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Spatial clustering of villages: a solution for agricultural area management: Case study of Aghmiyun agricultural area, East Azerbaijan Province, Iran

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Abstract

All of the world's basic needs are provided by the agricultural sector, and it also provides the raw materials required for industrial processes. Thus, the appropriate administration and development of agriculture are crucial. Like a number of other countries, Iran faces numerous social, economic, environmental, institutional, and human challenges in the development and administration of its agricultural sector. For managing the agricultural sector, Iran has established many different kinds of organizational structures. The Agricultural jihad centers work at the lowest level of the Iranian agriculture sector's governmental administration hierarchy. Each agricultural jihad center covers one or more rural district and a number of villages. The villages covered by each center are divided among the experts who work in the center. How to divide up villages among experts is a major problem facing agricultural jihad centers. Typically, the number of villages under expert administration is not homogeneous, and the allocation of villages among experts is not done appropriately. In this study, village classification has been investigated utilizing four different spatial clustering techniques: KMeans, KMedians, KMedoids, and Spectral Cluster. The findings indicate that while all of these techniques are capable of spatial clustering of villages, KMeans and KMedians are the most effective and useful techniques for clustering.

1. Introduction

Historically, agriculture has been the most important part of economic activities. And with the occurrence of the industrial revolution, the agricultural sector, in addition to providing the food needed by human societies, also became the supplier of the major part of the raw materials needed by the industry (Pinilla, 2019). For many countries worldwide, particularly developing countries, agriculture provides their main source of income for rural households, employment, added value, exports, addressing poverty, and ensuring food security for a growing population (Atay & Kartal, 2020; Kumar, 2018). Therefore, agricultural development is necessary for the growth of industry and the satisfaction of human population needs (Sabuncu, 2019).

Planning in the agricultural sector for maximizing yields and profit, improving the quality of products, developing agricultural technology and equipment, using new knowledge in agricultural activities, and protecting water and soil resources is very necessary (Margarido & Santos, 2015; Vlad, 2014; Chen, 2018; Kumawat et al, 2020).

agriculture sector faced by challenges such as illiteracy, poor socioeconomic conditions, lack of technical knowledge, small land holdings, land degradation, weather-dependent farming systems and adaptation to climate change (Dwivedy, 2011; Moreddu, 2015; Selvan et al, 2021).

Agriculture is also very important in Iran. About 50% of employment in rural areas of Iran is in the agricultural sector. More than 60 thousand villages and 25.9% of Iran's population live in rural areas that are directly or indirectly related to agricultural activities (Statistical Centre of Iran, 2016). Also, Iran has 5 million farmers in the agricultural sector, about 15 million hectares of agricultural land (Ministry of Agriculture Jihad, 2021) and about 130 million hectares of natural areas (Natural Resources and Watershed Management Organization Of Iran, 2023).

The agricultural sector in Iran is very broad and faces many challenges. Various organizational structures have been established at the national, provincial, county,

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and rural areas levels in Iran to regulate the country's agricultural sector.

Centers of agricultural jihad are engaged at the lowest level of the organizational structure and at the level of rural areas. A number of agricultural experts work inside of each of these agricultural centers, offering advice and instruction to farmers. For this reason, the villages covered by agricultural jihad centers are often divided between the experts based in the agricultural jihad center. Each expert is responsible for managing agricultural activities in a number of villages.

However, the fundamental issue is that, in this field, appropriate indications and methods for zoning and dividing villages between the experts working in the centers have not been developed. Therefore, the dividing of villages between experts is typically not done appropriately and equitably. The spatial clustering method has been attempted to be used in this study as a simple and helpful technique for zoning rural and agricultural areas. In order to improve agricultural area management, the aim of this article is to spatial cluster the villages under the management of the Aghmiyun Agricultural Jihad Center in the province of East Azarbaijan.

2. Method

This study is a type of applied research that was carried out using a quantitative methodology framework. The 48 villages that are under the Aghmiyun Agricultural Jihad Center in the province of East Azarbaijan make up the statistical population for this study. The required statistical data has been collected from the Agricultural Institute of Education and Extension in Iran. Spatial analysis and spatial statistics techniques in Arc Map and GeoDa software have been used for data analysis. Seven indicators in total, which is the number of farmers, the area under irrigation crops, the area under rainfed crops, the area of horticulture crops, the area of greenhouses, the population living in rural areas, and the distance between the villages and the Aghmiyun agricultural Jihad center were used in this study to cluster the villages geographically. Seven steps are involved in discovering and utilizing the index: a review of the literature, indicators identification, indicators validation, data collection, indicators weighting, indicators combination, and village spatial clustering. Based on the opinions of twenty experts in the fields of agriculture and rural development, the indicators have been validated and weighted. Here is how the research process works (Figure 1):

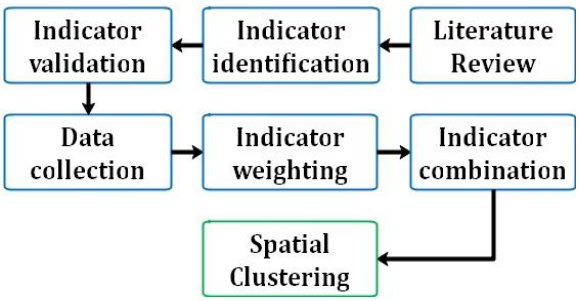

Figure 1. Research Process

2.1. Study Area

The Aghmiyun Agricultural Jihad Center's agricultural fields are included in the research area under study. As to the most recent data, Aghmiyun, Razlig, and Sayin are the three rural districts that are covered by this center. The Aghmiyun Agricultural Jihad Center covers fifty villages in total, two of which are uninhabited and have no agricultural activity. Sayin rural district has twenty-seven villages, Aghmiyun rural district has twenty-two, and Razliq rural district has one village out of a total of forty-eight villages (Ministry of Agriculture Jihad, 2023). Aghmiyun Agricultural Jihad Center is located in the central district of Sarab County, East Azarbaijan Province, northeastern Iran (Figure 2).

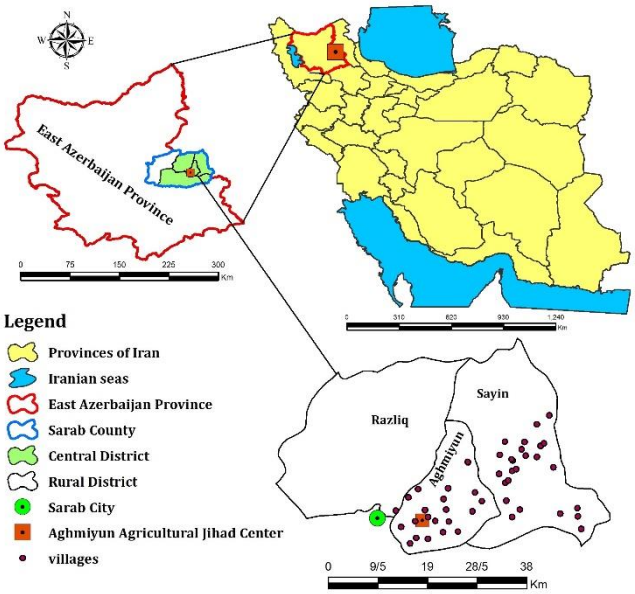

Figure 2. Location of the study area

3. Results

The indicators, their assigned weights, and the values associated with each have been taken into consideration at the beginning of the results section. The Aghmiyun Agricultural Jihad Center covers 12,018 of the rural population, 12,947 hectares of cultivated land, and 3,670 agricultural farmers “Table 1”.

Table 1. Weight and values of indicators

Indicator	Weight	Value
Number of farmers (person)	0.2	3670
Area under irrigation crops (hectares)	0.17	9015.25
Area under rainfed crops (hectares)	0.16	3488.6
Area of horticulture crops (hectares)	0.16	442.744
Area of greenhouses (hectares)	0.12	0.24
Rural population (person)	0.14	12018
Average distance between the villages to center (km)	0.05	20
Sum	1	-

Each village's weighted values were calculated separately by multiplying the data of the 48 villages under the Aghmion Agricultural Jihad Center by the indicator's weight.

To find the best method, several techniques for the spatial clustering of villages were evaluated in this section. Given that the Aghmiyun Agricultural Jihad Center employs three experts, it is required to divide the villages under its management into three zones, or three homogeneous clusters. Because of this, there can only be three clusters when applying various clustering techniques. These techniques are all explained below.

Step First: Based on the KMeans technique, the villages were clustered, cluster 1 has 21 villages, cluster 2 has 20 villages, and cluster 3 has 7 villages (Figure 3).

Step Second: Based on Kmedians technique, the villages were clustered, cluster 1 has 19 villages, cluster 2 has 17 villages and cluster 3 has 12 villages (Figure 4).

Step Third: Based on Kmedoids technique, the villages were clustered, cluster 1 has 19 villages, cluster 2 has 18 villages and cluster 3 has 11 villages (Figure 5).

Step Fourth: Based on Spectral Cluster technique, the villages were clustered, cluster 1 has 25 villages, cluster 2 has 14 villages and cluster 3 has 9 villages (Figure 6).

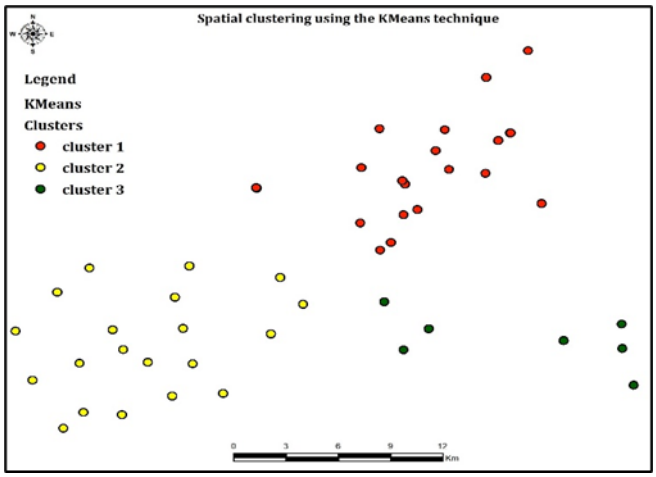

Figure 3. Clustering based on KMeans technique

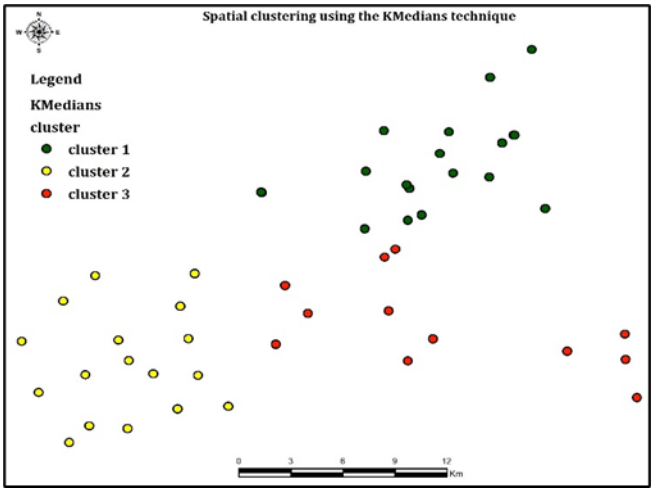

Figure 4. Clustering based on Kmedians technique

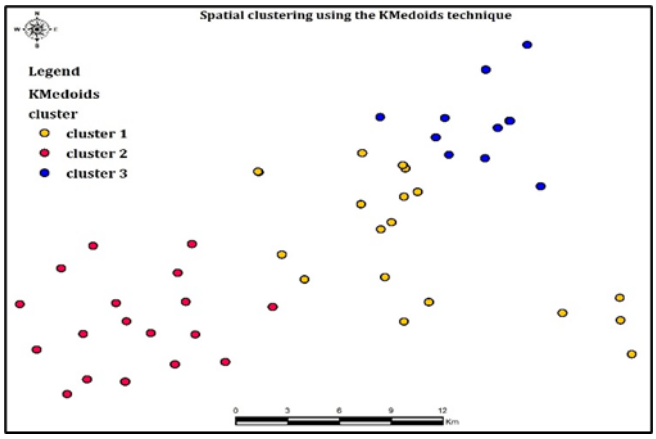

Figure 5. Clustering based on Kmedoids technique

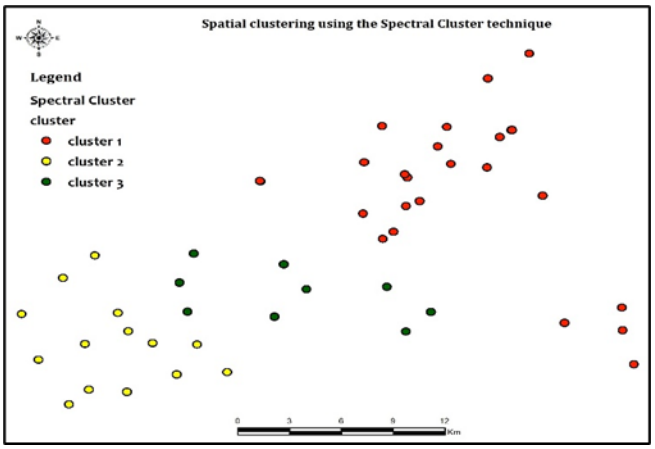

Figure 6. Clustering based on Spectral Cluster technique

4. Discussion

This article discusses the clustering of villages covered by agricultural jihad centers using four simple and helpful techniques. For the purpose of finding homogenous clusters, all four techniques are helpful. In spite of this, the results from the KMeans and Kmedians techniques are better than other techniques in terms of spatial neighborhood and cluster homogeneity.

5. Conclusion

Human societies depend on the agriculture sector for their food security. Furthermore, it meets a significant proportion of the industry sector's needs. Numerous social, economic, environmental, technological, and human resource issues challenge the agriculture sector. Managing human resources as well as providing services to farmers and villages is one of the major issues facing Iran's agriculture sector. In order to better support farmers and promote agricultural development, various types of organizational structures have been established in Iran's agricultural sector at the national, provincial, county, and rural district. In Iran's agricultural sector, the most primitive level of management organizational structure can be observed in agricultural Jihad centers located in rural district. Experts working in agricultural jihad centers are responsible for providing services and managing the villages covered by the center. For this reason, it is necessary to divide the villages effectively and equally among the experts.

The main problem is that, often, experts divide up villages without applying scientific or appropriate methods, which decreases the level of service provided to farmers. For this reason, in this article, an attempt has

been made to introduce suitable methods for zoning and spatial clustering of villages. In order to cluster the villages in the Aghmiyun Agricultural Jihad Center, four spatial clustering techniques—KMeans, Kmedians, Kmedoids, and Spectral Cluster—have been examined and tested in this study.

Table 2. Clustering based on different techniques

Clusters	Indicators	KMeans	Kmedians	Kmedoids	Spectral
cluster 1	Number of villages	21	19	19	25
	Number of farmers	599	552	871	871
	Area under cultivation	2293	1991	4039	3241
	Rural population	1676	1530	2220	2452
	Average Distance	30	30	24	30
cluster 2	Number of villages	20	17	18	14
	Number of farmers	3210	3065	3182	2352
	Area under cultivation	10020	9561	9838	7279
	Rural population	10509	10233	10491	7973
	Average Distance	7	6	6	5
cluster 3	Number of villages	7	12	11	9
	Number of farmers	595	787	350	1181
	Area under cultivation	2795	3556	1232	4588
	Rural population	1516	1938	990	3275
	Average Distance	24	21	33	13

The results of spatial clustering show that all four investigated techniques have the appropriate ability to cluster and divide villages into several homogeneous clusters. Despite the reality that each of these techniques produce different results. When it comes to village clustering, the KMeans and KMedians techniques are better than the others. Because of the spatial neighborhood between the villages has been observed in a more appropriate way and the clustering carried out using these two methods has been more homogeneous and equal. With using these two techniques, there is very little difference between the three clusters that are produced in terms of the number of farmers, the cultivated area, the average distance, and the number of villages that are located in each cluster.

Based on these results, the experts working in the agricultural jihad centers are advised to cluster and divide the number of villages among themselves using the KMeans and Kmedians techniques. Efficient rural zoning promotes better agricultural areas management and faster, higher-quality services for farmers.

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