



## The Effects of Earthquakes on Occurring in Türkiye on Demographic Structure and Agricultural Sector

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### HIGHLIGHTS

- Earthquakes significantly affect agricultural production and rural livelihoods.
- Population shifts after earthquakes alter regional food and labor supply patterns.
- Strong correlations were found between disasters and agricultural output losses.
- Türkiye's hilly topography increases earthquake impact in fertile agricultural zones.

### Abstract

This study aims to provide information on the relationship between earthquake disasters, demographic structure, and the agricultural sector in Türkiye. Natural disasters such as earthquakes bring many social and economic consequences. These include changes in population structure and damage to agricultural systems. Agriculture is one of the sectors most affected by these disasters. Earthquakes can cause damage to agricultural infrastructure, livestock production, cultivated lands, and food supply chains. Additionally, the agriculture-based industry, especially the food and textile sectors, may also be negatively affected. In countries where agriculture contributes significantly to national income, disasters can slow economic growth and rural development. In this study, several major earthquakes (magnitude  $\geq 6.9$ ) in Türkiye were evaluated in terms of their impacts on population and agricultural indicators. Simple and chain index calculations were made, and the Spearman rank correlation method was used to analyze the relationship between demographic changes and agricultural variables such as livestock numbers and crop production. The results show that there are strong positive correlations between population and indicators like cereals, fruits, and vegetables. It was found that earthquakes cause temporary or permanent migrations and disruptions in agricultural productivity. In addition, severe damage to rural infrastructure and livestock shelters was observed. The effect of public support and recovery efforts after the earthquakes was also evaluated. In conclusion, this study reveals that earthquakes significantly affect Türkiye's agricultural sector and rural population. The findings emphasize the need to develop integrated rural and agricultural policies that consider disaster risks. This research can provide insight for future planning in food security and disaster resilience.

**Keywords:** earthquakes; demographic change; agricultural sector; correlation analysis; rural migration; Türkiye

### 1. Introduction

Türkiye is located in the Alpine-Himalayan seismic belt, one of the most dynamic earthquake belts in the world, and is frequently faced with destructive earthquakes due to its geological structure on active fault lines

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(Şaroğlu et al. 1987; Pelit 2024; Şikoğlu and Ser 2024). The North Anatolian Fault Line (NAF), the Eastern Anatolian Fault Line (EAF), and the fault systems extending in Western Anatolia cause destructive earthquakes in different parts of the country (Ozel and Solmaz 2012; Şenol 2020; Ateş and Karataş 2023).

Considering the historical process, it is known that there have been 23 earthquakes with a magnitude of 6.9 and above in Anatolia since the 1500s. In the 20th century, Türkiye also experienced devastating earthquakes (magnitude 6.9 and above) (Ozel and Solmaz 2012). Some of these are; These earthquakes include the Mürefte earthquake in 1912 (magnitude 7.3), Ayvalık earthquake in 1919 (magnitude 7.0), Hakkari earthquake in 1930 (magnitude 7.6), Erzincan earthquake in 1939 (magnitude 7.9), Niksar-Erbaa earthquake in 1942 (magnitude 7.0), Tosya-Lâdik earthquake in 1943 (magnitude 7.2), Bolu-Gerede earthquake in 1944 (magnitude 7.2), Çaldıran earthquake in 1976 (magnitude 7.5), Gölcük earthquake in 1999 (magnitude 7.4), Düzce earthquake in 1999 (magnitude 7.2), and Van earthquake in 2011 (magnitude 7.2). When we look at the last 120 years (after 1900), it is seen that there have been 200 major and destructive earthquakes in Türkiye. This means that there are more than 1.5 major and destructive earthquakes every year. In these earthquakes, a total of 95 thousand people lost their lives, and nearly 600 thousand buildings were severely damaged (Yolcu and Bekler 2020). Especially earthquakes with a magnitude of over 6.9 are events that cause social, physical and economic difficulties and loss of life for human life, make it difficult to continue life in its normal course or interrupt it, and affect the life of living beings, as well as the social and economic structure of the country (Çetin and Yanar 2023). Earthquakes also affect social structure, population and economic activities in the long term (Tercan 2008). Demographic structure and the agricultural sector are among the areas that feel the effects of earthquakes most intensely (Şenol 2020). Major earthquakes change the population distribution and cause serious production and infrastructure losses in agriculture (Çığ and Toprak 2023). This situation has devastating effects on the livelihoods and living conditions of the population, especially in rural areas (Yenilmez 2023). The repercussions of such disasters can be more complex as the post-disaster recovery process takes longer, and vulnerable communities suffer more damage during this process.

This study examines the effects of earthquakes of magnitude 6.9 and above in Türkiye (1939 Erzincan, 1999 Gölcük, 2011 Van, 2023 Kahramanmaraş, etc.) on demographic structure and the agricultural sector. It aims to understand the interactions between earthquake impact and demographic structure and the agricultural sector and to contribute to the development of sustainable strategies in this context. A better understanding of post-earthquake problems and the development of effective solution strategies can shape not only emergency management but also long-term development policies. In this context, the results of the study are expected to contribute at both academic and practical levels.

## 2. Materials and Methods

The main material of the study consists of statistical data on population and the agricultural sector, reports on earthquakes, primary and secondary data, and scientific studies published by relevant institutions and organizations. Literature and statistics were analyzed, and index calculations were made to show annual changes. Simple and chained indices were used to measure change over time (Çömlekçi 1998). In simple indices, the aim is to determine how much the value of each period has increased or decreased compared to the previous period, and to examine the proportional changes of the values (Kaul and Chowdhury 2007). The general formula of the simple index is:  $I_t = (y_t/y_0) * 100$ , ( $I_t$  denotes the number of simple indices for period  $t$ ,  $y_t$  denotes the value of period  $t$  for which the index is to be calculated,  $y_0$  denotes the value of the period chosen as the base. The general formula of the chain index:  $I_t = (y_t/y_{t-1}) * 100$  ( $I_t$ : the number of chained indices for period  $t$ ).

In this context, the loss of life in earthquakes and the effects of demographic changes on population movements and losses in agricultural production were analyzed comparatively with statistical data. Correlation analysis was applied to examine the relationships between demographic structure, livestock assets, and production amounts in earthquake regions. Correlation analysis is used to measure the relationship between variables. Spearman's rank correlation takes values between -1 and +1. If the correlation coefficient is +1, it can be said that there is a positive perfect linear relationship between the variables, and if it is -1, it can

be said that there is a negative perfect linear relationship between the variables (Kalaycı 2017). The relationship between the agricultural sector and demographic structure was evaluated by utilizing scientific studies in literature.

### 3. Research Finding and Discussion

In Türkiye, earthquakes of magnitude 7.0 and above have deeply affected both social structure and economic activities throughout history. An overview of some of these earthquakes (1939 Erzincan, 1942 Erbaa-Niksar, 1999 Kocaeli/Düzce, 2011 Van, 2023 Kahramanmaraş) is presented below:

#### 3.1. 1939 Erzincan Earthquake Example

The 1939 Erzincan Earthquake is one of the largest earthquakes in Türkiye's history. The 7.8-magnitude earthquake on December 27, 1939, killed 32,962 people, injured 100,000 people, and severely damaged 116,720 buildings (Kandilli Observatory). Apart from Erzincan, the earthquake also affected Amasya, Tokat, Gümüşhane, and neighboring provinces (Arpacı 2018). Limited transportation and winter conditions created serious difficulties in search and rescue, health, and shelter services. This information on the demographic structure before and after the earthquake is based on the results of the general census. While the population of Erzincan was 157 thousand in 1935, it increased to 158 thousand in 1940 (Yavuz, 2016). This limited increase is related to the loss of life and migration. Migration and administrative changes caused a total population to change of approximately 65-70 thousand (Yavuz 2012). One area that was heavily affected by the earthquake was the agricultural sector. The 1939 earthquake disrupted crop and animal production in Erzincan to a great extent. The state provided animal and seed support to farmers (Yavuz 2016). The buildings destroyed in the earthquake and livestock losses are given in Table 1. A total of 41,837 buildings were destroyed, including houses, schools, mosques, and barns. In addition, a total of 44,342 animals, including 13,203 cattle, 29,412 sheep and goats, and 1,727 passenger animals, perished.

**Table 1.** The number of buildings were destroyed, and livestock wiped out in the earthquake.

| <b>Demolished Buildings</b>  | <b>Center</b> | <b>Refahiye</b> | <b>Kemah</b> | <b>Tercan</b> | <b>İliç</b> | <b>Total</b>  |
|------------------------------|---------------|-----------------|--------------|---------------|-------------|---------------|
| Number of Villages           | 138           | 100             | 75           | 80            | 68          | 461           |
| Number of Houses in Villages | 13,305        | 3,732           | 3,325        | 6,506         | 3,059       | 29,927        |
| Number of houses damaged     | 11,098        | 2,902           | 1,040        | 5,036         | 448         | 20,524        |
| Shop                         | 1,006         | 17              | 11           | 0             | 0           | 1,034         |
| Mill                         | 6             | 0               | 1            | 0             | 0           | 7             |
| Stable                       | 4,245         | 2,666           | 267          | 1,335         | 337         | 8,850         |
| Haystack                     | 3,494         | 2,337           | 275          | 1,474         | 297         | 7,877         |
| School                       | 62            | 28              | 3            | 1             | 1           | 33            |
| Mosque                       | 77            | 28              | 3            | 1             | 0           | 32            |
| Corral                       | 0             | 0               | 5            | 0             | 0           | 5             |
| <b>Wasted Animal</b>         | <b>Merkez</b> | <b>Refahiye</b> | <b>Kemah</b> | <b>Tercan</b> | <b>İliç</b> | <b>Toplam</b> |
| Ox                           | 3,336         | 1,607           | 13           | 199           | 5           | 5,160         |
| Cow                          | 4,590         | 1,864           | 65           | 181           | 4           | 6,704         |
| Manda                        | 973           | 360             | 6            | 0             | 0           | 1,339         |
| At                           | 738           | 187             | 0            | 23            | 0           | 948           |
| Merkep                       | 526           | 221             | 7            | 23            | 2           | 779           |
| Sheep                        | 18,670        | 9,518           | 394          | 536           | 46          | 23,164        |
| Goat                         | 0             | 5,383           | 77           | 689           | 99          | 6,248         |

### 3.2. 1942 Erbaa-Niksar Earthquake Example

In 1940, Erbaa had 72 thousand inhabitants, most of whom lived in rural areas, subsisting on agriculture. Tobacco and wheat were the main crops. Tobacco production was also an important source of livelihood in Niksar, where 35,326 people lived in its towns and villages, and 81.16% (28,671) of the population lived in rural areas. In addition, wheat, barley, rice and walnut production was not negligible. Tobacco, rice, and walnuts were the export products of the region. While the rice yield was 500,000 kg in 1936, it was estimated to reach 1,000,000 kg in 1937. The income from agricultural products, especially tobacco, in both districts ensured that the socio-economic status of the people was at a good level (Akkuş 2022). The loss of life and property in Erbaa as a result of the earthquake is given in Table 2. Tobacco production, one of the most important income items of Erbaa, was also negatively affected. Hundreds of thousands of kilograms of tobacco were buried under the rubble, and most of them became unusable. On the other hand, tobacco was also exposed to the ravages of winter and snow, and the warehouses used as tobacco warehouses were destroyed, leaving no structure suitable for storage. Processing the tobacco stored in rows in Erbaa was not possible due to a lack of space. Therefore, the Chief Directorate of Tokat İnhisar (Tekel) was asked to purchase the tobacco in Erbaa in series or send it to the warehouses to be established in the district of Tokat. Thus, the impact of the severe damage to Erbaa's economy was minimized. In Erbaa, where a significant part of the society was agricultural producers, the situation of the landless and the poor, who worked seasonally in wheat and tobacco cultivation and in winter as tobacco balancing and bundling laborers, posed a significant problem. After the earthquake, many women, widows, and orphans faced unemployment and hardship. These people, numbering around 500, struggled with food, shelter, and health problems throughout the winter.

On the agricultural level, it was found that the fall planting in Erbaa in 1942 was better than in 1941, but some of the fields that were ready for planting were not planted. In the background of this phenomenon, the loss of 492 cattle in the center and 2,161 cattle in the sub-districts and villages during the earthquake reduced the ability of producers to cultivate and cultivate the land. In addition, a significant number of farmers were busy clearing the rubble of their destroyed houses and constructing shacks on the other hand. These obligations severely disrupted agricultural production activities. Due to the vital role of cattle in the continuity of agricultural production, land cultivation, and planting, the producers in Erbaa requested that they be sent a few tractors and that they be provided with seeds from the wheat in the warehouse of the Office.<sup>95</sup> Within the framework of these agricultural developments, the Ministry of Agriculture decided to provide seed aid to farmers on January 12, 1943, and allocated 70 tons of wheat and 70 tons of barley to Erbaa and 50 tons of wheat to Niksar, and requested the provincial authority to distribute the seeds to the farmers and not to interrupt their cultivation.

**Table 2.** Erbaa-Niksar earthquake damage.

| Location              | Dead | Wounded | Partially Demolished House | Completely Destroyed House | Cattle Died | Perished Small Cattle |
|-----------------------|------|---------|----------------------------|----------------------------|-------------|-----------------------|
| Town                  | 210* | 239     | 496                        | 791                        | 492         | 216                   |
| Central District      | 49   | 94      | 151                        | 250                        | 952         | 000                   |
| Hayati Nahiyesi       | 73   | 156     | 563                        | 329                        | 235         | 8                     |
| Karayaka Sub-district | 14   | 37      | 500                        | 110                        | 111         | 126                   |
| Sonusa Sub-district   | 31   | 45      | 200                        | 300                        | 163         | 17                    |
| Bidevi Sub-district   | 66   | 74      | 107                        | 267                        | 700         | 3                     |
| Total                 | 443  | 645     | 2,017                      | 2,047                      | 2,653       | 370                   |

### 3.3. 1999 Kocaeli/Düzce Earthquake Example

The 1999 Kocaeli/Düzce earthquake (also known as the Gölcük earthquake) occurred with a magnitude of 7.8 according to Kandilli observatory data. In the earthquake, 120,000 houses were severely damaged and 2,000 were destroyed. The economic damage is estimated to be around \$23 billion. On the other hand, the earthquake, which occurred in industrialized and densely populated urban areas, especially in oil refineries,

various automotive factories, and Turkish maritime areas, increased the severity and caused great damage to life and property, both environmentally, socially, and especially economically (Marza 2004). The number of buildings that had to be completely removed after the earthquakes amounted to 23,400. Of the 93,000 houses and 15,000 businesses, 16,400 were severely damaged, while 220,000 houses were less severely affected. Widespread building collapses in the two earthquakes caused a significant number of casualties. There were 18,373 deaths and 48,901 hospitalized injuries, of which about 40% were permanently disabled (Durukal and Erdik 2008). The Kocaeli earthquake is considered to be the largest event to cause damage in an industrialized region since the 1906 San Francisco and 1923 Tokyo earthquakes. In the Kocaeli earthquake, 70% of the total insured losses were caused by direct damage and 30% by business interruption. The insurance industry's estimates of total insured losses resulting from the Kocaeli earthquake were in the region of \$1.5-3.5 billion, compared with the estimated \$550-750 million paid by the industry (Scawthorn and Johnson 2000). The region affected by the earthquake is both geographically large and economically dynamic. It constitutes the industrial heartland of Türkiye. The main industries are automobiles, petrochemicals, motor and railway vehicle manufacturing and repair, basic metals, synthetic fiber and yarn production and weaving, paint and varnish production, and tourism. The four most severely affected districts (Kocaeli, Sakarya, Bolu, and Yalova) account for more than 7 percent of the country's GDP and 14 percent of industrial value added. Per capita income is almost twice the national average. Despite containing only 4 percent of the country's population, the region provides more than 16 percent of budget revenues. The immediate surrounding districts (Bursa, Eskişehir and İstanbul) are indirectly affected by their close economic ties with the former area, for example industries and small businesses that provide material inputs to each other's production processes. They are also at a common seismic risk and therefore face great uncertainty for the future because of recent events. When we combine the seven cities, the wider earthquake zone accounts for 35% of the national GDP and almost half of the country's industrial production (Bibbee et al. 2000). Approximately 501.5 billion TL was required to repair irrigation structures in Kocaeli.

According to the Ministry of Agriculture and Rural Affairs, there is no significant damage in rural areas, but 621 barns, 39 poultry houses, and 2 fish facilities were damaged to varying extents. Some agricultural buildings and facilities were damaged by the earthquake. 327 cattle, 45 sheep and goats, 493,170 poultry and 154,500 fish died. 14,191 doses of vaccine were lost. In the poultry sector, production and slaughter programs of chicken combines were disrupted as many farmers' poultry houses were severely damaged. Prolonged and frequent power outages prevented the business from running, feed could not be sent to the poultry houses and animals could not be brought to slaughter from many poultry houses. Some chicken meat spoiled in cold stores and in refrigerated trucks during transportation. Most of the companies lost their dealer network in the earthquake zone, were unable to ship and sell their goods, could not collect their existing receivables and even lost the chance to collect them in the future.

### 3.4. 2011 Van Earthquake Example

The 7.2 magnitude Van earthquake on October 23, 2011 caused serious loss of life and property. In the 2011 Van earthquakes, 75% of the total 15,158 houses (excluding unclassified houses built after the earthquake) in Erciş City were damaged (Table 3). Of the damaged houses, 24% were heavily damaged, 10% were moderately damaged and 41% were slightly damaged. In Van, 16.8% of the working population is employed in the agricultural sector. Therefore, agriculture is an important economic activity in Van. Especially in the suburbs, this activity continues intensively. In addition to houses and workplaces, animal shelters used for animal husbandry activities were also severely damaged in the earthquake. As a matter of fact, 82% of the animal shelters (1,294 barns) were damaged to varying degrees in the earthquake.

**Table 3.** Structures destroyed in the earthquake.

| Damaged structures | Damaged | %     | No Damage | %     | Total  | %      |
|--------------------|---------|-------|-----------|-------|--------|--------|
| Housing            | 11,337  | 74.79 | 3,821     | 25.21 | 15,158 | 100.00 |
| Workplace          | 2,308   | 85.93 | 378       | 14.07 | 2,686  | 100.00 |
| Stable             | 1,294   | 82.32 | 278       | 17.68 | 1,572  | 100.00 |

The situation is clearer when looking at Table 4, which includes the population and agricultural sector before and after the earthquake (TUIK). While the provincial population was 979,671 in 2007, it increased to 1,022,310 in 2009 and to 1,035,418 in 2010. The statistics of these four years show that the province's population is in a continuous upward trend. While the increase in the provincial population was expected to continue in this manner, the earthquake that occurred in 2011 reversed this situation. In other words, instead of increasing, the province's population decreased and returned to the level of 2009. The population of 1,022,000 in 2011 continued its previous upward trend after the earthquake. It is observed that the population of the province decreased significantly in the census years after the earthquake and then increased again at constant rates.

In this part of the research, correlation analysis was conducted to determine the relationship between the population structure of Van province before and after the earthquake, as well as the production of cattle, small cattle, cereals, and other crops, and the total production of vegetables, fruits, beverages, and spice plants (Table 5). According to the Spearman correlation coefficient analysis, a positive and significant relationship was found between the demographic structure in Van province and the number of small cattle ( $r_{\text{Spearman}} = .775$   $p < 0.01$ ). The population increase in the province leads to a rise in ovine husbandry. No significant relationship was found between demographic structure and cattle numbers. One of the reasons for this may be the increase in subsidies for cattle breeding during the earthquake period, which disrupted the change due to population growth. There is a significant positive correlation between demographic structure and the production amount of cereals and other crops ( $r_{\text{Spearman}} = .723$   $p < .01$ ), total production amount of vegetables ( $r_{\text{Spearman}} = .875$   $p < .01$ ), fruits, beverages and spice crops ( $r_{\text{Spearman}} = .877$   $p < .01$ ). This indicates that an increase in population leads to an increase in crop production and a decrease in population leads to a reduction in crop production (Table 5).

Cang et al. (2022) analyzed China in the period between 1995-2018 and found that there is a significant inverted U-shaped relationship between disaster losses and economic growth. Tasri et al. (2022) found that unemployment and poverty variables have a significant effect on the disaster loss variable in their research involving Indonesia in the period 1990-2019.

The earthquake in the province caused a significant decline in the population during the census years and then the population started to increase again. To further elaborate on the issue, it would be sufficient to look at Table 6, which provides migration data for the province. While the number of migrants received by the province in 2008 was 21,187, it showed a continuous increase until 2012, and although the rate of increase in 2013 was higher than the previous periods, it was less than the previous year. In 2011, the year of the earthquake, this increases continued, albeit very slightly. In 2012, migration to the province increased by more than 2 times compared to the previous year and reached 50,003. This can be explained by the return of those who left the province during the earthquake and the positive effects of the investments made in the province. In 2013, although the number of migrants received by the province decreased significantly compared to the previous year, it was still high compared to the period before the earthquake. The number of migrants received by the province in this period is over 32 thousand. When we look at the amount of migration given by the province, it is noteworthy that the values change in a fluctuating manner. In 2008, 2009, and 2010, the province emigrated approximately 30,000 each year, but in 2011, due to the earthquake, the province emigrated 72,000. In 2012, although not as high as in the previous year, the province again experienced a high rate of emigration, exceeding 46 thousand, but declined to 38 thousand in 2013. These values indicate that the province continues to experience significant emigration, and it is understood that this trend intensified in the period following the earthquake. If we look at the net migration rate of Van province, it is noteworthy that the values are variable. In 2008, net migration was -9.01, in 2009 it was -4.21, and in 2010 it was -7.77. In 2011, the net migration deficit reached the highest level with -46.67 due to the earthquake. In the study conducted by Trinh et al. (2021) on Vietnam in the period 2006-2008, it was found that more severe disasters are directly related to a greater probability of migration.

**Table 4.** Changes in population, number of cattle, number of sheep and goats, cereal cultivation area, vegetable cultivation area and fruit cultivation area for 2007-2023.

| Years | Population |        |        | Cattle  |        |        | Small Cattle |        |        | Cereal    |          |        | Vegetable |        |        | Fruit  |        |        |
|-------|------------|--------|--------|---------|--------|--------|--------------|--------|--------|-----------|----------|--------|-----------|--------|--------|--------|--------|--------|
|       | *          | **     |        | *       | **     |        | *            | **     |        | *         | **       |        | *         | **     |        | *      | **     |        |
| 2007  | 979,671    | 100.00 | 100.00 | 181,513 | 100.00 | 100.00 | 2,665,446    | 100    | 100.00 | 269,029   | 100      | 100.00 | 34,988    | 100    | 100.00 | 12,555 | 100    | 100.00 |
| 2008  | 1,004,369  | 102.52 | 102.52 | 172,138 | 94.84  | 94.84  | 2,553,175    | 95.79  | 95.79  | 253,415   | 94.20    | 94.20  | 31,441    | 89.86  | 89.86  | 14,899 | 118.67 | 118.67 |
| 2009  | 1,022,310  | 104.35 | 101.79 | 174,612 | 96.20  | 101.44 | 2,451,078    | 91.96  | 96.00  | 227,758   | 84.66    | 89.88  | 30,613    | 87.50  | 97.37  | 14,589 | 116.20 | 97.92  |
| 2010  | 1,035,418  | 105.69 | 101.28 | 158,033 | 87.06  | 90.51  | 2,332,697    | 87.52  | 95.17  | 1,038,733 | 386.10   | 456.07 | 29,749    | 85.03  | 97.18  | 13,979 | 111.34 | 95.82  |
| 2011  | 1,022,532  | 104.38 | 98.76  | 198,049 | 109.11 | 125.32 | 2,304,525    | 86.46  | 98.79  | 1,218,859 | 453.06   | 117.34 | 32,281    | 92.26  | 108.51 | 14,252 | 113.52 | 101.95 |
| 2012  | 1,051,975  | 107.38 | 102.88 | 194,690 | 107.26 | 98.30  | 2,372,499    | 89.01  | 102.95 | 1,063,896 | 395.46   | 87.29  | 30,599    | 87.46  | 94.79  | 15,391 | 122.59 | 107.99 |
| 2013  | 1,070,113  | 109.23 | 101.72 | 192,843 | 106.24 | 99.05  | 2,483,657    | 93.18  | 104.69 | 923,056   | 343.11   | 86.76  | 36,017    | 102.94 | 117.71 | 15,991 | 127.37 | 103.90 |
| 2014  | 1,085,542  | 110.81 | 101.44 | 163,958 | 90.33  | 85.02  | 2,691,934    | 100.99 | 108.39 | 906,786   | 337.06   | 98.24  | 33,388    | 95.43  | 92.70  | 19,030 | 151.57 | 119.00 |
| 2015  | 1,096,397  | 111.91 | 101.00 | 167,388 | 92.22  | 102.09 | 2,703,581    | 101.43 | 100.43 | 1,012,865 | 376.49   | 111.70 | 36,402    | 104.04 | 109.03 | 25,345 | 201.87 | 133.18 |
| 2016  | 1,100,190  | 112.30 | 100.35 | 162,728 | 89.65  | 97.22  | 2,658,215    | 99.73  | 98.32  | 2,840,073 | 1,055.68 | 280.40 | 38,895    | 111.17 | 106.85 | 23,904 | 190.39 | 94.31  |
| 2017  | 1,106,891  | 112.99 | 100.61 | 186,099 | 102.53 | 114.36 | 2,738,054    | 102.72 | 103.00 | 2,676,788 | 994.98   | 94.25  | 66,775    | 190.85 | 171.68 | 25,186 | 200.61 | 105.36 |
| 2018  | 1,123,784  | 114.71 | 101.53 | 177,346 | 97.70  | 95.30  | 2,650,531    | 99.44  | 96.80  | 2,077,138 | 772.09   | 77.60  | 66,276    | 189.42 | 99.25  | 24,889 | 198.24 | 98.82  |
| 2019  | 1,136,757  | 116.03 | 101.15 | 180,693 | 99.55  | 101.89 | 2,708,012    | 101.60 | 102.17 | 1,707,764 | 634.79   | 82.22  | 71,592    | 204.62 | 108.02 | 22,090 | 175.95 | 88.75  |
| 2020  | 1,149,342  | 117.32 | 101.11 | 197,483 | 108.80 | 109.29 | 3,166,236    | 118.79 | 116.92 | 1,929,639 | 717.26   | 112.99 | 88,220    | 252.14 | 123.23 | 27,892 | 222.16 | 126.27 |
| 2021  | 1,141,015  | 116.47 | 99.28  | 166,401 | 91.67  | 84.26  | 3,384,220    | 126.97 | 106.88 | 1,568,159 | 582.90   | 81.27  | 105,754   | 302.26 | 119.88 | 33,983 | 270.67 | 121.84 |
| 2022  | 1,128,749  | 115.22 | 98.92  | 133,137 | 73.35  | 80.01  | 3,413,510    | 128.07 | 100.87 | 2,166,933 | 805.46   | 138.18 | 102,524   | 293.03 | 96.95  | 33,956 | 270.46 | 99.92  |
| 2023  | 1,127,612  | 115.10 | 99.90  | 133,193 | 73.38  | 100.04 | 3,280,145    | 123.06 | 96.09  | 2,241,235 | 833.08   | 103.43 | 102,227   | 292.18 | 99.71  | 34,193 | 272.35 | 100.70 |

Source: (TUIK, 2024)

Notes: \* Simple index values, \*\* Chain index values, Population: (person), Cattle: Cattle Production (Number), Small Cattle: Small Cattle Production (Number), Cereals: Production of cereals and other vegetable crops (tons), Vegetables: Total production of vegetables (tons), Fruits: Fruits, beverage and spice crops production

**Table 5.** Analysis of the relationship between demographic structure and agricultural sector of Van province.

|                |              | Correlations |        |              |        |           |        |        |
|----------------|--------------|--------------|--------|--------------|--------|-----------|--------|--------|
|                |              | Population   | Cattle | Small Cattle | Cereal | Vegetable | Fruit  |        |
| Spearman's rho | Population   | Correlation  | 1.000  | -.176        | .775** | .723**    | .875** | .877** |
|                |              | P            |        | .498         | .000   | .001      | .000   | .000   |
|                |              | N            | 17     | 17           | 17     | 17        | 17     | 17     |
|                | Cattle       | Correlation  |        | 1.000        | -.368  | -.164     | -.221  | -.341  |
|                |              | P            |        |              | .147   | .529      | .395   | .181   |
|                |              | N            |        | 17           | 17     | 17        | 17     | 17     |
|                | Small Cattle | Correlation  |        |              | 1.000  | .495*     | .902** | .843** |
|                |              | P            |        |              |        | .043      | .000   | .000   |
|                |              | N            |        |              | 17     | 17        | 17     | 17     |
|                | Cereal       | Correlation  |        |              |        | 1.000     | .676** | .664** |
|                |              | P            |        |              |        |           | .003   | .004   |
|                |              | N            |        |              |        | 17        | 17     | 17     |
|                | Vegetable    | Correlation  |        |              |        |           | 1.000  | .875** |
|                |              | P            |        |              |        |           |        | .000   |
|                |              | N            |        |              |        |           | 17     | 17     |
|                | Fruit        | Correlation  |        |              |        |           |        | 1.000  |
|                |              | P            |        |              |        |           |        |        |
|                |              | N            |        |              |        |           |        | 17     |

\*\* . Correlation is significant at the 0.01 level (2-tailed).

\* . Correlation is significant at the 0.05 level (2-tailed).

**Table 6.** Migration information regarding Van Province (2008-2013).

|                        | 2008   | 2009   | 2010   | 2011    | 2012   | 2013   |
|------------------------|--------|--------|--------|---------|--------|--------|
| Migration Received     | 21,187 | 22,866 | 23,231 | 23,415  | 50,003 | 32,118 |
| Migration              | 30,275 | 27,175 | 31,312 | 72,273  | 46,639 | 38,507 |
| Net Migration          | -9,088 | -4,309 | -8,081 | -48,858 | 3,364  | -6,389 |
| Net Migration Rate (%) | -9,01  | -4,21  | -7,77  | -46,67  | 3,20   | -5,95  |

### 3.5. 2023 Kahramanmaraş Earthquake Example

On February 6, 2023, two earthquakes of magnitude 7.7 and 7.6 occurred in Kahramanmaraş, affecting 15.7% of the 13.4 million population in the disaster zone covering 10 provinces. Moreover, such a large size of the disaster zone, which includes 13% of Türkiye's 25.3 million households, increases losses (TurkStat 2024). There are 3,029,422 households in the earthquake zone, with an average household size of 3.5 persons. Considering that the average household size in Türkiye is 3.2 persons, the number of people living in households in the provinces in the region is above the average of Türkiye (TCSBB, 2023). In the 10 provinces affected by the earthquake, there are natural protected areas, nature parks, wetlands, forest areas, wildlife development areas, and important river basins with endemic plant and animal species. 4.35% of Türkiye's ecologically important areas are in this region (TCSBB, 2023). According to a report prepared by the Presidency of Strategy and Budget of the Republic of Türkiye, the total number of houses categorized as urgent demolition, collapsed, or heavily damaged is 507,853. The number of houses with moderate damage was estimated as 130,054, and the number of houses with minor damage as 1,248,576 (Table 7). According to these data, 2,273,551 people directly faced housing problems after the earthquake. The ongoing impact of the earthquakes and the conditions in the earthquake zone deepen the housing problem.

On the other hand, 14,314 barns and 94,217 commercial establishments were severely damaged in areas declared “disasters affecting general life”; total damage amounted to \$2.2 billion. The geography affected by the earthquake’s accounts for about 20% of Türkiye's agricultural production. The effects of the earthquakes also displaced a large part of the local agricultural population (FAO 2023). The region's 40.3 million decares of agricultural land accounts for 16.9 percent of Türkiye's agricultural land. By 2022, 26 percent of Türkiye's fruit

growing area and 16.2 percent of its arable agriculture area are in these provinces. The region has an important place in the country's agriculture in terms of apricot, almond, pomegranate and olive production. In Türkiye, 13 percent of cattle and 17.8 percent of sheep and goats are found in the earthquake provinces. The provinces in the earthquake zone are located in the Seyhan, Ceyhan, Asi and Euphrates basins, which are among the richest basins in terms of water resources in Türkiye. Thirty percent of Türkiye's basin precipitation area and 39 percent of the annual runoff amount are in these basins (TCSBB 2023). The total number of agri-food enterprises in Türkiye is 457,723. Of these, 54,573 are affected by the earthquake. Adana has the highest number of enterprises (13,300), followed by Gaziantep (8,839), Hatay (8,829), Diyarbakır (8,600), and Kahramanmaraş (5,401) (FAO 2023). There are Adana, Diyarbakır, Gaziantep, Hatay, and Şanlıurfa Food Control Laboratories operating under TOBB in the region. Malatya Sugar Factories of Türkiye Şeker Fabrikaları A.Ş., privately owned Elbistan Sugar Factory, and Adana and Diyarbakır Meat Combines of the Meat and Milk Board are also operating in the region (TOBB 2024). Of the 12 privately owned product warehouses with a capacity of 558,250 tons in Adana, Diyarbakır, Gaziantep, Kahramanmaraş, and Hatay, 26.1 percent were heavily damaged, 33.4 percent were moderately damaged, and 40.6 percent were slightly damaged. The total cost of these damages is estimated at 221 million TL (11.7 million USD). In the livestock sector, 8,241 cattle, 64,260 sheep and goats, and 42,000 heads of poultry died. In addition, 533,000 chicks perished in Adıyaman and 168,000 in Malatya. In this context, it is estimated that breeders suffered a loss of 602.5 million TL (31.9 million USD) due to animal deaths (TCSBB, 2023). Of the 18 warehouses with a total capacity of 315,100 tons belonging to the Turkish Grain Board (TMO) in the region, 9.5 percent were destroyed, 22.1 percent were moderately damaged, and 68.4 percent were slightly damaged. Total damage is estimated at 81.6 million TL (4.3 million USD). As a result of this disaster, there was a significant loss of life among the elderly population, which is widespread in rural areas and villages, and serious damage to the agricultural sector. The population of 10.8 million in 2007 increased to 13.42 million in 2022 and then experienced a remarkable decline to 13.18 million in 2023. This decline may be due to migration movements and deaths in the region as a result of the 2023 Kahramanmaraş earthquake. The number of cattle increased by 96% in 2023 compared to 2007 (from 1,061,042 to 2,082,022). The highest increase was seen between 2018 and 2021, with a slight decline in 2022, and a rebound in 2023. The increase in 2023 may indicate the start of recovery efforts. There was an increase of 79% compared to 2007, but a decrease in 2022 compared to 2021, and an increase again in 2023. Small ruminants still play an important role in agricultural production.

**Table 7.** Damage assessment report by province.

| Province      | Total Emergency + Heavy + Destroyed | Number of Moderately Damaged Houses | Number of Less Damaged Houses |
|---------------|-------------------------------------|-------------------------------------|-------------------------------|
| Adana         | 2,952                               | 11,768                              | 71,072                        |
| Adıyaman      | 56,256                              | 18,715                              | 72,729                        |
| Diyarbakır    | 8,602                               | 11,209                              | 113,223                       |
| Gaziantep     | 29,155                              | 20,251                              | 236,497                       |
| Kahramanmaraş | 99,326                              | 17,887                              | 161,137                       |
| Malatya       | 71,519                              | 12,801                              | 107,765                       |
| Hatay         | 215,255                             | 25,957                              | 189,317                       |
| Kilis         | 2,514                               | 1,303                               | 27,969                        |
| Osmaniye      | 16,111                              | 4,122                               | 69,466                        |
| Şanlıurfa     | 6,163                               | 6,041                               | 199,401                       |
| <b>Total</b>  | <b>507,853</b>                      | <b>130,054</b>                      | <b>1,248,576</b>              |

Source: (TCSBB, 2023)

**Table 8.** Changes in population, number of cattle, number of sheep, grain planting area, vegetable planting area and fruit planting area between 2007-2023.

| Years | Population | *      | **     | Cattle    | *      | **     | Small Cattle | *      | **     | Cereal     | *      | **     | Vegetable | *      | **     | Fruit     | *      | **     |
|-------|------------|--------|--------|-----------|--------|--------|--------------|--------|--------|------------|--------|--------|-----------|--------|--------|-----------|--------|--------|
| 2007  | 10,817,288 | 100.00 | 100.00 | 1,061,042 | 100.00 | 100.00 | 3,215,340    | 100.00 | 100.00 | 13,041,023 | 100.00 | 100.00 | 3,742,040 | 100.00 | 100.00 | 3,054,548 | 100.00 | 100.00 |
| 2008  | 11,052,730 | 102.18 | 102.18 | 1,025,919 | 96.69  | 96.69  | 3,128,259    | 97.29  | 97.29  | 10,763,647 | 82.54  | 82.54  | 3,906,264 | 104.39 | 104.39 | 3,145,089 | 102.96 | 102.96 |
| 2009  | 11,249,820 | 104.00 | 101.78 | 1,033,063 | 97.36  | 100.70 | 3,913,990    | 121.73 | 125.12 | 12,366,071 | 94.82  | 114.89 | 3,791,752 | 101.33 | 97.07  | 3,644,044 | 119.30 | 115.86 |
| 2010  | 11,437,638 | 105.73 | 101.67 | 1,169,093 | 110.18 | 113.17 | 2,966,884    | 92.27  | 75.80  | 13,533,132 | 103.77 | 109.44 | 3,727,008 | 99.60  | 98.29  | 3,540,059 | 115.89 | 97.15  |
| 2011  | 11,639,701 | 107.60 | 101.77 | 1,334,631 | 125.78 | 114.16 | 3,489,608    | 108.53 | 117.62 | 14,458,721 | 110.87 | 106.84 | 3,548,796 | 94.84  | 95.22  | 3,764,982 | 123.26 | 106.35 |
| 2012  | 11,800,365 | 109.09 | 101.38 | 1,502,810 | 141.64 | 112.60 | 3,978,651    | 123.74 | 114.01 | 14,308,930 | 109.72 | 98.96  | 3,511,558 | 93.84  | 98.95  | 3,887,367 | 127.26 | 103.25 |
| 2013  | 11,969,176 | 110.65 | 101.43 | 1,533,505 | 144.53 | 102.04 | 4,329,221    | 134.64 | 108.81 | 15,716,089 | 120.51 | 109.83 | 3,668,539 | 104.47 | 104.47 | 4,201,888 | 137.56 | 108.09 |
| 2014  | 12,147,617 | 112.30 | 101.49 | 1,551,173 | 146.19 | 101.15 | 4,864,282    | 151.28 | 112.36 | 14,341,000 | 109.97 | 91.25  | 3,529,611 | 96.21  | 96.21  | 3,512,683 | 115.00 | 83.60  |
| 2015  | 12,310,842 | 113.81 | 101.34 | 1,542,274 | 145.35 | 99.43  | 4,459,827    | 138.70 | 91.69  | 15,830,804 | 121.39 | 110.39 | 3,683,854 | 104.37 | 104.37 | 4,461,650 | 146.07 | 127.02 |
| 2016  | 12,502,248 | 115.58 | 101.55 | 1,617,676 | 152.46 | 104.89 | 4,484,066    | 139.46 | 100.54 | 14,574,763 | 111.76 | 92.07  | 3,809,873 | 103.42 | 103.42 | 4,280,022 | 140.12 | 95.93  |
| 2017  | 12,676,288 | 117.19 | 101.39 | 2,026,425 | 190.98 | 125.27 | 4,965,520    | 154.43 | 110.74 | 16,067,602 | 123.21 | 110.24 | 3,736,190 | 98.07  | 98.07  | 4,809,681 | 157.46 | 112.38 |
| 2018  | 12,870,105 | 118.98 | 101.53 | 2,250,870 | 212.14 | 111.08 | 5,307,748    | 165.08 | 106.89 | 15,033,374 | 93.56  | 93.56  | 3,791,883 | 101.49 | 101.49 | 4,773,536 | 156.28 | 99.25  |
| 2019  | 13,028,146 | 120.44 | 101.23 | 2,264,371 | 213.41 | 100.60 | 5,565,337    | 173.09 | 104.85 | 15,163,870 | 94.38  | 100.87 | 3,787,499 | 99.88  | 99.88  | 4,472,875 | 146.43 | 93.70  |
| 2020  | 13,216,008 | 122.17 | 101.44 | 2,205,694 | 207.88 | 97.41  | 6,182,902    | 192.29 | 111.10 | 17,038,147 | 106.04 | 112.36 | 3,865,952 | 102.07 | 102.07 | 4,507,238 | 147.56 | 100.77 |
| 2021  | 13,309,886 | 123.04 | 100.71 | 2,165,024 | 204.05 | 98.16  | 6,462,097    | 200.98 | 104.52 | 16,284,255 | 101.35 | 95.58  | 3,840,039 | 99.33  | 99.33  | 5,255,053 | 172.04 | 116.59 |
| 2022  | 13,421,699 | 124.08 | 100.84 | 2,048,716 | 193.09 | 94.63  | 6,167,836    | 191.83 | 95.45  | 16,988,752 | 105.73 | 104.33 | 3,519,562 | 91.65  | 91.65  | 5,475,715 | 179.26 | 104.20 |
| 2023  | 13,188,335 | 121.92 | 98.26  | 2,082,022 | 196.22 | 101.63 | 5,755,648    | 179.01 | 93.32  | 17,725,885 | 110.32 | 104.34 | 3,534,541 | 100.43 | 100.43 | 7,301,395 | 239.03 | 133.34 |

Source: (TUIK, 2024)

Notes: \* Simple index values, \*\* Chain index values, Population: (person), Cattle: Cattle Production (Number), Small Cattle: Small Cattle Production (Number), Cereals: Production of cereals and other vegetable crops (tons), Vegetables: Total production of vegetables (tons), Fruits: Fruits, beverage and spice crops production (Tons)

Cereal production has been volatile. It peaked in 2020 (17 million tons), but declined slightly in the following years. In 2023, it increased again, reaching 17.7 million tons. This increase can be explained by improvements in production policies or a favorable change in climatic conditions. Vegetable production is generally stable, with a significant decline (91.65%) in 2022. In 2023, this production increased again. Post-earthquake revitalization efforts may have been effective here as well. This table shows that there is a general upward trend in agricultural production with population growth. However, deviations in some years (especially 2023) show that natural disasters and migration movements directly affect agriculture and livestock activities. Population declines during crisis periods, such as earthquakes, leads to temporary fluctuations in agricultural production. The increase in the number of fruits and small ruminants in particular shows that these areas have a higher resilience capacity (Table 9).

**Table 9.** Analysis of the relationship between demographic structure and agricultural sector of Kahramanmaraş province.

|                |              | Correlations |        |              |        |           |       |        |
|----------------|--------------|--------------|--------|--------------|--------|-----------|-------|--------|
|                |              | Population   | Cattle | Small Cattle | Cereal | Vegetable | Fruit |        |
| Spearman's rho | Population   | Correlation  | 1.000  | .914**       | .963** | .897**    | .007  | .917** |
|                |              | P            |        | .000         | .000   | .000      | .978  | .000   |
|                |              | N            | 17     | 17           | 17     | 17        | 17    | 17     |
|                | Cattle       | Correlation  |        | 1.000        | .909** | .782**    | .103  | .811** |
|                |              | P            |        |              | .000   | .000      | .694  | .000   |
|                |              | N            |        | 17           | 17     | 17        | 17    | 17     |
|                | Small Cattle | Correlation  |        |              | 1.000  | .855**    | .074  | .858** |
|                |              | P            |        |              |        | .000      | .779  | .000   |
|                |              | N            |        |              | 17     | 17        | 17    | 17     |
|                | Cereal       | Correlation  |        |              |        | 1.000     | -.113 | .904** |
|                |              | P            |        |              |        |           | .667  | .000   |
|                |              | N            |        |              |        | 17        | 17    | 17     |
|                | Vegetable    | Correlation  |        |              |        |           | 1.000 | -.044  |
|                |              | P            |        |              |        |           |       | .866   |
|                |              | N            |        |              |        |           | 17    | 17     |
|                | Fruit        | Correlation  |        |              |        |           |       | 1.000  |
|                |              | P            |        |              |        |           |       |        |
|                |              | N            |        |              |        |           |       | 17     |

\*\* . Correlation is significant at the 0.01 level (2-tailed).

Correlation analysis was conducted to determine the relationship between population structure and animal and crop production in Kahramanmaraş and its surrounding provinces (Table 9). The results of the analysis are like those of Van province. According to the Spearman correlation coefficient, positive and significant relationships were found between demographic structure and cattle ( $r = 0.914$ ) and ovine ( $r = 0.963$ ) livestock. Similarly, significant relationships were found between population and cereal ( $r = 0.897$ ) and fruit and vegetable production ( $r = 0.917$ ). This indicates that an increase in population increases production, while a decrease in population leads to a decrease in livestock and production. Panwar and Sen (2019) state that disasters affect different sectors according to their intensity and types, and that these effects are more pronounced in developing countries.

#### 4. Conclusion and Suggestions

Türkiye is located in a region prone to frequent natural disasters. Indeed, many earthquakes in the last eighty years, especially the Erzincan earthquake in 1939 and the Marmara earthquake in 1999, have caused the loss of many lives and heavy economic losses. Most recently, the 7.8 and 7.6 magnitude earthquakes in Kahramanmaraş on February 6, 2023, caused heavy losses not only to the regional economy but also to the national economy. The most obvious consequences of earthquakes are high mortality rates, physical

destruction of buildings and infrastructure, and extensive damage to agricultural land, all of which harm the regional economy. The physical loss of buildings and infrastructure, the decline in the labor force, and the loss of arable farmland not only cause short-term damage, but also have significant economic consequences, such as a decline in consumer confidence, potential earnings, and the production and quality of the labor force, leading to recessions and a slowdown in investment. As a result of the major earthquakes, infrastructure and superstructure collapsed, hundreds of thousands of buildings were destroyed, and qualified labor and education were lost. In addition, tourism in the region came to a halt, and agriculture and animal husbandry activities suffered a major blow. There is a lack of information on the quantitative economic impact of these disasters on agriculture, the characteristics of the affected population, food safety, production, and marketing. As a result of the earthquakes, collapses, cracks, landslides, slides, splits, or fractures in the agricultural lands make it difficult to carry out agricultural production. In addition, agricultural irrigation systems, i.e., agricultural structures such as irrigation canals and pipes, farms, animal shelters, etc, are damaged by these effects on agricultural lands. Migration due to these unfavorable conditions caused by earthquakes will also cause a delay in agricultural production. In addition to these physical problems, earthquakes also damage plant and animal production activities. These damages may be in the form of delay or inability to carry out agricultural production activities, as well as loss of products and stored inputs during harvesting, and animal waste. Distortions in the land structure will increase production and harvest losses, and feeding problems will arise due to collapse damage in farms.

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