyable tourism experiences by integrating digital content with the real environment. It is used to provide additional information about tourist and cultural sites.
- **Image Recognition:** Image recognition can be used to analyze images and videos related to tourist destinations, providing interactive and educational experiences for tourists.
- **Smart Marketing Techniques:** Used in tourism marketing for destinations through advertisements and promotional offers tailored to tourists' preferences and interests, contributing to increased accessibility and enhancing tourists' experiences.

Regarding the environmental dimension, the criterion has also shown improvement, as AI can help protect the environment and heritage through environmental monitoring, analyzing environmental data from various sources like satellites and remote sensing devices to detect changes in the environment and identify potential threats. It can predict natural disasters by analyzing geological and meteorological data to foresee events such as earthquakes and floods, enabling appropriate preventive measures. Additionally, Biological Classification and Analysis: AI can be used to analyze biological data to classify organisms and understand biodiversity, which is crucial for wildlife and marine environmental protection. Counteracting Illegal Poaching and Trade: AI techniques like neural networks and pattern recognition can be used to monitor illegal poaching and trade of wildlife and cultural heritage. Waste and Pollution Management: Data analytics and machine learning techniques can be applied to analyze waste and pollution data, identify the primary causes, and direct efforts towards better pollution management and waste reduction. Environmental Awareness: Technologies such as augmented reality and virtual reality can increase awareness of environmental issues, educate about the importance of protecting the environment and heritage, and encourage participation in conservation efforts. (Hamdan, 2024).

Thus, we observe that AI interventions in various areas of tourism networks affect their basic criteria, which are interconnected with the environmental, economic, social, and institutional goals of sustainable development.

Fifth: General Research Findings:

The study identified the specific criteria for tourism networks and the extent of artificial intelligence interventions to enhance them. The key findings include:

- **Economic Level:** We observed an increase in the effectiveness of rural areas as tourist destinations, due to their natural, cultural, historical, and religious resources that can be invested in, improved, and marketed through artificial intelligence tools. These tools analyze big data through research methodologies, including algorithms and specialized software for site analysis, in order to make planning decisions and identify the development trends of these sites. Consequently, this leads to increased economic returns from a rise in demand for local services and products.
- **Social Level:** We noticed a focus on cultural and social preservation to enhance the uniqueness of places and promote both tangible and intangible heritage through electronic marketing applications and promotional platforms. This has led to increased job opportunities, youth localization, and a balance between rural and urban areas. AI also intervenes in the institutional-governmental dimension, including the infrastructure for tourism services using recommendation systems. These systems study tourist preferences through software algorithms that gather and analyze tourist behavior and opinions. The results are aggregated in a recommendation matrix to identify attractive sites, while also facilitating services through smart robots that assist tourists throughout their journey. Strategic plans operate entire tourism network structures across vast areas via leisure trips and specific routes to enhance tourists' experiences and optimize the benefits for network operators, ensuring the distribution of development across the entire studied region through dynamic leisure programs.
- **Environmental Aspects:** AI played a role in reducing pollution, effectively managing forests, eco-tourism resorts, and encouraging farmers to market their local products through well-studied governmental plans that ensure agricultural marketing and increased agricultural economic returns. However, AI applications are still limited in this dimension and could be enhanced by promoting smart applications in agricultural tourism to make better use of environmental development in rural areas, which includes agricultural and vacant lands.

Additionally, the study developed a model for integrating the basic criteria of networks with artificial intelligence algorithms, intersecting the dimensions of sustainable development with network criteria. This model demonstrates how AI methodologies can intervene in each criterion and alter its characteristics using tools that match the outputs for optimal results for both tourists and local communities, such as applications or software systems. This research tool can be beneficial and developed for future research.

Sixth: Recommendations:

1. Continuous and intensive research on how to enhance the role of artificial intelligence in agricultural tourism.

2. Developing governmental development plans and visions that support the role of smart networks in institutions responsible for the tourism sector.

3. Investigating electronic programs and systematic systems that evolve continuously and provide real-time accurate information on tourist flows and their impact on the spatial development of rural areas.

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