Post-Disaster Population Mobility: Considerations for the February 2023 Earthquakes in Türkiye

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Abstract
The February 6, 2023 earthquakes in Türkiye caused immense destruction, displacing millions and highlighting the importance of understanding post-disaster mobility. This study examines the socio-economic and environmental drivers of population flows after the disaster, using Geographically Weighted Regression (GWR) to analyse data from receiving cities. Key variables include GDP per capita, unemployment, education, population density, and climate conditions. Findings show that displaced populations mostly relocated to nearby, less-affected cities rather than distant western regions. This shift reveals the critical need for targeted policies addressing infrastructure, employment, and social integration. Unplanned relocation can worsen inequality and deepen socio-economic divides. The study underscores the importance of integrating mobility data into disaster recovery planning, emphasising equitable, long-term strategies that enhance resilience and reduce vulnerability in both affected and receiving areas.

Keywords: Post-disaster mobility, earthquakes, unplanned relocations, urban resilience, Türkiye

Introduction

The increase in the frequency, intensity and impact of natural disasters worldwide in recent years has made disaster management and recovery processes even more critical. Among natural disasters, earthquakes, with their devastating and unpredictable effects, cause great loss of life and property on a global scale. An analysis of nearly 100 major earthquakes that have occurred worldwide since 1900 shows that 93% of global deaths are caused by earthquakes (Daniell et. al., 2017). If urgent, fair and permanent solutions to the economic, ecological, psychological and social problems that occur after earthquakes are not produced, much more serious problems, including security, will come to the agenda (İrdem and Mert, 2023). Foremost among these problems is the earthquake-related phenomenon of forced migration. This makes post-disaster population mobility an important focus in understanding not only the physical but also the social and economic consequences of disasters.

This post-disaster population mobility is considered as a critical variable for the success of response and recovery plans. Wu et. al. (2021) state that understanding and predicting the direction and pattern of post-disaster migration is important for assessing the vulnerability levels and resilience capacities of communities. Similarly, it is stated that migration directly affects the demographic structure, labour market, social service provision and infrastructure, and therefore, post-disaster flows are not only temporary but may cause permanent social transformations. This situation forces city administrators to think about laws and practices that will make cities resilient especially in times of crisis.

Türkiye is one of the countries with a high earthquake risk, and the occurrence of two major earthquakes of magnitude 7.8 and 7.5 on 6 February 2023, nine hours apart, centred in Kahramanmaraş, was recorded as a first in history. More than 50 thousand people lost their lives as a result of the earthquake. Approximately 13.5 million people in 11 provinces including Kahramanmaraş, Hatay, Adana, Gaziantep, Kilis, Osmaniye, Adıyaman, Şanlıurfa, Malatya, Diyarbakır and Elazığ were affected and thousands of people had to leave their homes and migrate to other regions. This mass population mobility is not only a coping strategy, but also brings new problems at social, economic and spatial level for the receiving and giving cities. The critical role of population dynamics after the occurrence of disasters requires an in-depth study of this issue in order to draw useful conclusions for

post-disaster response and recovery plans. Understanding the direction, triggering factors and consequences of post-disaster population flows is of great importance in terms of both increasing the effectiveness of response processes and producing long-term resilience policies. At this point, earthquake, which is one of the natural disasters and has a significant impact especially considering the damage and loss of life it causes, also stands out in the legal framework in Türkiye and in making significant decisions on prevention and post-disaster response. In this context, the study aims to contribute to better management of the post-disaster process by addressing the spatial and socio-economic determinants of post-earthquake migration movements.

This article progresses in four sections after the introduction. In the second section, it examines the conceptual framework of post-disaster population mobility, the triggering factors behind post-disaster migration patterns, and the human movements that followed past earthquakes in Türkiye. In the third section, material and method used are explained. In the conclusion section, an evaluation of the results of the study conducted and understanding the direction, triggering factors, and consequences of post-disaster population movements are presented.

Literature Review

Disasters are multidimensional crises that create not only physical destruction but also social instability and vulnerability. Disasters have serious destabilising effects on individuals and societies. Management of these impacts is only possible through planned and multi-actor co-operation. In the literature, this process is generally handled within the framework of the concept of 'disaster management'. Disaster management deals with the pre-planning of natural or man-made disasters, minimisation of damages, effective response at the time of disaster and organisation of post-disaster recovery process (Duruel, 2023).

Population movements following disasters are expected occurrences (Myers, 2002). Especially the loss of life caused by earthquake, which is one of the types of natural disasters, the psychological effects that people experience as a result of the loss of their acquaintances, the destruction or damage of their houses, or the fear of earthquake again in the region where they live lead individuals to different coping strategies. Post-disaster human mobility is one of the main coping strategies adopted by individuals and households to respond to adverse conditions and recover their pre-disaster lifestyles (Dickinson, 2013). Following the devastating effects of earthquakes, individuals who have experienced the earthquake leave the place where they live and migrate to different cities where they feel safer after the disaster in order to meet the basic needs of the affected population such as shelter and safety. These movements may include temporary and permanent relocation, resettlement and return. Human mobility may cause long-term population changes that affect the economy and social structure of the country (Ting-Hsiang et. al., 2024). However, this situation has caused and is thought to continue to cause many problems both in the abandoned earthquake zone and in the settled provinces. While migrating individuals struggle with the effects of being cut off from social networks, adaptation difficulties and psychological traumas, migrating regions lose resources and resilience, and their economic and social structures are weakened (Ting-Hsiang et. al., 2024). Understanding the interaction between the recovery of infrastructure systems and population movement (displacement and return) after such large-scale disasters is essential for developing policies that can enable population return in communities and promote sustainable development in hazard-prone areas (Aerts et al., 2018). Therefore, it is vital to take preventive measures to reduce the possible destructive effects after an earthquake and eliminate risks as much as possible.

The direction and intensity of post-disaster population mobility may vary according to the socio-economic characteristics of the migrating individuals. After the earthquake, individuals show three different tendencies: migration to villages/rural areas where those affected by the earthquake think that they are relatively safer; migration to provinces not affected by the earthquake; and migration to large cities. Groen and Polivka's (2010) study on the aftermath of Hurricane Katrina revealed that households that suffered housing damage and were economically disadvantaged were less likely to return. On the other hand, it was observed that some households returned to their damaged houses in a short time due to financial inadequacies and difficulties in finding accommodation elsewhere (OCHA, 2023). There are similar dynamics in the case of Türkiye. After the 1999 Marmara Earthquake, the rate of migration from the region doubled compared to the previous year, while the rate of migration recei-

ved decreased (Peker and Şanlı, 2022). After the 2011 Van Earthquake, approximately 250,000 people temporarily migrated to metropolises such as Istanbul, Mersin, Antalya, Ankara, Bursa and Izmir (Tiryaki Yenilmez, 2023). On 6 February 2023, a similar picture emerged in the Kahramanmaraş earthquake. It was determined that 800,000 people took shelter in villages in the first month of the earthquake and 3.3 million people left the earthquake zone and migrated to other provinces (Sağıroğlu et. al., 2023).

Earthquakes not only displace individuals, but also lead to long-term demographic and economic changes at the country level. In Türkiye, the impact of disasters becomes more evident in the context of regional inequalities. The regional plans and urban plans prepared in Türkiye since the 1960s in order to reduce regional development disparities have not achieved the expected success. While regional plans were inadequate in practice, cities developed in an unplanned and risk-insensitive manner (Özgen, 2007). The post-1980 liberal economic policies led to the concentration of population and investments in the western metropolises and coastal regions located in the most risky seismic belts of Türkiye (Yoloğlu and Zorlu, 2024). This situation has led to the spatial concentration of disaster risks in certain regions and revealed the inadequacies of the planning system in managing these risks. At this point, it is possible to say that the spatial planning system implemented in Türkiye has failed both in reducing disaster risks and in the balanced distribution of population.

The phenomenon of migration has been at the centre of academic research for many years, and many theoretical approaches have been developed to explain the causes, scope and dynamics behind migration movements. One of these approaches, the neoclassical theory, explains migration by economic factors, especially interregional labour demand and wage differences (Rodríguez-Pose and Ketterer, 2012; Scott, 2010). According to this model, individuals tend to move from regions where job opportunities are limited and wages are low to regions where employment is more easily available and wages are high (Whisler et al., 2008). On the other hand, there are also approaches that argue that migration decisions are not limited to economic factors; environmental and social opportunities that affect the quality of life can also be determinant in individuals' relocation decisions. Individuals may prefer to move to regions where wages are lower but more attractive in terms of lifestyle, social environment or natural environment (Nelson and Ehrenfeucht, 2020). Discussions on such opportunities were first raised in the 1970s when Graves (1979) showed the influence of climate factors in migration patterns in the US (Li et. al., 2023). Over time, the concept of amenities has expanded to a wider range of factors that affect quality of life, such as social relations, cultural richness, recreational opportunities, and social tolerance (Scott, 2010; Whisler et al., 2008). However, there is no clear consensus in the literature on the relative weight of economic factors and such life opportunities in migration decisions (Buch et al., 2014; Nelson and Ehrenfeucht, 2020). These differences are thought to stem from the diversity in the social and economic structures of countries (Lee and Kim, 2019). In this context, it is thought that understanding the spatial and socio-economic triggers of post-disaster migration movements in Türkiye will form an important basis for urban managers, planners and stakeholders involved in the process in terms of disaster management.

Material and Method

In this study, a Geographically Weighted Regression (GWR) model was employed to analyze the factors influencing post-disaster migration flows, with a specific focus on spatial heterogeneity. Unlike conventional global regression models, GWR assumes that the relationships between dependent and independent variables may vary across geographic space. As highlighted in the literature (Fotheringham and Sachdeva, 2022; Fotheringham et al., 2009), the underlying mechanisms driving migration flows can differ spatially, and the factors that attract individuals to particular regions are often shaped by local contexts. Therefore, the socio-economic and environmental determinants of migration are expected to exhibit spatially non-stationary relationships (Rijnks et al., 2018; Wang et al., 2019; Szymanowski and Latocha, 2021). To account for these regional disparities, GWR was selected for this study, as it assigns spatially varying weights to each observation based on geographic proximity. The migration data utilised in this research are based on the 2023 records of the Turkish Statistical Institute (TURKSTAT). The dependent variable comprises the number of out-migrants from provinces directly affected by the earthquakes that occurred in February 2023. The independent variables were selected based on an extensive review of the literature and were grouped into three main categories: economic conditions, socio-demographic

structure, and environmental characteristics (Table 1). These variables were derived from 2022 data in order to reflect the pre-disaster context, thus capturing the underlying conditions that may have influenced subsequent migration decisions.

Table 1. Description of variables

Categories	Variable	Source
Economic conditions	Gross domestic product ($) per capita	TurkStat, 2022
	Rental value of a residential property (Unit Prices per m²)	Endeksa, 2022
	Sales value of a residential property (Unit Prices per m²)	Endeksa, 2022
	Unemployment rate (%)	TurkStat, 2022
	Number of enterprises in the agriculture, forestry, and fishing sector	TurkStat, 2022
	Number of enterprises in the manufacturing sector	TurkStat, 2022
	Number of enterprises in the construction sector	TurkStat, 2022
Socio-demographic status	Not finishing a school rate (%)	TurkStat, 2022
	Primary and secondary education rate (%)	TurkStat, 2022
	High school rate (%)	TurkStat, 2022
	Bachelor's degree rate (%)	TurkStat, 2022
	Postgraduate rate (%)	TurkStat, 2022
	Population ratio in the 0-14 age group	TurkStat, 2022
	Population ratio in the 15-64 age group	TurkStat, 2022
	Population ratio in the 65+ age group	TurkStat, 2022
	Population density (per square kilometer)	TurkStat, 2022
Environmental characteristics	Earthquake risk level	Disaster and Emergency Management Authority, 2022
	Distance from the earthquake zone	ArcGIS Pro Living Atlas of the World
	Erinç rainfall activity index	Meteorology General Directorate, 2022
	DeMartonne aridity index	Meteorology General Directorate, 2022
	Average air temperature	Meteorology General Directorate, 2022
	Total annual precipitation (mm)	Meteorology General Directorate, 2022

Economic, social, and environmental factors are considered as major pull determinants that shape individuals' decisions to relocate in the aftermath of a disaster (Görür and Yüzbaşı, 2024). These determinants contribute to differences in perceived utility, which in turn influence the direction and volume of migration. In the category of economic factors, key labour market indicators such as gross domestic product (GDP), unemployment rate, and entrepreneurial activity were considered (Buch et al., 2017; Lee and Kim, 2019; Li et al., 2023). Additionally, housing prices in the destination provinces were included in the model as an economic variable associated with local living conditions (Li et al., 2023). Recent research has shown that non-economic factors have become increasingly influential in shaping migration preferences, complementing traditional economic determinants (Buch et al., 2017; Wu et al., 2019). Accordingly, this study also incorporated socio-demographic indicators such as age distribution, educational attainment, and population density to evaluate the attractiveness of potential destinations. Given the proven relevance of climatic and geographical factors in migration behavior (Görür and Yüzbaşı, 2024), environmental variables such as seismic risk level, average temperature, and precipitation were also included in the analysis.

During the data analysis phase, all variables were first normalised using the min–max scaling method. To address potential multicollinearity, factor analysis was conducted to identify and exclude variables that could compromise the reliability of the model. Subsequently, variables free from multicollinearity were included in various model configurations, and model performance was evaluated using the Akaike Information Criterion (AIC), R^2, and Adjusted R^2 metrics. The spatially varying effects derived from the GWR model were then visualised through maps, enabling the interpretation of statistically significant spatial patterns in migration dynamics.

Empirical Results

Figure 1 illustrates the migration patterns originating from the earthquake-affected region. According to the results, the provinces with the highest out-migration are Hatay, Malatya, and Kahramanmaraş, while Elazığ and Osmaniye recorded the lowest migration figures.

Post-disaster migration flows predominantly occurred either within the vicinity of the affected region or toward western parts of Türkiye. Provinces that experienced substantial out-migration—such as Hatay, Adıyaman, Diyarbakır, Malatya, Adana, and Kahramanmaraş—sent large numbers of migrants to Türkiye's three major metropolitan areas: Istanbul, Ankara, and Izmir. In addition to neighboring provinces, Antalya and Mersin emerged as key destination cities. Notably, Hatay, one of the provinces most severely impacted by the earthquake and the highest source of migration, witnessed large-scale population movements to a wide range of provinces, particularly in western Türkiye. By contrast, provinces that suffered less severe damage primarily experienced migration to adjacent provinces or select major urban centres.

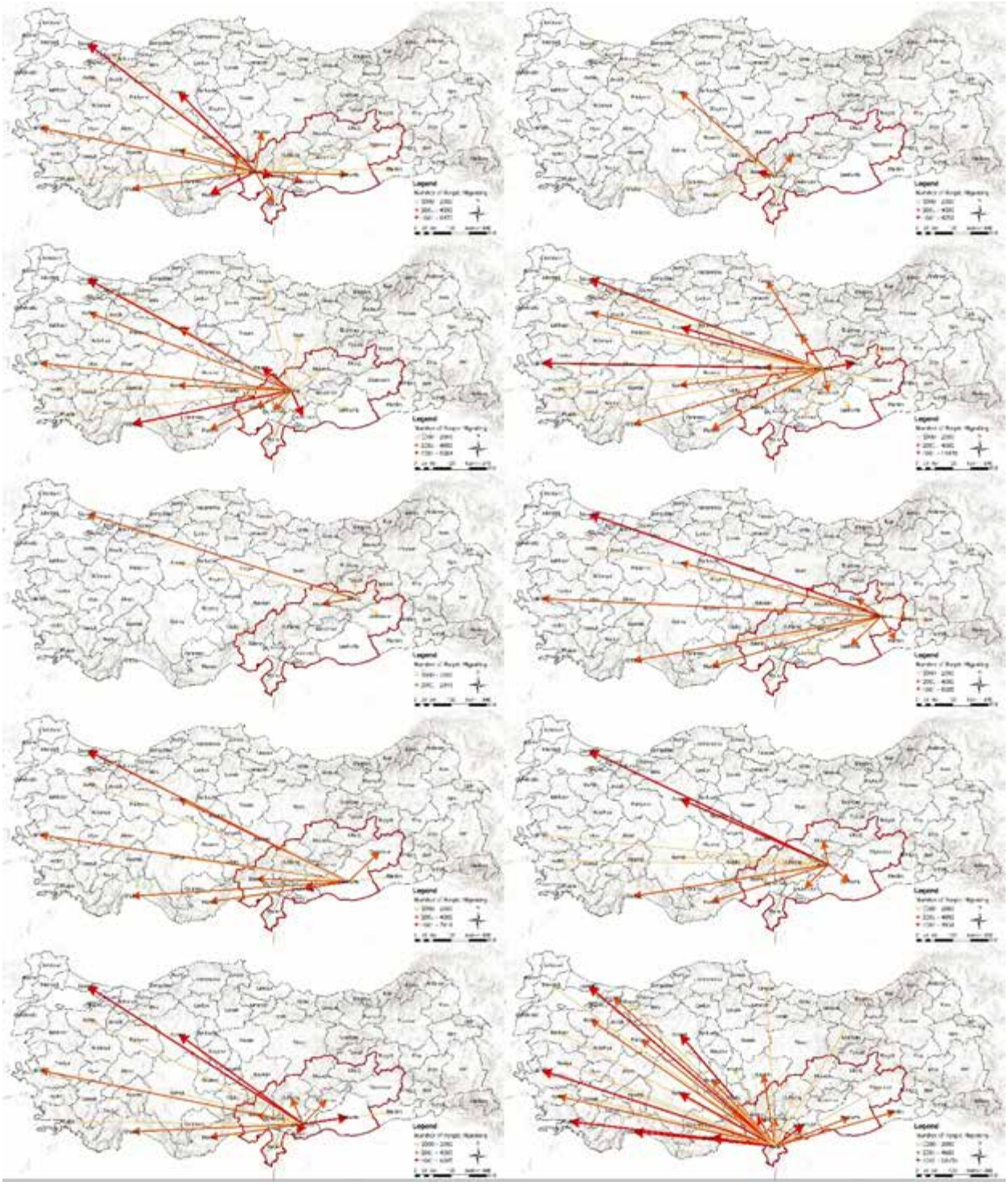

Figure 1. Spatial distribution of interprovincial migration density following the earthquake in Türkiye.

The results of the GWR analysis reveal how the effects of independent variables on the dependent variable vary across provinces, and these relationships are visualised through thematic maps. The figures include both the coefficient maps—which display the magnitude and direction of influence—and the statistical significance maps, which illustrate the spatial variability of effect strength.

Figure 2 presents the spatial relationship and significance levels between the number of migrants from the

earthquake-affected region (independent variable) and gross domestic product (GDP) per capita (dependent variable) across Turkish provinces. The coefficient distribution map indicates a strong negative relationship between GDP per capita and post-disaster in-migration in the coastal provinces of the Mediterranean region. In these areas, lower levels of GDP are associated with higher migration inflows following the earthquake. Conversely, in eastern Türkiye. a positive association was observed between GDP and migration inflows, although this relationship is not statistically significant. These findings reflect the spatial heterogeneity in economic attractiveness and the differentiated role of GDP in shaping post-disaster migration decisions across regions.

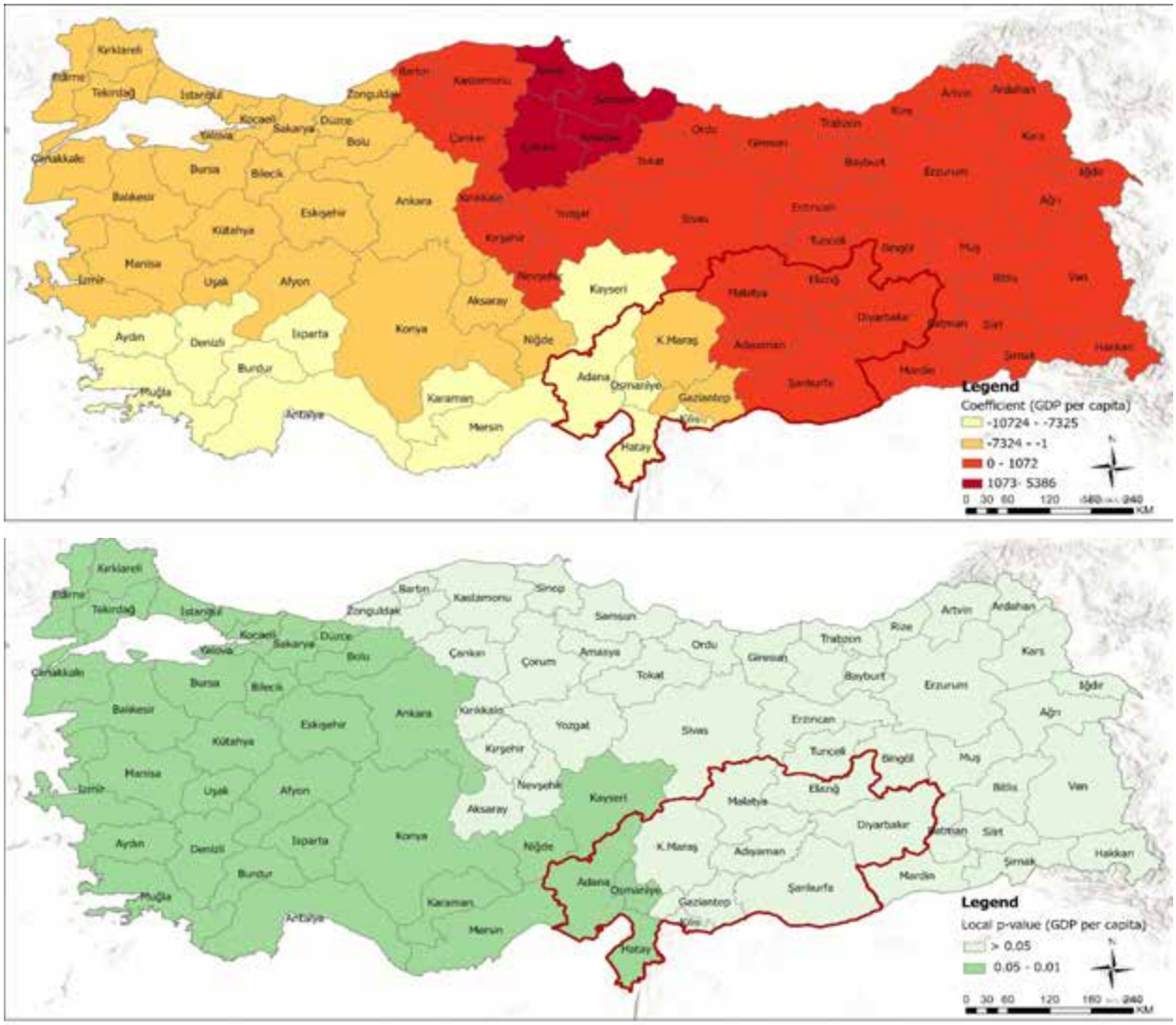

Figure 2. Distribution and significance of the relationship between GDP and post-disaster migration by province

Figure 3 demonstrates that the spatial effects of rental price levels on migration vary significantly across regions. In the northeastern provinces, increases in rental prices exert a negative impact on migration inflows, suggesting that rising housing costs act as a deterrent. In contrast, a positive association is observed in provinces located in Central Anatolia and western Türkiye, where higher rental levels are linked to increased migration inflows. This spatial divergence indicates that the influence of housing costs on migration decisions is not uniform across space. Notably, in western Türkiye, rental price increases do not appear to function as a deterrent, suggesting that post-disaster migration toward these regions is driven by factors other than affordability, and that housing costs are not a decisive factor in migration preferences in the western provinces.

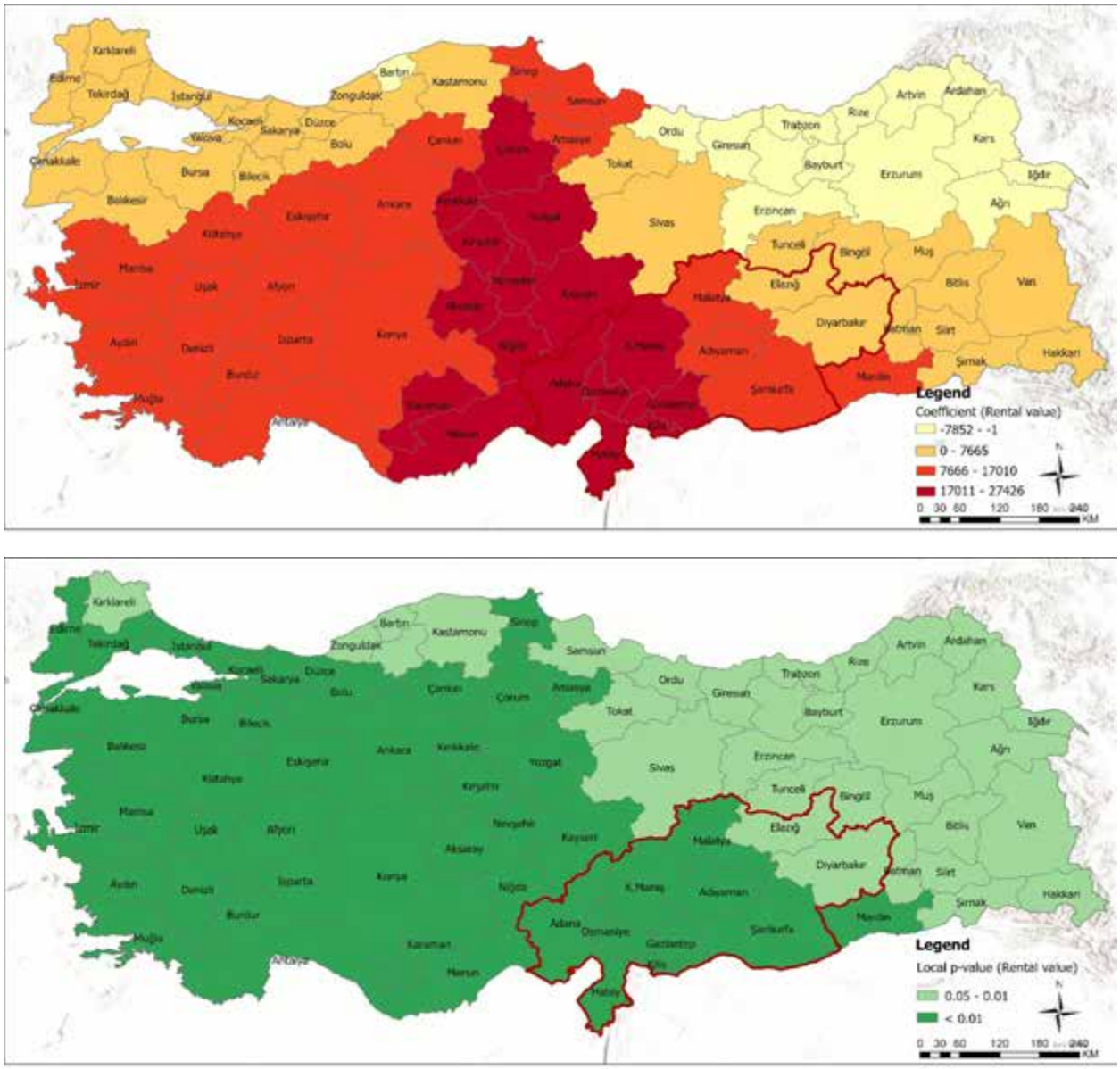

Figure 3. Distribution and significance of the relationship between rental value and post-disaster migration by province

Figure 4 reveals a positive relationship between the number of enterprises in the manufacturing sector and post-disaster migration across all provinces. This suggests that increases in the number of manufacturing enterprises are consistently associated with higher levels of in-migration from the earthquake-affected areas. The effect is particularly pronounced in the eastern regions of Türkiye, where industrial development remains in progress. These findings highlight that investment in the manufacturing sector exerts a significant positive influence on the migration attractiveness of less-developed provinces. In this context, the presence of industrial opportunities appears to act as a key pull factor, especially for populations relocating in the aftermath of the disaster.

Figure 4. Distribution and significance of the relationship between number of enterprises the manufacturing sector and post-disaster migration by province

Figure 5 illustrates the relationship between the proportion of the population holding a bachelor's degree and post-disaster migration. The results indicate a strong positive association between higher education attainment and in-migration in western Türkiye, suggesting that provinces with a higher share of university-educated residents attract more migrants from the earthquake-affected areas. In contrast, in eastern Türkiye, the relationship between the bachelor's degree rate and migration appears to be negative, meaning that increases in the proportion of educated residents are associated with lower levels of in-migration. However, this relationship is not statistically significant in the eastern region. These findings suggest that the higher concentration of educated populations in western Türkiye enhances the migration attractiveness of these provinces. This pattern can be linked to the more developed labour markets, diverse employment opportunities, and higher perceived quality of life in western regions, which collectively act as strong pull factors for disaster-induced migration.

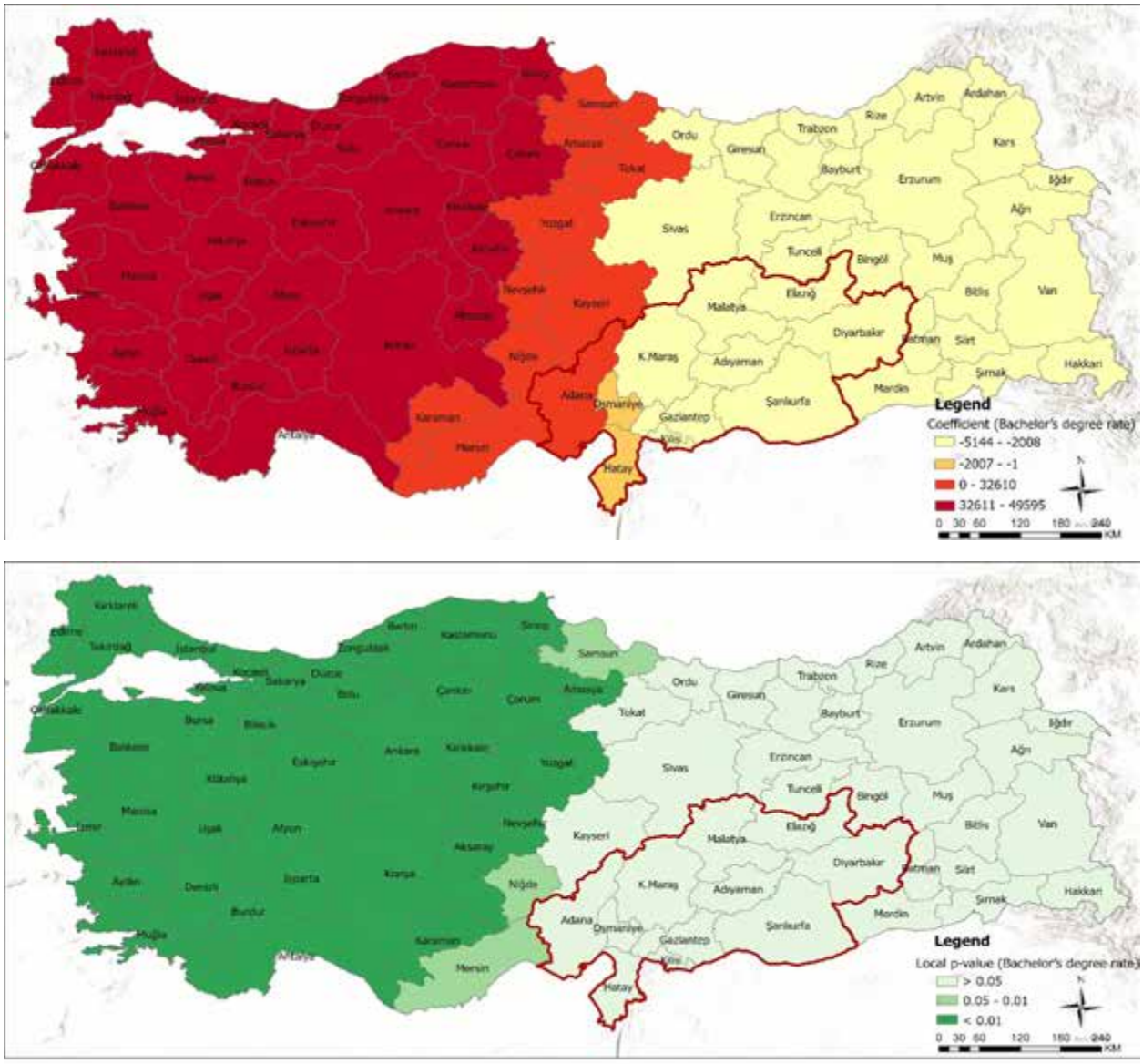

Figure 5. Distribution and significance of the relationship between Bachelor's degree rate and post-disaster migration by province

Figure 6 demonstrates the spatial variability in how provincial earthquake risk levels shape post-disaster migration patterns. In eastern Türkiye, higher seismic risk is significantly associated with reduced in-migration from the affected areas, suggesting that individuals are more likely to avoid relocating to high-risk zones in the aftermath of the disaster. In contrast, in western Türkiye elevated earthquake risk does not appear to discourage migration, indicating that risk perception exerts a less influential role in destination choices in these regions.

These findings highlight the geographically differentiated nature of risk perception in migration behavior. In particular, major western cities such as Istanbul and Izmir continue to attract significant post-disaster migration despite their high seismic vulnerability. This implies that the economic and social advantages offered by these urban centres, such as robust labour markets, higher quality of life, and strong institutional infrastructure, override concerns about earthquake risk, maintaining their appeal even in the face of elevated hazard exposure.

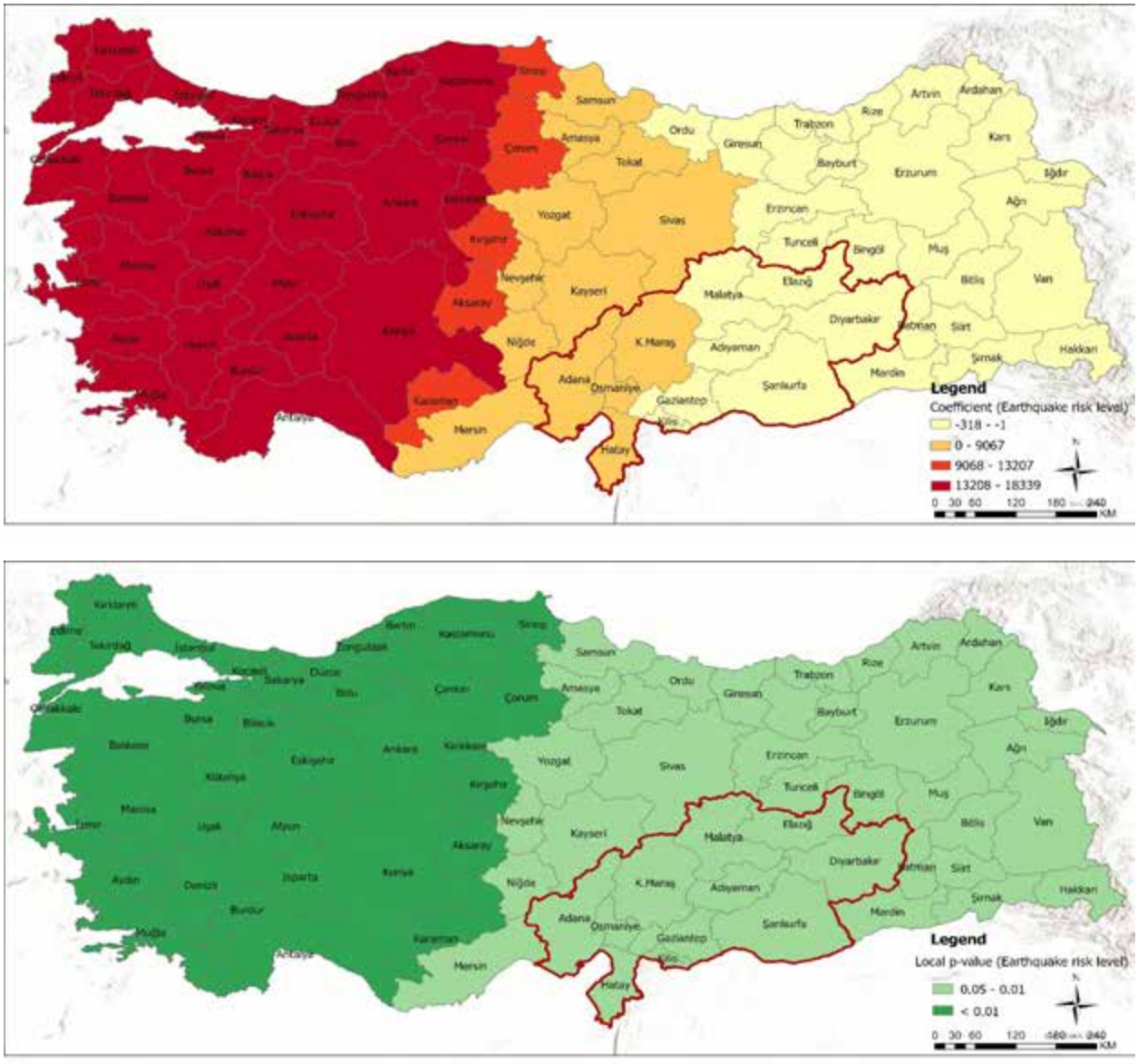

Figure 6. Distribution and significance of the relationship between Earthquake risk level and post-disaster migration by province

Figure 7 reveals the spatial relationship between the Erinç Rainfall Activity Index and post-disaster migration. The findings indicate that in eastern Türkiye, higher levels of rainfall activity are significantly associated with a decline in migration, suggesting that more intense and challenging climatic conditions may discourage displaced populations from relocating to these areas. This relationship was found to be statistically significant. In contrast, in western provinces, although an increase in the Erinç index shows a positive tendency to attract migration, this association does not reach statistical significance. This suggests that while greater climatic comfort may enhance migration appeal in the west, economic and social factors play a more decisive role in shaping post-disaster relocation preferences in those regions.

These results underscore the regionally differentiated impact of climate conditions on migration decisions. In the east, unfavorable weather patterns—despite potentially supporting agriculture-based livelihoods—may act

as a deterrent for disaster-affected individuals seeking resettlement. Conversely, in the west, the limited role of rainfall-related comfort highlights a greater dependence on structural and socio-economic advantages. Overall, the varying influence of the Erinç Rainfall Activity Index points to the non-uniform role of environmental factors in shaping post-disaster migration. Particularly in eastern provinces, climate-related constraints appear to exert a more pronounced effect, emphasising that disaster-induced mobility is not solely determined by economic considerations, but also by environmental conditions within the spatial context.

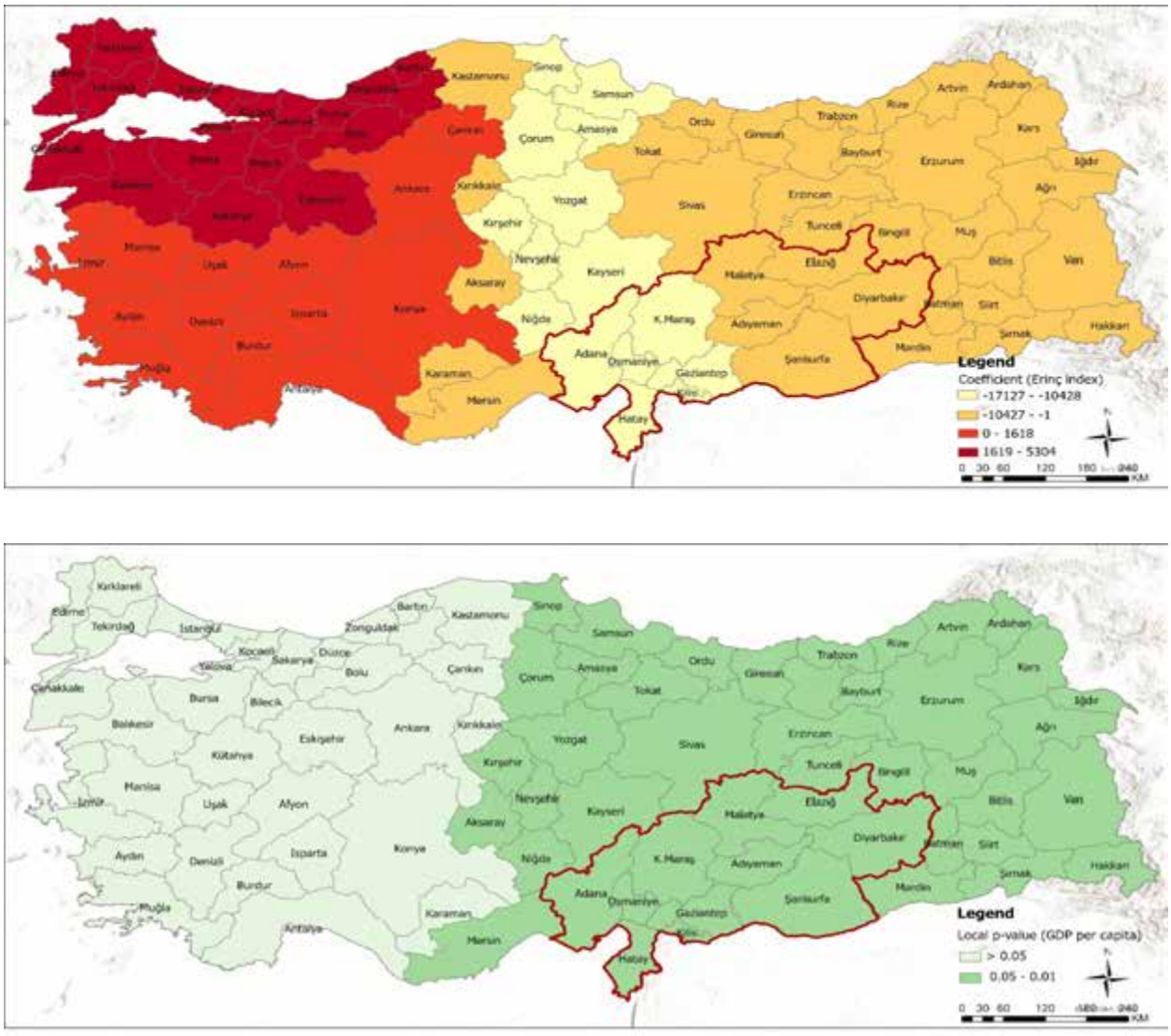

Figure 7. Distribution and significance of the relationship between Erinç rainfall activity index and post-disaster migration by province

Conclusion

This study demonstrates that post-disaster migration flows were disproportionately concentrated in the western regions of Türkiye—particularly in major metropolitan areas such as Ankara and Istanbul—compared to the eastern provinces. In the western regions, economic prosperity (as measured by GDP per capita) and higher education attainment emerged as primary pull factors driving migration. Conversely, in the eastern provinces, the expansion capacity of the manufacturing sector was identified as the most influential determinant shaping increased migration inflows.

On the other hand, factors such as seismic risk, rising housing costs, and adverse climatic conditions were found to suppress migration in eastern regions. Notably, these deterrent factors did not exhibit a significant impact on migration decisions in the west, where their influence appeared negligible.

These findings highlight that the spatial structure of post-disaster migration is shaped not only by economic opportunities but also by a complex interplay of environmental and socio-demographic factors. The fact that migration flows to the eastern regions are more sensitive to a broader range of variables suggests that these areas may be more vulnerable and volatile in terms of their migration dynamics. In this regard, the manufacturing sector's potential to attract migrants in the east holds strategic importance for the formulation of post-disaster population redistribution policies aimed at spatial balance.

Importantly, the study also reveals that post-disaster migration dynamics cannot be fully explained by economic indicators alone. In the eastern provinces, the increasing influence of environmental factors—particularly those linked to climate change—on migration decisions underscores the urgency of developing climate-adaptive settlement and development strategies. Therefore, effective governance of post-disaster migration requires the implementation of integrated policy frameworks that prioritise not only economic development but also environmental sustainability and regional resilience.

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