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GIS-Based Zoning for Sports Tourism Development in the Lut Desert, South Khorasan Province, Iran

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ABSTRACT

Tourism and sports are both among the major and recognized industries of the world. Both create opportunities for foreign exchange and cultural growth for countries, while also giving them a special status economically and socially. This research aimed to zone and assess the developmental potentials of sports tourism in the Lut Desert in the South Khorasan zone. To this end, we employed a mixed-method approach, using library resources and semi-structured interviews to collect data. This study utilized 11 participants selected through purposive sampling, chosen from a population of experts in the field of sports tourism. The Thematic Analysis method was used to analyze the interviews. The results illustrated that off-roading, air sports, and camel riding are among the most popular sports being hosted in the Lut Desert. Moreover, the most commonly recommended sports were track and field, marathons, sand hiking, and paragliding. In the zoning segment of the research, the GIS software was utilized to identify the regions of zones most suitable for hosting sports events in the Lut Desert. Finally, we concluded that through zoning and assessing the suitable regions for sports tourism in the Lut Desert, and by selecting the appropriate sports for each zone, we can create the opportunity for the growth of sports tourism in the province and attract sports tourists. Additionally, sports events in the South Khorasan zone must be held through political-security-executive considerations, as well as taking cultural, social, economic, the locals' livelihood, attractions, and the geological limitations into account.

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1. Introduction

The tourism industry is one of the world's largest, significantly contributing to economic and social development (Khan *et al*., 2020). Regions with strategic investments in tourism experience greater progress (Hamidi *et al*., 2020). Globally, tourism generates over 307 million jobs, accounting for 10.4% of the gross world product, with annual tourist numbers rising by 3.4% and expenditures by 6.7%, exceeding $2 trillion (Rahat, 2024). Sport, as a broad and multifaceted phenomenon, exerts considerable political, social, and cultural influence and has therefore become an important catalyst for tourism development (Zhang *et al*., 2025). So, sports tourism has become a form of special interest tourism in the world of tourism, which is starting to develop in various regions because it can encourage tourists to visit and increase economic growth and regional image (Fauzi *et al*., 2025). Sports tourism, a rapidly growing sector, integrates sports activities with travel, representing $5.4 trillion in value (Fayazade, 2021). It encompasses three key elements: sports-related places, activities, and participant motivations (Weed and Bull, 2009).

Iran's diverse climates, including deserts, offer substantial opportunities for sports tourism development. Deserts attract tourists with unique landscapes, wildlife, tranquility, and stargazing (Vazin *et al*., 2018). Over 500 million people reside in deserts worldwide, and countries like Tunisia earn $3 billion annually from desert attractions (Yaghoubi *et al*., 2020). The Lut Desert (Dasht-e Lut), Iran's largest, spans South Khorasan, Sistan & Baluchestan, and Kerman provinces and was inscribed on UNESCO's World Heritage List in 2016 for its natural features (Ghollasi Mood and malakoti, 2019). Recent studies emphasize its potential for sustainable adventure tourism, such as off-roading and paragliding, while warning of environmental risks like soil erosion from vehicle activities (Vahdat *et al*., 2025; Peng *et al.*, 2025).

Sports tourism in deserts requires multidisciplinary approaches, including psychological, political, legal, and transportation perspectives (Laflin, 2018). Major organizations like UN Tourism and the International Olympic Committee prioritize this market (Gibson, 2017). In Iran, desert sports tourism faces challenges like inadequate infrastructure and management (Amini *et al*., 2022). Domestic research often focuses on general factors influencing desert tourism, such as personal enjoyment, media influence, and infrastructural barriers (Kahdouei *et al*., 2024; Pazandeh *et al*., 2024). For instance, sustainable models highlight economic, social-cultural, and environmental benefits from desert capacities, including job creation and community development (Nayebi *et al*., 2025). However, studies overlook regional variations, climate specifics, and zoning for sports activities (Soltani and Noori, 2010).

South Khorasan, Iran's second-largest desert province, has untapped potential for sports tourism due to agricultural and industrial limitations. Effective spatial planning in tourism must balance infrastructural, environmental, and recreational criteria to ensure long-term regional sustainability (Altafi *et al*., 2023).

Its deserts feature unique attractions like 500m sand dunes, wind-sculpted structures, and the world's hottest spot, suitable for sand skiing, rallies, and astronomy (The Province's Economic Affairs Coordination Office, 2022-2023). The province boasts over 880 national heritage sites, 10 tourist regions, and water treatment centers for athlete rehabilitation (Mokarami Far, 2013). Recent geospatial assessments using GIS and multi-criteria methods, such as AHP-Promethee-GIS, demonstrate high suitability for adventure sports like cross-country and hiking in arid protected areas, emphasizing zoning to balance tourism with ecosystem conservation (Huang *et al*, 2025).

Despite these potentials, no study has zoned sports tourism capacities in the Lut Desert's South Khorasan portion based on geographical features. This research addresses this gap by zoning and assessing developmental potentials using a mixed-method approach, including GIS for spatial analysis and expert interviews. By identifying suitable zones and sports (e.g., off-

roading, paragliding, sand hiking), we aim to promote sustainable growth, attract tourists, and consider political, cultural, economic, and ecological factors.

2. Materials and methods

2.1. Study area

The study focuses on the South Khorasan portion of the Lut Desert (Dasht-e Lut), a hyper-arid interior basin in southeastern Iran, spanning parts of South Khorasan, Kerman, and Sistan-Baluchestan provinces (Murgante *et al*., 2021).

Geographical coordinates: The Lut Desert lies primarily between latitudes 28° to 32° N and longitudes 58° to 59° E, with the core area centered around 30°36' N and 59°04' E (Ahmady-Birgani *et al*., 2017).

Physiography and topography: This enclosed basin is bounded by the Nehbandan fault to the east and Nayband fault to the west. It features active sand seas (ergs) such as Rig Yalan (one of Iran's most active dune fields, with dunes reaching heights of 475–480 m), extensive yardangs (kaluts) up to 75–155 m high and over 150 km long, nabkhas, gravel plains, salt flats, and wind-eroded plateaus. Sand dune encroachment occurs in multiple directions, particularly from eastern alluvial fans, contributing to ongoing desertification processes (Ahmady-Birgani *et al*., 2017; Naseri and Mousavi, 2025).

Rainfall: The climate is hyper-arid, with annual precipitation typically less than 30–100 mm, mostly variable and concentrated in winter months. Central areas often receive less than 50 mm per year (Ahmady-Birgani *et al*., 2017).

Temperature and climatic conditions: Air temperatures in summer exceed 40–46°C, while land surface temperatures in regions like Gandom Beryan reach extreme global records (70.7°C in 2005 and higher in satellite data). Strong NNW winds (120-day winds) from June to October drive intense aeolian erosion, sediment transport, and dune mobility (Ahmady-Birgani *et al*., 2017; Naseri and Mousavi, 2025). These harsh conditions severely limit vegetation but create distinctive potentials for low-impact adventure sports tourism in stabilized or suitable zones (Fig. 1 illustrates the extent in South Khorasan Province).

These extreme environmental features underscore the need for careful zoning to support sustainable development while minimizing further wind erosion and dune encroachment.

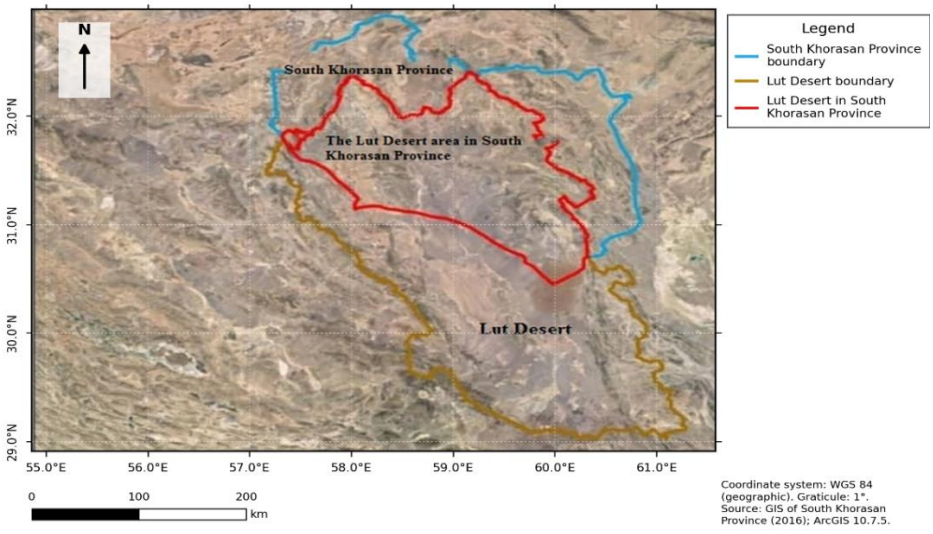


Fig 1. The Lut Desert boundry in South Khorasan Province

Fig 1. showing administrative boundaries, key access villages (e.g., Dehsalem), and major dune fields (e.g., Rig Yalan). (Source: Modified from GIS data of South Khorasan Province, 2016, and UNESCO World Heritage Centre maps, 2016.)

2.2. Methodology

In terms of research method, the current study employed a mixed-method approach (qualitative and quantitative). This study qualifies as a field study and applied research. The qualitative portion of the research used a statistical population of experts in the field of sports tourism, including authorities from the Ministry of Cultural Heritage, Tourism, and Handicrafts of South Khorasan; chairmen of organizations related to desert sports; managers of travel agencies in the province; tour leaders; sports management professors; and those involved in the field of sports tourism. The participants were selected through purposive sampling of the aforementioned population. Individuals' work experience and knowledge in the field of tourism and sports tourism were used as sampling criteria. Data collection continued until data saturation and the intended results were obtained, resulting in 11 participants.

Table1. Profile of the Interview Participants

ID	Professional Role	Organization / Institution Type	Field of Expertise	Years of Experience	ID	Professional Role	Organization / Institution Type	Field of Expertise	Years of Experience
P1	Ministry authority	Government	Sport tourism licy٫po	21	**P7**	University professor	Academia	Tourism	26
P2	Ministry authority	Government	tourism planing	18	**P8**	Tourism Expert	Government	Tourism educational officer	24
P3	Travel agency manager	Private sector	Tourism operations	11	**P9**	Sport	Private sector	Sport/tourism & racing	14
P4	Travel agency manager	Private sector	Tourism operations	17	**P10**	Sport	Private sector	Sport/games	17
P5	Tour leader	Private sector	Desert tours	8	**P11**		Government	Sport Event coordination	13
P6	Tour leader	Private sector	Ecotourism & sport tours	12					

Data were collected using qualitative and quantitative methods. Quantitative data and information related to the theoretical background of the research were collected through library sources such as documents, reports, and research articles in the field of sports tourism and the Lut Desert. These documents were mostly obtained from the Ministry of Cultural Heritage, reports, and statistical data of related organizations, previous studies, and geographical maps of the Lut Desert zone, which were all first analyzed and validated by the research team before

use. Semi-structured interviews were conducted to collect qualitative data for this study. Each interview lasted between 30 and 60 minutes. The interviews were recorded using the Easy Voice Recorder application. Then, using Braun and Clarke's six-phase framework, the data were analyzed using the MAXQDA 2020 software. During the first phase of the analysis, the researcher listened to each interview individually and transcribed it manually. The second phase involved coding data. Through this process, 1000 concepts were identified. In the third stage, the concepts were refined and filtered, resulting in 861 codes. These codes were then reviewed by the research team; redundant codes were removed, some were combined, and finally, 459 concepts were recognized. In the fifth phase, these concepts were categorized into three groups: ongoing sports, recommended sports, and secondary capacities. In the sixth stage, the analysis of secondary capacities led to the identification of 59 themes and 4 primary principles. In each phase of data analysis, we kept referring to the previous phases and compared the themes with the concepts and concepts with the interview transcriptions.

For the quantitative section of the study, spatial analysis was performed on the collected data using the GIS v. 10.7.5 software (source of the geographical maps: Geographic Information System of South Khorasan - 2016). Multi-criteria spatial decision-making tools coupled with GIS have proven highly effective for spatial zoning and suitability modeling (Eskandari Sani *et al*., 2026)



Fig 2. Flowchart of the Research Methodology: Mixed-Methods Approach for Zoning and Assessing Sports Tourism Potentials in the Lut Desert (South Khorasan Zone) of mentions by 11 experts in semi-structured interviews

3. Results

Tables 2, 3, and 4 present the final coding results derived from thematic analysis of semi-structured interviews with 11 purposively selected experts in sports tourism (from the population of relevant authorities, academics, tour operators, and practitioners in South Khorasan Province). The percentages in Figures 3 and 4 represent the relative frequency (%) with which each sport/activity was mentioned or emphasized by the experts as currently ongoing (Table 2/Fig. 3) or recommended (Table 3/Fig. 4). No separate quantitative questionnaire was used; these frequencies reflect code prevalence from the qualitative data.

Table 2 displays the sports activities and events that have been held in the Lut Desert so far.

According to Figure 3, the sports that are held most often in the Lut Desert are 1) off-roading, 2) air sports, and 3) camel riding and horseback riding, as they were deemed the most popular

sports based on the results of the questionnaire.

Table 2. The Final Coding of the Ongoing Events and Sports Activities in the Lut Desert, South Khorasan Zone

No.	Thematic Cluster	Extracted Codes (Specific Activities & Events)	Activity Scope
1	Motorized & Vehicular Sports	Desert racing and off-roading, Car rallies and racing events, Motorcycling races and desert circuits, Desert vehicular safaris	High-impact Mechanized Tourism
2	Aerial & Adventure Sports	Paragliding and light air sports, Desert ziplining, High-tension slacklining	Adventure & Aerial Recreation
3	Sand & Surface Sports	Sand boarding and sand skiing, Beach/sand soccer, Beach volleyball	Surface & Dune-based Sports
4	Traditional, Animal & Endurance Sports	Camel riding and horseback riding, Desert hiking and endurance walking, Track & field and desert marathons, Desert bicycling and cycling events, Indigenous local games	Eco-sports & Physical Endurance
5	Eco-Cultural Festivals & Commemorative Events	Salt sculpturing events at Kaji Salt Wetland, National Festival of Chahadashi Nomadic Women, UNESCO registration anniversary celebration of the Lut Desert, Commemorative event for the world's warmest recorded point, Local heritage-sports festival in Mazhan Khosf village, General domestic excursion activities	Periodic Eco-Cultural & Heritage Events

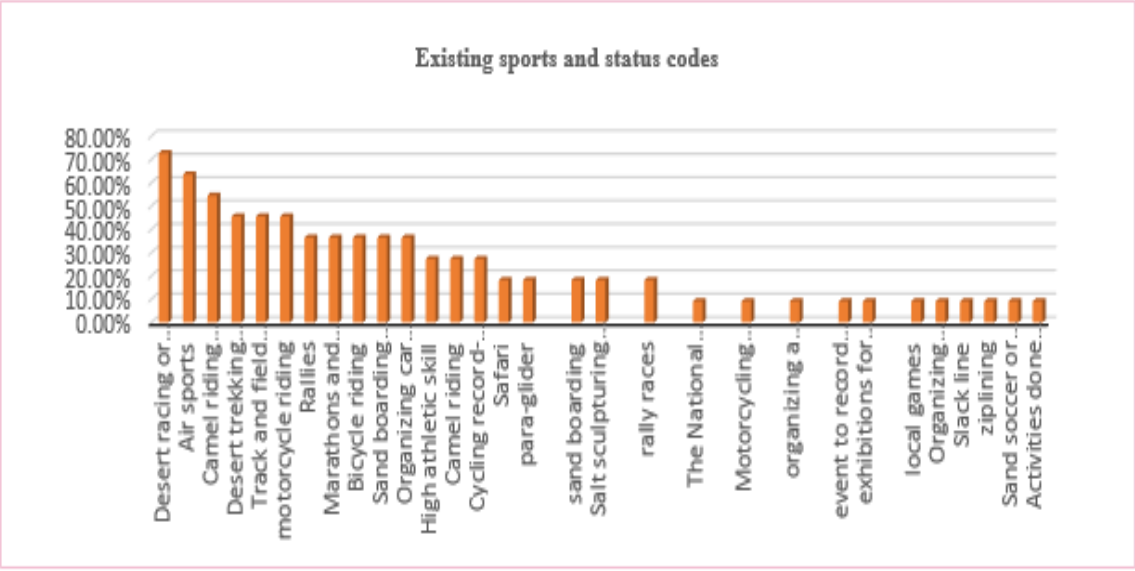


Fig 3. Relative frequency (%) of existing sports tourism activities in the Lut Desert (South Khorasan zone) based on expert responses.

Table 3. The Final Coding of the Recommended Events and Sports Activities in the Lut Desert, South Khorasan Zone (Recommended Events)

No.	Thematic Cluster	Recommended Activities & Events (Extracted Codes)	Modality / Tourism Typology
1	Wellness & Restorative Activities	Sand therapy and massage therapy, Desert yoga sessions, Desert silence meditation	Health & Wellness Tourism
2	Beach & Sand Ball Sports	Beach soccer and beach volleyball, Beach handball, beach tennis, and beach wrestling	Sand-based Competitive Ball Sports
3	Aerial & Adventure Sports	Paramotor and paragliding flights, Hang gliding and hot air ballooning, Desert ziplining	Adventure & Aerial Tourism
4	Endurance, Hiking & Geo-sports	Sand hiking and dune trekking, Track & field and desert marathons, Desert bicycle riding, Climbing Martian (Badland) Mountains	Physical Endurance & Geomorphotourism
5	Motorized & Traditional Racing	Desert off-roading and rally races, Motorcycling and motocross racing, Sand skiing and sand boarding, Camel riding races	Speed, Thrill & Traditional Sports

Table 3 displays the sports activities that can be performed in the Lut Desert, which were recommended by tourism and sports experts.

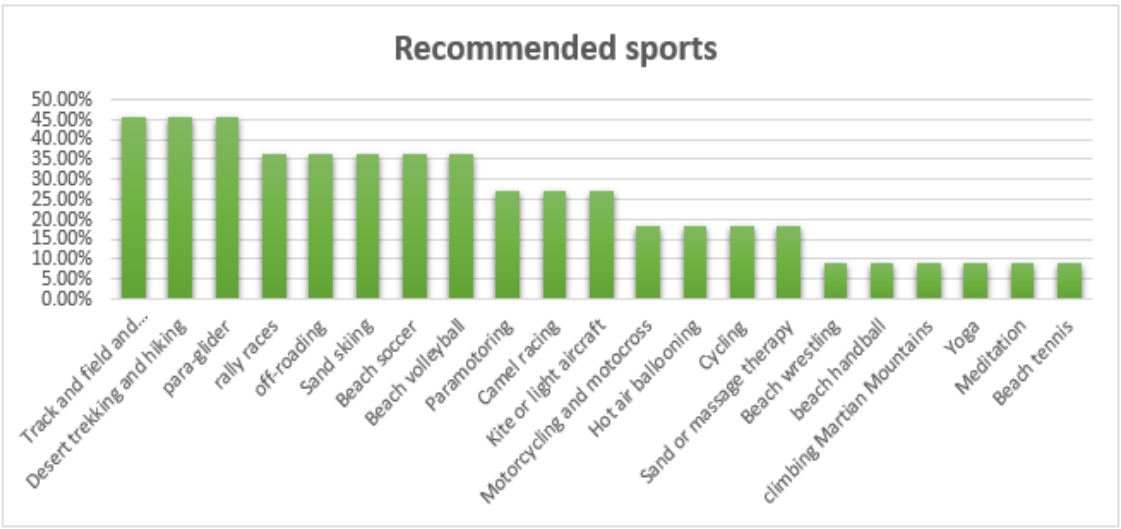


Fig 4. Relative frequency (%) of recommended sports and activities for the Lut Desert (South Khorasan zone) based on expert suggestions from semi-structured interviews.

As Figure 4 reveals, experts from the fields of tourism and sports tourism have recommended a set of sports that can be practiced and performed in the Lut Desert; out of this list, track and field and marathons, sand hiking, and paragliding take first to third place in terms of practicality. Rallying, off-roading, sand skiing, sand soccer, and beach volleyball follow these on the list.

Table 4. The Final Coding of the Secondary Capacities of the Lut Desert, South Khorasan Zone

Primary Dimensions	Secondary Codes & Sub-components (Structured Summary)	Number of Sub-themes	Relative Weight / Share (%)
Social Capacities	Traditional agricultural events (Harvesting Porkoo/Kabkab dates), World Crafts Council designation (Khorashad tobafi, handicrafts, UNESCO World Heritage & registered qanats (Baladeh, Akbarieh Garden, Rich intangible heritage (950+ national monuments, local games atlas, folk customs, Tourism hosting infrastructure (Rural base camps, local guides, hospitality)	16	27.4%
Environmental Capacities	Unique desert extremes & formations (Highest/longest kaluts, 80°C+ temp, 12m nabkas, 400m sand pyramids, Flora, fauna & protected habitats (Zagh Bor, Asiatic cheetah in northern Lut, Kaji Salt Marsh wildlife sanctuary, Water resources & scenic spots (Permanent salty river, palm groves, mineral water springs, desert night sky)	14	22.5%
Geologic Capacities	Geomorphological diversity (Rig Yalan, Gandomberian, Martian Mountains, Star & Egg Hills, Hamada Plain, UNESCO natural criteria (Unique geological/geomorphological features and earth history, Special geological outcrops (Gypsy salt crystals, cut precious stones, miniature landforms)	15	26.8%
Economic Capacities	Local livelihoods & cooperatives (NGOs, date packaging workshops, branding by Jihad Keshavarzi, Tourism infrastructure & income (Ecotourism lodges, desert camps, salt sculpture festival, Mobility & security logistics (Support vehicles: motorcycles, Hilux/Land Cruisers, security provisions, standard tourist services)	14	23.3%
Total / Summary	Comprehensive qualitative coding framework synthesized across the South Khorasan Lut zone	59	100

To synthesize the qualitative insights derived from the thematic coding process, the 59 identified secondary indicators were systematically categorized into the four core developmental dimensions outlined in Table 4. Following this thematic systematization, the relative prominence and weighting of each domain were quantified through content analysis and expert evaluation. The synthesis reveals that the developmental potential of the Lut Desert in the South Khorasan zone is distributed across these multifaceted dimensions, reflecting both intrinsic heritage values and socioeconomic revitalization opportunities. To facilitate a comparative visual assessment of these dimensions and demonstrate their strategic priority for regional desert management and sustainable tourism planning, the aggregate distribution and proportional weights of the secondary capacities are illustrated in Fig. 5.

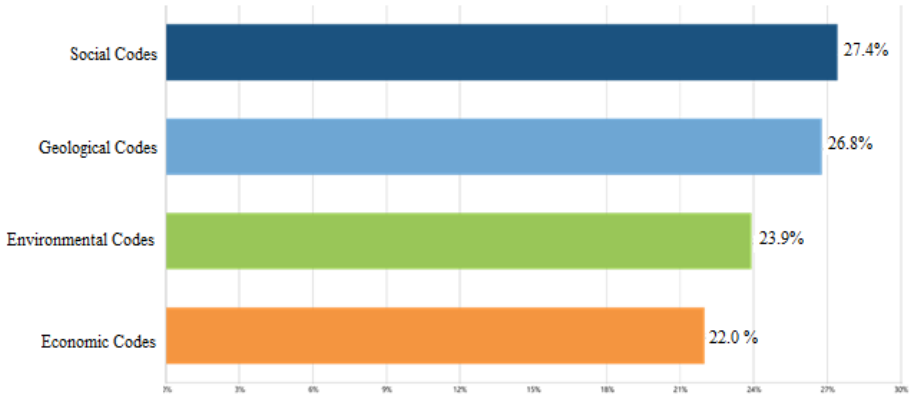


Fig 5. Amount of Secondary Capacities of the Lut Desert, South Khorasan Zone

Figure 5 shows that the capacities of the social domain are more important than other domains (27.4%). And so authorities should make the necessary investments in this area. Furthermore, the authorities should focus on further protecting the geological capacities of the Lut Desert, which is 26.8%.

4.1 Quantitative data software analysis

In this section, data was analyzed in the form of zoning maps using GIS software version 10.7.5; the researcher's findings are presented below.

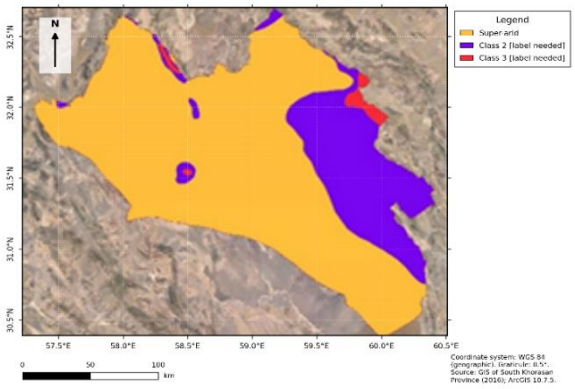


Fig 6. The desert climate of Lut in South Khorasan Province

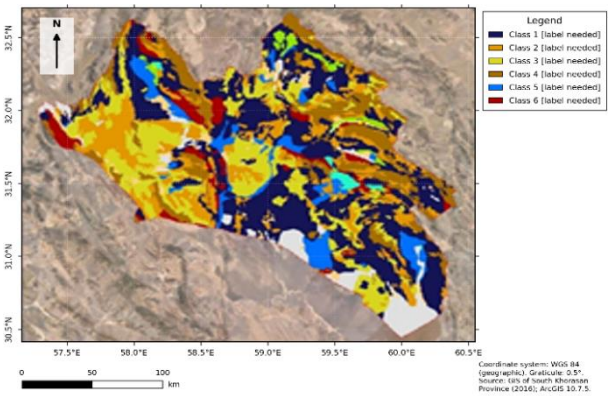


Fig 7. The land type of the Lut Desert in South Khorasan Province

Map No. 6 shows the climate of the Lut Desert in South Khorasan Province, which indicates that the Lut Desert has three zones: superarid, arid, and mild semi-arid. The largest zone in the Lut Desert is the superarid zone. The land types of the Lut Desert in South Khorasan Province include trench-shaped wind-blown alluvium, miscellaneous lands, mixed lands, lowlands, hills, alluvial and river plains, slope plains, floodplains, plateaus and upper terraces, mountains, residential and industrial areas, unstudied areas, and wind-blown debris; which are shown in Map 7. According to this map, the largest area is related to the plateaus and upper terraces in the Lut Desert area, followed by mixed lands and mountains.

The vegetation cover of the Lut Desert in South Khorasan Province can be classified into six distinct categories: (1) salt flats (devoid of significant vegetation), (2) moderate rangelands located in relatively cold mountainous regions, (3) irrigated agricultural lands, (4) rain-fed farmlands accompanied by fallow drylands, (5) high-quality and steppe rangelands occasionally interspersed with sparse trees, and (6) vegetation specific to saline plains and sand dunes.

According to Fig 8, the largest portion of the area is occupied by vegetation types characteristic of saline plains and sand dunes. Fig 9 illustrates the soil classification of the Lut Desert in South Khorasan Province, in which the various zones are represented by different colors. Interpretation of this map indicates that the dominant zone corresponds to the beige-colored areas, extending from the northwestern to the southeastern parts of the Lut Desert within the province. In contrast, the smallest zone is represented by the purple color, covering limited portions of the central, northeastern, and eastern regions.

Fig 10 illustrates the spatial distribution of air temperature across the Lut Desert in South Khorasan Province. This map depicts the temperature range prevailing within the region, indicating that the dominant air temperature across most parts of the Lut Desert varies between 17°C and 20°C**.** Fig 11 presents the spatial pattern of rainfall distribution within the

Lut Desert of South Khorasan Province. Precipitation levels across different parts of the desert exhibit considerable variation. According to the color-coded classification on the map, the northern and central portions of the Lut Desert receive an average annual precipitation ranging between 75–131 mm and 131–187 mm, respectively.

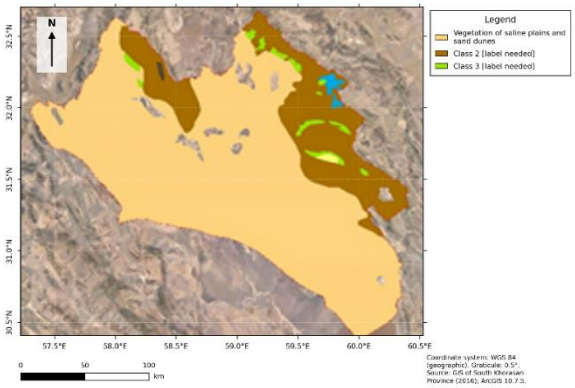


Fig 8. The type of vegetation in the Lut Desert in S. Kh. Province

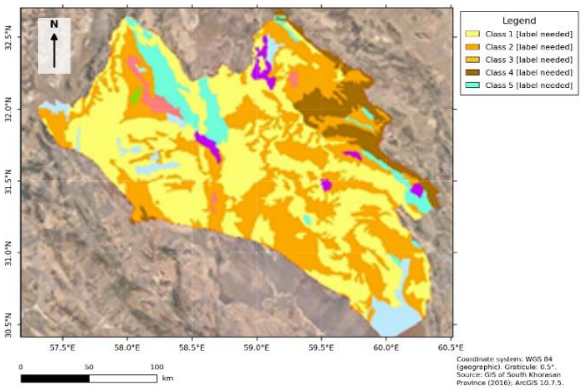


Fig 9. Soil classification of the Lut Desert in S. Kh. Province

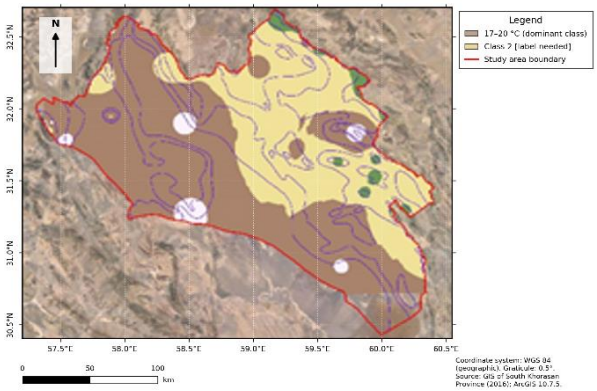


Fig 10. Air temperature zoning of the Lut Desert in S. Kh. Province.

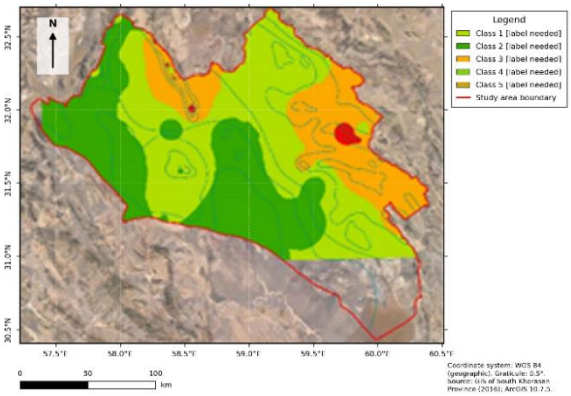


Fig 11. Rainfall amount in the Lut Desert in S. Kh. Province

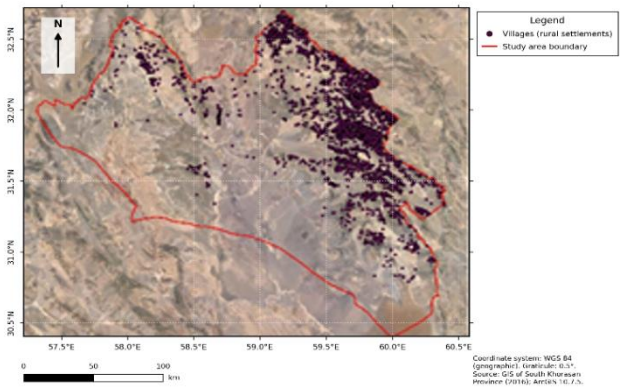


Fig 12. Villages located in the Lut Desert within the study area

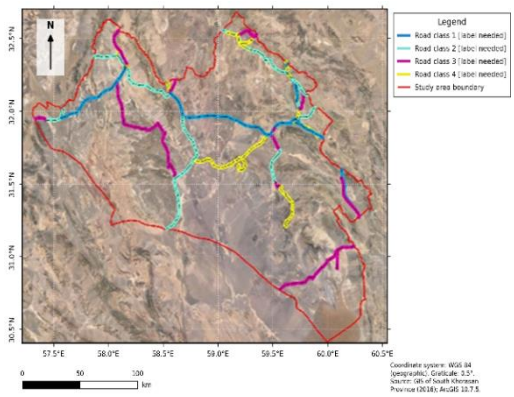


Fig 13. Roads located in the Lut Desert within the study area

Fig. 12 illustrates the distribution of villages located within the Lut Desert in the administrative boundaries of South Khorasan Province. The results indicate that the density of rural settlements is highest in the northeastern part of the Lut Desert within the province, gradually decreasing toward the southeastern regions**.** Fig. 13 presents the classification of existing roads across the Lut Desert in South Khorasan Province, categorized as follows: highways, narrow roads, moderately wide roads, wide roads, and ZC routes. The findings suggest that moderately wide roads constitute the most prevalent type, being distributed throughout nearly all areas of the Lut Desert within the provincial boundary.

Fig. 14 depicts the distribution of faults under the title *"Classification of Fault Types in the Lut Desert of South Khorasan Province."* The Quaternary faults exhibit the greatest density within the study area, with the majority concentrated in the northwestern part of the Lut Desert. Fig. 15 illustrates the topographic classification of the Lut Desert in South Khorasan Province. According to this map, the terrain slope gradually increases from the southern regions of the desert toward the northern foothills. Consequently, this topographic pattern holds significant relevance for sports and recreational activities that depend on ground slope, such as hiking or desert trekking.

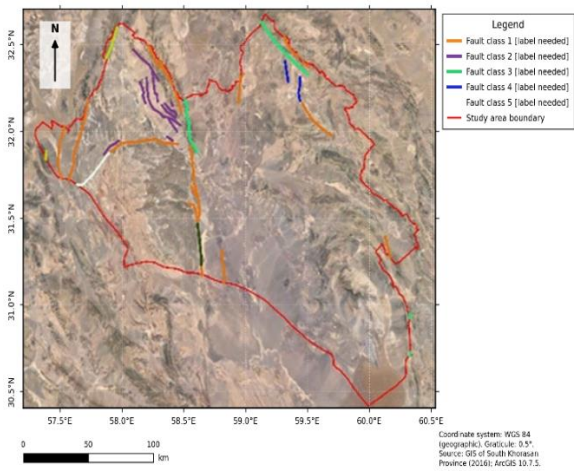


Fig 14. Classification of faults in the Lut Desert in South Khorasan Province

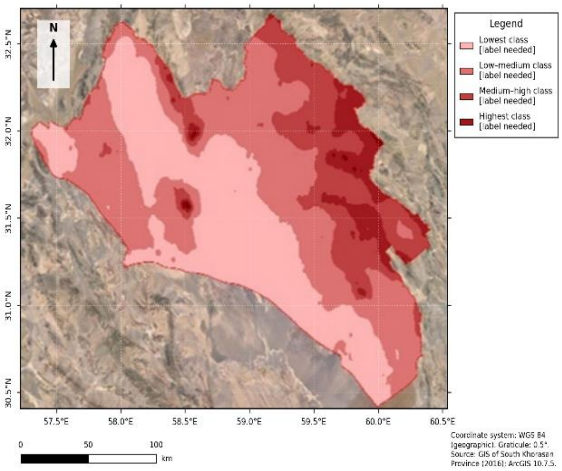


Fig 15. Topographic classification of the Lut Desert in South Khorasan Province

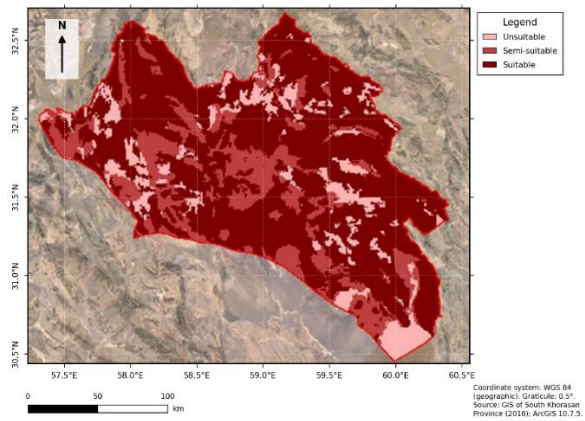


Fig 16. Lands with potential for sports tourism development in the Lut Desert, South Khorasan province

Fuzzy analysis refers to the overlap of various maps, and in this research, fuzzy analysis was used to obtain a singular map to determine the lands with the potential to create sports tourism attractions in the Lut Desert (South Khorasan province). Figure 16 shows the final output of the GIS analysis software, which displays three climate zones categorized as unsuitable, semi-suitable, and suitable. The zones that are marked as "suitable" are those that have proper infrastructure in terms of villages and routes in the Lut Desert; i.e., all welfare and housing facilities exist in these zones. In the suitable zones marked by a dark color in Figure 16, air sports (paragliding, paramotor, hot air ballooning, ziplining, hang gliding), sand skiing, driving races or off-roading, and rally races can be hosted. Beach sports (volleyball, soccer, handball, tennis, and wrestling), camel riding, sand hiking, bike riding, and local games can be practiced in semi-suitable zones. In unsuitable zones, no sports activities can be performed. Besides the selection of zones for holding sports events to develop sports tourism in the Lut Desert, other factors, such as the slope of the land, temperatures, accessibility of villages, routes, and transportation means, need to be taken into account.

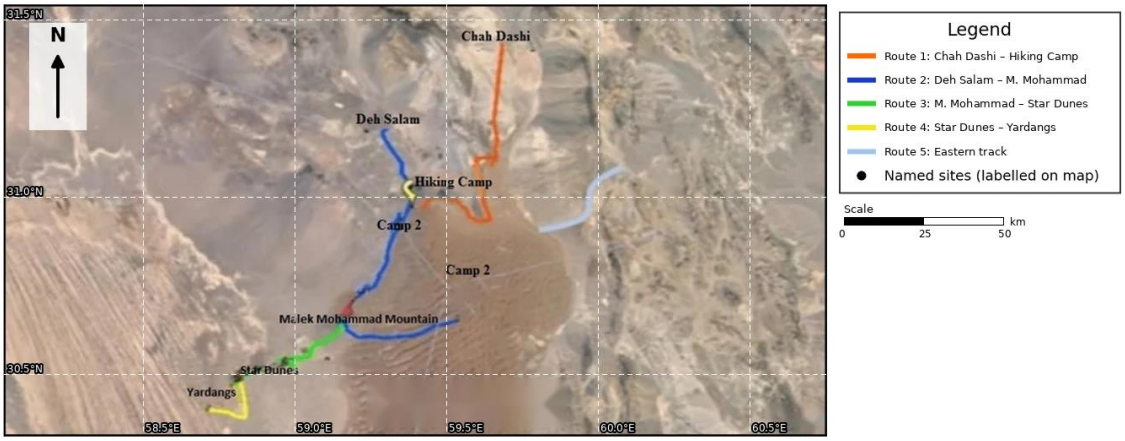


Fig 17. Suggested routes for easy tourist travel in the Lut Desert

4. Discussion

The zoning and assessment of sports tourism potentials in the Lut Desert's South Khorasan zone reveal a high suitability for adventure-based activities, aligning with expert-identified ongoing and recommended sports. As shown in Table 2 and Figure 3, off-roading (mentioned by ~80% of experts), air sports (~60%), and camel riding (~50%) dominate current practices, reflecting the desert's rugged terrain and cultural heritage. These activities leverage the region's unique geomorphology, such as 475-m dunes in Rig Yalan (Fig. 16, suitable zones), but require zoning to mitigate soil compaction and erosion risks.

Recommended sports from Table 3 and Figure 4, including track and field/desert trekking (~50%), paragliding (~45%), and rally races (~40%), emphasize low-impact endurance events suited to semi-suitable zones with moderate slopes and access (Fig. 16). Secondary capacities in Table 4 highlight environmental (e.g., geomorphological features like yardangs) and social-economic factors (e.g., local livelihoods through tour guiding), with 59 themes distilled into four principles: social integration, environmental sustainability, geological preservation, and economic viability. This integration guided our GIS fuzzy overlay, identifying 30% of the zone as suitable for high-intensity sports like off-roading, while restricting 40% (unsuitable areas) to protect fragile nabkhas and salt flats.

Compared to global studies, our zoning approach mirrors GIS-based multi-criteria evaluations in arid regions. For instance, in Chabahar's coastal desert (Iran), GIS zoning integrated environmental compatibility for ecotourism, prioritizing community sports areas and achieving balanced land use similar to our fuzzy membership for topography and rainfall layers (Aflaki Samani *et al*, 2025). Likewise, LULC analysis in GCC deserts using remote sensing showed tourism-driven vegetation loss in erg landforms, underscoring the need for our study's low-impact protocols to avoid the 21% bareland reduction observed there (Roy *et al*., 2026). In China's urban clusters, GIS for SDG 11 open spaces revealed air pollution declines (1.8 µg/m³/year), comparable to our zoning's emphasis on minimizing dust from rallies in high-temperature zones (Valdés-Rodríguez *et al*, 2025). These comparisons validate our findings, as Saudi Arabia's heritage tourism models integrated local economies without eroding cultural sites, akin to our principle-based capacities (Stoica *et al*., 2022).

Our results extend prior Iranian studies by spatially zoning sports to regional variations, unlike Kahdouei *et al*. (2024) and Jalalabadi and Ramezanzade Lasboyee (2024), which focused on general factors without GIS integration. This addresses desert-specific limitations, such as hyper-arid climate (<100 mm rainfall), promoting sustainable events with seasonal restrictions.

In this study, we first analyzed experts' perspectives in order to obtain an overview of their opinions on the development of sports tourism in the Lut Desert. The findings revealed the experts' positive attitude towards the development of sports tourism in the Lut Desert. Alamati *et al*. (2020) believe that Iran's deserts are among the regions with high potential for the development of sports tourism. Mazloomi Soveini and Gaspar (2022) are of the belief that a positive attitude towards sports tourism in deserts can increase the sports tourists' satisfaction levels and their behavioral and emotional reactions. The experts' perspective towards sports tourism in the Lut Desert, South Khorasan zone, is not just a national perspective, but an international one as well.

In Abu Dhabi, investing in sports activities is among the major branding strategies. Sports tourism development programs in this country are not only aiming to increase visitors, but their goal is to introduce the United Arab Emirates as an international sports destination (Hazime, 2011). Although to achieve this goal, they have had to focus on championship events such as Formula One races, golf, rowing, and tennis, they have not forgotten their culture; events such as camel riding, horseback riding, Salukis championships, and falcon racing attract attention as well (Valek, 2015). Even though many communities of conservative Muslims residing in deserts are not receptive and welcoming towards mass tourism or non-Muslim tourists due to the extreme differences in cultures (Weber, 2013), positive experiences from similar countries in this regard can be encouraging and prevent the clash between the local cultures and the tourists and the locals' resistance. On one hand, due to the extreme conditions of the desert ecosystem, mass tourism in such regions should be closely monitored as the environment's capacity can diminish quickly. For instance, a local herb used in traditional medicine can become endangered as a result of overharvesting, soil compaction, and its destruction directly by vehicles or a change in livestock (Azaizeh, 2003; Hammer, 2009). Weaver (2001) describes deserts and grasslands as "Cinderella" ecosystems, as they are unlike the more commonly advertised landscapes, such as rainforests, and await discovery. Therefore, it is essential to manage desert areas through the "leave no trace" policy, waste management, and minimum impact strategies. These biomes are vulnerable, with slow regeneration rates; therefore, once the impacts of human intervention and tourism become clearly visible, they lose their attraction to tourists, regardless of interests (Weber, 2013). The environmental and geological capacities identified in this study include: Kaluts; Nabkas; sand pyramids; palm groves; mineral water

springs; Flora and fauna; meteorites; the permanent salty river; salt lake; temporary ponds; the native bird of the Lut Desert (Zagh Bor); the habitat of the Asiatic cheetah; the wildlife sanctuary of the Kaji Salt Marsh; Gypsy salt crystals; beautifully-cut and precious stones; miniature artifacts; Hormak Valley; Rig Yalan; Rigi Plain; Lut Zangi Ahmad; Martian Mountains; Gandomberian; Kalshor River; Star Hills; small Kaluts; Diversity of fauna and flora of the Lut Desert; Malek Mohammad Mountain; Malek Mohammad Hole; Cheshm Lut; Hamada Plain, Tartil Gorge; Snake Tongue Gorge; Egg Hills; Dolphin Hills, etc. (Table 4). Each of these unique wonders can create original sports capacities, providing a special experience of sports in the Lut Desert. The environmental capacities have been studied by other researchers as well, including: the ecotourism capacities according to the ecological board (Bazmarabalashti, 2018) and the climate and geographical capacities (Ashouri, 2023). Deserts are extremely unique, strange to tourists, and in many cases, due to the low number of people residing there, untouched. Consequently, through proper marketing, they can become a new segment of tourism. Moreover, many of Iran's deserts are suitable for developing desert sports. The various regions of this wonderful land can be an exciting destination attracting tourists, and they have the potential to become an international host for sports tourists (Mazloomi Soveini and Gaspar, 2022). In addition, since everyone likes nature (Esmailnejad, 2021), the natural attractions of the desert, as well as the sports attractions, can lead to the growth of sports tourism in such zones.

Another type of capacity identified in this study is the economic capacity. This capacity includes codes such as creating local and rural workshops; holding a salt sculpture festival; Considering a mechanism for the income of local people; availability of desert tourism equipment and ecotourism lodges; Good environmental advertising and marketing; provision of accommodation and security conditions for tourists; and providing standard services to tourists. Mostafaei (2021) also states that tourism plays a significant role in the revival and diversification of the economy; however, it can also cause changes in the social, economic, and environmental status of various societies. By taking different studies and the requirements of sports tourism development into account, Seifpanahi Shabani (2022) provides a strategy for developing sports tourism in Iran in order to become a mighty power in the field, capable of competing with strong opponents such as Turkey and Thailand post-COVID-19. The results of this study reveal the lack of tourism marketing as the major weakness in the tourism industry, and point out that the first strategic step towards the growth of this industry to increase Iran's market share is active marketing of sports tourism. Zohrevandian (2024) also emphasizes the significance of marketing sports events, holding special events, creating a unique identity based on the province, building trust, and setting the quality of tourism services as the growth strategy for sports tourism. Additionally, he refers to the economic, social, and cultural resources as the potential outcomes of sports tourism growth as a result of branding exploratory sports. In this regard, developing specialized sports and adventure tourism destinations in arid areas serves as a strategic catalyst for destination branding, mental imaging, and enhancing regional tourism attractiveness in South Khorasan Province (Eskandari Sani & Rezaei, 2020). Furthermore, In a study investigating the sports tourism capabilities and potentials of the Razavi Khorasan province, Balali (2022) identifies factors such as the adaptation of spaces and sport organizations according to national and international technical standards, the number of sports facilities hosting provincial events, and transportation infrastructures within cities and between them. Besides Holy sites, she refers to local sports as one of the major tourism potentials of the region (Balali, 2022), which were also identified as one of the social codes in the current study (Table 4).

Abdollahi Bahnemiri (2023) also emphasizes the mediating role of social media in the

development and growth of sports tourism through sports communications. In research conducted by Moradi Doliskani (2021), the role of social marketing in the development of sports tourism in Tehran province is also highlighted. Zolghadr (2024) introduced the social-cultural obstacles regarding the growth of sports tourism in terms of education, media, family, security, cultural-religious, environment, and communication. Nevertheless, it seems like the cultural and social aspects of sports tourism are still not researched enough (Mostafaei, 2021). Moreover, since the shopping behavior in sports tourism has the most correlation with social aspects on one hand (Ghadimi, 2023), and on the other hand, sport is itself a social factor that can popularize tourism and affect social aspects, considering social variables can positively impact the growth of sports tourism, increase its benefits, and decrease the potentially detrimental effects. Rohani (2020) also revealed that clothing and garments, ancient values, language, cooking styles, and food variation are among the cultural factors influencing the growth of tourism; therefore, regarding planning tourism, designing systems, facilities, and equipment, it is essential to take cultural and social factors into account.

In our field visits, the zones of the Lut Desert were assessed for hosting sports events in terms of slope of the land, flora and fauna, temperatures, accessibility routes, housing and sports infrastructures, villages as tourism targets, etc., and according to the results, the suitable zones were identified based on these features. In this regard, heydarzadeh *et al*. (2017) attempted to zone the Shahrood county based on 15 criteria in the GIS environment, which include the slope, distance between villages, road distances, distance between faults, land functions, rangelands, the Clouds Forest, landslides, tourist attractions, river distances, the distance between flood plains, services, wildlife, and elevation. The results of the study revealed that among the tourist attractions in the Shahrood county, the Clouds Forest and the Salt River were the first and second priorities, respectively, in the upcoming development of ecotourism. Esmailnejad *et al*. (2021) point out that preparing a map of the natural hazards zones of the South Khorasan province can help planning experts and authorities of this province in various areas, such as managing soil and natural resources conservation, development and tourism planning, navigating the suitable lands for cities and villages, environmental planning, navigation and transportation paths of labor, power, etc.

Another finding of this study was the extraction of sports activities that can not only be practiced in the region, but can also attract the fans of the sports as well. Based on the results of the interviews conducted with experts, as well as analysis of the related documents and the geographical conditions of the region, sports such as sand skiing, off-roading, bike riding, marathons, hiking on the dunes, paragliding, paramotor, ziplining, hot air ballooning, motorcycling, camel riding, local games of the regions, etc. can be hosted in the Lut Desert. Hashemi *et al*. (2020) provide a list of sports that can be performed in the deserts of the Qom province, which includes (horse and camel) riding races, marathon races, rallies, safari championships, paragliding, motorbike cross racing, mountain and desert biking, barefoot hot sand resistance championships, hovercraft, slackline, and navigation races. Regarding sports tourism, Mohamadi Turkmani *et al*. (2021) also refer to sports events such as walking on sand, hosting barefoot hot sand resistance championships, night camping in the desert, camel and horseback riding races, sand skiing, hot air ballooning in the desert sky, etc. The aforementioned sports and events are practical because in the Lut Desert region of the South Khorasan province, there exist the highest sand dunes suitable for sand skiing, paragliding, hot air ballooning, and in general, any air sports; and this is the distinct feature of this desert, distinguishing it from other deserts in the country. In the margins of the well-known place called "Rig Yalan", located 34 km from the Dehsalem village, driving, off-roading, and motorbike events can be hosted without causing harm to the nature or the animal population of the Lut Desert.

Therefore, the results of the current study are in line with those of Hashemi *et al*. (2020) and Mohamadi Turkmani *et al*. (2021).

In a study, Soltani and Nouri (2010) aimed to assess the environmental capacity of the Khansar region using the ecological model of tourism to identify the developmental capacities of tourism. Their results showed that all parts of the region have high levels of capacity to develop extensive or focused recreation, and most villages have the capacity for the development of some type of tourism. Aliabadi and Hashemi (2015) suggested activities such as canoe tripping, skiing, water skiing, mountain climbing, and hiking in a study of the feasibility of uniting ecotourism and sports tourism in the Kermanshah province. Malekzadeh *et al*. (2017) also assessed the sports ecotourism potentials in the Bafq district and suggested sport activities such as beach sports, sand skiing, desert tourism, camel riding, motorcycle riding and safari, desert trekking, bike riding, and paragliding. Mohamadi Turkmani *et al*. (2021) did a feasibility study of ecological-humanitarian development of sports ecotourism in the deserts of Qom, and identified 14 zones for the development of ecotourism in 26.5% of the total area of the province. Jaberi (2024) aimed to identify the requirements of developing desert sports in Kerman and found 5 factors, including infrastructure, hosting events, encouragement and support, marketing, education, and preparation, as the primary requirements of desert sports in the province. An analysis of the different data layers of Mianeh County also shows that this county has a high potential for the growth of sports tourism in the fields of mountain climbing and camping, nature therapy, water sports, winter sports, hunting and fishing, hiking, and trekking (Noori Khanyourdi, 2021). The Al Maha Desert Resort, located in the UAE Sahara, claims to combine luxury and ecotourism principles. All 42 units of this resort include a swimming pool and high-quality service (average room rate = 1000 to 2500 USD per night); however, this resort is located in a protected area, away from the grazing lands of the camels (Ryan and Stewart, 2009). Generally, beliefs and environmental behaviors, as a system of attitudes towards the relationship between humans and nature, determine conservationist behaviors or act as frameworks used for interacting with nature. This system can be considered as a new policy of public participation in terms of social aspects through creating social integration, cultural aspects by moral commitments, economic aspects through cost reduction, and political aspects through popularizing a new form of policy making (Vrselja, 2024). The current study also identified multiple environmental and geological capacities in this zone, which require education and effort, while being a major attraction for sports tourism. These capacities, in their interactions with the social and economic capacities of the region, should be inserted in the province policymakers' agenda in order to take advantage of the natural, social, and economic capacities of the province, as well as the major capacities in sports, games, and sports events, leading to the development and growth of sports and the province.

Limitations include the small expert sample (n=11), though saturation was achieved, and GIS reliance on 2016 data; future work could incorporate real-time satellite imagery for dynamic zoning. Overall, this study provides a replicable model for arid sports tourism, balancing growth with ecological integrity.

5. Conclusion

Zoning and prioritizing sports tourism in the Lut Desert shows that hosting sports events in the Lut Desert requires special care and respect towards the desert boundaries, and for such events in the South Khorasan zone, one must consider political-security-executive factors and take the cultural, social, economic, locals' livelihood, attractions, and ecological capacities into account. Organizations and institutions related to the fields of tourism and sports, including the Ministry

of Cultural Heritage, Tourism and Handicrafts, travel agencies, the Ministry of Sport and Youth, and sports organizations in the province, can help attract sports tourists by supporting research institutes, private sectors responsible for housing for tourists, and introducing the region to domestic and international tourists. Since sports tourism plays a significant role in a society's growth (Hallmann and Breur, 2010; Taks, 2013; Kim *et al*., 2015; Liu, 2017; Hautbois *et al*., 2019), we recommend that provincial authorities help create opportunities for the development of sports and employment, and popularize the local culture through proper and fundamental planning and taking action.

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Data availability
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Data Availability Statement
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethical considerations
The authors have strictly adhered to ethical standards and research integrity, ensuring the authenticity of all data and avoiding any fabrication, falsification, or plagiarism.

Conflict of interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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