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# Dynamics of population change in rural areas of Türkiye: A spatial analysis of villages

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**Abstract**
The migration from rural to urban is a critical issue handled by different disciplines. Rural development strategies aim to improve rural areas and reduce inequalities. To formulate the various strategies, it is important to identify the causes of migration. This study aims to analyze the spatial tendency of population change in rural areas in Türkiye and put forward factors that cause this migration. First, LISA analysis is used to reveal spatial patterns of migrations. Then, the causes for migration have been analyzed with aspatial and spatial regression analysis. According to the study results, the change in the rural population in Türkiye shows a spatial autocorrelation. Settlements with high/low populations tend to cluster geographically. According to regression analysis, the presence of primary schools, the presence of the service sector, and the manufacturing sector employment positively affect rural population growth. Contradiction to this, distance to first-tier cities and the presence of a livestock sector have a negative effect. These results can guide policymakers to control and evaluate urban-rural population balance by providing local-scale suggestions for an emerging economy.

**Keywords**
Rural-urban migration, SAR, Migration factors, LISA analysis, YER-SİS.

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## 1. Introduction

The global rural population has been diminishing over an extended period. Internal migration, spurred by urbanization, is an ongoing process, involving not only movement from rural to urban areas but also between different cities (Julide & Okşak, 2021). The reduction in rural population is attributed to both the attractiveness of cities and the unappealing aspects of rural life (Hu et al., 2023), with economic factors playing a predominant role. Kalinowski et al. (2022) characterize the challenges in rural areas as a cycle of decline, where economic stagnation adversely affects rural employment, prompting the migration of financially struggling young individuals to urban centers. This migration exacerbates economic downturns, disrupts essential services in rural areas due to depopulation, and, consequently, leads to more migration to urban areas. This cyclic process creates a self-sustaining pattern.

Figure 1 illustrates the evolution of rural and urban populations in certain regions from 1950 to the projected data until 2050, as reported by the United Nations in 2018 (United Nations 2018). Globally, there has been continuous growth in the urban population, and this trend is expected to persist. Notably, between 2005 and 2010, the world witnessed a significant milestone as the urban population surpassed the rural population for the first time. While China managed to mitigate the decline in rural population between 1965 and 1975, the subsequent years saw a rapid continuation of this decline. In low-income countries, rural populations still hold an edge over urban populations, despite the increasing urbanization trend.

As seen in Figure 1, Türkiye's urban population started to increase in the 1950s and gained momentum, especially after the 1980s. The urban-rural gap has consistently widened over time. Güler & Kâhya (2019) conducted a study assessing migration reasons from rural areas in Türkiye, categorizing them into human and natural factors. A total of 28 reasons, falling into these two categories, were identified in their study. According to the

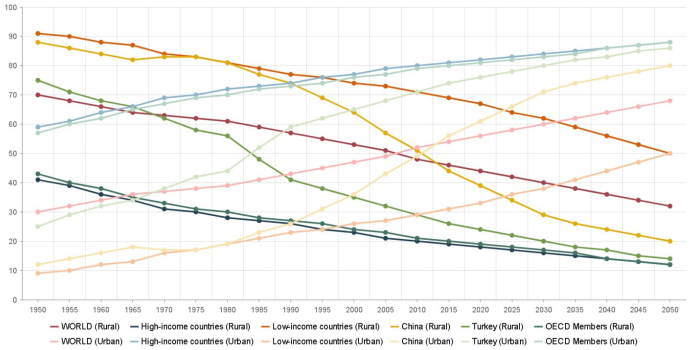


***Figure 1.*** *Rural and urban population rates between 1950-2050 in the world (created by the authors based on the United Nations data).*

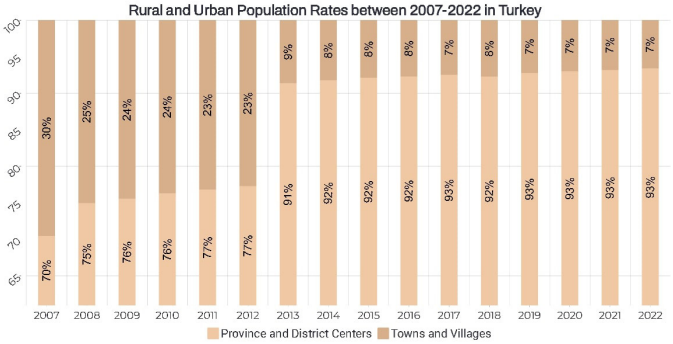


***Figure 2.*** *Rural and urban population rates between 2007-2022 in Türkiye (created by the authors based on the Turkstat data).*

National Rural Development Strategy (2021-2023), a downward trajectory is expected to persist in Türkiye's rural areas, with some settlements projected to experience more significant population declines than others (Republic of Türkiye Ministry of Agriculture and Forestry, 2021).

Prepared from Turkish Statistical Institute (TurkStat) data, Figure 2 shows the changes in rural and urban areas of Türkiye between 2007-2022. According to Figure 2, it can be observed that the trend of decreasing rural population continues, with a dramatic rise in urban population in 2012. The reason for this critical change in 2012 was the change in the status of rural settlements in Türkiye introduced by Law No. 6360. This change resulted in a shift from administrative rural to urban status of rural settlements in 30 metropolitan provinces. Before 2012, Türkiye officially used two criteria for distinguishing between urban and rural areas. The first criterion was administrative, designating all provincial and district centers as urban areas. The sec-

ond criterion was demographic, using a population threshold of 20,000 for urban areas (State Planning Organisation, 1985). However, in 2012, Law 6360 classified all settlements, including rural settlements and villages, in 30 metropolitan provinces as urban settlements, regardless of their previous rural characteristics. This regulatory change triggered debates and discussions about the uncertainty of rural-urban definitions. The Law implemented in 2012 has many negative aspects that are discussed in the literature. First of all, with this law, settlements with rural status were transferred to the same level as urban neighborhoods. This has caused rural settlements to have similar economic obligations as urban settlements and has increased the cost of living (Kızılaslan et al., 2016). Consequently, in 2023, TurkStat introduced a new definition that categorizes settlements into three classes: densely populated areas (cities), intermediate-density areas (towns and suburbs), and thinly populated areas (rural areas) which is based on the system used by the European Statistical Office (TurkStat, 2023).

This study aims to contribute to the existing debates on rural population changes by examining the settlements that have changed within the rural-urban definition. It compares settlements that have been transformed into neighborhoods (*mahalle*) by changing their status with rural settlements that still retain their village status (*köy*) and tries to develop a perspective on Law No. 6360. The study also examines the factors affecting rural population change in Türkiye and their impact levels. By conducting regression analysis, the study aims to provide a comprehensive understanding of the various variables that contribute to population changes in rural areas. This approach improves the interpretation of factors affecting rural population dynamics, leading to more effective results. Considering that population change is a dynamic process (Chi & Ventura, 2011) and this change has spillover effects that can affect neighboring settlements, this study also analyzes rural population changes spatially and evaluates the clustering tendencies of settlements. This approach allows the spatial patterns of population decline in Türkiye's rural settlements to be examined and sheds light on spillover effects in these settlements. In consideration of the need to study rural areas at the micro (local) spatial scale highlighted by Wang et al. (2018), given the potential variability of rural population changes at the micro settlement level (Julide & Okşak, 2021), our approach involves using rural settlement boundaries and analyzing data at this local scale. This allows us to gain more specific insights into rural areas. Unlike previous research, our study uses the dataset of the Research Project on Urban and Rural Settlement Systems in Türkiye (Türkiye'de Kentsel ve Kırsal Yerleşim Sistemleri (YER-SİS) Araştırma Projesi) conducted by the Ministry of Industry and Technology to evaluate rural population change. This dataset stands out as the most comprehensive and the most recent dataset as it is the first study to assess the whole of Türkiye at such a detailed scale. While many studies are based on a limited number of settlements, the analysis in this study utilizes a large dataset with 37020 samples and provides a solid basis for a comprehensive examination of rural population changes. As a result, this study is expected to contribute to the literature by providing analysis at the rural settlement scale, analyzing different variables associated with rural population change, enabling comparison of settlements with changing status, and providing aspatial and spatial analysis.

The study consists of 5 chapters. The first and second chapters of the study include general information about the study and a literature review on population change in rural areas and the factors affecting change. In this chapter, the current situation was revealed by examining the sources on the subject, and the deficiencies were identified. The third chapter presents the dataset used in the study and the methods used to analyze the data. The fourth chapter presents the data. The spatial distribution of the population in rural areas in Türkiye, the spatial distribution of population changes in rural areas, and the status of population change are an-

alyzed. In the last chapter, the results of the analysis are interpreted, and the conclusions and interpretations of the study are given.

## 2. Literature review

As the rural population declines, it is stated that the age group that migrates the most from rural areas is young people (Johnson & Lichter, 2019). Settlements with declining populations due to youth migration are likely to experience a decline in services and economic sectors. Some studies suggest that settlements with already low populations tend to experience a faster decline in the future (Johnson & Lichter, 2019). Similarly, a high population of rural settlements in the initial phase has a positive effect on future population change. The mass exodus of young people perpetuates the negative cycle of rural decline (Johnson & Lichter, 2019; Julide & Okşak, 2021; Lorenzen, 2022). Research into the factors and causes influencing population change is typically categorized into three areas: economic, public services, and spatial.

Economic condition is one of the most critical factors causing rural decline (Keddie & Joseph, 1991). Research has shown that unemployment and income levels strongly correlate with population change (Millward, 2005). Economic differences between urban and rural settlements, such as income differences and GDP per capita rates, encourage migration from rural areas to urban areas (Julide & Okşak, 2021; Liu et al., 2017; Lorenzen, 2022; Yu et al., 2022). Many people migrate from rural areas to cities for better economic conditions. In addition, economic diversity in urban areas is another reason for migration (Julide & Okşak, 2021; Lorenzen, 2022; Xingwei et al., 2023; Yu et al., 2022). In a study analyzing the factors affecting rural population change in China, it was observed that the importance of the variable of arable land per capita decreased over time and was at a lower level of importance between 2010-2017 (Yu et al., 2022). This might be due to the modernization of agriculture, people living in rural areas have become more dependent on economic conditions rather than environmental factors (McLeman et al., 2022). It has also been seen that the importance of non-agricultural economic opportunities and agricultural crop productivity has increased over time (Yu et al., 2022). Drought, on the other hand, stands out as an effective factor in the long run as it indirectly affects households' economies, even if not directly (McLeman et al., 2022). This can be attributed to the increasing importance of crop productivity, the growing importance of non-agricultural economies, and the increasing dependence on economic conditions.

The underdevelopment of public services in rural areas is another factor that negatively affects population change. Especially health and education factors can be very effective (Xingwei et al., 2023; Yu et al., 2022; Yürük & Batmaz, 2023). Studies investigating the impact of education on population change in rural areas show that the lack of educational facilities negatively affects population change (Lykke Sørensen et al., 2021). This makes the distance to cities, where the service sector is well-established, an important issue. The effect of proximity to urban areas on population change in rural areas is frequently mentioned in the literature (Cawley, 1994; Oruç & Çağlar, 2022; Sheludkov et al., 2021; Yu et al., 2022; Zhang et al., 2020). Especially the distance to highly populated and developed cities may affect rural population changes more (Liu et al., 2017; Wang et al., 2018). This is mainly due to the high employment opportunities and improved basic services in developed cities (Bülbül & Köse, 2010; Millward, 2005). Transportation infrastructure is also considered in some studies as it affects accessibility to cities. Since easy access to highways increases access to services and economic activities, it can eliminate some factors that prevent rural population growth (Lorenzen, 2022). Wang et al. (2018) in their study on the relationship between rural poverty and different variables, stated that the distance variable can provide various results and the distance of rural settlements to different provinces may affect rural poverty differently.

In the literature, many researchers emphasize the impact of geological

***Table 1.*** *Population change variables in literature (Created by the authors).*

| DIMENSION | INDICATORS | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|
| Population | Annual natural growth rate | X | | | | | | | |
| | Number of rural population | X | | | X | | | | |
| | Rural population density | | X | | | X | | X | |
| | The percentage of population change | | | | X | | | | |
| | The total population living within five road-kilometres of the settlement | | | | X | | | | |
| | In-migrants population | | | | | X | | | |
| Economic | The gross product of the primary industry | X | | | | | | | |
| | Gross industrial production | X | | | | | | | |
| | GDP per capita / Change rate of per capita regional GDP | X | | | | | | | |
| | Rural electricity consumption per unit area | | X | | | | | | |
| | The growth rate of real GDP | | | X | | | | | |
| | The income difference | | | X | | | | | |
| | Presence of a tourist sector | | | | X | | | | |
| | Unemployment rate | | | | | X | | | X |
| | Household income/Rural residents income | X | X | | | X | | X | |
| | Resource-industry employment | | | | | X | | | |
| | Commuting outside census subdivisions (CSD) | | | | | X | | | |
| | Change rate of agricultural labor productivity | | | | | | X | | |
| | Agricultural economic density | | | | | | | X | |
| | Off-farm economic opportunity | | | | | | | X | |
| | Poverty/low wages | | | | | | | | X |
| | Small local market | | | | | | | | X |
| Spatial/ Natural | Average slope | X | | | | | | | |
| | Surface fragmentation and terrain | X | | | | | | X | |
| | Urbanisation rate | X | X | X | | | X | | |
| | The altitude of the settlement | | | | X | | | | |
| | Accessiblity to road | | | | X | | | | |
| | The distance to the administrative centre or city center | X | | X | X | X | | X | |
| | The distance to the nearest neighbouring settlement | | | | X | | | | |
| | Rainfall | | X | | | | | X | |
| | Tempature | | X | | | | | X | |
| | Wind speed | | X | | | | | | |
| | Annual relative humidity | | X | | | | | | |
| | Climate change | | | | | | | | X |
| | Quality of landscape | | | | | | | | X |
| | Biodiversity, soil quality, etc. | | | | | | | | X |
| Agriculture | Potential productivity for crops | X | | | | | | | |
| | Output value of agriculture, forestry, animal husbandry, and fishery per unit area | | X | | | | | | |
| | The per capita arable land | X | | X | | | | X | |
| | Change rate of cultivated land area | | | | | | X | | |
| | Declining agriculture | | | | | | | | X |
| | Change rate of nonagricultural output value | | | | | | X | | |
| Services | Provision of public services | | | | | | | X | |
| | Living conditions | | | | | | | | X |
| | Social/public services | | | | | | | | X |
| | Health services | | | | | | | | X |
| | Telecommunications/Internet | | | | | | | | X |
| Social | Fertility level | | | X | | | | | |
| | Ageing population | | | | | | | | X |
| | Women, young people | | | | | | | | X |
| | Education level | | | | | | | | X |

A=(H. Zhang et al., 2020), B=(L. Zhang et al., 2021), C=(Liu et al., 2017), D=(White, 1985), E=(Millward, 2005), F=(Hu et al., 2023), G=(Yu et al., 2022), H=(Karcagı Kováts & Katova Kováts, 2012)

and topographic factors on population distribution (Yu et al., 2022). Zhang et al. (2021), in their study in Jiangxi Province, China, state that population distribution is significantly correlated around lakes and mountainous areas. Zhang et al. (2020), also noted that the population living in rural areas generally prefers plains, basins, and deltas. Therefore, it can be said that slope is also effective in the spatial distribution of the population.

Table 1 shows a list of variables included in some studies in the literature that spatially address population change in rural settlements. Indicators are grouped under six dimensions: population, economic, spatial/natural, agriculture, public services, and social. Considering the diversity of the indicators, it can be said that economic variables are mostly discussed. Secondarily, spatial variables show diversity. The population dimension in the table shows that the most used population variable is rural population density. In the spatial dimension, distance to the administrative center or city center and urbanization rate were the most mentioned variables.

Chi & Ventura (2011) highlighted four crucial elements to be considered when investigating population change: temporal aspects, spillover effects, and spatial dimensions. Their study investigated population changes in the USA across three distinct periods, employing a comprehensive four-step analysis. This analysis incorporated 32 variables categorized under five dimensions: demographic factors, livability, accessibility, developability, and desirability. In another study on rural population change, Keddie & Joseph (1991) conducted a non-spatial analysis, calculating population change percentages and utilizing ANOVA analysis to assess the effects of variables. Hu et al. (2023) performed a spatial analysis of the rural population in China, examining 357 administrative units. The analysis explored the variables influencing population change during the periods 2000-2010 and 2010-2020. The study employed Moran's I analysis in the first stage to assess spatial agglomeration patterns. In the second stage, Geographically Weighted Regression (GWR) was utilized to analyze spatially varying data between 2000-2020. Another study by Yu et al. (2022) spatially analyzed population change in rural areas using the GeoDetector method. This approach examined the effects of various factors on population change and their interactions with each other. Bijker & Haartsen (2012) investigated migration patterns in rural areas based on the popularity of settlements, categorizing rural areas into three classes using the material values of dwellings. They analyzed rural population changes related to these groups using different indicators.

In Turkish case studies, the rural population is interpreted with proportional data and graphs at the country

level (Canpolat & Hayli, 2018), while in some studies, rural population change is evaluated with data and graphs at the provincial level (Yılmaz, 2015). Most of the studies in the literature do not employ spatial statistics. Although spatial studies at the scale of rural settlements are limited, there are studies that reveal the causes of rural-urban migration through descriptive analysis. Addressing these studies will contribute to the creation of rural-urban migration indicators specific to Türkiye. Studies in the literature draw attention especially to economic concerns in rural-urban migration movements in Türkiye (Öztürk et al., 2018). In Canpolat & Hayli (2018), it is stated that employment opportunities in urban areas increase the seasonal or daily population mobility between rural and urban areas in Türkiye. Lack of sufficient support for agricultural activities in rural areas, lack of social security and economic instability are some of the factors that trigger migration to the city (Baybaş et al., 2023). Based on these findings, it can be said that economic variables are important for research on rural population change in Türkiye. In addition, the fact that public services in urban areas are more developed compared to rural settlements is another important reason (Canpolat & Hayli, 2018). Lastly, it is underlined in the literature that villages are lacking in social activities (Baybaş et al., 2023).

The spatial studies conducted in Türkiye are based on basic statistics and generally provide an analysis of the current situation (Gümüş & Körhasan, 2009). Gürbüz & Karabulut (2008), which carried out a similar study with this research, evaluated the population change on a provincial scale and evaluated the population change in rural areas with 39 variables. Correlation analysis was used to test the relationship between migration and the determined variables. According to the results of the study, the variables with the highest degree of relationship with rural migration are the amount of land per household (decare), physiological population density, and mortality rate (Gürbüz & Karabulut, 2008). Canpolat & Hayli (2017), spatialized the settlements with decreasing and increasing populations in the rural settlement scale. The reasons affecting rural population change are discussed through descriptive analysis. According to the results of the study, the differences in living standards between rural and urban areas and the limited economic opportunities in rural areas due to the agricultural policies pursued after 1980 led to a decrease in the population in rural settlements. Improvement of transport infrastructure, location of rural settlements, high accessibility to public services, and favorable economic conditions are considered as factors that positively affect population growth in rural areas (Canpolat & Hayli, 2017).

It has been observed that rural-urban migration is an important problem worldwide and various studies have been conducted on the subject. In this section, the general situation of the rural-urban migration problem and the general factors affecting migration in the literature are examined. According to the research, it has been observed that the causes of migration vary according to time and place. Therefore, it is thought that it is important to perform analysis specific to each settlement and to support the current population change analysis with recent data.

## 3. Materials and methods

### 3.1 Data

In this study, spatial and non-spatial data are considered to evaluate rural data. A dataset was created by considering variables from the literature and available data at the rural settlement scale. Table 2 shows the settlement dataset used in this research. Population data for rural settlements between 2018-2022 were obtained from the TurkStat. The YERSIS database created by the Ministry of Industry and Technology in 2018 was used to obtain the economic variables influencing population change. From this database, economic activity data showing the existence of different sectors and agricultural production structure data showing the diversity of agricultural production were obtained. In the YER-SİS database, a dataset of 37036 settlements was created, including settlements

***Table 2**. Data information table (Created by the authors).*

| Source | Qualification | Settlement Types | Number of Settlements | | 2022 Population | 2022 Population (%) |
|---|---|---|---|---|---|---|
| YERSIS (2018) | Rural Settlements | Town *(Belde)* | 37,036 | 386 | 1,165,760 | 6.90% |
| | | Town to Neighborhood *(Beldeden Mahalle)* | | 1,346 | 3,767,439 | 22.31% |
| | | Village *(Köy)* | | 18,186 | 4,491,502 | 26.59% |
| | | Village to Neighborhood *(Köyden Mahalle)* | | 17,118 | 7,465,197 | 44.20% |
| TurkStat (2018) | Neighbourhood | Town Neighborhood/Town *(Belde)* | 50,255 | 1,587 | 1,165,192 | 1.37% |
| | | Metropolitan District Neighborhood *(Büyükşehir Belediyesi Mahallesi)* | | 25,842 | 66,510,399 | 78.16% |
| | | Province Center Neighborhood *(İl Merkezi Mahallesi)* | | 1,468 | 7,715,597 | 9.07% |
| | | District Center Neighborhood *(İlçe Merkezi Mahallesi)* | | 3,163 | 5,215,281 | 6.13% |
| | Village | Village | | 18,195 | 4,489,049 | 5.28% |
| MAKS | Neighbourhood | Neighbourhood | 50,686 | 32,060 | 80,606,469 | 94.72% |
| | Village | Village | | 18,195 | 4,489,049 | 5.28% |

***Table 3.** Description and descriptive statistics of variables (Created by the authors).*

| Variables | Description | Source | Mean | Min | Max | Std |
|---|---|---|---|---|---|---|
| **Primary School** | 1 if there is a primary school within the neighbourhood's boundaries, 0 if not. | YERSIS | 0.3394 | 0 | 1 | 0.4735 |
| **Health Center** | 1 if there is a family health centre within the neighbourhood's boundaries, 0 if not. | YERSIS | 0.1349 | 0 | 1 | 0.3416 |
| **Manufacturing Emp.** | 1 if there is factory work within the neighbourhood's boundaries, 0 if not. | YERSIS | 0.1621 | 0 | 1 | 0.3685 |
| **Service Activities** | 1 if there is a labour force in service activities (Hotels, restaurants, tourism, etc.) within the neighbourhood's borders, 0 if not | YERSIS | 0.0495 | 0 | 1 | 0.2169 |
| **Distance (log)** | The distance to the cities with the highest socioeconomic development level | HGM | 5.4590 | 0 | 7 | 1.0240 |
| **Population (log)** | Total population in 2018 | TurkStat | 5.5167 | 1 | 11 | 1.0881 |
| **Livestock** | A value of "1" is given if animal husbandry is practised as agricultural production and "0" if it is not. | YERSIS | 0.9840 | 0 | 1 | 0.1255 |
| **Population Change (log)** | Total population change in rural areas between 2018 and 2022. | TurkStat | 8.3582 | 0 | 10 | 0.0653 |
| **Settlement Type 1** | The settlements have village status according to the YERSIS | YERSIS | | | | |
| **Settlement Type 2** | The settlements that changed their status from village to neighbourhood by law, according to YERSIS. | YERSIS | | | | |
| **Settlement Type 3** | All settlements that have a rural function, according to YERSIS. | YERSIS | | | | |

with village status, towns, and settlements transformed from towns to neighborhoods and from villages to neighborhoods within the scope of Law No. 6360. The YER-SİS analyzed settlements that were considered rural before Law No. 6360, even if they did not have rural legal status. As a result of matching the population data obtained from the TurkStat and the economic data obtained from the YER-SİS, 37,020 rural settlements were evaluated for this study. For the specialization and visualization of the data, digital boundary data of urban and rural settlements in Türkiye were obtained from the General Directorate of Population and Citizenship Affairs (MAKS). As shown in Table 2, according to the settlement types of the YER-SİS, the settlements that converted from village to neighborhood (the settlements that changed status with Law No. 6360) had the highest percentage in 2022. According to the TurkStat data, Metropolitan district neighborhoods have a population of 78.16%, while villages have a population of only 5.28%.

ArcGIS 10.8 software was used for geographical analysis. Road and highway data obtained from Open Street Maps and point data of settlements obtained from the Ministry of National Defense General Directorate of Mapping (HGM) were used for spatial analysis. With the highway data obtained from Open Street Maps, distance analysis was created in a GIS environment, and the minimum distance of each settlement to the highways was calculated. Digital distance data of city centers were created using the point data of settlements. Distance analysis was created for each rural settlement, and the distance of the settlements to the city center was analyzed. Slope and elevation data were obtained in the GIS environment, and Min-Max values for each settlement were calculated and included in the analysis.

The variables are given in Table 3 with their descriptions and sources. Variables obtained from the YER-SİS, such as primary school, family health center, manufacturing employment, service activities, and presence of livestock in agricultural production are included in the analysis as dummy variables. The distance to the cities in the highest socioeconomic development level, population by rural settlements in 2018, and population change between 2022-2018 contain data in different ranges. In order to be analyzed correctly and compared with each other, the data that were not in the range of 1 and 0 were normalized with the logarithmic normalization technique recalculated in the range of 1 and 0, and

included in the analysis. Lastly, we use the natural logarithm of the dependent variable (population change). The descriptive statistics of variables are given in Table 3.

### 3.2 Methodology

In the literature, it is stated that there is an interaction between settlements when different variables are evaluated (C. Wang et al., 2023). After collecting and organizing the necessary data, spatial autocorrelation methods were used to reveal this situation and to understand the existence of the interaction between the population variables in Türkiye. Figure 3 shows the steps performed in the study and the methodologies used. LISA analysis reveals the pattern of interaction between settlement populations before analyzing the spatial factors affecting rural population change. Regression analysis is then conducted to understand how much the variables affect population change. OLS (Ordinary Last Square) and SAR (Spatial Autoregressive) methods were used to analyze the impact of variables on population change. While OLS analysis does not take spatial interaction into account when analyzing the relationship between the dependent variable and the independent variables, SAR analysis includes clustering in the analysis when evaluating the relationship between variables. To understand how spatial interaction affects the relationship between variables, both of these analysis are conducted and the results are compared.

#### 3.2.1 Global Moran's I

Global Moran's I method is one of the analysis that reveal the spatial distribution pattern of settlements. With this method, the distribution and clustering pattern of settlements are analyzed, and all settlements are evaluated simultaneously and assigned a value between 1 and -1. A Moran's I value close to 1 indicates clustering and a value close to 0 indicates random distribution (Moran, 1948).

$$I = \frac{N \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\left(\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}\right) \sum_{i=1}^{n} (x_i - \bar{x})^2} \quad (1)$$

In this formula, $N$ represents the number of observations, and $\bar{x}$ is the variable's mean. $x_i$ shows the variable value at a particular location. $x_j$ is the variable value at another location. $w_{ij}$ is the weight indexing location of $i$ relative to $j$.

***Equation 1 .*** *Global Moran's I formula.*

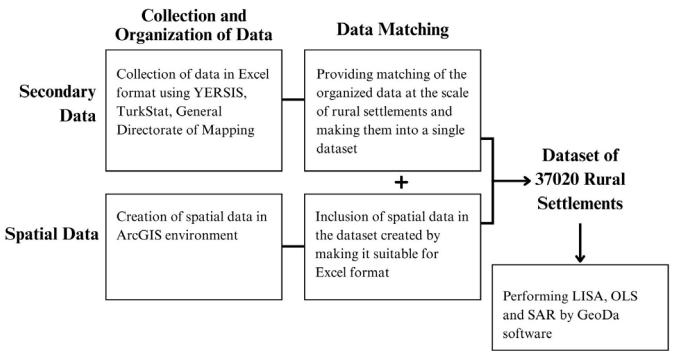


***Figure 3.*** *Methodology diagram.*

#### 3.2.2 Local Moran's I

The Moran's I model, introduced by Anselin (1995), is used to analyze each value with its neighboring values and to show spatial interaction. In this study, the k-Nearest Neighbors method is used for calculating the weights of rural settlements, and six neighbors are considered. With this step, whether the population changes clustering or not is evaluated spatially. The formula for LISA analysis is given below.

$$I_i = \frac{x_i - \bar{x}}{S_i^2} \sum_{j=1, j \neq i} \omega_{i,j}(x_j - \bar{x}) \quad (2)$$

The symbol $I_i$ in this formula represents the Local Morans I value calculated for the observation unit. $x_i$ and $x_j$ represent the values of observation units i and j. $\omega_{i,j}$ is the weight matrix value of the spatial relationship between observations i and j. $\bar{x}$ gives the mean value of all observations. $S_i^2$ gives the variance of the observation units.

***Equation 2.*** *Local Moran's I formula.*

In the scatter plot of this model, the upper right section shows the high-high (H-H) distribution, and the lower left section shows the low-low (L-L) distribution. The values located in the H-H or L-L sections indicate a clustering pattern. The values in the lower right and upper left sections show low-high (L-H) and high-low (H-L) distributions. The settlements in these sections have an opposite relationship with neighboring settlements.

#### 3.2.3. OLS (Ordinary last square)

Variables affect population changes for different reasons, such as economic, topographic, or ecological. Thus, the relationship between population change in rural areas and other variables has been revealed by the OLS method. The formula of the OLS method is given below.

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i \quad (3)$$

In this formula, $y_i$ represents the dependent variable, and $x_i$ represents the independent variable. $\beta_0$ represents the value of the dependent variable at $x_i = 0$. $\beta_1$ represents the slope of the linear regression equation. $\varepsilon_i$ is the error term.

***Equation 3.*** *OLS (Ordinary Last Square) formula.*

This formula aims to minimize the error term, that is, to minimize the difference between the observation and the actual variable value.

### 3.2.4. SAR (Spatial autoregressive)

The Spatial Autoregressive (SAR) model controls spatial interaction which is included with the spatial weight matrix. Therefore, the SAR model is used in this study to have spatial interaction in the correlation between variables obtained with OLS (Anselin, 1980).

$$y = \rho w_y + x\beta + \varepsilon \quad (4)$$

In this formula, $y$ represents the dependent variable. $\rho$ represents the spatial autoregression parameter: how the observation value is related to neighbouring units. The symbol $w_y$ is the spatial weight matrix value. $x$ is the independent variable. $\beta$ represents the coefficients of the independent variable. $\varepsilon$ represents the error term (Anselin, 1980).

***Equation 4 .*** *SAR (Spatial Autoregressive) formula.*

With these methods, the relationship between population change in rural settlements and its determinants will be analyzed and spatially addressed.

## 4. Results

This study includes various visualization techniques and spatial factors to analyze the spatial variation of population and change in rural settlements. The population change map of all rural settlements in Türkiye between 2018 and 2022 is analyzed in Figure 4. Although rural areas generally experience population loss, the population of some settlements is increasing. When the population change map (Figure 4) is evaluated, it is observed that rural settlements in the Aegean and Mediterranean coastal regions of the country and rural settlements located near metropolitan cities generally show positive population change. While the population decrease is high in the Eastern Black Sea Region, the population decrease is low in the Western Black Sea Region, and in some settlements, the population is even increasing. To understand whether the decreases or increases in settlements show a regional characteristic, clustering analysis should be performed. In this study, LISA analysis was used to analyze spatial clustering.

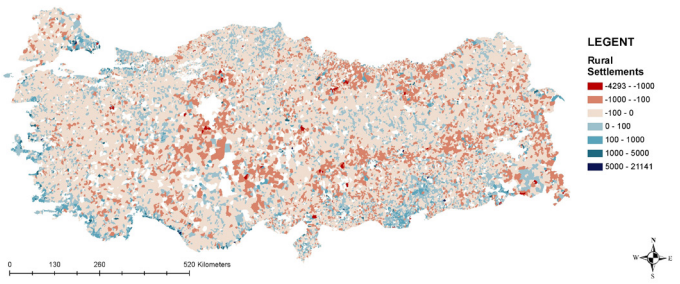


***Figure 4.*** *Population change between 2018-2022.*

Initially, the cluster analysis of the total population changes of rural settlements for the years 2018 and 2022 was analyzed separately. According to 2018 LISA cluster analysis results (Figure 5), a low population is clustered in Eastern Anatolia, Central Black Sea regions, and southeast of the Marmara region. The high rural population shows a high clustering pattern in Central Anatolia, Thrace, and the coastal settlements of the Mediterranean and Aegean regions. In 2022, low population clusters are observed especially north of Ankara and in the eastern regions (Figure 6).

In addition, the clustering trend of population change values in rural areas of Türkiye between 2018 and 2022 is revealed by conducting a LISA analysis (Figure 7). Regions with population growth are clustered especially along the coasts of the Mediterranean and Aegean regions. On the other hand, rural settlements with declining populations are clustered in parts of Central Anatolia, the Eastern Black Sea region, and the southern Eastern Anatolia region. The clustering of population changes in certain regions may be a consequence of the fact that population change is regionally affected by certain variables. To ascertain this, regression analysis was employed to ascertain the extent to which and in what direction the variables affect population change.

In the regression analysis, population change in rural settlements between 2018 and 2022 was taken as the

dependent variable, while the presence of primary schools, the presence of family health centers, manufacturing sector employment, the presence of service sector activities, the presence of livestock sector in the agricultural sector, distance to cities in the first tier in terms of socioeconomic development level and total population in 2018 were taken as independent variables. In regression analysis, three models were created according to the type of settlements. Model 1 includes 18183 settlements with village status in non-metropolitan provinces, while Model 2 includes 17104 settlements that have been transformed from villages to neighborhoods in metropolitan provinces. In Model 3, all rural settlements, regardless of their current legal status, are considered and evaluated comprehensively. Settlement Type 1 and Settlement Type 2 comprise settlements (villages or urban neighborhoods) defined solely by the legislation (Law no. 6360), without considering the specific characteristics of each settlement. It also highlights the problematic nature of the former rural definition by Law No. 6360. Such changes emerging with the law can be expected to affect population change in rural settlements. Therefore, the change in status must be included in the study to understand its impact on the factors influencing population change in rural areas.

According to the results of the OLS (Table 4), in all three models, primary school, manufacturing sector employment, distance to first-tier cities, and initial population have statistically significant effects on rural population change. Since we use the natural logarithm of rural population change as a dependent variable, a lower rate of rural population change does not directly imply decline in population. It suggests a slower growth or a decrease in population. Based on the coefficient signs, it is possible to argue that the presence of primary schools and higher manufacturing sector employment opportunities cause higher rural population change. Conversely, lower rates of rural population change can be experienced in settlements with a higher distance to cities and a higher initial population. Model 3 excels with a lower AIC and higher log-likelihood, showcasing a better fit and simplicity compared to other models. This result is expect-

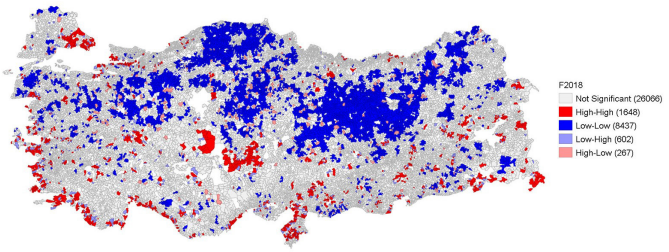


***Figure 5.*** *LISA map of rural population in 2018. (Moran's I Value: 0,314).*

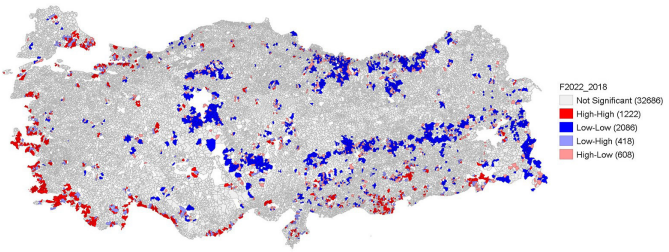


***Figure 6.*** *LISA map of rural population in 2022. (Moran's I Value: 0,308).*

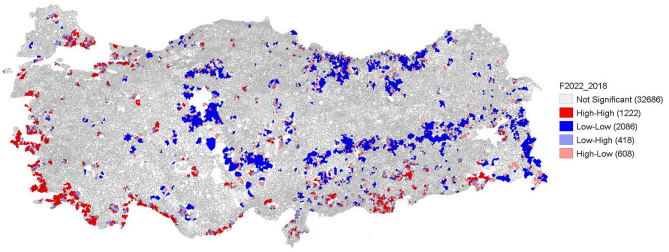


***Figure 7.*** *LISA map of rural population Change Between 2018-2022 (Moran's I Value: 0,166).*

***Table 4.*** *OLS (Ordinary Last Square) and SAR (Spatial Lag Model - Maximum Likelihood Estimation) results.*

| Variables | Model 1 Settlement Type 1 | | Model 2 Settlement Type 2 | | Model 3 Settlement Type 3 | |
|---|---|---|---|---|---|---|
| | OLS | SAR | OLS | SAR | OLS | SAR |
| W_Pop Change | | 0.2528*** | | 0.0803*** | | 0.2283*** |
| | | (0.0114) | | (0.0137) | | (0.0086) |
| Primary School | 0.0043*** | 0.0039*** | 0.0049*** | 0.0046*** | 0.0033*** | 0.0027*** |
| | (0.0004) | (0.0004) | (0.0016) | (0.0016) | (0.0009) | (0.0009) |
| Health Center | -0.0018*** | -0.0019*** | 0.0017 | 0.0015 | -0.0017 | -0.0016 |
| | (0.0005) | (0.0005) | (0.0022) | (0.0022) | (0.0011) | (0.0011) |
| Manufacturing Emp. | 0.0017*** | 0.0019*** | 0.0037** | 0.0036* | 0.0035*** | 0.0031*** |
| | (0.0005) | (0.0005) | (0.0017) | (0.0017) | (0.001) | (0.001) |
| Service Activities | 0.0052*** | 0.0047*** | 0.0021 | 0.0016 | 0.0191*** | 0.0160*** |
| | (0.001) | (0.001) | (0.0026) | (0.0026) | (0.0016) | (0.0016) |
| Distance | -0.0025*** | -0.0019*** | -0.0011* | -0.0010* | -0.0035*** | -0.0027*** |
| | (0.0002) | (0.0002) | (0.0006) | (0.0006) | (0.0004) | (0.0004) |
| Population | -0.0075*** | -0.0068*** | -0.0038*** | -0.0037*** | -0.0020*** | -0.0022*** |
| | (0.0002) | (0.0002) | (0.0008) | (0.0008) | (0.0004) | (0.0004) |
| Livestock | 0.0016** | 0.0017** | -0.0064* | -0.0059* | -0.0139*** | -0.0111*** |
| | (0.0008) | (0.0008) | (0.0036) | (0.0036) | (0.0018) | (0.0017) |
| Constant | 8.4069*** | 6.2873*** | 8.3892*** | 7.7173*** | 8.3997*** | 6.4851*** |
| | (0.0016) | (0.0959) | (0.0063) | (0.115) | (0.0034) | (0.0719) |
| **Log-likelihood** | 45555.4 | 45800.7 | 18970.6 | 18988.6 | 48652.8 | 49021.2 |
| **Akaike info criterion** | -91095 | -91583.4 | -37925 | -37959.2 | -97290 | -98024.5 |
| **Number of Observation** | 18183 | 18183 | 17104 | 17104 | 37020 | 37020 |

*p<0.1 **p<0.05 ***p<0.01 Dependent variable is population change between 2018-2022.

ed since the other two models employ different dependent variables based on legally defined types of settlements. LISA analysis reveals that there are spatial clusters in population change in rural areas. Since OLS analysis does not consider spatial interaction when analyzing the effects of variables on population change, SAR analysis has been conducted to include the spatial dimension in the effect of variables on population change.

According to the results of the SAR (Table 4), all three models consistently exhibit a significant and positive spatial lag coefficient (W_Pop Change) in relation to rural population change. This finding strongly indicates that changes in rural populations in one spatial unit are positively influenced by the changes in neighboring units. The observed spatial spillover effects corroborate the initial hypothesis, thereby substantiating the existence of significant spatial interdependence within the dataset. Similar to the OLS results, Model 3 displays a better fit than the other two models for the SAR findings. Model 3 demonstrates that an increase in primary school services, manufacturing employment, and service sector activities variables leads to a higher rate of rural population growth. Our findings regarding the impact of educational services on population changes in rural areas are consistent with existing literature such as in Lykke Sørensen et al. (2021). They also found that inadequacy of educational services in settlements has a negative effect on population change. Surprisingly, no statistically significant relationship was found between the presence of health centers and rural population change even though the importance of health services is emphasized in the literature (Yürük & Batmaz, 2023).

Non-agricultural sectors gain importance as economic income is not satisfactory due to reasons such as insufficient agricultural support (Baybaş et al., 2023; Yu et al., 2022). The increasing tendency of the rate of population growth of rural settlements with service activities such as hotels and restaurants and settlements with manufacturing labor can be associated with the importance of non-agricultural economic sectors on population change (Öztürk et al., 2018). The other variable that has a significant effect on the rate of rural population growth is the presence of livestock activities. Interestingly, an increase in the livestock activities variable can cause a decrease in the rate of rural population growth. This finding supports the arguments in the literature on the importance of a non-agricultural economy.

Along with livestock sector activities, an increase in the distance to first-tier cities, and initial population, are also associated with slower rural population growth. This can be interpreted as areas with remote locations, larger populations, or higher livestock activities experiencing less dynamic population changes between 2018 and 2022. The distance to the main cities, especially, attracted a lot of attention in the literature. It is possible to say that the population decreases with increasing distance to developed cities (Liu et al., 2017; Wang et al., 2018). One of the reasons why rural settlements close to urban centers do not tend to decrease in population is that they have access to basic services and some economic activities through these cities (Lorenzen, 2022). Similarly, studies conducted in Türkiye indicate that seasonal and daily mobility from rural to urban areas is highly related to economic reasons and accessibility of areas (Canpolat & Hayli, 2018).

## 5. Conclusion

Research on changes in rural populations reflects diverse perspectives and determinants. When reviewing various studies on rural areas, several limitations become evident. Firstly, migration studies often operate at higher scales, such as city and province levels, due to data constraints. Moreover, some studies focus exclusively on specific regions and lack spatial analysis, restricting their examination to only descriptive analysis. Recognizing the importance of comprehending the reasons for rural population changes, this study adopts a village-scale (micro level) approach, acknowledging the distinctive characteristics of each rural settlement. In this study, the analysis of

population changes in Türkiye's rural areas involves Moran's I statistics to uncover spatial interactions in rural areas. The results confirm the spatial interactions between rural settlements and support the idea that changes in one settlement affect the surrounding settlements, leading to clusters in certain areas. The cluster maps of LISA analysis also indicate a strong tendency for a clustering pattern of settlements with low population, especially in the eastern provinces. In contrast, settlements located in the Aegean coast and Thrace region experienced a clustering of high population growth between 2018 and 2022. The OLS and SAR analysis investigate factors influencing population change in rural areas, utilizing three models: settlements labeled as "village" (Model 1), those transitioning from "village to neighborhood" (Model 2), and all rural settlements (Model 3). According to the OLS results, variables such as the presence of primary schools, manufacturing employment, service sector activities, and the livestock sector significantly impact population change. While certain factors contribute to population growth, others, like distance to developed city centers and the absence of basic services, lead to a decline in the population growth rate. The SAR analysis corroborates these findings, highlighting the influence of various variables on population change in rural settlements. Model 3 underscores the positive effects of primary schools, manufacturing employment, and service sector activities on population growth rates.

Drawing insights from the study's conclusions, several recommendations emerge for policymakers and stakeholders involved in Türkiye's rural development. Firstly, the recognition of the important role of primary schools in influencing population change highlights the need to increase investment in educational facilities and underlines that education is a key driver of rural development. Secondly, to stimulate population growth, policymakers should encourage the diversification of economic activities within rural settlements, focusing on the promotion of manufacturing employment and service sector activities that have demonstrated positive impacts. Thirdly, the SAR analysis underscores a notable and positive correlation between changes in population within Türkiye's rural settlements and their neighboring units, highlighting the significance of regional interdependence. In response, policymakers can adopt targeted strategies to harness these spatial dynamics. Initiatives fostering collaboration and information exchange among neighboring settlements should be prioritized to amplify positive population trends. Additionally, the findings emphasize the need for nuanced, tailored rural development policies that account for the distinctive characteristics of each settlement, acknowledging that a uniform approach may not be effective. Finally, conducting field studies is suggested to gain in-depth insights into the positive and negative factors influencing population change, accounting for the specific context of each settlement. By embracing these recommendations, we believe that policymakers can formulate more effective strategies for sustainable and balanced rural development, ensuring the well-being and prosperity of Türkiye's rural populations.

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