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# Application of GIS and RS in Tourism

## Case study: Sulaimaniyah Province, Kurdistan Region, Iraq

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***Abstract:***

As one of the most significant economic sectors, tourism can create numerous job opportunities and generate significant development almost worldwide. To expand the tourism industry, new technologies play an essential role that should be taken into consideration. Geographic Information Systems (GIS) and Remote Sensing (RS) are two of the main aids helping the tourism industry. During recent years, the Sulaimaniyah Governorate of the Kurdistan region of Iraq (KRI) has hosted of hundreds of thousands of tourists from Iraq's middle and southern parts. In the KRI, political and security situations accompanied by numerous natural attractions with pleasant weather conditions have motivated the Iraqi tourists to travel and even settle in the KRI. This study aimed to utilize the GIS/RS techniques to produce some accurate maps and information, using statistical tourism-related data and satellite data, that could be used for decision making and planning in the tourism industry. The used method focuses on creating needed spatial information layers then overlayping them in a sort of single maps to display spatial distribution of different touristic information which helps managers and users to interprete and analyse current situation more easily. This study displayed how GIS/RS can provide helpful information in tourism planning and development. The created maps showed that Sulaimaniyah suffers from a lack of highways and the unbalanced geographical distribution of hotels and tourist facilities. Produced maps also showed that there are only three short highways exist in the city. On the other side, the spatial distribution of hotels hardly follows the distribution of most visited attractive spots.The only well-organized facility that can meet the tourism demand, to a high degree, are restaurants. The results also revealed that visitors' distribution during the spring and summer seasons is not following the same pattern. During spring, tourists are mostly inclined to visit well-organized, attractive spots and natural, accessible attractions. In summer, the accessible higher elevation spot with better weather conditions (e.g., Hawraman, Sitak, Qandil) has been more interesting for local tourists or from the south and middle parts of Iraq.

**Keywords:** Tourism industry, GIS, RS, Kurdistan Region, Iraq, Sulaimaniyah

**الملخص:**

كواحد من أهم القطاعات الاقتصادية، يمكن للسياحة أن تخلق العديد من فرص العمل وتنشأ تنمية كبيرة في جميع أنحاء العالم تقريبًا. لتوسيع صناعة السياحة، تلعب التقنيات الجديدة دورًا أساسيًا والتي يجب أن يؤخذ في الاعتبار. نظم المعلومات الجغرافية (GIS)والاستشعار عن بعد (RS) هما من أهم الوسائل التي تساعد صناعة السياحة. خلال السنوات الأخيرة، استقطبت محافظة


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السليمانية بإقليم كردستان العراق (KRI) مئات الآلاف من السياح من الأجزاء الوسطى والجنوبية من العراق. في إقليم كردستان العراق، دفعت المواقف السياسية والأمنية المصحوبة بالعديد من عوامل الجذب الطبيعية ذات الظروف الجوية اللطيفة السياح العراقيين إلى السفر وحتى الاستقرار في إقليم كردستان العراق. هدفت هذه الدراسة إلى الاستفادة من تقنيات نظم المعلومات الجغرافية / RS لإنتاج بعض الخرائط والمعلومات الدقيقة، باستخدام البيانات الإحصائية المتعلقة بالسياحة وبيانات الأقمار الصناعية، والتي يمكن استخدامها لصنع القرار والتخطيط في صناعة السياحة. تركز الطريقة على إنشاء جميع طبقات المعلومات المكانية المطلوبة ثم تراكبها في نفس الخرائط لعرض التوزيع المكاني للمعلومات السياحية المختلفة مما يساعد المدراء والمستخدمين على تفسير وتحليل الوضع الحالي بسهولة أكبر. وأظهرت النتائج أن محافظة السليمانية تعاني من نقص في الطرق السريعة والتوزيع الجغرافي غير المتوازن للفنادق والمرافق السياحية حيث لا يوجد سوى ثلاثة طرق سريعة قصيرة في المدينة. من ناحية أخرى، نادرًا ما يتبع التوزيع المكاني للفنادق توزيع المواقع الجذابة الأكثر زيارة ، والمرفق الوحيد المنظم جيدًا الذي يمكنه تلبية الطلب السياحي، إلى درجة عالية، هو المطاعم. كما أوضحت النتائج أن توزيع الزوار خلال فصلي الربيع والصيف لا يتبع نفس النمط. خلال فصل الربيع، يميل السائحون في الغالب إلى زيارة الأماكن الجذابة المنظمة جيدًا ومناطق الجذب الطبيعية التي يسهل الوصول إليها. في الصيف ، كانت المنطقة المرتفعة التي يمكن الوصول إليها والتي تتمتع بظروف مناخية أفضل (على سبيل المثال، هورامان، سيتاك، قنديل) أكثر إثارة للاهتمام للسياح المحليين أو من الأجزاء الجنوبية والوسطى من العراق.

**الكلمات المفتاحية:** صناعة السياحة، نظم المعلومات الجغرافية (GIS) ، الاستشعار عن بعد(RS) ، إقليم كردستان العراق، محافظة السليمانية.

**پوختە:**

وەکوو یەکێک لە سێکتەرە هەرە گرنگەکانی ئابووری هەر وڵاتێک، کەرتی گەشتیاری دەتوانێت ژمارەیەک زۆر هەڵی کار بڕەخسێنێ و هەروەها ببێتە هۆی پێشکەوتنی بەرچاو لە سەر ئاستی هەموو جیهاندا. لە ئێستادا زانست و تەکنۆلۆجی سەردەمیانە ڕۆڵێکی زۆر گرنگ دەبینێت لە پەرەسەندنی گەشتیاری و دەبێت ڕەچاو بکرێت. سیستەمی زانیاری جوگرافیایی(GIS) و زانستی دوورپێوی (RS) وەکوو دوو بەشی سەرەکی زۆر هاریکار ئەژمار دەکرێن بۆ گەشەی کەرتی گەشتیاری. لە ماوەی ئەم ساڵانەی ڕابردوودا، پارێزگای سلێمانی لە هەرێمی کوردستان (هـ.ک)، میواندارى سەدان هەزار گەشتیار بووە کە لە ناوەڕاست و باشووری عێراقەوە سەردانی ئەم پارێزگایەیان کردوە. دۆخی سیاسی و ئەمنی گونجاو و هەروەها هەبوونی ژمارەیەک زۆر ناوچەی سروشتی سرنج ڕاکێش لە هەرێمی کوردستان، بۆتە هۆی ئەوە کە ساڵانە ڕێژەیەکی زۆر گەشتیار سەردانی بکات و تەنانەت لەوێ نیشتەجێ ببن. ئامانجی ئەم توێژینەوەیە بەرهەم هێنانی هێندێک نەخشە و زانیاری باوەڕ پێکراوە، بە بەکار هێنانی دوو زانستی GIS و RS، کە بتوانرێت لە کەرتی گەشتیاریدا بو بڕیاردان و پلاندانان بە کار بهێنرێت. هەروەها دوو دەستە داتا بۆ جێبە جێ کردنی ئەم توێژینەوە بەکار هاتوە کە بریتین لە داتا ئاماری و وێنەی مانگی دەسکرد. مێتۆدی سەرەکی لەم توێژینەوەدا بە دوو قۆناخدا تێدەپەڕێت. یەکەم ئامادە کردنی هەر یەک لەو نەخشە تایبەتانەی کە لە بواری گەشتاری دا سوودمەندن، دووەم، تێکەڵ کردنی ئەو نەخشانە بۆ بەرهەم هێنانی هەندێ نەخشەی تازە کە پیشاندەری زانیاری پیویستە بۆ شیکاری و تاوتوێ کردنی دۆخی ئێستەی کەرتی گەشتیاری و دەتوانێت هاریکاری بەڕێوەبەران و بە گشتی بە کارهێنەران بێت. ئەنجامەکان ئەوەمان پیشان دەدات کە سلێمانی کەم بوونی ڕێگای گشتی زۆر پێوە دیارە و هەروەها فاسیلیتی و پێداویستی گەشتیاری بە شێوەیەکی ناهاوسەنگ تیایدا بڵاو بوەتەوە. بە پێی نەخشەکان تەنها سێ ڕێگەی گشتی تیایدا تێبینی دەکرێت. لە لایەکی ترەوە، هۆتێلەکان لەم سنوورەدا بە جوانی لە سەر ناوچە گەشتیاریەکان دابەش نەکراوە. بە تەنها ڕێستورانتەکان بە شێوەیەکی گونجاو بڵاو بوونەتەوە و دەتوانێت پێداویستی گەشتیاران تا ڕادەیەکی زۆر دابین بکات. لە هەمان کاتدا، نەخشەکان دەری دەخات کە جۆری بڵاوبوونەوەی گەشتیاران لە وەرزی بەهار و هاوین دا یەکسان نیە. لە وەرزی بەهاردا، گەشتیاران زیاتر سەردانی ناوچە سرنج ڕاکێشەکان ئەکەن کە بە باشی ڕێک خراون و بە ئاسانی دەس دەکەون. لە هاویندا، ئەو ناوچانەی کە بەرزترە و کەشێکی فێنکتریان هەیە زیاتر سەردان دەکرێن (هەورامان، سیتەک، قەندیل، ...) لە لایەن گەشتارانی ناوەوە و دەرەوەی هەرێمی کوردستان.

**کلیلە وشە:** کەرتی گەشتیاری، سیستەمی زانیاری جۆگرافیایی، دووڕپێوی، هەرێمی کوردستان، سلێمانی، عێراق.

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## 1. Introduction

Tourism is one of the most significant economic sectors, have created numerous job opportunities and generated an extensive development all over the world. The sector, known today as an industry and has engaged many sectors, aims to serve domestic, international, business, and leisure visitors. The tourism industry has also made many other business fields opportunities, including accommodation, transportation, food and beverage, sports, and culture [1]. According to annual research by the World Travel & Tourism Council (WTTC) (**Figure 1**).

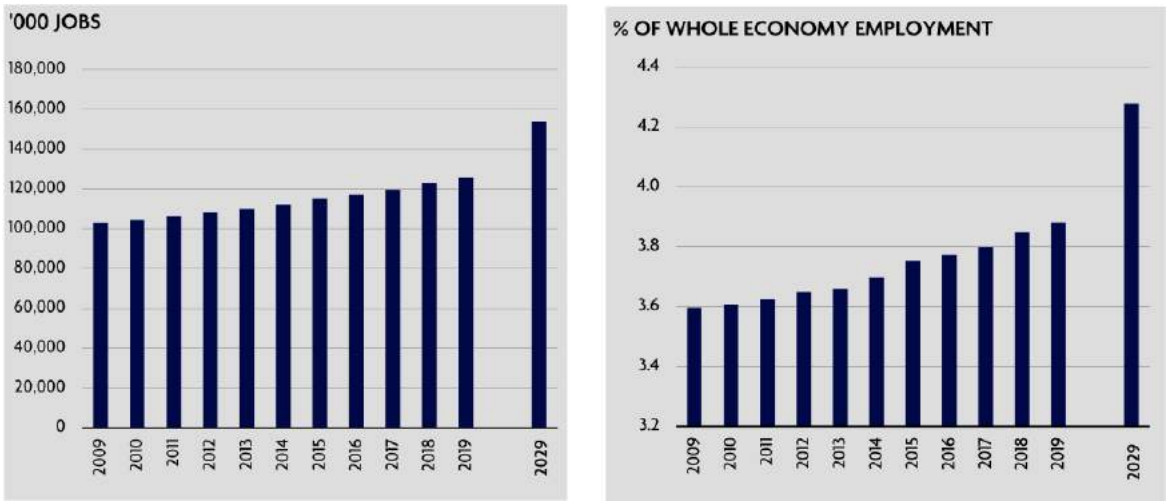


**Figure 1:** The total contribution of Travel & Tourism to employment (including wider effects from investment, the supply chain and induced income see page 2) was 318,811,000 jobs in 2018 (10.0% of total employment). This is forecast to rise by 2.9% in 2019 to 328,208,000 jobs (10.1% of total employment). [1]

Tourism can be considered as one of the world's most rapidly expanding industries, contributing over ten percent to global Gross Domestic Product (GDP) and generating employment for almost 318 million people in 2019. New technologies play a substantial effect to expand the tourism industry that should be taken into account. The Geographic Information Systems (GIS) and Remote Sensing (RS) technology, among them, is one of the best aids helping the tourism manager. As a decision-supporting tool, GIS can be used in tourism for sustainable tourism planning, visitor flow management, and optimized tourism site selection.

GIS is considered as a database and mapping technology dealing with geographic data. It is an organized set of computer hardware, software, and geographic data, which helps users store, organize, manipulate, analyze, and display spatial geographic data to generate useful information to be used in decision-making [2, 3]. Each data in GIS has its space representation. GIS can display data in a visual and simple form. GIS provides a reliable tool for users to interact between different spatial data (layers) [4]. The layers of spatial data can also easily be linked with ranges of attribute tables, including spatial data properties called databases. The link is an interaction between the digital map and database, which means by applying any change in the map, the database will automatically be updated, and vice versa. In the end, all obtained results can be easily and effectively visualized via


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new, synthetic, and thematic maps (new layers). RS can provide a wide range of spatial data by taking high-resolution images of the Erath in different reason and on different scales [5]. These data, then, can be used in GIS system platforms for classifying land uses and producing thematic maps and information layers.

As a decision-supporting tool, GIS can be used in tourism for sustainable tourism planning, visitor flow management, and optimized tourism site selection [6]. Therefore, it can be concluded that GIS's potential in tourism management and development is indeed high and should not be ignored. Tourism has been used GIS potentials in many developed countries, but in many other regions (e.g., Kurdistan Region in Iraq) it's not still sufficiently used to improve business operations, both in the tourist offer and tourist demand. This study aims to prepare some base layers to assist in the planning of tourism policy.

For the sustainable development of a region, it is necessary to consider its domestic population's interest. In terms of tourism development recently, researchers have a trend to entertain the residents and the way they can be engaged in tourism activities and get benefits from these. However, many studies emphasize that environmental conservation plays a vital role in ecotourism development [7]. It's also reported that tourism can be a source of some catastrophic like forest fires [8]. Furthermore, Touristic area, like Darbandikhan in Iraq, are of high potential to experience high rate of expantion both in area and population [9]. So, a well-organized plan should be developed and GIS can assist as a decision-supporting tool. Briefly, In the tourism industry, GIS is used to provide digital layer used for producing either printed map and internet-based maps, attraction maps, topographic maps, roads map, and so on. Furthermore, the GIS system offers excellent opportunities to develop modern tourism applications providing a high range of maps using satellite-derived and field data [4]. This technology integrates a database with unique visualization and geographic maps. Nowadays the tourism and GIS integration seems like a challenge for tourism planning. Furthermore, GIS now is intensely employed to provide tourists with what they should do and where to go. Developing and managing tourist resources and processes are the major keys to obtaining tourism in any country [4]. It often takes a long time and cost to respond to any requests of tourist demands. Therefore, an information system should be available to answer needs related to tourist issues. A planned method should be considered to make a good and optimized relation between environment and marketing [10].

On the side of tourist demand, GIS also plays an important role. Searching for tourist resources, helping in making travel decisions, facilitating mobility, access roads, and tourist destination are all kinds of challenges that tourists may face traveling to foreign countries, visiting new and attractive locations, travel planning, finding optimal and affordable locations for accommodation, etc [11]. Since the tourism structure is complex, a multidisciplinary perspective will be needed to obtain a sustainable tourism system. Developing a decision-making system is widely an important topic for tourism development planners and managers because it will help them monitor the impact of tourism, tourism marketing, management of cultural resources, etc. [11].

According to the report of the Head of Kurdistan Region's Board of Tourism [12], numbers of tourists flocked to the region so far in 2018, overcoming a slump in recent years. Overall, in Iraq, the temperature will go up to 50º Celsius during summer in mid-day, especially in the country's south.

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This condition encourages people to visit the north of Iraq, the IKR, to stay in cooler areas and family-friendly tourist destinations. Based on the report published for 2018 [12], more than 1,300,000 tourists have visited the KR, mostly from the southern and central parts of Iraq, in the first six months. The report also revealed that numerous Iraqis had visited the KR during the three major holidays of the Kurdish New Year, known as Newroz, and the Islamic feasts of Eid al-Fitr and Eid al-Adha. During Eid al-Adha, 349,000 tourists visited the Kurdistan Region in 11 days. Continued the report, approving that the total revenue produced from the visitors for the KR was nearly $118,000,000 [12].

The current study aimed to utilize the potential abilities of GIS/RS techniques to produce some accurate maps and information that could be used for decision making and planning in the tourism industry in Sulaymaniyah province, KR, Iraq.

## 2. Study Area

This study concentrates on Sulaimaniya Province (Fig. 2) in the IKR, which is located in the North of Iraq. The IKR borders Syria in the west, Iran in the east, and Turkey in the north, where fertile plains meet the Zagros mountains [13].

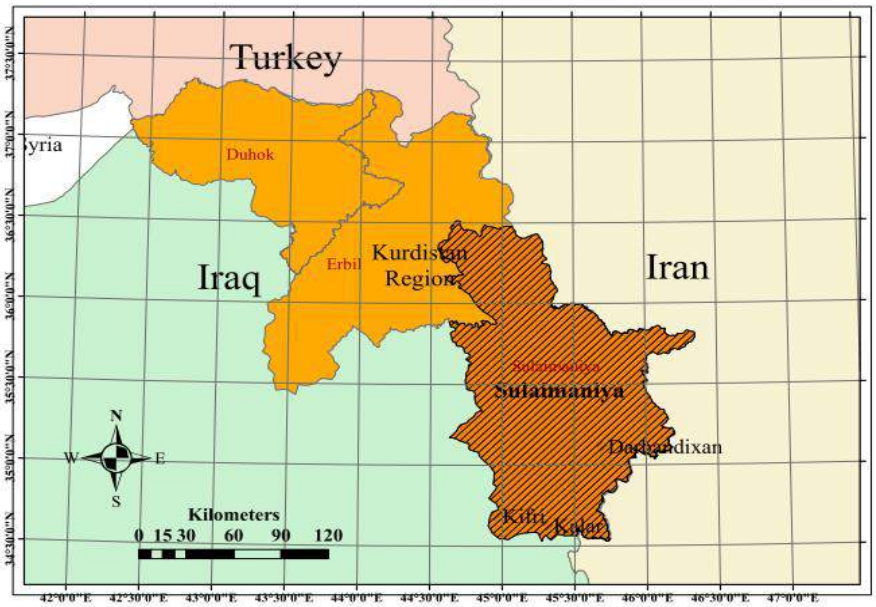


**Fig.2:** Sulaimaniya, located in Kurdistan Region, in the North of Iraq. It is created in Arc GIS. The shapefiles of administrative boundaries, which is accessible at Esri open data [13]

It is traversed by the Sirwan river, the Great Zab river, and the Little Zab river [14]. IKR extends on an area of 40,643 km$^2$[12]. It resided by almost 3,800,000 residents in 2002 [15]. The annual rainfall ranges between 375-724mm [14]. It is also reported that KRG, the climate of the Kurdistan Region, is semi-arid continental. It means it is cold and wet in winter and very hot and dry in summer. Significantly, the summer months from June to September are very hot and dry except for the mountainous areas (e.g., Hawraman, Qandil, Penjwen, etc.). In July and August, the hottest months, mean highs are 39-43 degrees and often reach nearly 50 degrees [15]. Sulaimaniya governorate (Fig. 3) characterized by several natural attraction sites including springs, caves, lakes, mountains area, as well as man-made attractions like historical buildings, ancient caves, etc. In recent years Sulaimaniya


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province has been hosting many tourists from the Southern part of Iraq. Political and security conditions in the IKR accompanied by numerous natural attractions with nice weather conditions have motived them to travel and even immigrate to KR.

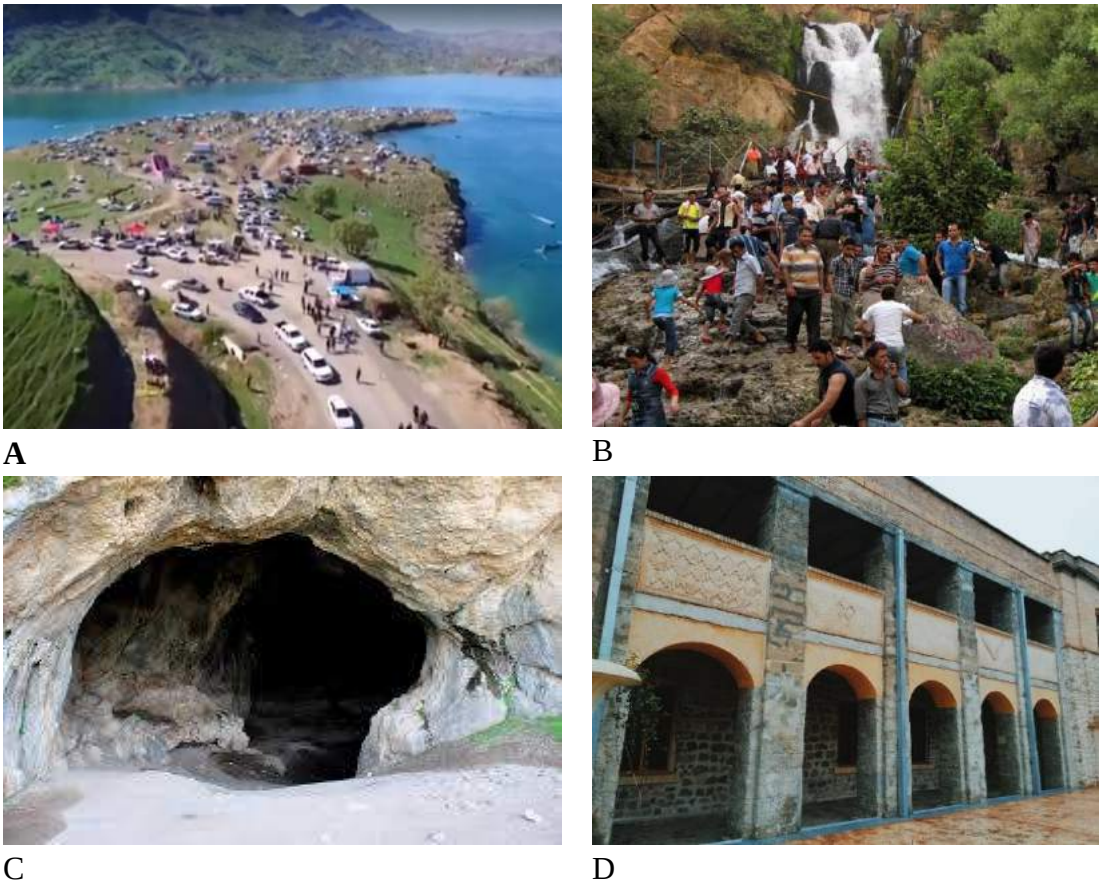

**Fig.3:** the natural attraction in Sulaimaniya Province. A: Darbandikhan lake, B: Zalm Spring, C: Hazarmerd Cave, D: Saray Sulaimaniyah

## 3. Materials and Methods

Tourism planning needs to access reliable spatial data and maps. GIS help planner by providing integrated maps and analyzing transportation facilities (i.e., both transportation services), service (e.g., visitor information, tour and travel operations accommodation, restaurants, shops, money exchange, medical facilities, postal services, etc.), attraction (i.e., natural, cultural, human-made attraction), and, here also cited as tourism infrastructure [14]. To do so, GIS-based tourism planning needs accurate spatial data to be collected and processed, as we as, all locations and their interrelations should be defined and analyzed within a spatial context. For this purpose, GIS can describe and identify tourism infrastructure elements geometrically, thematically, and topologically (**Figure 4**). This study, then, is trying to use GIS technology's potential abilities to produce some fundamental maps to make reliable information to be used in decision-making and planning in the tourism industry in the study area.

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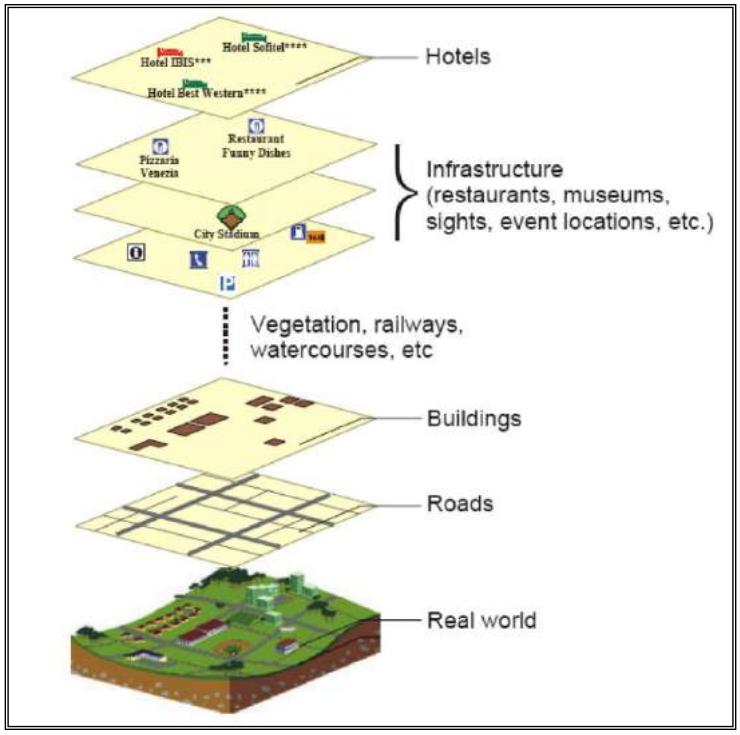


**Fig.4:** integrating layer to make a Touristic map [17]

### 3.1 Materials

Two main sets of data have been used in this study. The first set was statistical tourism-related data (e.g., restaurants, hotels and hostels, parks, tourism facilities, etc.) and historical areas and buildings provided by Sulaimaniya Tourism Administration. Furthermore, to obtain data access ways (road network), two sources were used, accessible data and maps provided by the Tourism Administrator of Sulaimaniya and the open ESRI's shape file data downloaded in ESRI websites [18]. The second set of data was satellite-derived data. On the other hand, the satellite-based data are the other data in use. SRT Digital Elevation Model (DEM) was used to display topographic characteristics of the study area, which was downloaded from the United States Geological Survey (USGS) official website in 6 separate frames (**Figure 5**).


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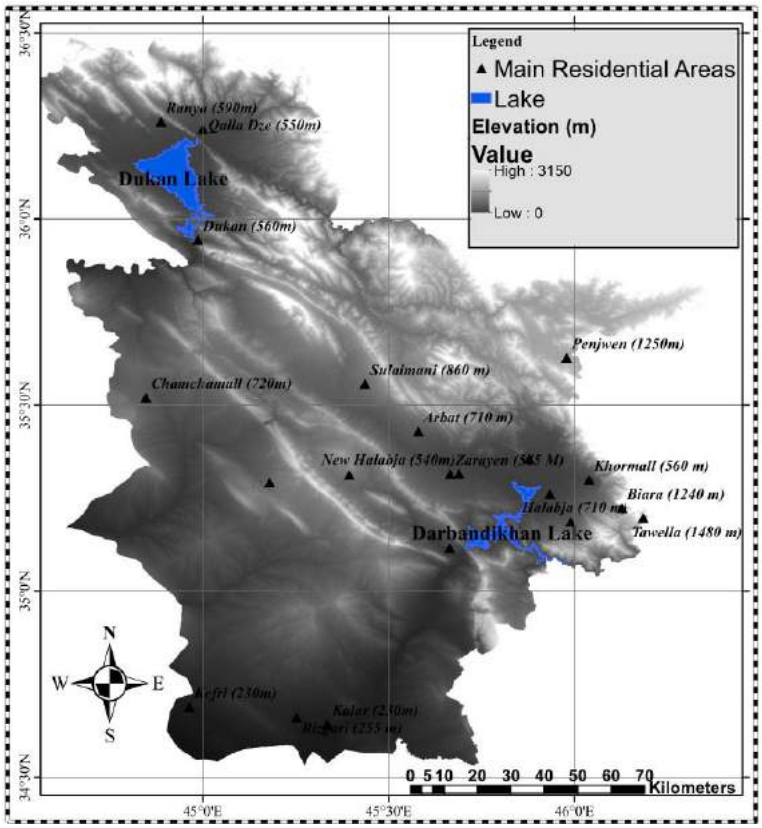


**Fig.5:** SRTM (30m Resolution) Digital Elevation Model (DEM) [19]

### 3.2 Methods

Arc GIS 10.8 and ENVI IDL 4.7 have been used as the leading platform to analyze spatial data. The DEM frame layers were mosaiced in ENVI IDL 4.7 software to create a single raster that can be handled easier. Using the masking function, the study area was extracted using the intersection function between the raster DEM and the vector file of the study area's boundary. (**Figure 5**). As seen in figure 5, the location of the main residential area and their approximate elevation above Mean Sea Level (MSL) have been cited.

Obviously, road networks, either coverage or quality, are considered a significant factor in the tourism industry. The road networks were classified into the highway, major, and minor roads. Any road in the study area was named one of the road classes and displayed in its layer using Arc GIS. By integrating road layers and overlapping them with other tourism, factors will let us the way visitors can reach attractive or necessary points. Using the same way, it is tried to create separate classes for each spatial tourism-related factor, called thematic maps. The locations of different spatial tourism classes (i.e. main residential areas, Hotels, and Hostels, Restaurants, Mosques, Attractions, Lakes, parks, etc.) were determined and, then, they were converted into separate classes using Arc GIS (**Figure 6, 7, 8,** and **9**).

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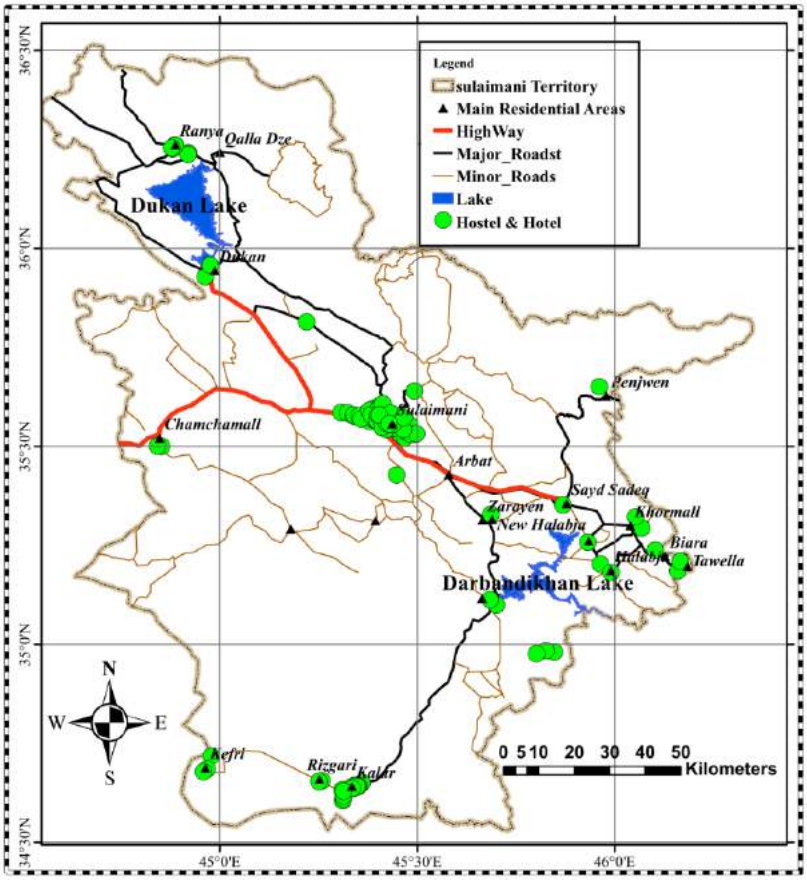


**Fig.6:** Distribution of Road network, lake, main residential area, and hotel and Hostels in Sulaimaniya Province.

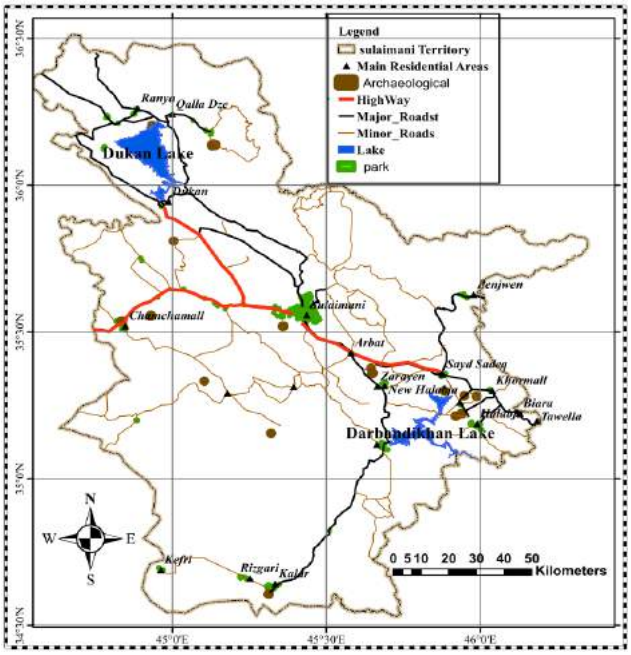


**Figure7:** Distribution of Parks and Archaeological spots in the study area.


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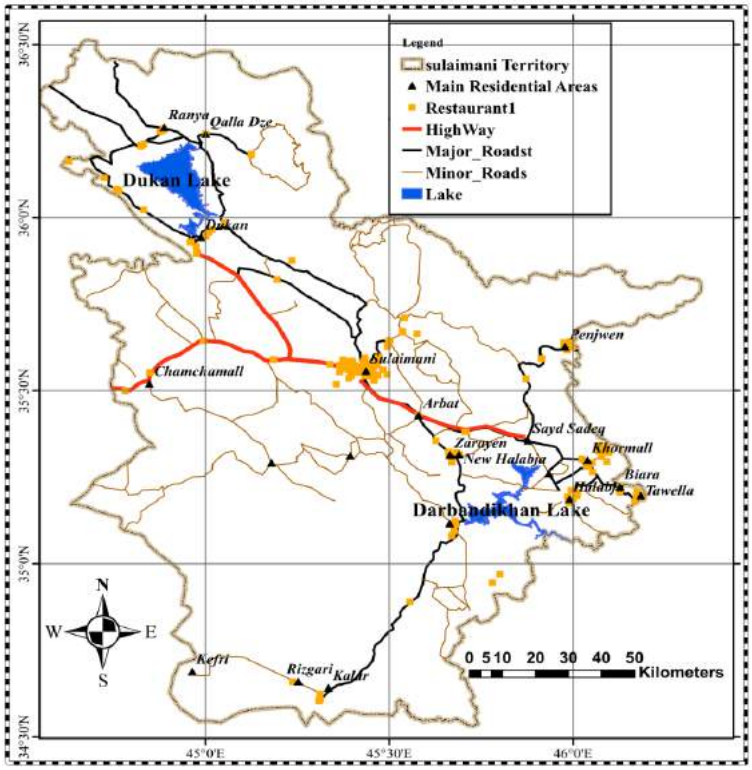


**Figure 8**: Distribution of Restaurants spots in the study area

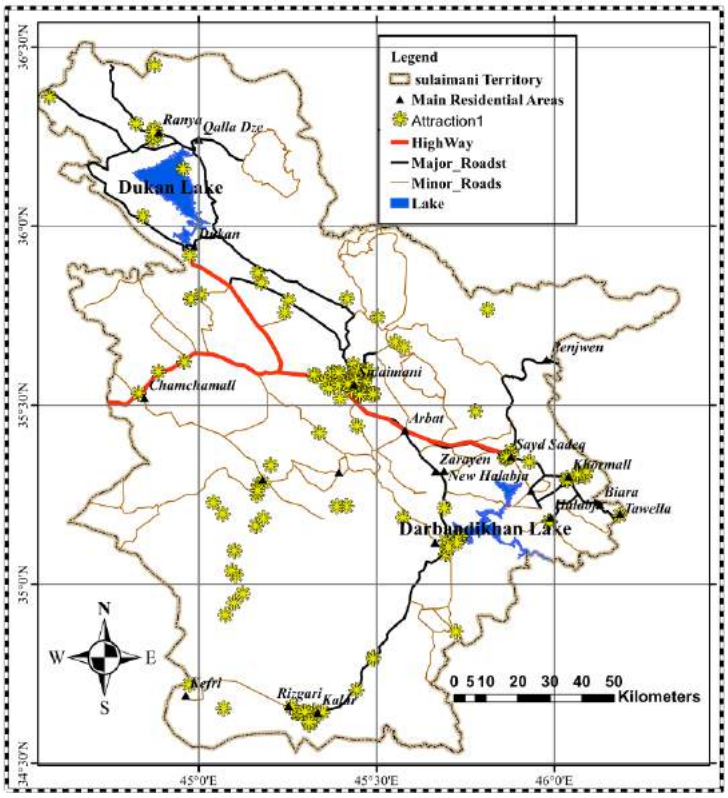


**Figure 9:** Distribution of attractions spots in the study area

Each one also includes its database, which shows some basic information about the class members (e.g. coordinates, land use, name, etc.). Integrating these layers will let us produce a range of valuable

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maps that planners can use each one to extract meaningful information about how the different facilities and attractions are distributed and how they can be better considering tourism demands. Besides, the distribution of tourists during the touristic season also has been converted into a layer. By integrating visitor's distribution and other layers, the planner might make a reliable assessment of how well the facilities are distributed to meet tourists' demands. It is also accompanied by layers of elevation (**Figure 10 & 11**). This layer classified the study area into five classes. It is considering the elevation from MSL. It should be considered too since the elevation directly affects weather conditions (**Figure 10 & 11**). It is possible to make a throughout the map to display all layers on the same map by adding them into one map, but it sometimes sounds confusing. Arc GIS lets us make different maps considering the user intention. That iswhy the produced map in this study has displayed any or some of the factors in any single map to have a clearer vision and interpretation.

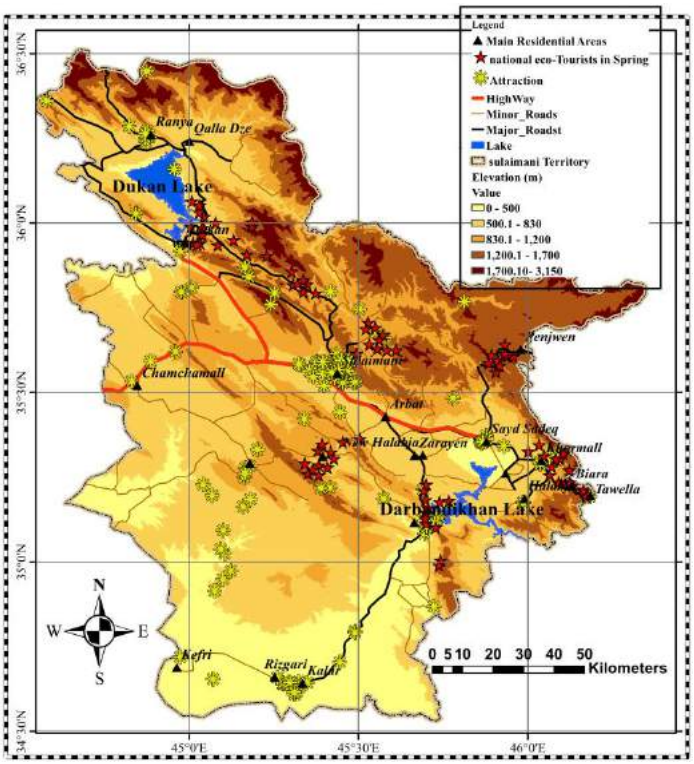


**Figure 10:** Classified area based on an elevation over Mean Sea Level (MSL). Tourists seemed to follow mostly attractive well-organized areas, in spring.


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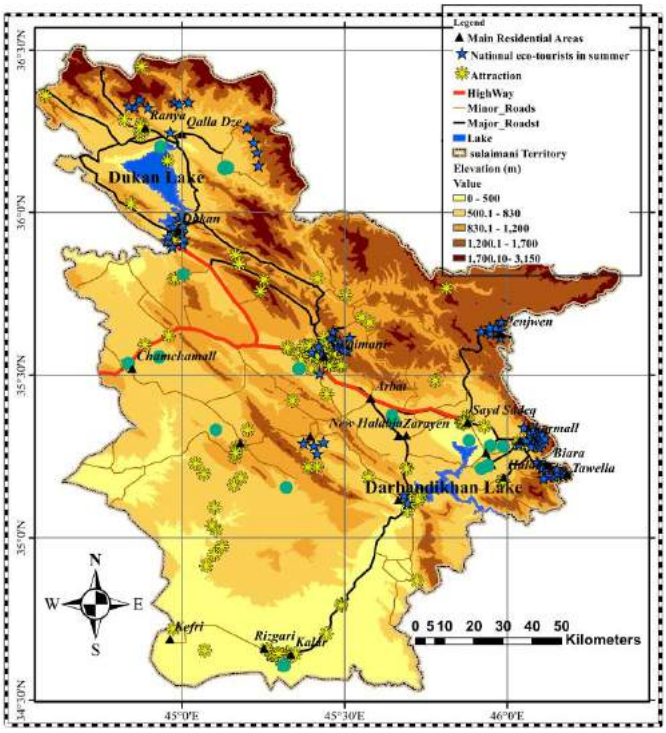


**Figure 11:** Classified area based on elevation over Mean Sea Level (MSL). Tourists seemed to follow mostly attractive higher areas with cooler weather condition, in Summer.

## 3. Results and Discussion

First of all, the study area suffers from a lack of highways, and there are only three short highways inside it (**Figure 6**). The only standard way to get to a tourist area is Sulaimaniya and Dukan city. Comparing the hotel layer (**Figure 6)** and tourists' distribution (**Figure 10**) shows that hotels' distribution hardly follows the most visited and attractive spots. Figure (7), show the distribution of Parks and Archaeological spots in the study area. The main park bodies are located in Sulaimaniya city, and other areas lack well-organized parks. Inversely, Archaeological spots are spread almost all over the province, but there is a very low inclination to visit archeologic spots (Figure 7) that planners should consider researching to find out why. The only well-organized facility which can meet the tourism demand to a great extent are restaurants (**Figure 8**). Comparing the distribution of restaurants and most visited spots (**Figure 10**) and attraction map (**Figure 9**), reveals an acceptable spatial correlation between them. It means that a tourist will most probably find a restaurant in the most attractive spots over the study area. The results also reveal that the distribution of visitors during the spring and summer seasons is not following the same pattern (**Figure 10 and Figure 11**). During spring (**Figure 10**), tourists are mostly inclined to visit the well-organized attractive spots (e.g. Sulaimaniya city, Dukan), as well as natural attractions with rather good access ways and excellent weather conditions (e.g. Hawraman area, Dukan, Penjwen, Sitak, Gharadakh area, Darbandikhan, Qalladze, etc.). This inclination has been changed during summer. In summer, the accessible higher elevation spot with better weather conditions (e.g., Hawraman, Sitak, Qandil, Penjwen) has been more interesting for tourists, either local or south and central part of Iraq (**Figure 11**). The map also reveals that a trendy area like Dukan in summer would not host people as the colder areas like Hawraman or Penjwen.

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## 4. Conclusions and Reccomendation

This study displayed how GIS/RS can provide helpful information in tourism planning and development. Providing precise information about acces ways, facilities and the their spatisal and temporal distribution, RS/GIS can present pricless tool for managers to see the area in different scales. The results also revealed, the only well-distributed sector that met the tourism demand is the restaurants. Considering the different pattern distribution of tourists in spring and summer, as proved by the study, should be to make better decisions and planning. To face this challenge, supervised temporal planning can be a good proposal. Finding most visited spots and high potential spots that already lack enough facilities, the developed maps can also be helpful for investors to decide where to invest.

Regarding the precious potentials of RS/GIS in the tourism industry, It's highly recommended to conducts more researches on making precise maps to have a throughout spatio-temporal view about the future of tourism industry in KR.

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