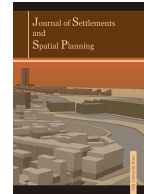




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Spatial Analysis of the Distribution of Urban Centres in Tafila Governorate, Using GIS


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ABSTRACT

This research paper investigates the spatial distribution of urban centres in Tafila Governorate, by determining their spatial extension, their actual centre of gravity, the expected and the median centre. To analyse this pattern spatial statistical methods were used and the technical capabilities represented by the technology of geographic information systems. The results of the study showed the average locations for the distribution of urban centres, the location of the spatial mean, the weighted spatial mean according to the population, and the location of the spatial mediator and the weighted spatial mediator. A convergence between these sites was found clearly evident. In addition, the weighted standard distance for the spread of urban centres was calculated, and the direction of the spatial distribution of the urban centres was determined to show the extent of dispersion of those centres around the weighted spatial mean. The study also showed that the distribution pattern of urban centres in the governorate takes the spatial scattered pattern by applying the closest neighbour analysis; the analysis showed the population weight in the form of points and in the form of rings reflecting the population density of the communities in each of the areas selected for study. In addition, by using Thiessen polygons, the drawing of urban centres' areas (regions) was revealed. The study recommended the necessity of classifying urban centres, developing special planning standards compatible with the local reality, and creating a comprehensive database in collaboration with the authorities responsible with the planning process of urban centres.

1. INTRODUCTION

Geography is concerned with studying and analyzing the spatial distribution pattern of geographical phenomena, as it represents the starting point for understanding the behaviour of geographical phenomena, their spatial relationships and their interpretation (Saoudi N. H. A., 2022). Spatial relationships include the idea of linking geographical phenomena that are governed by distances between geographical phenomena (Muhammad, 2018). The study of the spatial interrelations and patterns of

distribution of geographical phenomena is considered one of the geographical trends that have met with acceptance by geographers, through the shifts in the research trends of relations in the distribution of the single phenomenon spatially, natural and human (Anthony et al., 1996).

The detection of spatial distribution patterns of urban centres indicates the importance of taking the spatial dimension of phenomena into account in studying the forms of correlation for spatial organization, and causal analysis by modelling and classifying correlations (Chisholm, 1971). In addition to

this, the arrangement and variation of the spatial distribution of urban centres, and accordingly the study of urban centres distribution patterns, is a facilitating factor in the application of the concept of the site that was dealt with by different theories, and a reflection of regional development. Therefore, the spatial distribution of phenomena is the essence of the work of spatial studies (Bazazo, 2009), and highlighting the role of the spatial dimension at any spatial planning level, as they study the various phenomena on the surface of the earth with the aim of describing, analyzing and interpreting them (Alsaleh and Alsyriani, 2000), and in the end to find out whether the spatial distribution of phenomena constitutes a specific pattern, or is just random (AlQuhtani, 2022). If the distribution shows a specific pattern, then this means that there are factors behind the formation of this pattern, so the researcher in spatial planning tries to find them (Aldulaimi, 2015), but if the distribution is random, this indicates the presence of forces of chance that are difficult to explain (Al-Muzaffar, 2005).

Geographic information systems are a relatively new technology, and they help reveal patterns of geographical distribution of phenomena on the surface of the earth. They also help in data collection, storage, analysis, and output in a way that enables the interpretation, correlation and explanation of variables, in a way that was not available before. And most importantly, an advantage of these systems is the ability to link different information and employ it in providing solutions to the problems at hand, on the basis of providing many alternatives from which one can choose what suits the researcher and the purposes of the study (Alsaleh and Alsyriani, 2000).

The 35 urban centres in Tafila Governorate are distinguished by not being distributed in a regular or balanced manner in terms of population, as the results of the 2015 General Population Census indicate, that 46% of them are less than 500 people. The percentage of the population in this category exceeds 2.4% of the total population of the Governorate, while the percentage of urban centres with a size of more than 500 inhabitants and less than 5,000, rises to 37%, but the percentage of those who live there is only about 19.6% of the Governorate's population. The percentage of urban centres whose size exceeds 5,000 people constitutes 17% of the total urban centres despite the fact that their population is 78% of the total population of the governorate (Department of Statistics, 2015). It is worth noting that population distribution is one of the important elements in development planning from a demographic perspective as it relates to economic and social development programs and plans, since the dispersal of population groups impedes the implementation of development plans in a balanced manner (Ayasrah, 2016; Taran et al. 2020)).

The main objective of this research is to reveal the pattern, or spatial clustering, of urban centres in

Tafila Governorate, according to the number of inhabitants in each urban centre; for instance, the extent of similarity between the sites of converging urban centres and the number of their inhabitants. Among the objectives of the research is to determine the pattern of spreading urban centres in Tafila Governorate, and the form of their spatial extension. The research also aims to determine the spatial scope of the influence of urban centres on the basis of their hierarchy. The study is based on the hypothesis that the spatial distribution of urban centres in Tafila province is characterized by randomness, not having a fixed pattern and not being controlled by any natural and human phenomena.

1.1. Previous studies

Tafila Governorate lacks scientific studies related to the application of the spatial analysis methodology for urban centres, using the technology of geographic information systems. However, there are studies that the researcher sought, commensurate with the technical dimension of this study. For examples, Muhammad (2018) studied a spatial analysis of the distribution of urban centres using GIS, and Merkens and Vafeidis (2018) addressed the topic of settlement patterns to improve the spatial distribution of population in coastal impact assessments. Fang et al. (2018) investigated the globally fractal patterns of human settlements in river networks. Oguz-kirca and Lirtzis (2018) studied the settlement patterns and spatio-temporal investigations through aerial and GIS applications. Ayasrah (2016) focused on the spatial characteristics of the distribution of urban centres using GIS. Alsaleh and Alsyriani (2000) focused on the spatial distribution pattern of rural urban centres, while Alabdali (2016) investigated the distribution of rural urban centres. Abdulwahab et al. (2015) examined the assessment of livelihood activities of rural farmers. Zhang et al. (2014) also investigated the spatial point pattern analysis of human settlements and geographical associations. Cheewinsiriwat (2013) studied the use of GIS in exploring settlement patterns of the ethnic groups. Linard et al. (2012) investigated the population distribution, settlement patterns and accessibility across Africa in 2010. Kryvobokov (2011) examined the subject of defining apartment neighbourhoods with Thiessen's and fuzzy equality clustering, as well as Alazzawi (2010) aimed to reveal the spatial distribution pattern of rural urban centres. Employing a similar approach, Sarkar (2010) analyzed human settlement patterns using RS and GIS. Levin et al. (2010) studied the maps the settlement of southern Palestine, 1799-1948. Ahmed (2009) researched the settlement patterns and functional distribution in an emerging community. Coombes and Raybould (2001) examined the public policy and population distribution. Luo et al. (2000) discussed the subject of settlement patterns by using

GIS mapping and analysis. And finally, Goodwin et al. (1984) studied settlement patterns in rapidly growing rural areas.

1.2. Study area

The study area is located in the Hashemite Kingdom of Jordan, approximately 183 km south of the capital, Amman, and extends between two degrees of latitude ($30^{\circ}35'40''$ and $31^{\circ}00'08''$), and two longitude ($36^{\circ}06'46''$ and $35^{\circ}16'36''$), as shown in Figure 1.

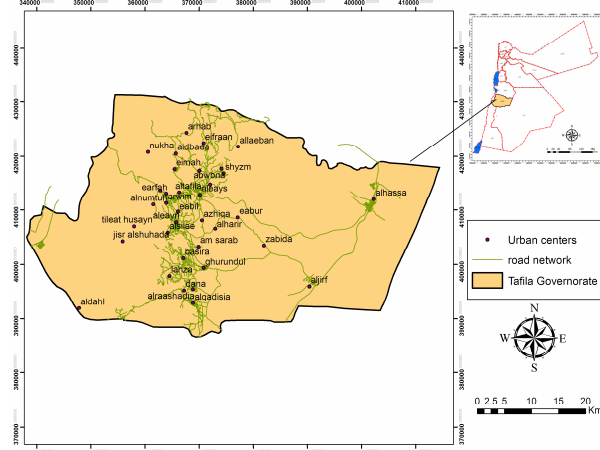


Fig. 1. The study area, urban centres in Tafila Governorate (source: prepared by authors).

The study area occupies an area estimated at 2,209.3 km² (Royal Geographical Centre, 2016). According to the general population and housing census for the year 2015, the population of Tafila Governorate comprised 96,291, which is 1% of the total population of the Kingdom. By gender, males represent 52.3% of the Governorate's population, females 47.7%, and the population density is of 43.5 individuals/km². The average family size is 4.9 members, which is less than the average family size for the Country (5 members), and the population is distributed among different age groups, where children under the age of 15 made up 36.4% of the total population. Population in the age group 15-64 constitutes 59.9% of the Governorate's population, while the percentage of the elderly (65 and over) is 3.7%, indicating that the community of Tafila Governorate is a young society (Department of Statistics, 2015).

The Governorate of Tafila consists of three Districts comprising 35 village communities, and the Qasbah al-Tafila District constitutes 63% of the Governorate's population. The Governorate centre is represented in the city, and includes 27 population agglomerations, of which 7 are localities in which the population exceeds 1,000, and the total population of the district is 60,803. The Governorate also includes the Busayra District: its centre is the town of Busira, and there are 8 localities in it, of which 3 are communities of more than 1,000 inhabitants. The population of this

district reached 25,245 in 2015, in addition to the Al-Hasa District: its centre is the town of Al-Hasa, and it includes 3 communities. The population of the towns was 96,291 in 2015. Figure 2 shows the administrative divisions of Tafila Governorate.

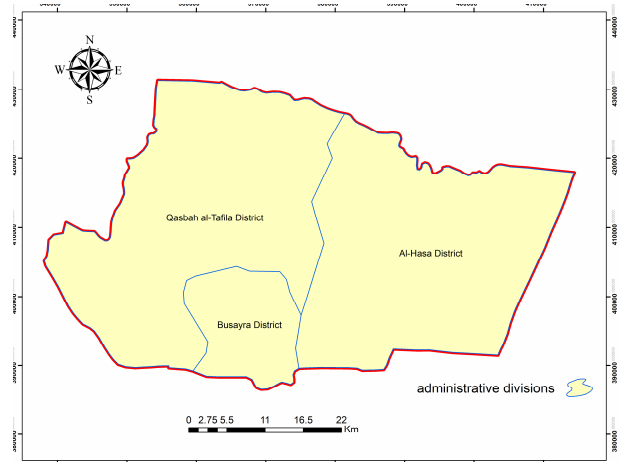


Fig. 2. Administrative divisions of Tafila Governorate (source: prepared by authors).

2. STUDY METHOD

Similar to other studies aiming to investigate the distribution of communities in Ma'an Governorate (South of Jordan), our study is a descriptive, analytical, spatial approach of digital data. Quantitative analytical, statistical, and graphic representation methods were employed to determine the spatial range of the influence of urban centres, to measure the density of the geographical distribution of the population, and describe the pattern of spreading urban centres, and the shape of their geographical extension (see Taran et al., 2020). The researchers employed GIS software, as one of the important programs in cartographic and geographical analysis, including multiple analytic tools for spatial analysis.

2.1. Data sources

The research was based on the administrative boundaries layer, and the population centres of Tafila Governorate for the year 2017, all of which are derived from the Geographic Information Systems Department in the Department of Statistics, and the population data were obtained from the Department of Statistics, the General Population and Housing Census of 2015.

2.2. Data analysis and processing tools

The study used a set of spatial analysis tools, available in the ArcGIS software, which were used successfully in similar studies (see Taran et al., 2020):

Average Nearest Neighbour Relationship Rate to detect the pattern of spreading urban centres in Tafila Governorate; the closest neighbour index is

expressed as the ratio between the viewing distance divided by the expected distance, as the expected distance is the average distance between adjacent urban centres in a hypothetical random distribution. The index value ranges between zero and a value of 2.15. If the index value is zero, then it indicates a non-uniform distribution pattern; if the index value is equal to one, the random distribution pattern appears. If the index value is 2.15, then the trend is the pattern of regular distribution, and there are several shapes and patterns between the random patterns, the irregular pattern and between the random pattern and the regular pattern, ranging between aggregate and dispersed.

Mean centre: it is the site that occupies the central position between the points under study (urban centres in Tafila Governorate). It is possible to express the extent of the importance of each cluster in terms of its weight, the number of inhabitants in each urban centre. In the present case, we designate it as the weighted mean centre, to be used when we want to give each urban centre a weight proportional to its population.

Spatial mediator or central feature: it is the site that separates it from other sites, which are less than the distance between those sites, and anywhere else.

Standard Distance: it is a measure of spatial dispersion and spread. This is an indicator to measure the extent of the spatial divergence or concentration of the vocabulary of the phenomenon, and often the standard distance is used to draw a circle called the standard circle through which it is possible to know the extent of the focus, or spread of the spatial dimension of the phenomenon, and the centre of the circle is the location of the mean centre. The large size of the circle indicates an increase in spatial spread.

Directional Distribution: the distributional direction reveals whether the spatial distribution of the phenomenon has a specific distribution.

Kernel Density Analysis: to show the pattern of population density in an area (Esri, 2014).

Point Density: it shows the nature of the density distribution of a point phenomenon based on a known value such as population.

Analysis of Thiessen polygons: the construction of Thiessen polygons consists of connecting the centre of urban centres closest to each other with straight lines so that each centre is linked to its neighbouring centres, and then cutting these lines vertically with bisectors that end in the boundaries of the region, or when they are not bisectors that meet in the vertices of the triangles outside the boundaries of the territory in which they are used.

2.3. Data preparation procedures

At this stage, a base map for Tafila Governorate was prepared in order to perform spatial

analysis (ArcMap), and it was obtained from the Department of Statistics of the Muscat Coordinate System (Jordan JTM), where the following layers appear: A - Laying out the administrative boundaries of Tafila Governorate in the form of an area (polygon); B - Population groupings layer in the form of points, including the population field; C - Road layer in the form of a line (polyline).

3. RESULTS AND DISCUSSION

The population of Tafila Governorate is distributed among 35 localities, the most important of which is the city of Tafila, which is considered the centre of the Governorate, and the number of urban residents in the Governorate is 75,069, constituting 78% of the total population, which is estimated at 96,291 inhabitants. According to the general population and housing census in 2015, the proportion of the rural population is 22% of the total population of the Governorate (Department of Statistics, 2015).

3.1. The distribution pattern of urban centres in Tafila Governorate

For the analysis of the distribution pattern of the urban centres in Tafila Governorate, the neighbourhood relationship model was used, as the technique of neighbourhood relationship analysis is one of the most important techniques for analyzing spatial patterns. It is one of the clues used to study point phenomena on the surface of the earth by describing, analyzing and interpreting them depending on the Poisson distribution for spatial distributions (Cole and King, 1968). Through the application of neighbourhood relationship analysis on the urban centres within the administrative border of Tafila Governorate, it was found a dispersed geographical distribution as the defining pattern of the sites located and included in the study area (Fig. 3). It was indicated that the result of dividing the calculated mean of urban centres by expected mean was 1.16, which is a number close to one. This means that urban centres have a dispersed spatial pattern, and it falls within a range of confidence level (0.10), as the analysis showed that the value of Z reached 1.84. This is a clear indication of a standard deviation from the mean that represents the dispersed distribution, and it lies between the critical values of the criterion Z that ranges between 1.65 and 1.96, which indicates that the shape of the geographical pattern of the distribution of population centres is dispersed. The dispersed pattern has a high confidence level of 90% and a statistical significance of less than 10%.

The results of the techniques of the closest solution mean reducing the distance of the journey that any person travels within the level of Tafila Governorate in order to obtain certain services such as health, educational, entertainment and other services. And it

entails the distribution of the population on a fixed set of facilities that reduce distance to a minimum (economically), based on the distance they travel to obtain these services, in a manner that achieves spatial development within the planned goals (Taylor, 1977).

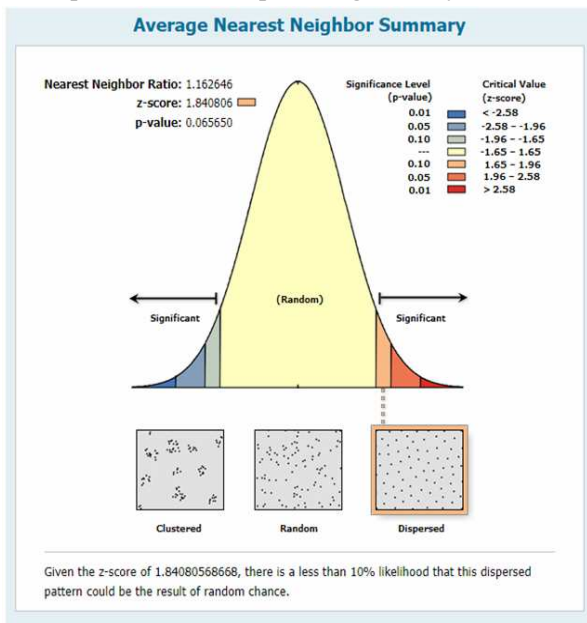


Fig. 3. The spatial distribution pattern of urban centres at the level of Tafila Governorate (source: prepared by authors based on ArcMap software).

The spatial distribution of urban centres in the clustered pattern takes a convergent linear form along the main roads, as is the case in the settlements clustering linearly in the areas of Tafila, Hasa, and Basira. In general, the spatial distribution of points in the converging pattern takes different forms. Its location is a natural, social, or economic phenomenon, and it is important to distinguish the spatial patterns, depending to a large extent on the significance of the continuous scale of the values of the nearest neighbourhood (Alsaleh and Alsyriani, 2000). Thus, we obtained a standard and descriptive guide for the distribution pattern of urban centres in Tafila Governorate. The evidence indicates that the pattern of urban centres spread is not characterized by any form of convergent clustering or regular clustering, but it is rather random, dispersed or divergent.

3.2. The actual and hypothetical (expected) centre of urban centres in Tafila Governorate

The weighted spatial mean was also calculated to provide an accurate picture of the type of spatial distribution of the selected urban sites in Tafila Governorate. According to the number of inhabitants in each settlement, it represents the centre of gravity for the spatial distribution of urban centres in Tafila Governorate. Figure 4 was elaborated based on the results of the spatial analysis. The weighted mean centre for all urban centres is found located in Tafila

Governorate, near the city of Tafila, in the middle of the largest urban centres in the Governorate: Ain Al-Bayda, Al-Eis, Sweimeh, Izhaika, Abel and Erwim; this is where it appeared that the city of Tafila overlaps the point of the weighted spatial median. Moreover, the spatial centre point and the spatial median were found without taking into account the number of inhabitants of urban centres as a weight. A rapprochement also appeared between them.

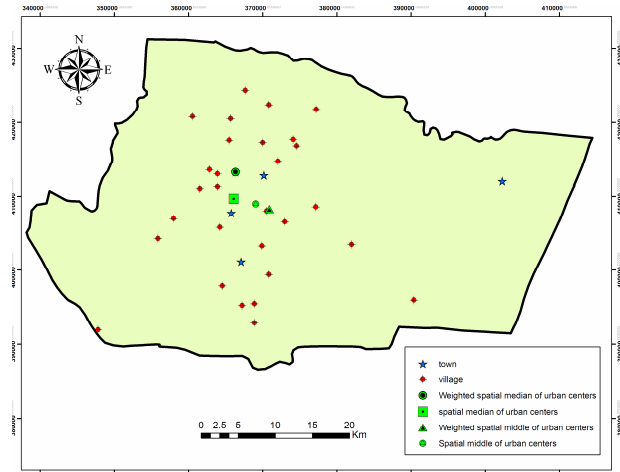


Fig. 4. The middle and median centre of urban centres in Tafila Governorate (source: prepared by authors).

3.3. The trend of spreading of urban centres in Tafila Governorate

The trend of the spread of urban centres in Tafila Governorate has been determined as follows:

The standard dimension and the ideal dimension. To show the extent of dispersion of urban centres around its weighted mean centre, the weighted standardized distance was calculated, and the direction of its distribution, as shown in Figure 5.

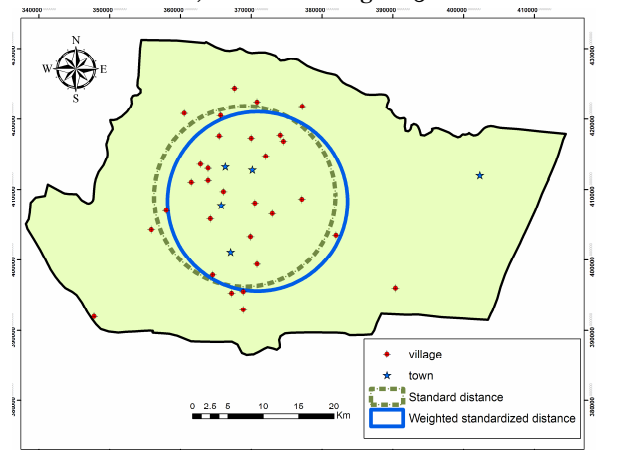


Fig. 5. The weighted standardized distance of urban centres in Tafila Governorate (source: prepared by authors).

According to the results of mean spatial analysis and the weighted spatial analysis, and the circle whose radius represents the standard distance, it has reached the length of the radius of the circle that represents the weighted standard distance in relation to

urban centres, which is (12.5) km. The circle contains 22 populated areas out of the 35 communities of the total urban centres in the Governorate, which consists 78% of the total governorate population, the most important of which are: Tafila city, Ain al-Bayda town, al-Eis, Basira, Qadisiyah, Grendel, Aima, Arwim, etc. The length of the radius of the circle for urban centres, which represents the standard distance without taking into consideration the population, was about (13) km and it contained 23 communities out of 35 urban centres which are under study.

The trend of urban centre distribution. The actual weighted trend of the distribution of urban centres spread according to population takes on an oval shape that extends towards east and west, and the direction of their distribution without taking the population as a weighted criterion has an oval shape that extends almost in the same direction as the previous one, as appears in Figure 6.

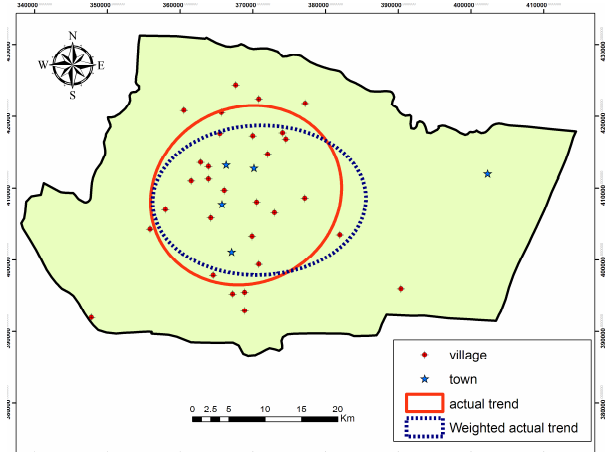


Fig. 6. The weighted trend of urban centres in Tafila Governorate (source: prepared by authors).

This extension is largely related to the topography of the area that is to some extent flat to wavy, and its height above sea level ranges between 1200-1600 m.

3.4. Density and weight of the geographical distribution of the population in Tafila Governorate

For the purpose of analyzing density, the population weight of urban centres was determined and distributed as points, where the large points in refer to the places of population gravity (Fig. 7).

Kernel analysis has also been applied to identify the density of the geographical distribution of the population over the area of Tafila Governorate by calculating the density of points around the centre; and the value is higher at the centre and decreases moving away from it; the results of the analysis are shown in Figure 8. A circular neighbourhood link in the form of rings reflects the population density of urban centres, and their distribution as points in each domain, and it

shows the surface trends as shaped by the geographical spread of those urban centres.

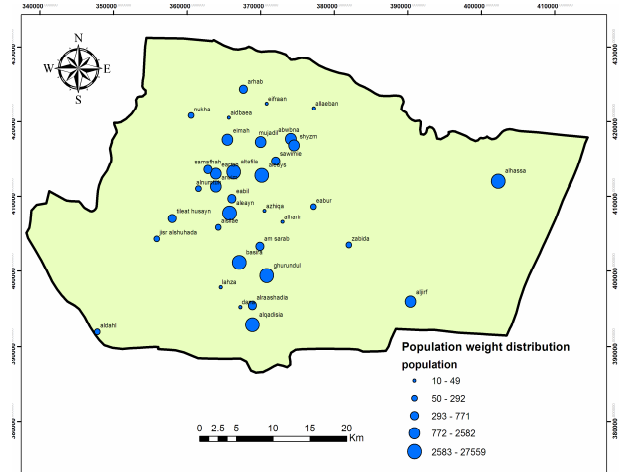


Fig. 7. Population weight distribution of urban centres in Tafila Governorate (source: prepared by authors).

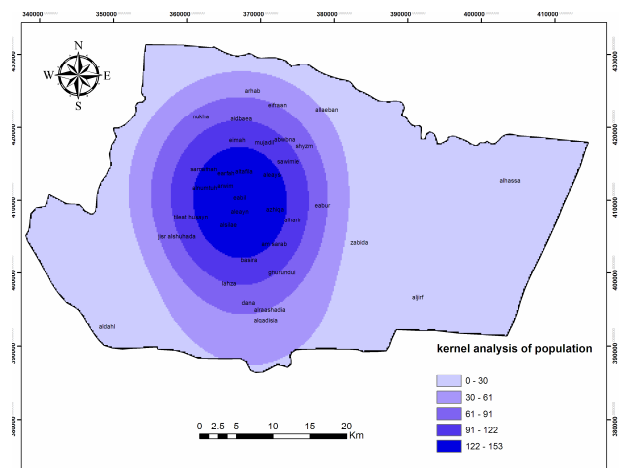


Fig. 8. Kernel analysis of population density trends for urban centres in Tafila Governorate (source: prepared by authors).

The Kernel analysis showed densities of urban centres around the weighted spatial midpoint, especially the city of Tafila, and clusters, such as Al-Ais, Arafa, Samafha, Erwim, Abel, Azhaimh, Ain Al-Baida, and Sila.

3.5. Analysis of the areas of influence of urban centres and their service region in Tafila Governorate

In order to map the areas of influence of the urban centres, the ranks of the urban centres were determined. Thiessen polygons were then used on the basis of non-intersecting or overlapping of the areas of influence of the regions of urban centres of similar ranks. Urban centres have been classified into three main ranks as a basis for distribution, according to the criteria of provision levels for certain services, such as the availability of services: medical care such as a hospital, a comprehensive health centre located in the

city centre; services provided by directorates of government departments and institutions; banks and banking services. Other services are provided by businesses and facilities such as goldsmith shops, jewellery shops, high schools, primary schools, post office; and large shopping centres, such as: the mall, vegetable market, sports complex, craft area, the main complex of public transport buses, high-tech electrical appliances stores, clothing stores, wholesale and retail. In addition to the standard of services, the population was taken into consideration, and accordingly, urban centres in Tafila Governorate were categorised into three main ranks:

1). The first rank (Tafila city). It is the only community that includes the provision of all the aforementioned services, and this means that the city provides a range of services for itself, in addition to serving all urban centres of the smaller towns and villages in the Tafila Governorate. In the absence of any of the above services, the grouping is classified as belonging to a lower level.

2). The second rank (towns). The lowest rank of the first city here is in terms of the capacity of the regions it serves, and the associated size of population and services of a certain quality. Accordingly, the number of urban centres that are classified as a town in the Tafila Governorate comprise four clusters: Ain Al-Baida, Al-Ais, Al-Basira, and Al-Hasa. What is classified as a town only involves providing six types of services for itself in addition to a number of villages located within its territory: a comprehensive health centre, a secondary school, a primary school, a post office, and retail stores. In the event that none of the above services are available, the community is classified as belonging to a lower level, and the application of the Thiessen polygon drawing showed areas (regions) of this rank from urban centres that were organized throughout the study area. This is presented in Figure 9, which reveals a number of villages in some of its regions.

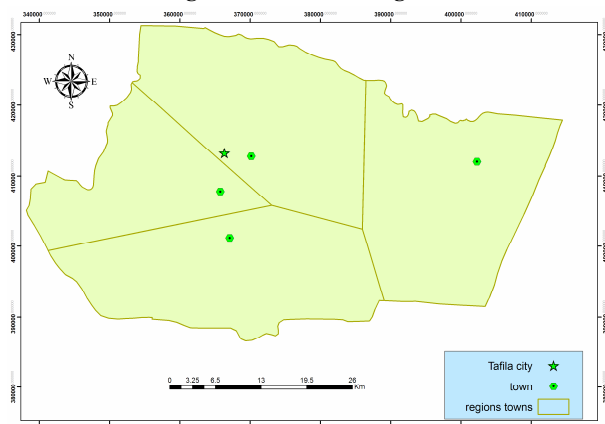


Fig. 9. Application of Thiessen polygons diagram for township regions in Tafila Governorate (source: prepared by authors).

The towns provide for them, in addition to what they offer themselves. These areas are

distinguished by the fact that the villages within each of them are closer to the town than any other similar settlements.

3). The third rank (villages). The lowest rank of the town in terms of the number of inhabitants they serve, and the services associated with that of a certain quality. Accordingly, the number of urban centres that are classified as a village in the Tafila Governorate amounted to 30 clusters, which only involve the provision of two types of services. Among the previous services are: elementary school and retail stores. The application of polygonal drawings (Thiessen) showed areas of this rank of urban centres that were organized around the study area that only serves itself, as presented in Figure 10.

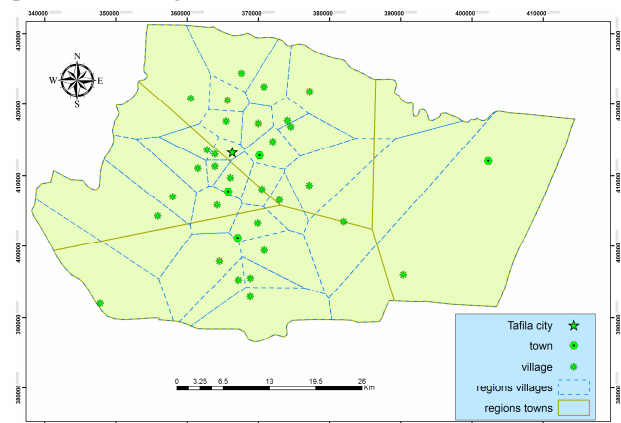


Fig. 10. Application of (Thiessen) polygons diagram for village regions in Tafila Governorate (source: prepared by authors).

4. CONCLUSION

The results of the study showed that there is a dispersed pattern of the geographical distribution of urban centres distribution in Tafila Governorate. This is in line with the findings of Taran et al. (2020) who found similar patterns in Ma'an Governorate. The results of the study also showed the identification of the actual and hypothetical (expected) centre of urban centres in Tafila Governorate. Based on population indices, the spatial mean and the weighted spatial mean represent the centre of gravity for the geographical distribution of urban centres in the Tafila Governorate; it is located near the city of Tafila in the middle of the largest urban centres in the Governorate: Ain Al-Baida, Al-Ais, and Sweimeh. Azaheka, Abel, Erwim. The spatial mediator point and the weighted spatial mediator were also determined, as the convergence of each other appeared clearly. The standard distance and the weighted standard distance (according to population) were calculated for the spread of urban centres around the weighted spatial mean, and the direction of urban centres distribution in order to show the extent of their dispersion. The length of the radius of the circle, which represents the weighted standard distance with respect to urban centres, was 12.5 km. It contained 22

population agglomerations out of 35 total urban centres under study. Those centres include 78% of the total population of the Governorate, the most important of which are: the city of Tafila, the towns of Ain al-Baida, al-Eis, Busira, al-Qadisiyah, Girandal, and Eima Warim.

It also appeared that the actual weighted trend of the distribution of urban centres spread according to the number of inhabitants takes on an oval shape that extends towards east and west. The direction of their distribution without taking the population as a weighted criterion into consideration has an oval shape that extends almost in the same direction as the previous one. This extension is shaped to a large extent by the topography of the area, which is characterized somewhat by being flat to wavy. The study analyzed the density of the population heavyweights in the form of points, and the spatial distribution of the population over the area over which Tafila Governorate extends using Kernel density analysis. This analysis showed that there is a density of urban centres around the weighted spatial midpoint, especially the city of Tafila, and clusters, such as: Al-Ais, Arafa, Samafha, Arwim, Abel, Azhaimah, Ain Al-Baida and Al-Silaa. The results of the study also revealed three main ranks, namely: the first city rank, the town rank, and the village rank, as a basis for the distribution of urban centre ranks according to the criteria for providing certain levels of services. In light of this, areas of influence (regions) urban centres were drawn using polygons (Thiessen) on the basis of non-intersection or overlapping areas of urban centres of similar ranks. In light of the results of the study, the following can be recommended. There is a necessity to classify urban centres in the study area in terms of quantity and quality based on specific criteria that fit, and urban planning processes, taking into account the distribution, size and functions of urban centres, in order to increase the efficiency of sites that will define urban centres in performing their tasks, production, and service functions, provided that the ranks of urban centres are taken into consideration to reach certain levels. Also, there is a need to work to create a comprehensive database that can be used in setting appropriate development plans for the development of services and their development in the study area in coordination with the supervising authorities responsible for urban and service planning. In addition, there is a further need to stimulate the authorities concerned to use geographic information systems (GIS) technology in studying and analyzing the spatial distribution related to various phenomena and activities, and to explore the needs of the population with a number of urban service centres located within its territory, which reflects an almost ideal form of spatial distribution of urban centre sites throughout the study area. This achieves the goals of spatial development. In light of using spatial planning for public services, it is possible to determine the adequacy of spatial correlation on one hand, and the factors

affecting the spatial distribution pattern on the other, such as natural and human factors with different variables, so as to reach a desired balance in spatial development.

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