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Spatial Analysis Of Accommodation Distribution Pattern In Ha'il City, Saudi Arabia, Using Geographic Information System (GIS)

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Abstract:
The study aims to analyze the locational distribution patterns of accommodations in the city of Hail, Saudi Arabia, using the technology of Geographic Information Systems (GIS). The study used primary data to achieve the study's objectives. The primary data was obtained via the Global Positioning System (GPS) as the (x, y) coordinates of each accommodation in the city. Data were processed and analyzed to generate a geospatial database for accommodations using ESRI ArcGIS Pro software. A map of accommodation distribution was generated. Several analytical methods were employed to analyze accommodation distribution patterns and concentrations, such as multi-ring buffer, Kernel Density, Mean center, Central feature, Standard distance, Directional distribution, and the Average Nearest Neighbor analysis. The result shows that accommodations in Hail City are clustered and concentrated on the city's west side, with a notable agglomeration. Furthermore, the results showed that the accommodations in the city of Hail are located far away from the CBD area. The study concluded that GIS is a valuable tool that can help analyze phenomena with the ability to store, manage, display, and analyze large amounts of data on a digital platform.

Keywords*: Accommodations, spatial analysis, distribution patterns, GIS, Saudi Arabia, Hail*

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I. INTRODUCTION

Saudi Arabia boasts a profound historical heritage accompanied by a rich culture and ample natural resources, complemented by breathtaking scenic vistas as attested by frequent sojourners. Moreover, Saudi Arabia harbors numerous sites of cultural and historical eminence. The Kingdom of Saudi Arabia extends an abundance of offerings to vacationers, affording extensive tourism prospects.(Anis Ur Rehman, 2022).

The exceptional geographical location of Hail City, in addition to its diverse assortment of tourist destinations, plays a pivotal role in attracting visitors and tourists, both domestically and internationally. Over the past two decades, Hail City has witnessed numerous reforms and urban developments. These developments include establishing a new state university, a new specialist hospital, and several tourism events such as the *Desert Festival*, the *Summer Nights Festival, and the Hail International Rally*. Consequently, an increase in the number of tourists, visitors, and students leads to an increase in accommodations in response to the reasons above for demand. The Hail International Rally, for example, has emerged as one of the most notable and significant athletic spectacles in Saudi Arabia, captivating multitudes of sightseers annually. Abdel Azim Ahmed (2017).

Since accommodation location data inherently includes geographical information, adopting GIS technologies offers added efficiency in storing, retrieving, analyzing, and visualizing this data. Consequently, GIS techniques can further enhance accommodation location decisions by collaborating with more robust theoretical and empirical models. Additionally, with the expansion of the Internet and the availability of extensive data, GIS location analysis has entered a new phase of sophistication.

The current study has directed awareness towards urban tourism, a subject matter that has not been extensively examined from a geographical viewpoint. The main emphasis has been placed on the accommodation industry, particularly the establishments of accommodations, which have progressively gained significance in the urban environment. More specifically, this study aims to analyze the distribution patterns and concentration of accommodations in Hail. The research questions of this study are: 1) How large is the accommodation industry in the city of Hail? 2) What are the distribution patterns of the accommodations in the

city of Hail? 3) Is there a concentration of accommodation in Hail? 4) What are the geographic factors behind the distribution of accommodations?

This study contributes to the existing body of literature by introducing the application of spatial statistics to analyze the distribution pattern of accommodations. The remaining study is organized as follows: Section 2 reviews the relevant literature after this introduction. Section 3 describes the methodology and materials. Section 4 lists the results and discussion. Finally, section 5 presents the conclusion.

II. Literature Review

Extensive research on spatial distribution patterns of accommodation/accommodation has been widely examined by researchers worldwide. These studies have been conducted in different fields of knowledge, such as Business, management, economics, tourism, leisure, hospitality, and geography. These studies can be divided into two spatial scales: national and regional/city. More research needs to be conducted from a geography background and adopted spatial statistics to investigate the nature of the spatial distribution of accommodations/accommodation.

Although several studies have been conducted on the spatial distribution of accommodations in Saudi cities, there were no studies conducted in Hail City. For example, (Al-Shehri, 2020) found that the distribution of accommodations in Taif City was clustered, and the Kernel density analysis proved that the highest concentration was on the city's west side. In another city (Al-Omari, 2017) conducted a study on accommodation spatial distribution using geographic information systems and the nearest neighbor index in the city of Al-Madinah and revealed that the distribution was clustered and affected by the location of the Holy Mosque and the main roads.

Three studies took place in Jeddah City, Saudi Arabia. First, (Aldughairy & Alharbi, 2022) utilized GIS to analyze the spatial distribution of accommodations and found that the number of accommodations increases near the main roads. Likewise, the (Sabae, 2013) investigation, the Kernel density analysis revealed a concentration in the distribution of accommodations on the city's main streets, and the highest congestion of accommodations was in the airport area and the old city. Additionally, (Justinia, 2010) discovered that the central business district (CBD) came first in terms of the total number of accommodations, and Large-scale accommodations are distributed away from the CBD. In contrast, small ones are located in the CBD area.

A few studies from the Middle East and North Africa (MENA) have investigated the distribution patterns of accommodations. According to (Almangoush, 2022) results showed an apparent variation and clustered in the geographical distribution of accommodations in Misrata, Libya. The distribution direction is associated with urban growth and public services. (Aldwaikat, 2017) analyzed the distribution of accommodations in the Greater Amman area, Jordan. The study revealed that most of the accommodations were concentrated in the western part of the city. (Halabi, 2017) showed that the distribution pattern of accommodations in Jericho, Palestine, was clustered, irregular, and concentrated in the city center and not uniformly distributed throughout the city area.

Early work has been done in Toronto, Canada (Wall et al., 1985). According to them, the investigation indicated that the average size of establishments has increased markedly, and the vast accommodations, which are less constrained spatially than the smaller units, are concentrated in the downtown and the airport areas. Not surprisingly, accommodations are not randomly distributed and tend to be regionally clustered. (Parra et al. 2022) investigated the spatial analysis of accommodation establishments in Boyacá, Colombia, and found evidence of an intense concentration in five clusters associated with three city municipalities. However, there is a high level of dispersion of the establishments explained by the road corridors and a growing development towards the natural attractions.

Three studies from one African country, Nigeria, have examined accommodation/accommodation distribution. (Kika and Ikezam, 2022) Analyzed the spatial distribution pattern of accommodations in Port Harcourt Metropolis, Nigeria, and showed that the spatial distribution pattern of accommodations was significantly clustered, the directional ellipse was east to west, and the accommodations were concentrated in a particular location. (Adeyemi, 2013) indicated that accommodations were located in all parts of the city of Akure. However, the city axis had the highest concentration of accommodations, and a few accommodations were close to the central business district. Additionally, (Omogunloye & Ayeni, 2012) employed GIS to build a geographic database of accommodations in the city of Lagos, and the database showed that the Local Government Areas of Lagos state have the highest number of accommodations.

Studies from Europe have also explored the spatial patterns of accommodation distribution. For instance, (Rodriguez et al., 2020) claim that the spatial distribution of accommodation establishments in Extremadura, Spain, is not uniform throughout the regional territory. (Belej, 2021) applied the kernel density estimation (KDE) of Points-of-Interest data to show the spatial distribution of different types of accommodations in Poland and found a close relationship between the type of accommodation and the type of tourist attraction. (Hang and Song, 2020) discovered that the accommodation industry in Beijing exhibits a

polycentric clustering pattern in terms of space, with a predominant presence within a 20 km radius of the city center and at a relatively large scale.

Asia has also witnessed several studies on accommodation distribution patterns. For example, (Songhua, 2022) showed that the distribution of chain accommodations within the central urban area of Wuhan is highly uneven, with the majority being concentrated. This concentration exhibits a distinct "clustering distribution pattern," with the accommodations mainly situated near the train station, commercial district, tourist attractions, and major roads. (Li et al., 2020) indicated that during the time frame spanning from 2003 to 2018, there was a consistent and notable growth rate observed in the accommodation industry located in Beijing due to significant historical events, including the Olympic Games, which exerted a considerable influence on the development and progression of the accommodation industry within the city and experienced a gradual shift from a centralized agglomeration towards a more dispersed and diffused state. (Qin et al., 2023) identified a concentration of Chinese star-rated accommodations, and the hot spots of accommodations are correlated with the economic conditions of the local area and reliance on foreign investment.

Reviewing previous studies shows that tourism accommodation is not evenly or randomly distributed throughout cities; instead, it is confined in spatial clusters to certain specific locations. These studies agreed on the importance and critical role of all accommodations in the tourism industry. In addition, most of the literature agreed with the importance of spatial tools and techniques such as GIS and other spatial statistical analyses. However, to the author's knowledge, previous work has not used the multi-ring Buffer analysis, nor studies have been conducted in the city of Hail, which this study is trying to do.

The current study utilizes multi-ring Buffer analyses and several spatial statistics analyses to explore and visualize the spatial distribution of accommodations in Hail City, seeking to fill this gap.

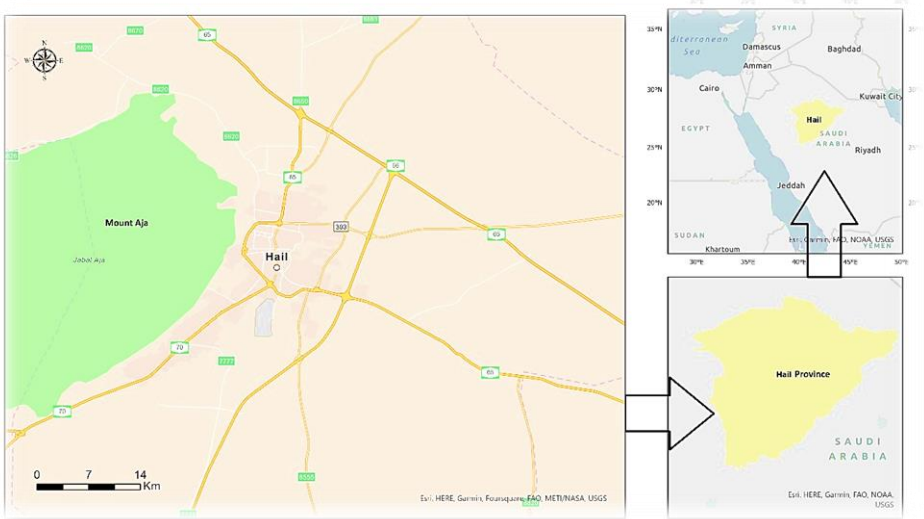
III. MATERIAL AND METHODS

The study area

This study was conducted in the city of Hail, Saudi Arabia. (Figure 1). Hail City is a medium-sized city with a population of 448,623. (Saudi Census, 2022). Hail city is the capital of the Hail province and is located at latitude 27.5114° N and longitude 41.7208° E, with an area of 400 km². Hail City serves as the administrative and regional center for the Hail province. Hail City is located at 980 m above sea level. Hail City is (645) kilometers away from the capital of Saudi Arabia, Riyadh, (820) kilometers away from Jeddah on the west coast, and (1200) kilometers away from Dammam on the east coast.

The climate of Hail City is continental. The mean annual temperature is 23°C, averaging 35–42 °C in the summer and 5–15 °C in the winter. Precipitation approaches 110 mm with two peaks of rainfall in March and November. Humidity becomes as low as 17% in the summer and approaches 54% during winter. The mean annual relative humidity is 35%. The city is connected to the major cities in the neighboring Saudi regions via highways and a regional airport. The airport offers both domestic and international flights. A new international airport was planned to be constructed, as Ha'il has a strategic location in the Middle East because it takes only one hour by plane to reach 11 Arab capitals. Ha'il has a crucial logistical role in northern Saudi Arabia's rail system (SAR). The railway links Hail City to Riyadh (645 km) to the south and the Saudi-Jordan border north (650 km). Figure 1 shows the location of Hail City within the region and the country.

Figure 1: Location of Hail City and Hail Province



Source: Fieldwork 2023

Data Source and Analysis Procedure

The primary data of this study is the geographic coordinates (x, y) of all accommodations in the city (88 accommodations). Data has been collected via GPS devices and transferred to the well-known software ArcGIS Pro v.3.1.3.

After data were collected, a geographic database for the accommodations was built. The database contained name, addresses, and locations. When data set up, a map of whole accommodations in the study area was generated.

After that, several analysis techniques were employed as follows:

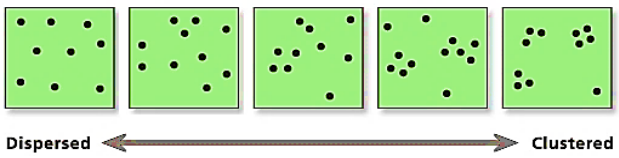
1. Kernel Density Analysis: used to calculate the density of features in their neighborhoods. It can effectively transform the data of discrete points into a map of continuous density to visually display the spatial distribution of points. Kernel Density analysis can be used for quick calculation and visualization with the aid of the spatial analysis technology of GIS. The formula is as follows:

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

2. Multi-ring Buffer analysis creates multiple buffers around the input features at specified distances. These buffers can be merged and dissolved using the buffer distance values to create non-overlapping buffers.
3. Spatial Statistics Analysis: SSAs are used for various types of analyses, such as analyzing spatial distributions, relationships, pattern analysis, shape analysis, and statistical comparisons of spatial datasets. The chosen analyses are:

A. The Nearest neighbor analysis: this analysis calculates the nearest neighbor index based on the average distance from each feature to its nearest neighboring feature. The Average Nearest Neighbor tool returns five values: Observed Mean Distance, Expected Mean Distance, Nearest Neighbor Index, z-score, and p-value. If the average distance is less than the average for a hypothetical random distribution, the distribution of the features being analyzed is considered clustered. The features are considered dispersed if the average distance is greater than a hypothetical random distribution. The formula is as follows:

$$R = \frac{r_o}{r_e} = \left(\frac{\sum_{i=1}^{n} d_i}{n} \Big/ \frac{0.5}{\sqrt{\frac{n}{A}}}\right)$$



B. Central Feature: It identifies the most centrally located feature in a point, line, or polygon feature class. The feature associated with the smallest accumulated distance to all other features in the dataset is the most centrally located.
C. Mean Center: It identifies the geographic center (or the center of concentration) for a set of features. The mean center is a point constructed from the average x and y values for the input feature centroids.
D. Standard Distance measures the degree to which features are concentrated or dispersed around the geometric mean center. The standard distance is helpful as it provides a single summary measure of feature distribution around their center.
E. Directional Distribution: It creates standard deviational ellipses or ellipsoids to summarize the spatial characteristics of geographic features: central tendency, dispersion, and directional trends.

IV. RESULT AND DISCUSSION

Distribution map

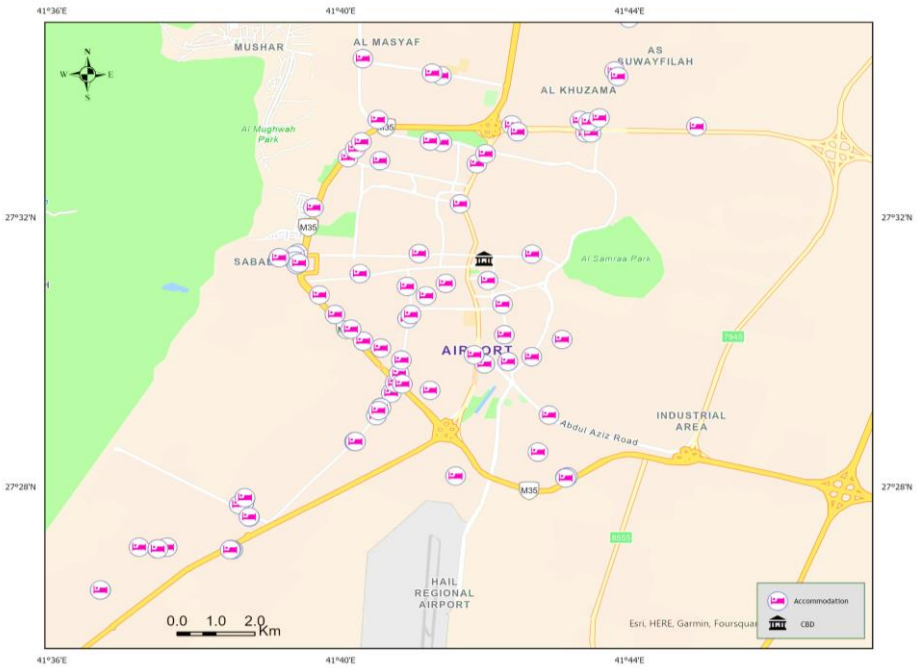
The spatial point patterns analyzed in this study are the total number (whole population) of accommodation establishments in Hail City on 1 October 2023. (88 spatial points). Figure 2 shows the spatial distribution of accommodations in Hail City.

As shown on the map, most accommodations are located within the city ring road (in bold yellow), with a notable concentration on the west and north sides. It can be seen that the majority of accommodations are located on the city's main roads, which means accessibility is one of the top priorities when deciding to choose an accommodation location. The map also shows that most accommodations are outside the Central Business District CBD since the CBD area has long been under construction and renovation, which, not surprisingly, means a lack of accommodations.

Regarding distribution in the city neighborhoods, figure 3 and 4 illustrates that two neighborhoods out of 27, namely Niqrah and Wusaitah, had 25% of the population because Niqrah is close to the airport, and services are available for the Wusaita neighborhood. Generally speaking, the city's west side is more developmentally than the others.

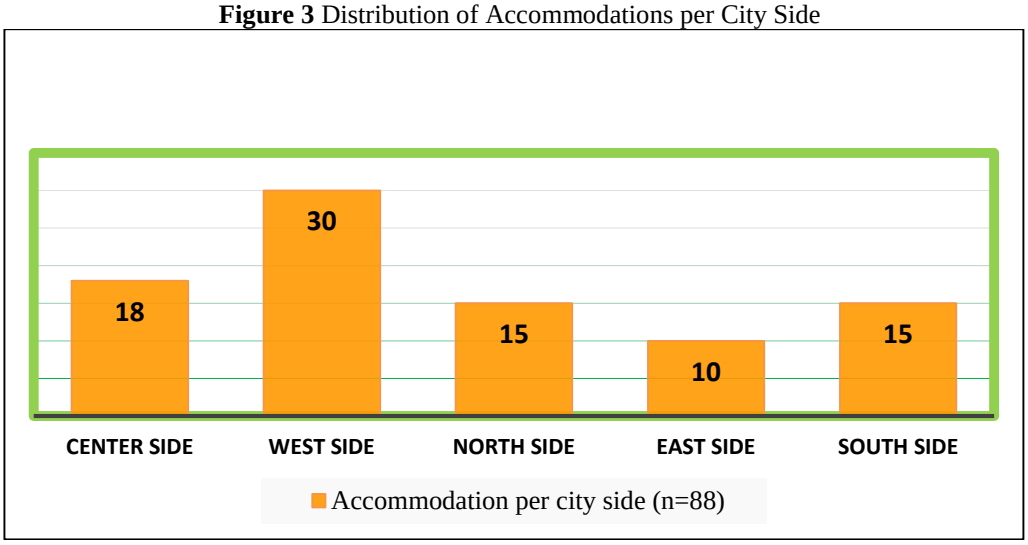
Furthermore, the concentration of accommodations on the north ring of the city might be affected by the only university and the specialist hospital. In contrast, the accommodations could be better distributed on the east and south sides of the city, with only ten on the east side and 15 on the south side. The reason is that the east and south sides do not contain any entertainment or governmental and public services. The only two shopping malls are located on the north and west sides of the city.

Figure 2. Map of accommodation distribution



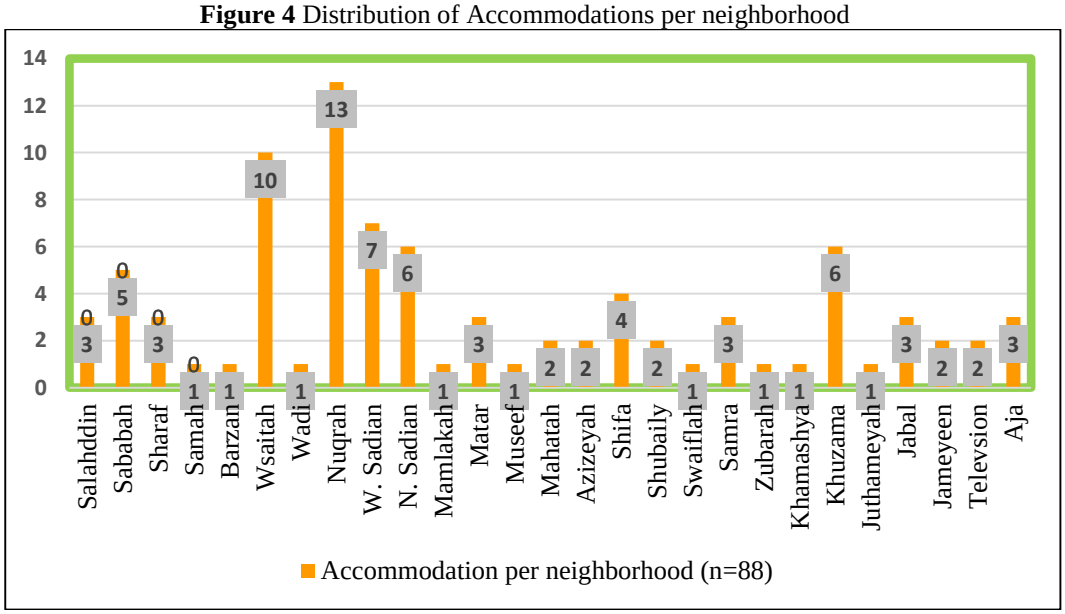
Source: Fieldwork 2023

Figure 3 Distribution of Accommodations per City Side



Source: Fieldwork 2023

Figure 4 Distribution of Accommodations per neighborhood



Source: Fieldwork 2023

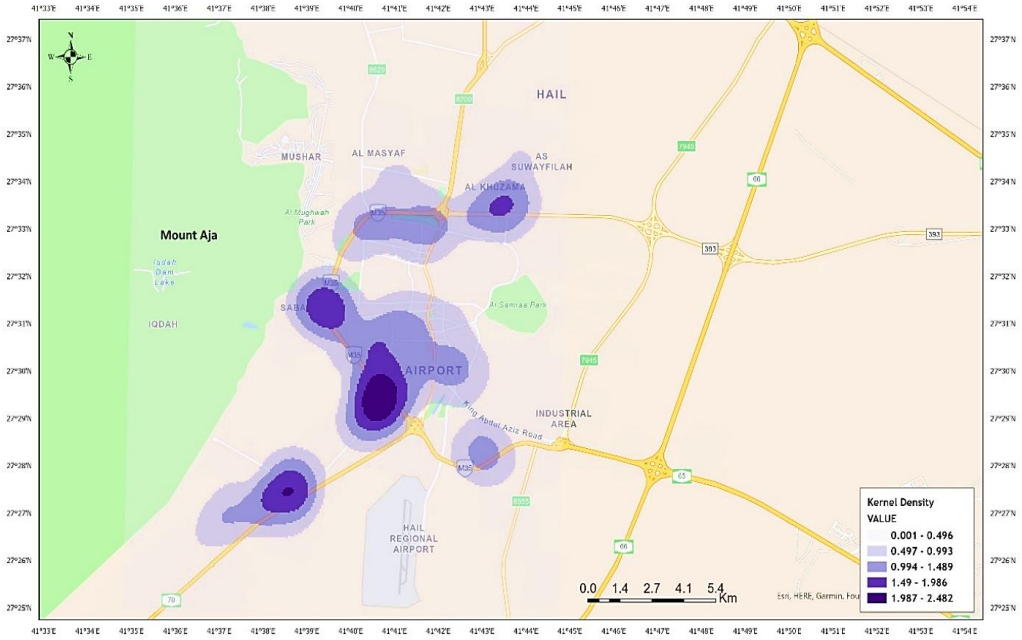
Kernel Density

Figure 5 shows the results of the Kernel density analysis. It can be seen that there are four varying levels of hotspots within the city. These can be classified as follows:

1. A tow High density were noticed on the Southwestern Ring Road, near the airport area. The closeness to the airport and the city's biggest shopping mall might explain that concentration.
2. Tow medium densities: a one near Mount Aja area, which contains attracting rural resorts and camping. The other density is located on the north ring road. As mentioned earlier, the only explanation for that is the closeness to the university and the specialist hospital.
3. Low densities on the other sides of the city: northwest, central, east, and southeast.

Like any service in the tourism industry, accommodations are affected by several geographic and non-geographic factors. These factors include accessibility, tourist attractions, nature resorts, and economic supplies.

Figure 5 Results of Kernel density analysis of accommodations in Hail City



Source: Fieldwork 2023

Multi-ring Buffer

Figure 6 shows the results of the analysis of the Multi-ring Buffer, which has created buffer polygons around CBD to a specified distance. In this case, a distance of 1 km is set due to the size of the city.

The results indicate that each zone around the CBD area contained several accommodations. The first zone contains only one accommodation. The second zone contained seven accommodations. The rest of the zones are in the table below.

Table 1.Aaccommodations per zone

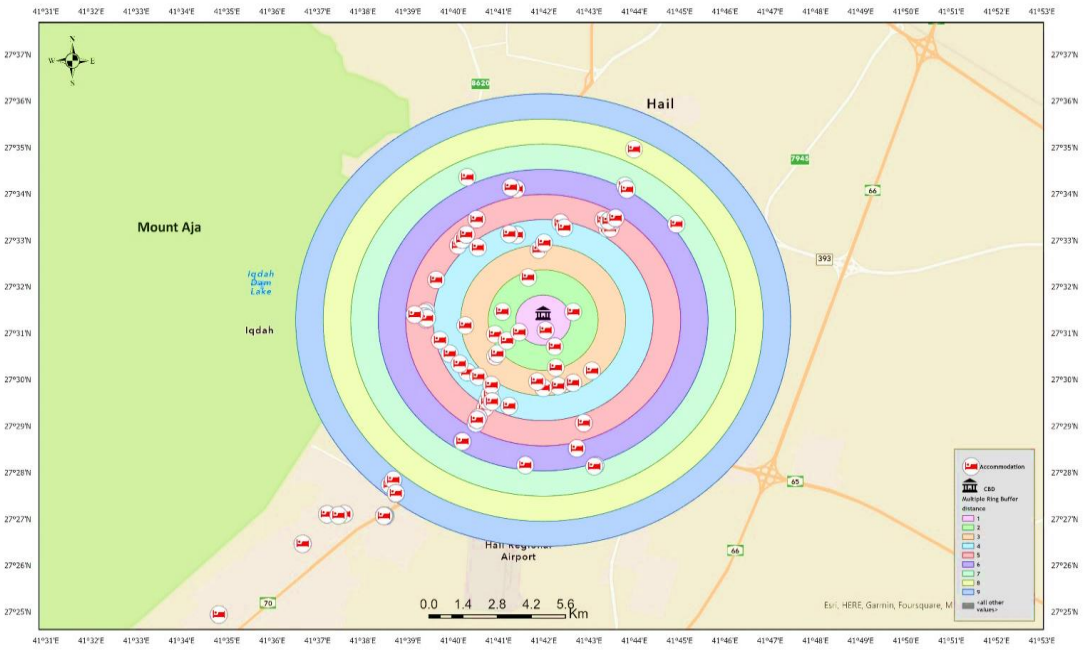
Zone	Number of accommodations	Zone	Number of accommodations
First	1	Sixth	19
Second	7	Seventh	5
Third	9	Eighth	6
Forth	12	Ninth	1
Fifth	15	Tenth	3

In hotel location distribution literature, Ashworth and Tunbridge (1990) proposed the Tourist-historic city model (THC Model):

The typology of accommodation locations within medium-sized Western European provincial towns indicates six types of location zones: 1)Traditional city gates. 2) Railway station/approach roads. 3) Main access roads. 4) Nice" locations. 5) Transition zones and urban periphery on a motorway. (6) airport transport interchanges. These different zones are associated with different types of accommodations.

Comparing the results with Ashworth's THC model, it seems this model does not apply to Hail since it is neither a historic town nor a European. Some researchers suggested that, while this model applies to tourist-historic cities, it may not be appropriate for non-tourist-historic cities. Yang et al. (2014).

Figure 6 Results of Multiple Ring Buffer analysis of accommodations in Hail City.



Source: Fieldwork 2023

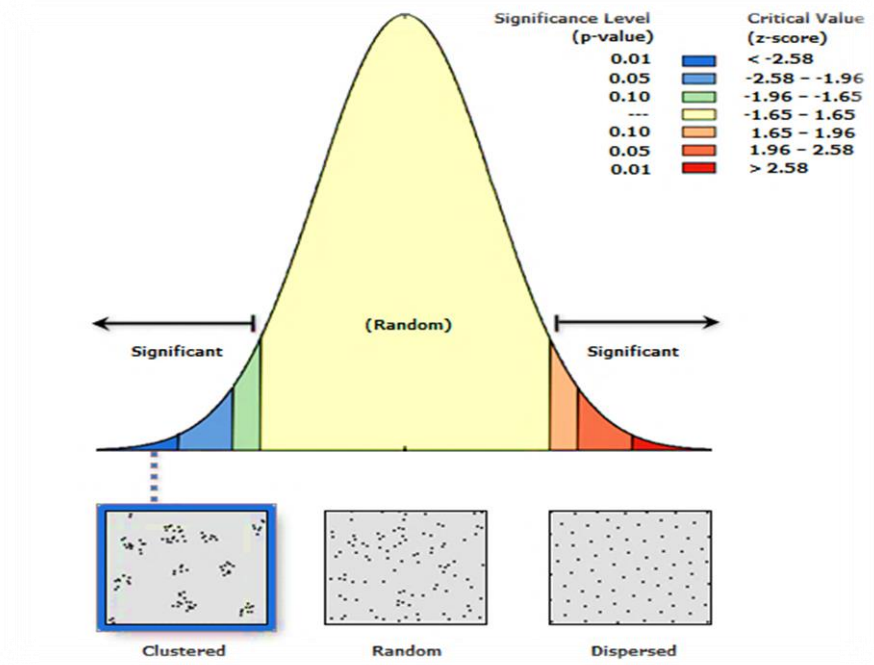
Spatial Statistics Analysis

The Average Nearest Neighbor

Figure 7 shows the results of the nearest-neighbor analysis. It indicates that the distribution pattern of accommodations in the city of Hail is clustered rather than random or dispersed. The analysis also showed that the observed mean distance is 521.8090 m, while the expected mean distance is 929.1539 m. The value of the nearest neighbor ratio is 0.561596. with a Z-score of z-8.088109, there is less than a 1% chance that this pattern results from random chance.

These results support the other analyses run earlier in this study, such as the Kernal density and the multi-ring Buffer analyses, demonstrating an agglomeration in a few parts of the city.

Figure 7 The results of the Average Nearest Neighbor



Average Nearest Neighbor Summary	
Observed Mean Distance	521.8090 Meters
Expected Mean Distance	929.1539 Meters
Nearest Neighbor Ratio	0.561596
z-score	-8.088109
p-value	0.000000

Mean Center and 4.3 Central Feature

Figure 8 shows the results of the Mean Center and Central Feature analyses. Both indicate that the Mean center of accommodations in the city tends towards the southwest of the city, likewise the Central Feature. It is due to the concentration of the accommodations on the city's west side.

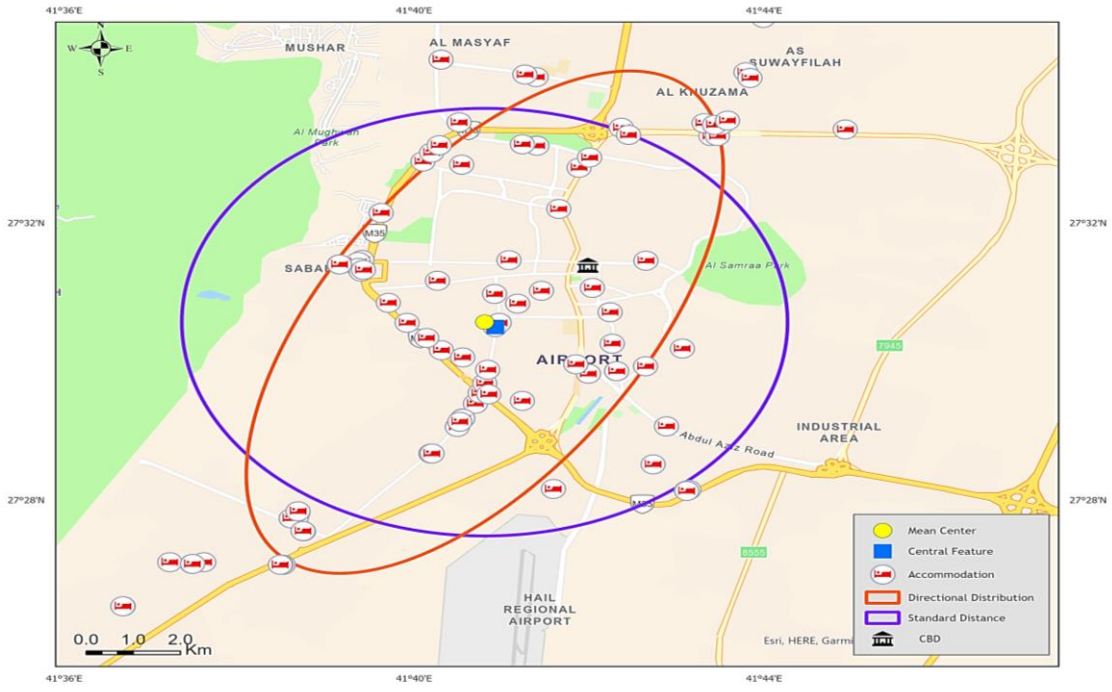
Standard Distance and

The results of the Standard Distance analysis show that the circle size is relatively large, which means an increase in the spread of the phenomenon. It might be explained by the small number of accommodations located on the city's margins. In addition, the circle shows that about four-fifths, or 80%, of the accommodations are located within the scope of the circle.

Directional Distribution

The Ellipses direction results show that it extends from the northeast to the southwest concurrent with the city's expanding direction, which avoids the nearby valleys and mountains.

Figure 8.
Analysis of the Mean Center, Central Feature, distance standard, Directional Distribution of accommodations.



Source: Fieldwork 2023

IV. CONCLUSION

This study aimed to identify the spatial distribution patterns of accommodations in the city of Hail in Saudi Arabia and map them out. The study has brought attention to urban tourism, which has received limited attention from a geographical perspective. The primary focus has been on the commercial accommodation sector, specifically the accommodation structures, which have become increasingly prominent in the urban landscape.

The study has demonstrated the significance of Geographic Information Systems (GIS) in analyzing accommodation locations, concluding that accommodations in Hail City have a clustered spatial distribution, with a notable concentration around the city's west side.

Moreover, the findings of the multiple spatial and statistical analyses used in this study support several previous studies results. For instance, the distribution patterns of accommodations are clustered and most of the accommodations are located on main streets and near the airport area. In addition, more than half of accommodations are located in upper-class neighborhoods.

Furthermore, the results partly substantiate the claim by Ashworth and Tunbridge (1990) in their urban tourism model, which suggests that accommodations with similar characteristics cluster together and are commonly located along primary transportation routes..

Finally, various statistical techniques have been employed to investigate the distribution spatial patterns of these landscape features. However, the underlying reasons for these concentration distributions still need to be fully understood. Other scholars are expected to explore these statistical methods further, encouraging geographers interested in tourism to adopt more innovative research methodologies.

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