



# DROUGHT-INDUCED HUMAN DISPLACEMENT IN TURKEY

Amir H. Delju, Etienne Piguet, Martine Rebetez and Abdullah Ceylan

## **Authors**

Amir H. Delju, Etienne Piguet, Martine Rebetez, Abdullah Ceylan

Amir H. Delju, World Meteorological Organization (WMO), Geneva, Switzerland  
adelju@wmo.int

Etienne Piguet, Geography Institute, University of Neuchatel, Neuchatel, Switzerland  
etienne.piguet@unine.ch

Martine Rebetez, WSL Swiss Federal Research Institute, Neuchatel, University of Neuchatel, Neuchatel, Switzerland  
martine.rebetez@wsl.ch

Abdullah Ceylan, Turkish State Service (TSMS), Ankara, Turkey  
aceylan@mgm.gov.tr

Corresponding author: Amir H. Delju, Tel: +41 22 730 8360, Fax: +41 22 730 8042

## **Abstract**

This paper analyses the correlation between drought spells, using the Standardized Precipitation Index and internal migration in rural communities in Turkey between 2007 and 2015. It aims to assess the quantified and evidence-based relationship between the compound effect of drought and migration in Turkey. As the correlation coefficient between the SPI and the Rate of Net Migration showed direct links between drought and internal migration, we arranged the twelve statistical regions of Turkey into three groups: a) magnet for migrants, b) neutral regions, and c) sources of out-migration. Based on the review of reference materials, it appeared that economy and security were the most powerful non-climate factors that affected migration. In our analysis, we demonstrate that the impact of drought varies across the country depending on each region's climate pattern, socio-economic situation, security, and stability. The net impact of drought and climate variability on migration in Turkey is determining, yet not absolute. It hides behind non-climatic elements, some of which appear as strong drivers for migration. The study also revealed that in the regions where security was not an issue, wet periods coincided with a lower flow of out-migration from rural areas. Finally, we have noted that the economic diversification of Turkey presents attractive opportunities and thus affects the preferred choice of rural emigrants for internal displacement.

## **Keywords**

Drought

Climate

Impact assessment

Agriculture

Internal migration

Turkey

## **Acknowledgments**

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## 1. Introduction

The purpose of this paper is to explore and describe the correlation between drought as a natural climatic “push factor” and human displacement amongst small-holding farmers and rural communities in Turkey. In order to assess the net impact of moderate to extreme droughts as push factor and environmental stressor on internal migration dynamics between 2007 and 2015, we monitored the movement of rural populations in drought periods, particularly in Eastern and Central Anatolia, which are the main croplands of the country. Push factors here refer to those factors that lead populations to leave their homes.

Droughts are classified into four types: meteorological, hydrologic, agricultural and socio-economic (Wilhite D. et al. 1985). There are many ways in which droughts differ from most other climatic events, especially as their onset and end do not occur in a distinct way; they creep in slowly and linger, especially socio-economic droughts until all their multifaceted impacts have faded away (Wilhite D. et al. 1985). According to the Intergovernmental Panel on Climate Change (IPCC)’s Fifth Assessment Report (AR 5) (2013), with high confidence, droughts during the 21st century will have bigger magnitude and longer duration than those observed since the beginning of the 20th century in many parts of the world (Masson-Delmotte, V. et al. 2013, p. 386). Furthermore, under scenario RCP 8.5 of the IPCC (2014), “in presently dry regions, drought frequency will likely increase by the end of the 21st century” (medium confidence) (p.14).

There is no one definition proposed for drought and each type of it has a unique definition, while all are interlinked in one way or another. For the purpose of this study, we have used standardized precipitation (McKee et al. 1993), which is routinely used to characterize meteorological drought. Droughts threaten agriculture and food security globally. According to Wilhite D. & Glantz M. (1985), they develop in slow temporal patterns and underlying impacts may remain for a long period of time, even during wet periods. However, each drought presents a unique set of impacts based on its onset, period, intensity and geographical coverage. These vary according to its severity, length, and spatial extent, as well as on social and economic factors and dynamics (Wilhite D. et al. 1985).

Based on the above considerations, we selected Turkey for a number of reasons: a) the ease of access to high standard meteorological data, b) the availability of a wide range of socio-economic information required for this study, and c) the important contribution of agriculture to Turkey’s GDP.

## 2. Geography

### 2.1. Geography

Turkey lies between 39° North and 35° East. It connects Southeastern Europe to Southwestern Asia. Turkey has eight neighboring countries: Armenia, Bulgaria, Georgia, Greece, Iran, Iraq, Nakhchivan, and Syria. This country is surrounded by large bodies of water such as the Mediterranean Sea in the south, the Aegean Sea in the west, and the Black Sea and the Sea of Marmara in the north (CIA 2017).

### 2.2. Climate

We have used data from the Turkish State Meteorological Service (TSMS) to present the climate of Turkey. According to Sensoy S. et al (TSMS 2008), summers in Turkey are hot and dry, while winters are generally mild to cold and wet. However, winters in the eastern part of the country are severe and temperatures of –30°C to –38°C can be observed in the

mountainous areas. In terms of rainfall, Sensoy S. et al (TSMS 2008) have recorded an annual average of 2,200mm in the Black Sea coasts (Ritz and Hopa), and 250mm to 300mm in Konya, Central Anatolia, and in Iğdır, Eastern Anatolia. For the period 1971-2000, TSMS (2008) has reported annual average precipitation in Turkey of about 640mm, showing a decreasing trend of 29mm per 100 years.

### *2.3. Socioeconomic factors*

According to the Investment Support and Promotion Agency of Turkey (hereafter “ISPAT”) (2017), although industry and services are the main drivers of Turkey's economy today, traditional agriculture and the food industry still account for about 20% of the working population. Between 2002 and 2016, ISPAT (2017) data shows that the contribution of agriculture to Turkey's overall GDP increased by 40% and averaged a contribution of 9% between 2000 and 2010. In 2016, this contribution represented USD 52.3 billion or 6.1% of Turkey's GDP (Investment Support and Promotion Agency of Turkey 2017; CIA 2017). Moreover, this country has been the world's 7th largest agricultural producer (OECD 2012; Investment Support and Promotion Agency of Turkey 2017). Over the past decade, however, a number of industrial sectors such as the automotive industry, information, and communication technology (ICT), and tourism, have become more lucrative and profitable than agriculture. As a result, they now play an essential role in the country's economy, in particular as sources of employment.

Perception of drought period is different in various localities, depending on their climate system, however, in all cases, lower than “normal” precipitation is a prerequisite. For example, in dry regions lack of precipitation or very little rainfall for several months is considered a drought, while in wet regions, the absence of precipitation for two consecutive weeks or so establishes drought condition. After their onset, droughts continue for a much longer period. Beyond these quantitative elements, socioeconomic drought differs markedly from the other types because it associates the supply and demand of some economic good or service with elements of meteorological, agricultural, and hydrological drought. In other words, it implies that the lack of proportion between water supply and corresponding population requirement is one of the indicators in the severity of socioeconomic drought (Wilhite D. et al. 2014).

Drought vulnerability assessment helps better understand a broad range of socio-economic impacts and put it in a conceptual framework (González Tánago I. et al 2016). Vulnerability in drought-stricken areas depends on population, the social condition of people and their dependency on water (Wilhite D. et al. 2014). Drought severity depends not only on natural factors such as the period, intensity and geographical coverage but also on water-intensive human activities and the type of vegetation in the affected region (Sivakumar et al 2002). Nevertheless, in all scenarios, early preparedness against droughts can significantly reduce vulnerability and its impacts (Sivakumar M.V.K. et al 2002). In a comprehensive approach to drought early warning, a combination of physical elements from precipitation to other data such as water supply and soil moisture are considered all together with social indicators (Wilhite D. et al. 2014).

### *2.4. Demographics*

Since 2007, Turkey has established the Address-Based Population Registration System (ABPRS) to implement more efficient public services and to obtain updated information on population, localities and population movements. Before 2007, in and out-migration in provinces and regions were not available to the authors of this paper.

According to the ABPRS and TurkStat (TurkStat 2015), the country's population was 77.7 million as of 31 December 2014. The percentage of people living in the province and district centers increased from 77.3% in 2012 to 91.3% in 2013 (TurkStat 2015). Looking at TurkStat (2015) data, one can see that this sharp increase is linked to the establishment of fourteen new metropolitan municipalities and the enlargement of municipal areas by the merging of towns and villages in all of the country's thirty metropolitan provinces. In 2014, the percentage of people living in the province and district increased again to reach 91.8% (TurkStat 2015).

In 2014, according to TurkStat (2015), İstanbul was the most populated province with 18.5% of the total population. Other provinces, in order of population magnitude, were: Ankara (6.6%), İzmir (5.3%), Bursa (3.6%) and Antalya (2.9%). The least populated province was Bayburt, in Northeast Anatolia, with 80,607 inhabitants.

### 3. State of the Art

Direct and indirect studies of drought-related migration have been conducted in various regions of the world; many of which may be used for developing insights into future trends. Although most of these studies focus on cross-border migration, they confirm that drought indirectly affects household income and triggers in-country human displacement, particularly among younger inhabitants, who are potentially more able to look for job opportunities in major cities and provinces. For example, Dell M. et al. (2012) show that in poor countries, "a 1°C rise in temperature in a given year reduces economic growth that year by about 1.3 percentage points" (p.67). Furthermore, Dell M. et al. (2012) argue that higher temperatures in poor countries not only reduce agricultural output, they also lead to "reductions in industrial output and political stability" (pp. 92-93).

In terms of resilience and adaptability to drought, climate and weather conditions such as drought and flood appear to be natural threats to agricultural production and have the potential to disrupt feedstock prices (Deloitte 2010). Other researchers further show that income level and poverty play a determining, yet not absolute, role in migration from rural areas (Leighton M. 2011; Janvry de A. et al. 1997, in Piquet E. eds. 2011).

Researchers such as Afifi T. et al. (2015) have mostly focused on another climatic parameter, rainfall, and related climatic events including floods, drought, seasonal shift, and dry spells. They consider rainfall to be one of the most important climate variables affecting the livelihoods of farmers and pastoralists in rural areas worldwide (Afifi et al. 2015).

While drought episodes can lead to migration, not all of them do. In most vulnerable communities, migration is the last option to cope with food insecurity, which can be caused by drought (Afifi T. et al. 2015). This simple fact, noticeable in rural areas, leads to a range of theoretical, conceptual and empirical challenges for those who work with environment and migration issues. The livelihoods and well-being of populations in rural areas, villages and towns are closely tied to agriculture and other natural resource-based activities. Such activities are intrinsically sensitive to climatic variability.

As a number of regions may become more frequently exposed to severe drought conditions, the net effect of climate-induced changes in the agricultural sector is likely to generate more migration out of the agricultural sector and into non-farming opportunities. As employment opportunities further decline, there would be an increase in rural out-migration from more marginal areas "exacerbating urbanization and long-term, more distant patterns of migrations for those who are able" (Black R. et al. 2008, p. 56). It is interesting to consider this trend in conjunction with the key role played by natural

population increase in urbanization (Cohen B. 2003) and the establishment in Turkey of fourteen new metropolitan municipalities and the enlargement of municipal areas in 2014.

Furthermore, beyond unemployment, which can be an important factor in migration decision, cultural variables, such as common languages and shared history, also play an important role in decisions to migrate (Afifi T. et al. 2008). This is probably the case in Turkey, where industry and tourism are two growing sectors, which serve as population magnet and revenue diversification sources in different geographical regions of the country. This might increase the pace of domestic rural-urban migration, and, to a lesser extent, international migration. According to the World Bank, “this increased migration will likely follow well-established migration networks, making it hard to isolate the extra migration due to climate change” (Haddad M. and Shepherd B. 2011, p.293)

When considering the impact of drought-induced economic pressures, Chen Y. et al. (2009) use a Coupled Regional Economy-Ecology Model to draw a two-way interaction between the ecosystem and a regional economy with consumption and production pattern. In contrast, the economic gap can also stand as a key factor for one-way migration. Collier et al. (2011) argue that “higher incomes in destination countries provide a strong ‘pull’ factor, while low incomes in the countries of origin exert a ‘push’ to migrate” (p. 3). However, in terms of vulnerability on an international scale, purely economic aspects aside, low- and lower-middle-income countries are less resilient to climate change than high-income countries and their livelihoods are more vulnerable (Stern N. 2007).

In contrast to the purely economic argument on migration, other groups of scientists focus on vulnerable communities’ access to vital resources, such as water and soil. For example, Grey et al. (2011) has looked at the effects of soil quality on population mobility, aiming to understand better the correlation between soil condition, especially soil moisture and “human migration or other social outcomes for potentially vulnerable households” (p. 1). A further interesting concept here is that of natural capital. According to research by Ellis F. (2000), in agricultural households, soils can be regarded as a form of natural capital. Natural capital also includes land, water, and wildlife. It supports rural livelihoods and complements reserves of human, social and physical capitals (Ellis F. 2000; Nawrotzki R. J. et al. 2012).

Further to the above-mentioned approaches, researchers argue that, except in extreme cases, population displacements are always the result of a multi-causal relationship between environmental, political, economic, social, and cultural dimensions (Piguet E. et al. 2010, p. 1). It is indeed undeniable that climate change has a range of diverse impacts across countries (Black R. et al. 2011). In fact, according to Warner K. et al. (2014), the question is not whether environmental drivers are the sole factors triggering human displacement, but rather how the interactions of these factors lead to migration choices.

Another possible interpretation of such results is that climatic impacts are so complex that they cannot be entirely explained by a single aspect. However, we believe that the physical and social impacts of drought are more clearly observed and tracked in climate-sensitive sectors, particularly in water and agriculture.

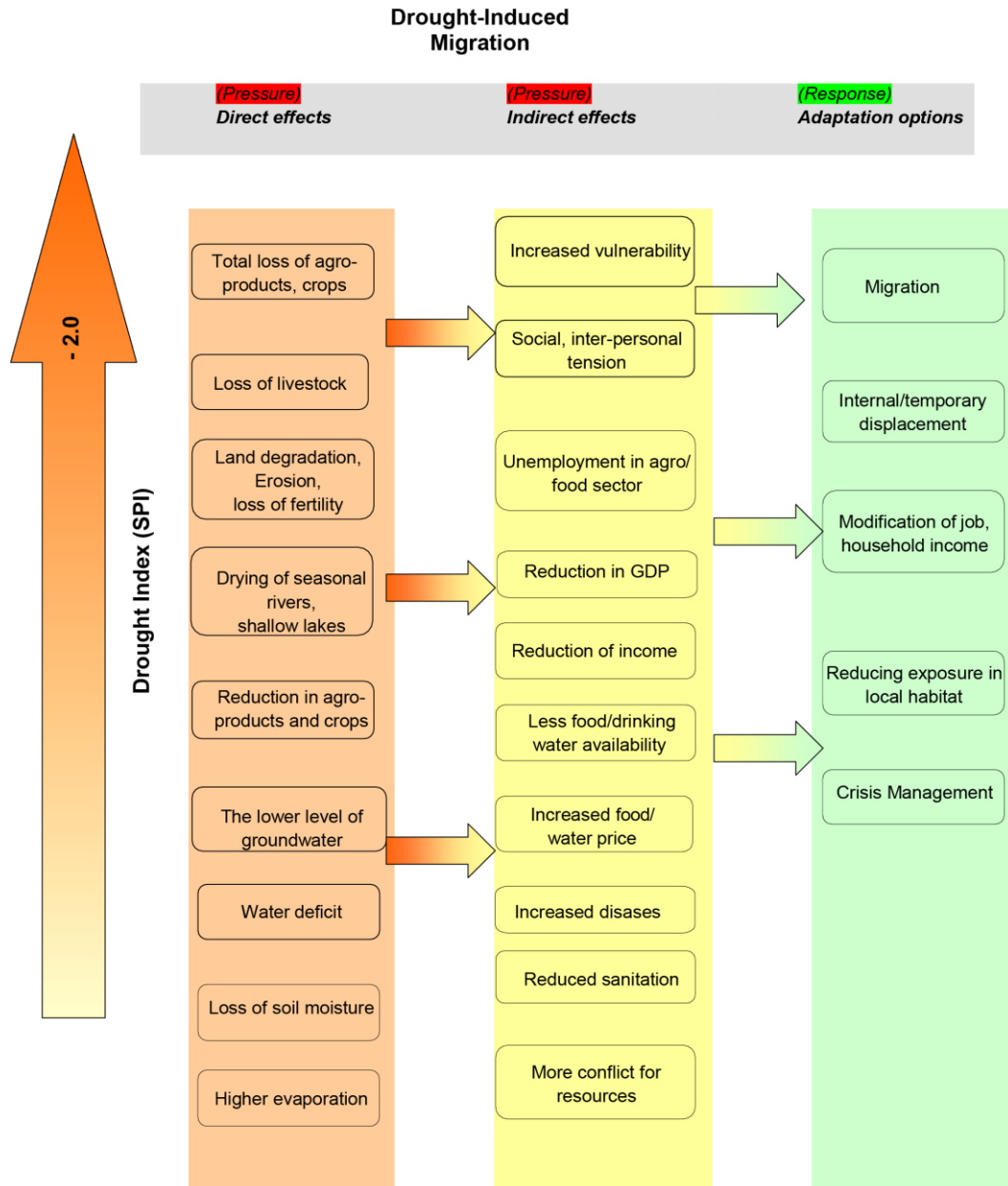
We have noted through our analysis that most of the studies on drought and migration did not conduct an independent analysis of climatic parameters; rather they have based their interpretations and conclusions on overall global and regional climate change reports, which were intended for other purposes. Additionally, in the majority of cases, calculations of the climatic parameters, particularly temperature and rainfall, are conducted separately and without making meaningful linkages. In the case of drought, there are standardized methodologies which factor in either rainfall or additional parameters such as temperature,

evaporation and soil moisture - depending on the availability of such datasets, as well as on climatic patterns and geographical circumstances. These methods help draw quantified values for the intensity and frequency of droughts. Furthermore, the results produced following such methods can be compared across different regions with markedly different climates.

Research on migration patterns, which used non-climatic data, often faces issues of lack of consistent and comparable indicators such as time-series data on net migration (Sherbinin A. D. et al. 2012). Analysis of time-series is an ideal way to capture climate-induced consequences. Recent research by Dallmann I. et al. (2017) focused on India has used the Standardized Precipitation Index (SPI) for their study in combination with census data to analyze bilateral migration rates. The results in their paper show that drought frequency acts as a push factor on “inter-state migration in India”. There are other case studies such as Kadirbeyoglu Z. (2009)’s EACH-FOR Turkey Case Study Report, which are based on interviews of local communities by a team of experts, that show that in certain cases (e.g. Suruç district, Urfa city), long drought periods combined with groundwater depletion have led to forced migration. Such extreme cases are very few and cannot be attributed to the whole country.

#### **4. Hypothesis**

Based on the existing literature, our overall assumption for this case study is that drought is a natural push factor and environmental stressor only in synergy with socioeconomic parameters. Furthermore, it acts as a multiplier of pressure on local water access, agricultural productivity and employment (Delju A. H. et al. 2012), which in turn might lead to internal migration. This is especially the case in the agricultural sector where the impact on living conditions could be such that a proportion of the farmer community might be forced off their land. We assume that drought and desertification threaten rural households directly by affecting resources such as land and water and indirectly by contributing to the decline of agricultural income or rural employment (Leighton M. 2011; Pigué E. et al. 2010). Figure 1 identifies a number of direct and indirect parameters, which play a role in the drought-induced migration process. The indirect impacts of drought were not in the scope of this paper. This figure shows that migration should not only be seen as a short-term escape strategy, but also as a long-term adaptation strategy to reduce vulnerability to income fluctuation and security instability. Nevertheless, obviously, a more in-depth understanding of how climatic factors affect migration choices will help to shape adequate policies and investments strategies (Warner K. et al. 2014).



**Figure 1:** A conceptual model of physical and social factors in drought-induced migration

## 5. Data and methods

### 5.1. Climate Data

We have used the monthly mean precipitation data of two hundred and ten synoptic and climatological stations in Turkey for the period of 1971 to 2015. A distribution map of these stations is given in figure 2. Although this period was much longer than the demographic data available to authors, we have chosen the longest period and a maximum number of stations with reliable data to provide a full understanding of the frequency and intensity of drought spells in Turkey. In climatology, the general recommendation by the World Meteorological Organization (WMO)- (WMO 2011, No. 100) to show secular trends is to use at least thirty-year periods of reference. The data used in this study was made

available by the Turkish State Meteorological Service (TSMS). As a WMO operational standard, TSMS historical data archives and climatological time series are quality controlled and calibrated to be free from spurious data and bias, in the case of change of instruments or relocation of the stations. The randomness of the annual data sets of monthly mean precipitation for 1971 to 2015 was investigated by TSMS through tests for homogeneity. The stations with complete time series were selected for data analysis.

| Index                | Climate condition |
|----------------------|-------------------|
| [+] 2.0              | extremely wet     |
| [+] 1.5 to [+] 1.99  | very wet          |
| [+] 1.0 to [+] 1.49  | moderately wet    |
| [-] 0.99 to [+] 0.99 | near normal       |
| [-] 1.0 to [-] 1.49  | moderately dry    |
| [-] 1.5 to [-] 1.99  | severely dry      |
| [-] 2.0 and less     | extremely dry     |

Table 1: SPI values, Source: WMO 1090, 2012, p4

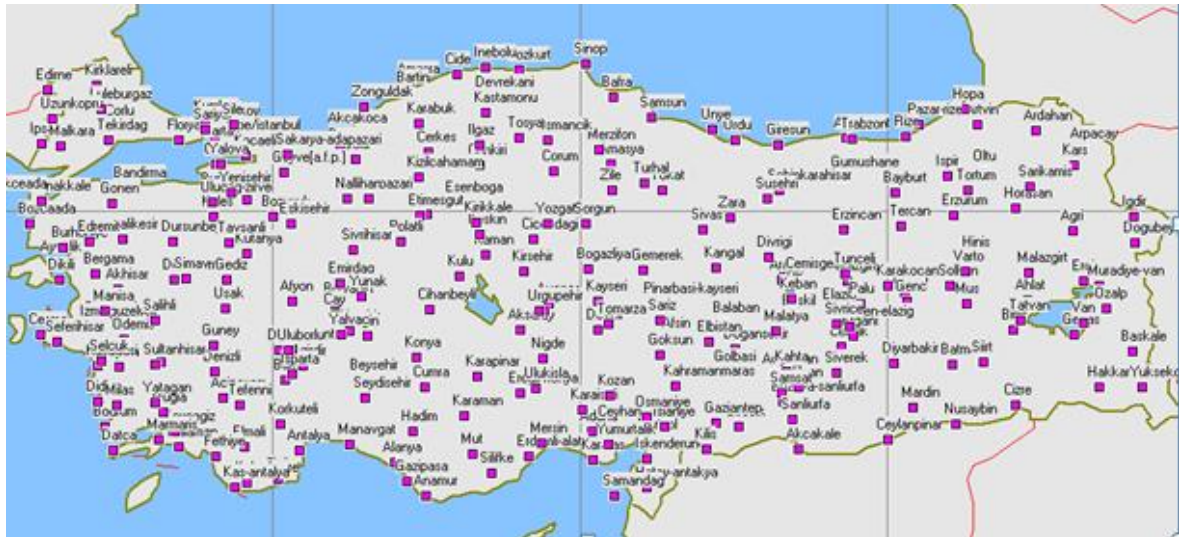


Figure 2: Distribution of synoptic and climatological stations in Turkey. Courtesy of the Turkish State Meteorological Service (TSMS)

| SPI/RNM CORRELATION COEFFICIENT PER YEAR AND REGIONS |           |        |           |        |           |        |           |        |           |        |           |       |           |       |           |       |                                |
|------------------------------------------------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|-------|-----------|-------|-----------|-------|--------------------------------|
| Year                                                 | 2007-2008 |        | 2008-2009 |        | 2009-2010 |        | 2010-2011 |        | 2011-2012 |        | 2012-2013 |       | 2013-2014 |       | 2014-2015 |       | Correlation Coefficient/Region |
| Region                                               | SPI       | RNM    | SPI       | RNM    | SPI       | RNM    | SPI       | RNM    | SPI       | RNM    | SPI       | RNM   | SPI       | RNM   | SPI       | RNM   |                                |
| Istanbul                                             | -0.46     | 2.10   | 1.7       | 3.06   | 2.14      | 7.77   | 0.48      | 8.98   | 0.06      | 2.20   | 0.581     | 4.7   | -1.129    | 1.0   | 0.966     | 3.5   | 0.57                           |
| Western Marmara                                      | -0.86     | 9.73   | 0.56      | 4.03   | 2.22      | 4.62   | 0.75      | 4.95   | 0.31      | 7.74   | 0.702     | 5.9   | -0.278    | 14.0  | 1.673     | 6.1   | -0.68                          |
| Aegean                                               | -1.24     | 3.70   | 0.79      | 1.74   | 1.104     | 0.10   | 0.06      | 0.13   | 0.55      | 2.60   | 0.999     | 1.6   | -0.466    | 4.6   | 1.286     | 3.2   | -0.50                          |
| Eastern Marmara                                      | -0.86     | 12.57  | 0.56      | 6.37   | 2.22      | 5.51   | 0.75      | 6.18   | 0.31      | 5.27   | 0.702     | 6.6   | -0.278    | 7.7   | 1.673     | 9.7   | -0.47                          |
| Western Anatolia                                     | -0.83     | 2.98   | 0.86      | 4.60   | 1.25      | 5.59   | 1.47      | 7.05   | 0.105     | 3.62   | 0.702     | 3.8   | -0.278    | 5.2   | 1.673     | 6.6   | 0.79                           |
| Mediterranean                                        | -1.06     | 2.15   | 0.41      | 0.52   | 1.016     | 0.58   | 0.12      | -1.24  | 0.86      | -1.09  | 0.293     | -0.7  | -1.403    | 0.3   | 0.463     | 0.0   | -0.49                          |
| Central Anatolia                                     | -0.83     | -9.00  | 0.86      | -4.99  | 1.25      | -8.95  | 1.47      | -8.78  | 0.105     | -4.11  | -0.251    | -4.8  | -1.079    | -6.6  | 1.598     | -6.5  | -0.16                          |
| Western Black Sea                                    | 0.66      | -4.35  | 1.1       | -2.40  | 1.36      | -11.16 | 0.39      | -8.80  | 0.51      | -3.20  | -0.358    | -5.7  | -0.792    | -7.7  | 0.33      | -4.4  | 0.00                           |
| Eastern Black Sea                                    | 0.66      | -2.24  | 1.1       | 0.63   | 1.36      | -8.98  | 0.39      | -9.88  | 0.51      | 7.29   | -0.358    | -3.6  | -0.792    | -1.8  | 0.33      | -5.9  | -0.10                          |
| Northeastern Anatolia                                | -0.83     | -26.12 | 0.86      | -14.72 | 1.25      | -13.58 | 1.47      | -12.46 | 0.105     | -15.35 | -0.225    | -19.2 | -1.783    | -19.3 | -0.475    | -21.0 | 0.78                           |
| Central-eastern Anatolia                             | -0.91     | -10.89 | 0.04      | -9.09  | 1.3       | -9.08  | 0.25      | -16.49 | -0.29     | -7.19  | -0.225    | -7.1  | -1.783    | -12.2 | -0.475    | -12.6 | 0.15                           |
| Southeastern Anatolia                                | -2.06     | -7.56  | -0.97     | -7.12  | 0.09      | -3.80  | -1.07     | -4.11  | 0.005     | -7.55  | 0.271     | -5.7  | -1.69     | -6.1  | -0.053    | -8.4  | 0.12                           |
| Correlation Coefficient/Yr.                          | 0.017     |        | 0.34      |        | 0.45      |        | 0.05      |        | 0.41      |        | 0.75      |       | 0.83      |       | 0.84      |       | 0.26                           |

**Table 2:** Mean annual SPI and annual Rate of Net Migration (RNM) correlation coefficients in 12 Statistical Regions in Turkey

## 5.2. Demographic and Socioeconomic data

Table 3 provides definitions of the demographics related terms used in this paper, as defined by the TurkStat Online Portal ([www.turkstat.gov.tr](http://www.turkstat.gov.tr)).

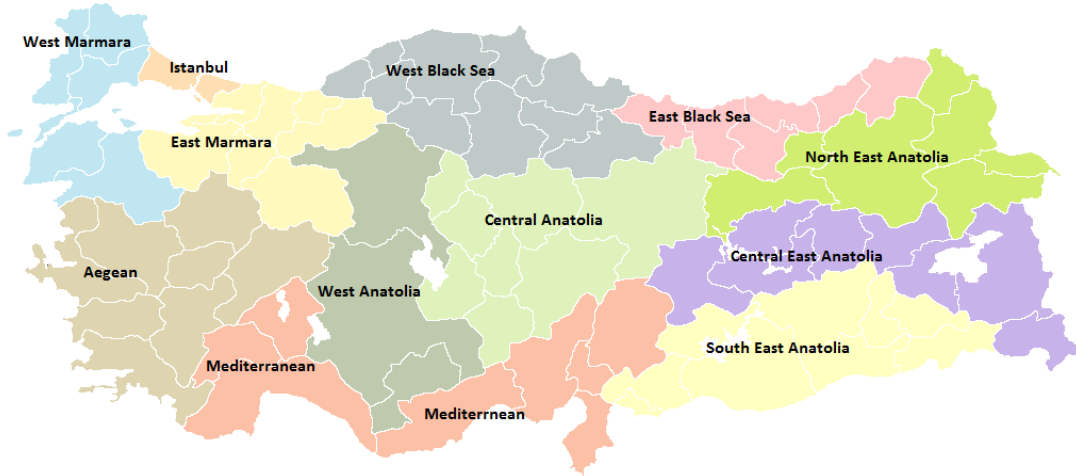
### Key Definitions of Migration-Related Terms by TurkStat

|                                        |                                                                                                                                                                                                                          |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Internal migration</b>              | Internal migration is defined as changes in usual residence addresses of a population within one year in the specific areas (region, province, district, etc.) within the country.                                       |
| <b>In-migration</b>                    | Migrants who arrive in a specific area from other areas within the country.                                                                                                                                              |
| <b>Out-migration</b>                   | Migrants who depart from a specific area to the other areas within the country.                                                                                                                                          |
| <b>Net migration</b>                   | The difference between in-migration and out-migration for a specific area. If in-migration is more than out-migration, net migration is positive. If out-migration is more than in-migration, net migration is negative. |
| <b>The rate of Net Migration (RNM)</b> | The Rate of Net Migration (RNM) is the number of net migration per thousand (‰) persons who are able to migrate.                                                                                                         |

Source: Online <http://www.turkstat.gov.tr>

**Table 3:** Key Definitions of Migration-Related Terms

The following socioeconomic data presented in this paper was obtained from the TurkStat online portals. The Demographic data comprises annual internal migration (in and out-migration) in provinces from 2007 to 2015 in the twelve statistical regions (Figure 3), which compose the Nomenclature of Territorial Units for Statistics (NUTS) (Eurostat Statistics Explained, Glossary, 2017) in Turkey. We have calculated the annual Rate of Net Migration (RNM) based on the above-mentioned data.



**Figure 3:** Twelve statistical regions in Turkey - Reproduced on the basis of Eurostat 2017

The data used excludes the rate of international migration because it is not considered as a possible outcome of environmental consequences in Turkey. This obviously is a limitation of our study. However, the scientific literature generally considers that the main migratory consequences of environmental changes are internal rather than international (Piguet E. 2013). The supplementary socioeconomic data in this paper includes the annual share of agriculture in the GDP of Turkey. This data is used merely to construct a theoretical framework.

### 5.3. Methods

#### 5.3.1. Standardized Precipitation Index (SPI) for drought monitoring

We have used the Standardized Precipitation Index (SPI) for monitoring meteorological drought based on the long-term precipitation data for the period 1971-2015. However, due to limited demographic data, only the period 2007-2015 was chosen to study the correlation between drought and the net rate of migration. We have calculated 1-month aggregation of drought magnitude per year and got mean annual SPI index for the mentioned period. We have followed the WMO methodology (WMO No. 1090, 2012), according to which “the SPI calculation for any location is based on the long-term precipitation record for the desired period” (p. 9). This calculation can result in either positive or negative values, which in this case, correspond to either greater than annual median precipitation, or less than mean annual precipitation. According to the SPI methodology, “drought starts when the SPI value is equal or below -1.0 and ends when the value becomes positive” (WMO No. 1090, 2012, p. 9).

According to McKee et al. (1993), the advantage of the SPI method is that it defines peak intensity and the accumulated magnitude of the drought. We have calculated 1-month aggregation of drought magnitude per year and got mean annual SPI index.

They express Drought Magnitude (DM) as (p. 2):

$$DM = -\left\{ \sum_{j=1}^x SPI_{ij} \right\}$$

A further advantage of the SPI is that it provides a better representation of anomalies for wet and dry spells than the Palmer Drought Severity Index (PDSI) (Guttman, N.B. 1998, pp 113–121).

However, the SPI is sensitive to the quantity and reliability of the data used to fit the distribution. Researchers recommend using at least thirty years of high-quality data (McKee T.B. et al. 1993). We have chosen to use the SPI for drought monitoring because it is a preferred index for regions with reasonable precipitation patterns. The SPI is more applicable to regions where the volume, seasonality, and form of precipitation differ widely between each of the locations (WMO No. 1090, 2012). In addition, the WMO methodology presents it as effective in analyzing both wet and dry periods/cycles (WMO, 2012).

### 5.3.2. Rate of Net Migration (RNM)

According to the definition by TurkStat (TurkStat 2017), the Rate of Net Migration is “the number of net migration per thousand persons who are able to migrate”. Its calculation is shown in table 4.

#### The Rate of Net Migration (RNM)

The Rate of Net Migration (RNM) is calculated by the following formula:

$$m_{(i-i)} = [(M_{i,i} - M_{i,i}) / (P_{i,t+n} - 0,5 * (M_{i,i} - M_{i,i}))] * k$$

Where:

|                       |                                              |
|-----------------------|----------------------------------------------|
| $m_{(i-i)}$ :         | Net migration rate                           |
| $M_{i,i}$ :           | In-migration                                 |
| $M_{i,i}$ :           | Out-migration                                |
| $M_{i,i} - M_{i,i}$ : | Net migration                                |
| $P_{i,t+n}$ :         | Population residing in "i" at the time "t+n" |
| i:                    | The place in which migration is defined      |
| k:                    | Constant (k=1000)                            |

**Table 4:** Rate of Net Migration Calculation (Source: TurkStat)

### 5.3.3. Correlation coefficients between drought indices and Rate of Net Migration (RNM)

We have applied statistical correlation coefficients to find out whether two variables, namely the mean annual drought indices in the SPI and the annual Rate of Net Migration (RNM), are meaningfully correlated or not. The following equation is used for the correlation coefficient:

$$\text{Correl}(X, Y) = \frac{\Sigma(x - \bar{x})(y - \bar{y})}{\sqrt{\Sigma(x - \bar{x})^2 \Sigma(y - \bar{y})^2}}$$

Since the period of the RNM demographic data available to the authors was limited to 2007-2015, we had to limit the SPI analysis at the regional level to 2000-2015 as well, to be consistent. We deliberately chose to focus our empirical analysis on simple statistical methods as the lack of control variable impaired the building of a multi-variant model.

## 6. Results

The SPI analysis is based on observed precipitation data. Figure 4 shows the anomalies of annual average precipitation from 1950 to 2015 compared to the 1971-2000 base period.

The charts in figure 5 represent mean annual values of SPI for the different regions of Turkey for the period 2000-2015. Although we would have preferred to run calculations of the SPI values at the regional level for the period 1971-2015, from a practical standpoint, we chose the recent decade as it matched the demographic data available to us more accurately and allowed establishing a more meaningful correlation between findings of drought analysis and internal migration. The SPI values in Figure 5 show a constant dry period starting in 2004, which reached an extremely dry level in 2008, particularly in Marmara, Aegean and Southeastern Anatolian regions. This was immediately followed by a particularly wet year in 2009, which caused widespread flooding in the Black Sea, Marmara, and Mediterranean regions. In 2013, the case of extreme drought shifted Eastward, affecting predominantly the Central and Eastern Anatolia regions. The accumulation of these extreme conditions has had a severe negative impact on the agricultural sector and has put additional pressure on already burdened farmers and herders. A comparison between the SPI values and share of agricultural sector in the gross domestic product (GDP) in figure 6 (Statista 2018) from 2007 to 2015 shows that the mentioned share decreases in 2007 and 2008 followed by 2013-2015, inclusive and it increases in wet years, from 2009-2012.

The annual rate of net migration for the period 2007-2015 (Figure 7) shows a relatively low level of temporal variability. Despite climatic variations, the regions that are gaining or losing migrants remained largely the same during the selected period. Along with table 2, Figure 7 shows that the correlation coefficients for a given year and for the years after a drought spell are discernibly larger than for wet years; yet, not strong enough to relate them exclusively to drought. For example, coefficients for 2012-2013, 2013-2014 and 2014-2015 are bigger than in preceding years: this can be attributed to post-drought migratory behavior in the impacted regions.

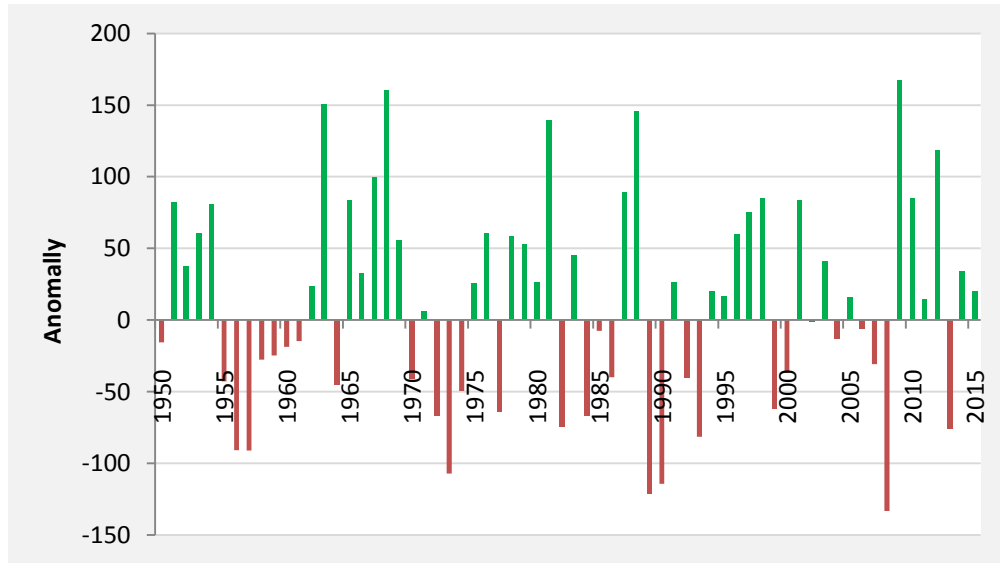
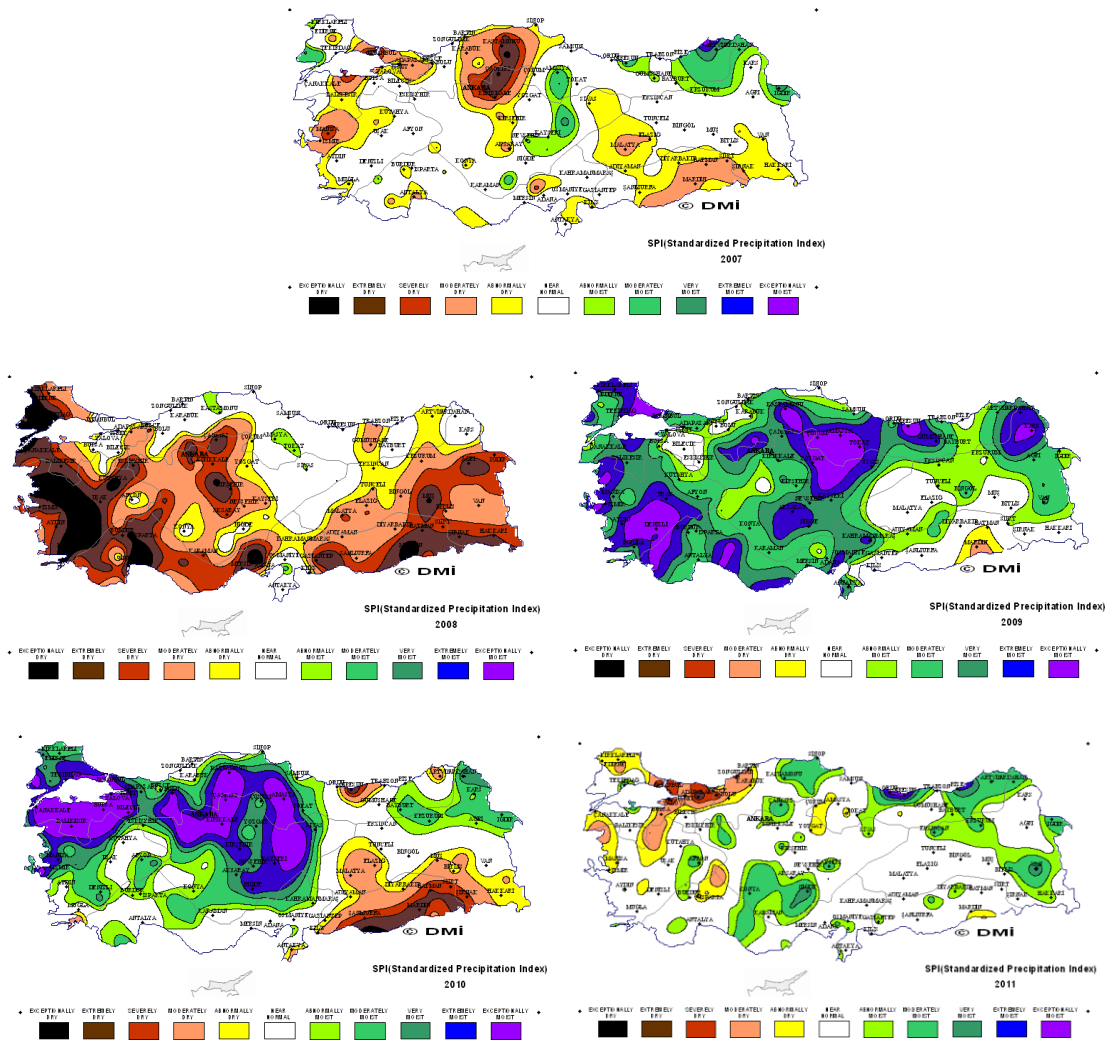
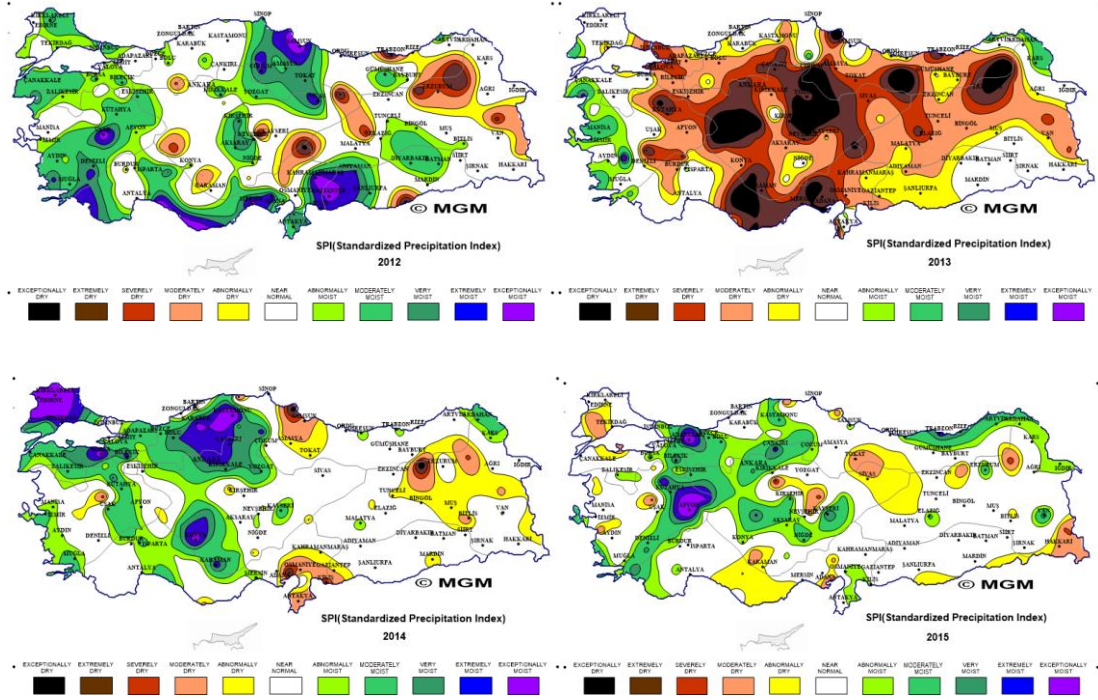
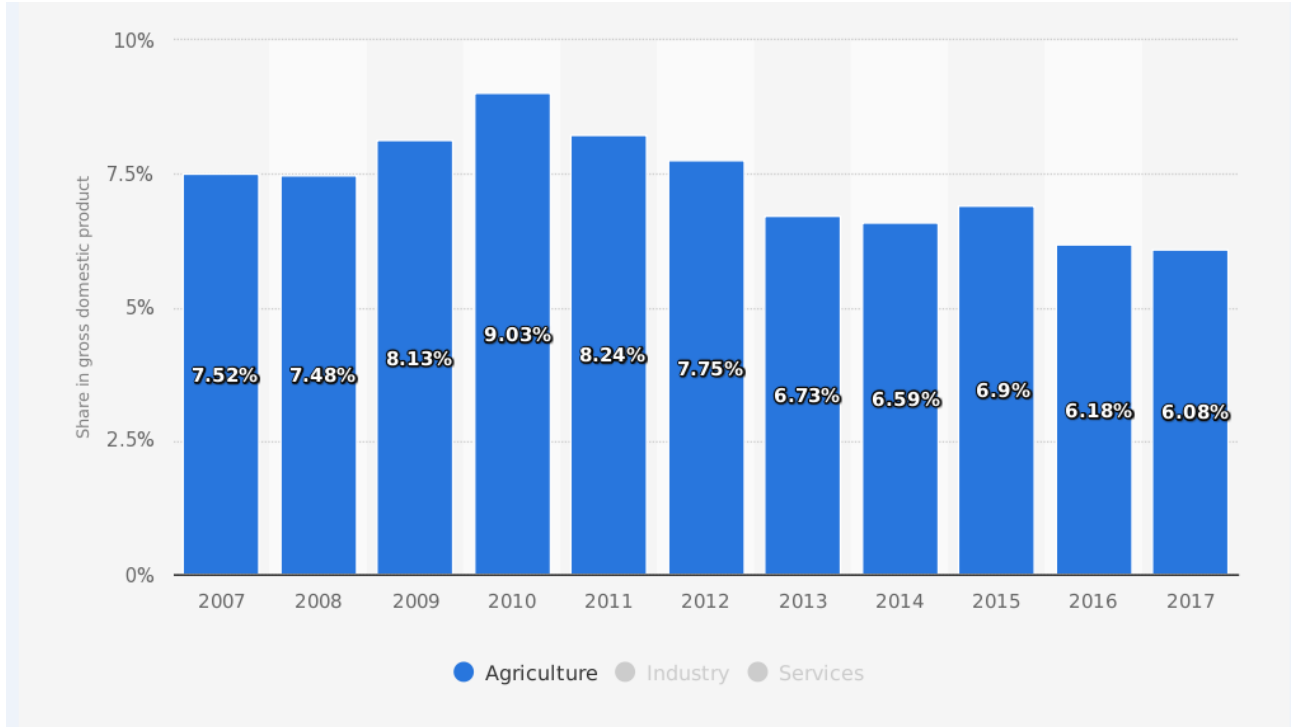


Figure 4: Anomaly of annual average precipitation for 1950-2015 as compared to the 1971-2000 base period

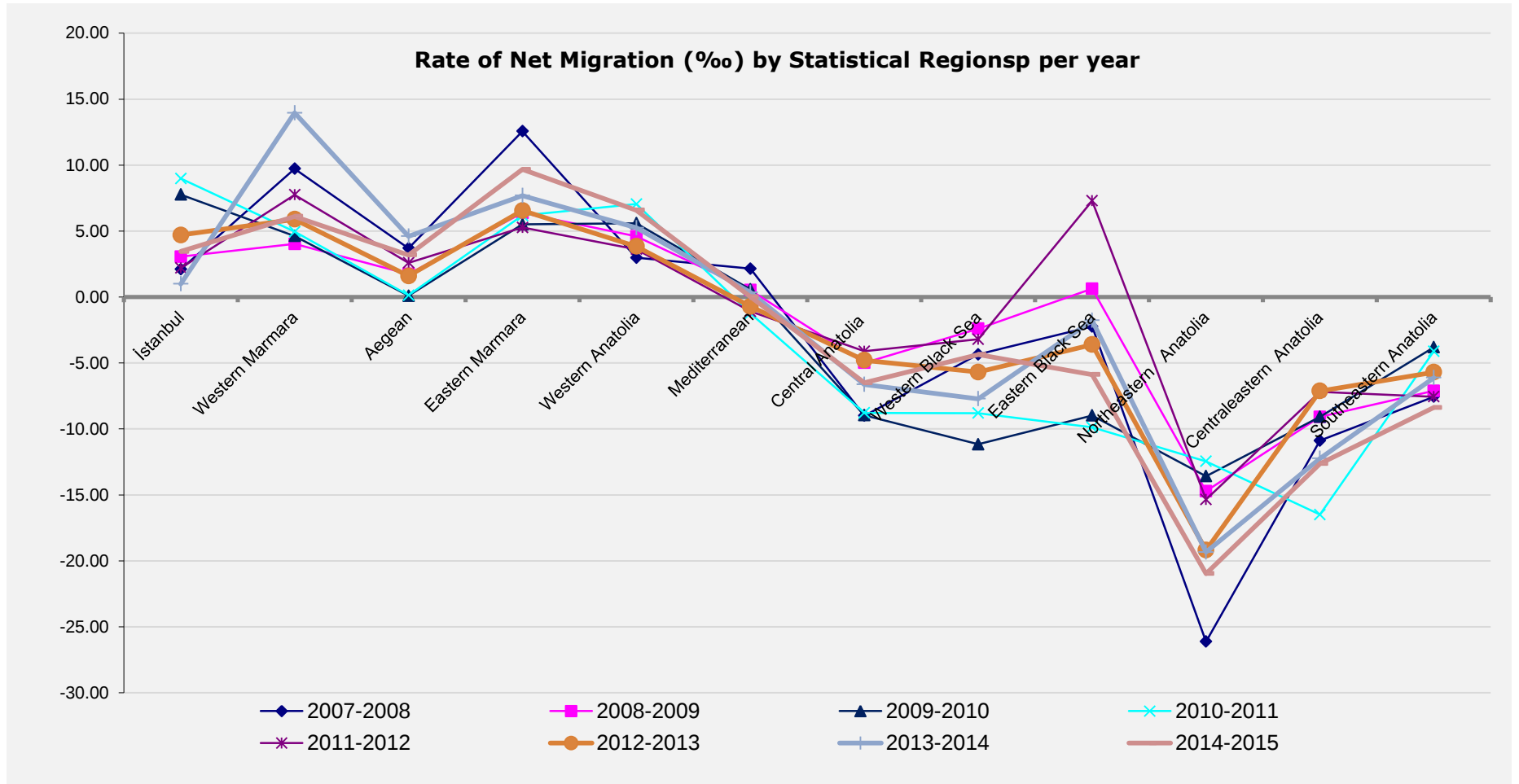




**Figure 5:** Annual mean values of Standardized Precipitation Index, Turkey (2007-2015) - (Charts by A. Ceylan, TSMS)



**Figure 6:** Share of Agriculture in Turkey's GDP (2007-2017), Statista, 2018



**Figure 7:** Annual Rate of Net Migration (‰) per year at twelve statistical regional levels (data source: TurkStat)

It is interesting to note at this point that, as shown in Figure 8, in some regions such as Northeastern Anatolia, wetter periods are associated with lower levels of emigration. To shed light on this, we computed a series of correlation coefficients (Table 2). Although we conducted a significance testing of the correlation coefficient, we did not report it in the table as our data represents the whole population and not a random sample. The first series of coefficients (bottom line of the table) allows answering the question: “during a certain year, are wetter region attracting more migrants?” Whereas the second series of coefficients (last column of the table) allows answering the question: “is there an impact of the SPI on net migration over the years?” Both positive and negative values for the correlation coefficients between the SPI and the RNM can be observed in Table 2. The difference between negative and positive correlations is stronger in dry years such as 2008, 2013 and 2015. Although there is no systematic and strong direct link between drought and migration on a year-region basis, according to the findings available to us, we can still draw some interesting facts. As a result, we have classified the twelve statistical regions of Turkey in three groups by the typology of drought-migration-economy-security nexus:

Group 1: Magnet for internal migrants: mainly western parts of Turkey, including Istanbul, Western and Eastern Marmara, and Western Anatolia.

Group 2: Neutral: mainly central parts of Turkey, including Central Anatolia, Aegean, and the Mediterranean. The rate of net migration in these Regions has remained nearly stable both in dry and wet periods.

Group 3: Source of out-migration: mainly eastern parts of Turkey, including Southeastern, Centraleastern and Northeastern Anatolia.

According to this classification, the regions in Group 1 are major economic hubs in the country. On the other extreme, the regions in Group 3 have recorded the highest rate of out-migration. This is particularly the case for Anatolia, which faces security instability.



## 7. Discussion

In this study, we have identified two sets of polarized regions in the east (group 3) and west (group 1), and a neutral region in the central part of Turkey (group 2). The least developed areas with a high level of instability (group 3), such as Eastern and Southeastern Anatolia, are more vulnerable to drought occurrences than other regions and are a clear source of migration. In these regions, where traditional agriculture remains the main source of income, the Gross Domestic Product (GDP) is below the national average and unemployment is also higher than in the western, more urban regions. Additionally, the socio-economic vulnerability in these regions is combined with deep security concerns. As a result, even in wet periods and appropriate climatic conditions, out-migration flow does not cease.

Regions in group 1 however, such as Istanbul, Western/Eastern Marmara, and to some degree Western Anatolia, serve as population magnet and hubs. The correlations for Western and Eastern Marmara were negative, even though the above-mentioned Regions are among the top four GDP per capita (Eurostat 2017). This is probably due to the wider economic effect of neighboring Istanbul. However, both mentioned regions may require further socio-economic study, beyond drought impact. These areas, with more metropolitan cities, offer better job opportunities and wider settlement options. Therefore, these regions have a more diversified economy and drought does not disrupt their socio-economic stability. This confirms the notion that annual or biennial drought by itself cannot stand as a sole push factor for migration. This conclusion is somehow different if the drought persists over a number of years and is amplified by one or more pull factors, such as economic growth in the tourism and industry sectors, which might trigger population movements. The above considerations have played a determining factor in the establishing of new metropolitan municipalities and the required enlarging of municipal areas of the past ten years.

Turkey has a heterogeneous geographical, economic, and social landscape. Internal migration thus affects population distribution and dynamics. Geographical heterogeneity might in some cases support economic diversity and opportunities for localities, which are more exposed to droughts, floods, and other climate extremes. Although these findings provide meaningful quantifiable information rather than categorical types of data, we found out that, due to the multi-causal nature of migration, especially east-west migration, the relation between drought and migration is neither simple nor direct.

In social systems, the predominant reaction of human beings to physical changes in the environment is complex and includes both direct and indirect aspects. Nevertheless, it is clear that the intensity and duration of drought has a counter effect on agricultural production, GDP, and employment in this sector.

In this study, we show that climate and environmental impacts are intrinsically combined with economic and social impacts. Historical trends show that migrants, in the case of droughts, prefer to move internally with the aim of moving back to their homes and communities once the drought is over. However, the surveillance of population migration out of the Northeastern and Southeastern regions of Turkey shows that security issues play a stronger role than drought and associated social and financial factors in migration decisions and clearly contribute to the east-west internal movement of populations.

## 8. Conclusion

This study has explored the correlation between drought and the rate of net internal migration at the regional level in Turkey. Our study shows that drought slowly brings about direct impacts. Though not in the scope of this paper, obviously, subsidiary implications are generally observed, such as poverty and unemployment, which influence a household's decision on migration, particularly during extreme and prolonged droughts. It should, however, be noted that economic aspiration and security instability concerns are the main drivers for internal migration in Turkey. This is especially the case for people living in rural areas, attracted by neighboring urban life, which offers more diversified job opportunities, public support facilities, and stable living conditions. In fact, the sharp rise in the growth of metropolitan municipalities and the enlargement of the municipal borders in Turkey over the past ten years support the findings of this study. These findings are applicable to the country under study, Turkey, and cannot be translated to other countries without a similar analysis or extrapolated to a global discussion on the complicated interaction between drought and migration. We have noted that ultimately, migratory behaviors may differ from one city and region to another, depending on the overall climatic and socioeconomic situation.

We finally conclude that natural sciences alone are not likely to provide all the needed answers and insights in the drought-migration nexus, and thus interdisciplinary research on drought impact assessment will be critical to future socio-economic studies.

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### Contact:

MAPS - Maison d'analyse des processus sociaux  
Rue A.-L. Bréguet 1  
CH - 2000 Neuchâtel  
Tél. +41 32 718 39 34  
[www2.unine.ch/maps](http://www2.unine.ch/maps)  
[maps.info@unine.ch](mailto:maps.info@unine.ch)