Big Data Insights into Mobility and Demographic Change in Alpine Municipalities: The Case of the Metropolitan City of Turin

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Abstract

This paper contributes to the growing body of research exploring how Big Data and Artificial Intelligence can inform the understanding of demographic dynamics and environmental challenges in mountain regions. Focusing on the Alpine municipalities of the Metropolitan City of Turin, the study investigates how climate change interacts with social, economic, and infrastructural drivers to shape mobility patterns from 2002 to 2022. By integrating official statistics (such as the ones from ISTAT and local municipalities) with dynamic data sources, such as Airbnb (to assess residential attractiveness) and Open Street Maps (to evaluate access to essential services), the analysis offers a granular and multi-dimensional perspective on (im)mobility in the Alps. The study addresses key methodological challenges, including the definition of mountain areas, indicator selection, and data integration. Additionally, the research develops a transferable analytical framework that systematizes six core dimensions of city-to-mountain migration dynamics, providing a standardized methodological tool for comparative research across different mountain contexts. While primarily descriptive, the research identifies how climate vulnerability, territorial fragility, and uneven service provision influence demographic shifts. The findings provide a basis for future predictive modelling and support the design of adaptive territorial strategies.

Keywords

Migration, climate change, analytical framework, population dynamics, mountain areas.

1. Introduction

The increasingly uneven and severe effects of climate change have made human mobility one of the central challenges on the global agenda. While migration decisions stem from multiple drivers, climate change is expected to be among the most influential. According to projections, over 200 million people may become internal climate migrants by 2050 [1], raising the urgency of understanding how environmental pressures intersect with socioeconomic vulnerabilities. Identifying the drivers of migration and their social impacts is a crucial step toward incorporating human mobility into climate adaptation and mitigation strategies. Evidence-based research and spatially sensitive models are essential to support effective policy responses and promote sustainable development.

Mountain areas are particularly vulnerable to the consequences of climate change and represent key observatories for studying demographic transitions. The European Alps are already experiencing accelerated warming, more frequent extreme events, and increasing climate instability [2]. Understanding demographic shifts in such contexts requires considering climate trends and their

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interaction with economic, social, and infrastructural dynamics. In this regard, big data and non-traditional statistical sources offer promising avenues to observe territorial transformations in real-time. Official statistics do not always offer a comprehensive representation of human mobility trends—for example, they often fail to capture emerging forms of multifocal dwelling, the extensive use of second homes, and other nuanced residential practices. In contrast, data from platforms like Airbnb can provide a proxy for residential attractiveness and long-term stay potential in mountain areas. In contrast, Open Street map data helps assess the availability and accessibility of essential services. These tools allow for more granular and dynamic insights into the factors that shape (im)mobility in fragile Alpine contexts.

This study aims to explore the drivers of migration and (im)mobility in the mountainous municipalities of the Metropolitan City of Turin (CMTO), with a focus on the interaction between climate change and other socioeconomic, cultural, and infrastructural variables. By combining institutional data with alternative sources, the analysis seeks to offer a comprehensive picture of recent demographic trends and the conditions that influence decisions to stay, leave, or move into mountain territories. Methodologically, the study addresses several challenges: defining mountainous areas, selecting robust indicators to capture demographic and environmental dynamics, and integrating heterogeneous datasets. Additionally, the study develops a transferable analytical framework that systematizes the multidimensional nature of city-to-mountain migration, providing a methodological foundation for comparative studies across different mountain contexts. The approach highlights the complexity and multidimensionality of migration processes in mountain areas, showing that while climate change is a relevant factor, it operates in conjunction with multiple territorial dimensions that affect mobility choices.

2. Literature review

The current literature on mobility dynamics in mountainous regions, particularly in relation to climate change, remains limited—especially in the Global North. Much of the existing scholarship focuses on migration induced by extreme weather events in broader contexts or on outmigration from mountain areas. As a result, the nexus between climate-induced migration and mountainous territories remains underexplored and conceptually fragmented.

Within this field, a “middle-ground” perspective has gained traction. Rather than viewing climate change as a direct or isolated driver, recent studies highlight its role within complex, multi-causal, and non-linear mobility systems [3, 4. Migration decisions emerge from the interaction of ecological, economic, social, and political variables, along with individual characteristics and contextual constraints [5, 6]. In this light, climate change may either increase migration propensity (by intensifying existing vulnerabilities) or, conversely, limit mobility due to reduced resources—what scholars refer to as the "trapped populations" phenomenon.

Although most climate-induced mobility occurs within national borders, research has predominantly focused on urban destinations, especially large capital cities [3]. This urban-centric focus has left peripheral and rural areas, often more exposed to climate risks, largely unexamined in migration and climate research. This raises key questions about the reality and future of mountain regions, particularly those with strong agricultural dependency and limited infrastructure.

Recently, however, mobility in mountain areas has attracted increasing attention. Migration is often used as a strategy to diversify livelihoods, reduce dependency on natural resources, and respond to environmental and economic pressures [7, 8]. In economically more developed countries, new mobility flows into mountain regions have been observed [7, 8, 9], reversing long-standing outmigration trends and altering the demographic landscape. This shift has also intensified pressure on mountain ecosystems, which are already vulnerable due to climate and land use changes [10].

In the European Alps, the availability of granular environmental and demographic data has enabled more detailed studies on migration patterns. Research has addressed diverse phenomena, including the arrival of “new highlanders” [11, 9], the settlement of refugees [12], international immigration [8], and integration dynamics [13]. In Italy, studies have pointed to active “stayers”,

returnees and new inhabitants as key actors in repopulating mountain areas [14, 15]. Brandano et al. [16] highlight migration trends and the role of newcomers in fostering local resilience in fragile areas of the southern Apennines, while Membretti and Tartari [15] analyse diverse types and motivations of mobility in the so-called Padana metromontane region. However, despite these initial efforts, the role of climate change within these dynamics is still insufficiently addressed.

In sum, despite increasing attention to demographic trends in Alpine areas, significant knowledge gaps remain. In particular, further research is needed to understand how climate impacts intersect with other migration drivers and how these dynamics shape the decision to migrate—or remain—in mountainous regions, within the wider urban-mountain framework of interactions.

3. Scope, hypothesis and research questions

The prior section indicates two outcomes to be considered. First, the linkages between climate change and human (im)mobility are complex and the scholarship has not yet reached an agreement on how much climate events influence the decision-making process of migrating or staying. Second, migration studies in the Alps have mostly focused on immigration without placing climate change as a key factor in (im)mobility flows.

Following precedent exploratory research conducted in the Apennines about migration and climate change nexus [16], the hypothesis underlying this study is therefore that climate change, in combination with other relevant territorial factors (social, economic, cultural and infrastructural), is emerging as an important factor in influencing the demographic dynamics of mountain areas, with particular reference to migration flows, whether temporary or permanent, within a metro-montane framework.

Thus, considering the need for a broader and updated overview of migration trends in the European Alps, this analysis – focused on the Alpine municipalities of CMTO (Metropolitan City of Turin[2]) – aims to identify migration patterns within the study area and to/from the mountains to the city of Turin. As the purpose is to provide a broader overview of mobility trends and to understand the potential socioeconomic and environmental drivers, three questions guide this research. First, what are the most significant demographic trends in the study area? Second, what are the main migration trends in CMTO mountainous areas between 2002 and 2022? Third, how can climate change, combined with other factors, influence (im)mobility flows?

Aiming to contribute to the growing body of literature and the knowledge of the Alpine Convention, this research project focuses on 144 municipalities part of the Convention within CMTO[3]. This area is part of the only Italian Metropolitan City with a territory comprising the European Alps which has been the subject of innovative metro-montane policies and case study for the Alpine Convention. Additionally, the area presents two unique characteristics. First, it has already suffered climate change consequences: temperature increase, uncertainty regarding heavy rainfall patterns, and increased length of dry periods, among others [17]. More specifically, studies on climate change scenarios in the Piedmont region underline a deficit of precipitation, anomalies in tropical nights, and increases in temperature in the mountains [15]. These changes have potential implications for economic stability and life quality in the area.

Second, although communities located in the Alps have suffered from depopulation for several decades [18], this trend has changed since the 1990s and turned the area into a destination for migrants [9, 19]. The so-called “new highlanders” [14, 11] are a remarkable case to link migration in mountainous areas and the potential influence of climate change consequences on this population. As Modica [15] notes, the climate-related effects manifest unevenly according to territorial geography and particular socioeconomic characteristics, with significant implications for

[2] The Metropolitan City of Turin is the administrative unit at the provincial level. Located in Piedmont – western part of Italy – it comprises 312 municipalities.

[3] The definition of mountainous areas and the selection process of the municipalities for this study is detailed in Appendix A.

vulnerability and preparedness for extreme events. Yet, the interplay between climate change and territorial fragility remains underexplored in current research. In this context, data were also collected on the availability of essential services, based on the hypothesis that their presence may act as a factor of "restanza" (i.e., remaining) or territorial attractiveness in mountain areas, especially concerning climate and environmental pressures.

4. Data collection and Methodological Framework

Within the framework of migration as a non-linear, complex, and multicausal phenomenon, this study seeks to explore the interplay of diverse factors by organising the collected data into three main categories. First, demographic data includes population structures and dynamics, such as migration, age, citizenship, natural growth, and sex. Second, climate change and environmental data cover temperature, humidity, precipitation, and risk indicators, in line with previous analyses [15]. Third, other relevant drivers of migration encompass aspects like unemployment, access to basic services, and territorial accessibility[4].

Amid the exploratory focus of this paper, two main analytical objectives were established. First, to explore the spatial and temporal variations within the study area. Second, under the metromontane concept, to understand the main origin of immigrants in the city of Turin and the destinations chosen by people leaving the city. To do so, the choropleth mapping method is used to visualise variations in the territory: population growth, climate change indicators and essential services were categorised to represent differences in the selected municipalities. Additionally, a Sankey diagram was implemented to better feature the leading origin and destination municipalities of people moving to and from the capital city.

Several challenges have emerged regarding data availability and consistency. Climate change data, for instance, is limited at the municipal level. Consequently, this study focuses on anomalies in temperature (°C), total precipitation (mm), and relative humidity (%) during the summer months, defined as deviations between the current period (2002–2022) and a reference baseline (1970–2000). In addition, the composite fragility index from ISTAT is only available for 2018, 2019, and 2021, while data on landslide and hydrological risks is restricted to 2020. Temporal gaps in data availability at the municipal scale further limit the analysis. For example, data on pharmacies is available only from 2005 onward; tourism data from 2005; housing prices from 2004; and banks between 2002 and 2021. For hospitals and healthcare institutions, data merely reflect the opening year of each facility, without indicating whether the service remained continuously available throughout the study period.

While essential indicators—such as unemployment rates—have been integrated at the municipal level, other variables remain difficult to obtain with sufficient temporal and spatial granularity. Commuting data, for example, is either unavailable for some municipalities or inconsistent over time, thereby limiting its use in longitudinal analysis. Similarly, although alternative data sources such as Data for Good or Inside Airbnb offer promising opportunities, their inclusion was not feasible due to limitations in data accessibility, processing capacity, and analytical resources.

To complement traditional sources, the study incorporates data from Open street Maps to assess the availability and accessibility of services [20, 21]. To do so, we consider different kind of services: food access, transport, postal services and banking, education, healthcare, civic infrastructure, community hub (cafè, bar, pub), and shops for private purchases. This approach offers a more holistic understanding of territorial transformation and aims to support future policy strategies for regeneration and adaptation in mountain regions. As a result, through Open Street Maps data, detailed information on service locations can be retrieved, enabling a clearer understanding of local infrastructure and its potential influence on mobility patterns. This method also supported spatial

[4] A detailed overview of indicators, timeframes, and sources is provided in Appendix B.

analysis by identifying areas of service concentration or scarcity, offering a valuable contextual layer for interpreting demographic and migratory trends.

While this study primarily employs descriptive statistics and spatial visualization techniques to examine demographic and infrastructural patterns, it forms part of a broader research trajectory aimed at deepening the analytical understanding of climate-related (im)mobility. Future stages of this work will extend the methodological framework by incorporating statistical and spatial modelling approaches, including Geographically Weighted Regression (GWR), to analyze the relationships between population dynamics, climate anomalies, and territorial fragilities. These tools will allow for more detailed analysis of causality, spatial heterogeneity, and scenario-based forecasting, complementing the descriptive insights presented in this paper.

Despite some data limitations, the study employs descriptive statistics to characterise the territory and explore the interactions among various drivers of demographic and mobility change. Although the specific influence of each variable on migration dynamics or population growth is not quantitatively assessed, the data provides a comprehensive overview of local trends. A collection of maps and visual materials related to the processed datasets is available in Appendix C.

5. Results

Between 2002 and 2022, the municipalities selected experienced modest overall population growth (+2.6%), largely sustained by both internal and international migration. This is in line with the overall trend in CMTO. While the early 2000s showed positive demographic trends, a shift toward population decline has emerged since 2013, with marked drops during the COVID-19 pandemic. Natural growth stayed negative throughout the period, underscoring the structural-demographic fragility of the region. Without migratory inflows, the area would likely face significant depopulation. Residential mobility data reveals a predominantly intra-provincial dynamic, with most movements oriented toward urban or peri-urban centres. Migration to the mountains mainly originates from CMTO, particularly the city of Turin and surrounding municipalities, along with some international contributions, notably from Eastern Europe. This pattern highlights the central role of local mobility and the relative attractiveness of mountain territories for specific segments of the population.

Despite limited natural growth, many alpine municipalities have experienced net population loss over the two-decade period, with several facing depopulation. These demographic trends intersect with environmental changes reshaping territorial liveability and economic viability. Climate data indicates significant warming, with summer temperature anomalies frequently exceeding +2°C compared to the 1970–2000 baseline. Winters are also warming, albeit less intensely. Relative humidity has generally declined, particularly during summer, while precipitation changes have been more modest. Nonetheless, even slight reductions in rainfall, when coupled with higher temperatures, contribute to drier conditions and increased vulnerability to environmental risks.

These shifts carry tangible consequences. Warmer and drier summers can heighten health risks, increase cooling energy demands, and may threaten water availability [22, 23]. Combined with more frequent and intense extreme weather events, such as wildfires or droughts, these conditions can influence individual and household decisions regarding where to live. Data on exposure to hydrological and landslide risks further illustrate the region's vulnerability. In several municipalities, significant portions of the population, buildings, and businesses are located in high-risk zones. While not widespread, landslide exposure in some mountain towns is particularly acute, potentially limiting future development or repopulation efforts. Thus, certain effects of climate change may push people away from more fragile mountain areas, while other effects—such as heat stress in increasingly overheated cities—may conversely attract new residents toward higher-altitude zones.

Territorial accessibility also remains a critical issue. Many mountain municipalities are located more than 20 minutes away from the nearest main road or train station. Remote valleys—especially those less connected to major corridors—face compounded challenges in terms of physical isolation and service provision. On the contrary, cases such as the Susa Valley, despite its relative distance

from Turin, benefit from relatively good infrastructure access, highlighting the importance of connectivity over simple geographic proximity. However, the issue goes much deeper. As emphasised by the National Strategy for Inner Areas (SNAI), and notably discussed by Tantillo [24], accessibility must be understood not only in terms of distance or infrastructure but also regarding the effective availability of essential services and opportunities for local development—dimensions in which many Alpine areas remain structurally disadvantaged. Building on these multifaceted territorial dynamics, and considering the complex interplay of factors that influence city-to-mountain migration patterns, we propose a comprehensive analytical framework that systematizes the key dimensions affecting (im)mobility decisions (Table 1). This framework integrates six core dimensions—demographic, climate and environmental, economic, infrastructure and services, social and cultural, and territorial—each encompassing specific macro-level indicators that capture the essential drivers of migration flows. The demographic dimension tracks population dynamics and migration patterns, while the climate and environmental dimension addresses the growing influence of environmental pressures and climate anomalies on residential choices. Economic indicators assess livelihood opportunities and housing market conditions, while infrastructure and services indicators evaluate the foundational economy that underpins territorial attractiveness. Social and cultural factors capture community dynamics and quality of life aspects, while territorial indicators characterize geographic and accessibility constraints. This multidimensional approach recognizes that migration decisions in mountain contexts result from the complex interaction of these various factors rather than single determinants, providing a robust analytical tool for understanding and comparing urban-to-mountain mobility patterns across different geographic and national contexts.

Table 1
Macro-level indicators framework for analyzing city-to-mountain migration patterns.

DIMENSION	KEY INDICATOR
DEMOGRAPHIC	• Population growth rate (%) • Net migration rate (in-migration minus out-migration) • Natural population change (births minus deaths) • Population density (inhabitants per km²) • Age structure (% population 0-14, 15-64, 65+) • Foreign-born population (%)
CLIMATE & ENVIRONMENT	• Temperature anomalies (°C deviation from long-term average) • Precipitation anomalies (mm deviation from long-term average) • Extreme weather events frequency • Environmental risk exposure (floods, landslides, droughts) • Air quality index • Natural hazard vulnerability index
ECONOMIC	• Unemployment rate (%) • Income levels (median household income) • Housing affordability (price-to-income ratio) • Economic diversification index

	• Tourism intensity (tourist arrivals per resident) • Remote work opportunities
INFRASTRUCTURE & SERVICES	• Healthcare accessibility (hospitals/clinics per capita) • Educational services availability (schools by level) • Digital connectivity (broadband coverage %) • Transportation accessibility (distance to major transport hubs) • Essential services (food access, postal services, retail) • Energy infrastructure resilience
SOCIAL & CULTURAL	• Cultural amenities availability • Social services provision • Quality of life indicators • Local governance effectiveness • Social integration measures
TERRITORIAL	• Altitude and topography • Geographic accessibility (travel time to urban centers) • Land use patterns • Settlement typology (urban, peri-urban, rural) • Protected areas coverage (%) • Territorial fragmentation index

Note: This framework provides a set of indicators applicable across different national contexts for comparative analysis of urban-to-mountain migration dynamics.

These multifaceted challenges across mountain territories underscore the complex and interconnected nature of factors that influence urban-to-mountain migration patterns. Our analysis reveals that demographic dynamics, while showing modest overall population growth (+2.6%), mask significant spatial heterogeneity, with migration flows being predominantly intra-provincial and heavily dependent on Turin's metropolitan influence. Climate and environmental pressures are becoming increasingly pronounced, with summer temperature anomalies frequently exceeding +2°C and declining relative humidity creating new stressors for both residents and ecosystems. Economic conditions remain fragile, characterized by limited employment opportunities, volatile tourism-dependent sectors, and housing markets that reflect broader territorial inequalities.

More critically, the provision of essential services across mountain territories remains profoundly uneven and structurally inadequate. Banking facilities, secondary education institutions, and healthcare infrastructure exhibit significant spatial disparities, with numerous municipalities experiencing complete service gaps in one or more sectors. Although incremental improvements have occurred—such as the modest expansion of pharmaceutical services—the overall pattern of service distribution continues to perpetuate long-established territorial inequalities.

Given the complexity of these interacting forces, we propose a comprehensive analytical framework that systematizes the key dimensions affecting city-to-mountain migration decisions across six core areas: demographic, climate and environmental, economic, infrastructure and services, social and cultural, and territorial factors (Table 1). This framework recognizes that migration decisions result from the dynamic interaction of multiple drivers rather than isolated determinants, providing researchers with a standardized analytical tool for comparative studies across different mountain regions and national contexts. While our empirical analysis focuses specifically on the 144 Alpine

Convention municipalities within the Metropolitan City of Turin, the proposed indicators framework is designed to be transferable and applicable to mountain territories globally. The complete dataset and detailed indicator specifications for our study area are provided in the appendix B, offering a practical foundation for future research applications and cross-regional comparative analyses.

6. Discussions and Conclusions

This research aimed to understand the main factors influencing mobility patterns in the Alpine municipalities of the Metropolitan City of Turin. Despite having achieved a deeper knowledge of the environmental and climate change indicators in the territory, as well as the basic services available – all of which have a potential impact on the decision to migrate or stay – further research is needed. Beyond these empirical findings, this study contributes a comprehensive analytical framework that systematizes the multidimensional nature of city-to-mountain migration dynamics across six core dimensions: demographic, climate and environmental, economic, infrastructure and services, social and cultural, and territorial factors. This framework, designed for transferability across different mountain regions and national contexts, provides researchers worldwide with a standardized tool for comparative analysis of urban-to-mountain mobility patterns.

Firstly, available data on new and cancelled residencies does not indicate the characteristics of the migrating population (age, gender, citizenship). This constitutes an important aspect as the needs and vulnerabilities vary greatly among social groups and, at the same time, can be a factor of (im)mobility[5].

Secondly, the impact of tourism trends, temporary residencies and long-term tourism could be potentially linked to migration flows. For instance, the growth of Airbnb could influence renting and house purchase prices. Moreover, to fully understand the intersection of influencing factors and the role played by each of them, better data quality must be included in the analysis. Additionally, implementing artificial intelligence combining climate scenarios and demographic trends is essential to understand at the municipality level the risks faced by the population and to tailor adaptation strategies[6]. The proposed framework addresses these analytical challenges by providing a structured approach to integrate diverse data sources and indicators, facilitating more robust comparative studies across different territorial contexts.

The complexity of the factors involved, in a rapidly changing context such as the Alps, also suggests the use of AI to help define possible scenarios for the near future. In particular, through the use of digital twin modelling of the territory and its drivers of change, it will be possible to further investigate the dynamics considered here in greater depth, with a view to scenario planning with regard to the issue of vertical human mobility.

As Modica [15] highlights, it is increasingly common for individuals and families to make residential choices in metro-mountain areas considering climate conditions which, until recently, were marginal. These choices can often be understood as coping mechanisms or adaptation strategies to the effects of climate change. Nevertheless, this scenario raises a fundamental question: whether and how people—even in economically advanced countries—might choose to move internally toward more climatically temperate areas, and what natural and human factors might guide their decisions. Our framework contributes to addressing these questions by offering a systematic methodology for analyzing the complex interplay of factors that influence such migration decisions, with potential applications extending beyond the Alpine context to mountain regions globally.

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[5] In that sense, research efforts are being carried out with the collaboration of ISTAT and the University of Turin.

[6] A new research project on residential mobility, demographic scenarios, and climate change in Italian Alpine municipalities is currently underway, under a framework agreement between the University of Turin and ISTAT. This project—launched in the context of Italy's Presidency of the Alpine Convention—aims to update RSA5 data and develop innovative methodologies and data sources, with a focus on the interrelation between demographic trends and climate/environmental changes.

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Declaration on Generative AI

The authors have not employed any Generative AI tools.

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Appendix A. Definition and selection of municipalities in mountainous areas of the Metropolitan City of Turin.

In Italy there are at least three differing definitions for mountainous areas.

- From a statistical perspective, a mountain is defined by the Italian National Institute of Statistics (ISTAT for its acronym in Italian) as a territory characterised by an altitude of no less than 600 meters above sea level [25].
- From a legal perspective, in Piedmont, the Deliberation of the Regional Council[7] n° 826-6658 (1988) has determined a list of municipalities as completely or partially mountainous [25]. Additionally, the Rural Development Complement[8] (CSR for its acronym in Italian) updated in November 2023 has categorized municipalities as mountainous, hilly, lowlands or a mixture of the three [26].
- There is also an "administrative mountain", which corresponds to the set of local administrative bodies in a vast area for the management of services, valorisation, protection and mountain development: former mountain communities and mountain unions fall into this typology [25].

Given the aim of this research, the municipalities listed as mountainous by ISTAT and CSR were compared to those included as part of the Alpine Convention [27] in the Province of Turin[9]. As a result, there are:

- 105 municipalities listed as mountainous areas by ISTAT and CSR, part of the Alpine Convention.
- 38 municipalities listed as mountainous or partially mountainous areas by CSR are part of the Alpine Convention but considered hilly areas by ISTAT.
- 1 municipality part of the Alpine Convention, classified as a hilly and lowland area by CSR and as a hilly area by ISTAT.

In sum, there are 144 municipalities in CMTO part of the Alpine Convention, located in mountainous or partially mountainous areas according to the classification provided by ISTAT and CSR, which have been selected for this analysis. For a detailed list of municipalities in each classification, please refer to the section “List of municipalities under analysis”.

The following map provides an overview of the municipalities considered by each institution and the ones selected for this research project.

[7] Authors’ translation from “Deliberazione del Consiglio Regionale”.

[8] Authors’ translation from “Complemento Sviluppo Rurale”.

[9] Since April 2014, the Province of Turin has become the current Metropolitan City of Turin (CMTO as per its acronym in Italian).

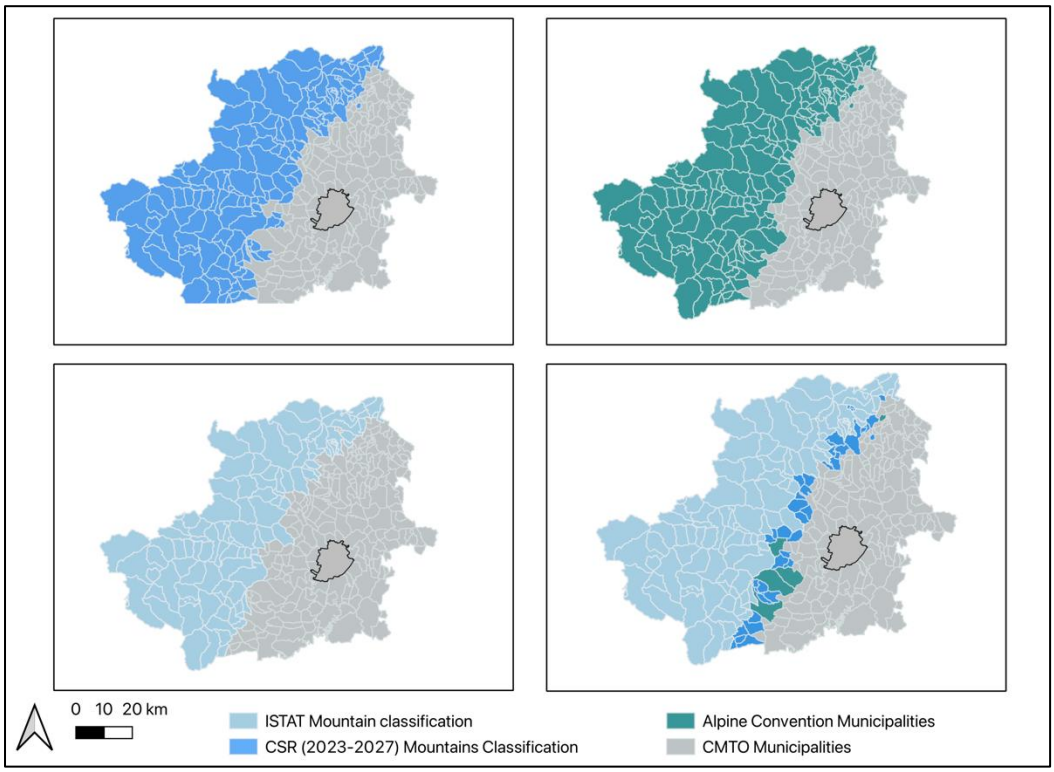

Figure 1: Municipalities in the Metropolitan City of Turin located in mountainous areas selected for the analysis. Source: Authors' creation based on ISTAT, CSR, and the Alpine Convention classifications.

Appendix B. List of indicators and sources selected for the study.

Indicator	Time measurement	Source
Births	Annually	Ufficio Statistico - CMTO
Deaths	Annually	Ufficio Statistico – CMTO
Total Population	Annually	Ufficio Statistico – CMTO
Population by sex	Annually	Ufficio Statistico – CMTO
Population by age	Annually	Ufficio Statistico – CMTO
Population density	Annually	ISTAT
Percentage of foreign population	Annually	Ufficio Statistico – CMTO
Ageing rate (percentage of population over 65 years old)	Annually	Ufficio Statistico – CMTO
New residencies	Annually	Ufficio Statistico – CMTO
Origin of new residencies (previous municipality or country other than Italy)	Annually	ISTAT
Cancelled residencies	Annually	Ufficio Statistico – CMTO
Municipality of destination of cancelled residencies	Annually	ISTAT
Tourist arrivals	Seasonally	Economia turistica - CMTO AirDNA – Inside Airbnb
Average overnight stays	Seasonally	Economia turistica – CMTO AirDNA – Inside Airbnb
New tourist accommodations	Annually	Economia turistica – CMTO
Banks	Annually	OpenStreet Map/Banca d'Italia - ISTAT
Pharmacies	Annually	OpenStreet Map/ Ministero della Salute
Schools (by educational level)	Annually	OpenStreet Map/ Dati Piemonte
Housing - purchase	Annually	Agenzia delle Entrate

Housing - rental	Annually	Agenzia delle Entrate
Unemployment	Percentage	ISTAT
Temperature	Monthly average	Copernicus
Total precipitation	Monthly average	Copernicus
Relative humidity	Monthly average	Copernicus
Hydrological risk	5 years	ISPRA
Drought index	5 years	ISPRA
Fragility index	-	ISTAT
Altitude in meters above sea level	-	ISTAT
Internal area classification	2014-2020 & 2021-2027	ISTAT
Accessibility and proximity to train stations and roads	-	ISTAT

Appendix C. Data visualisation.

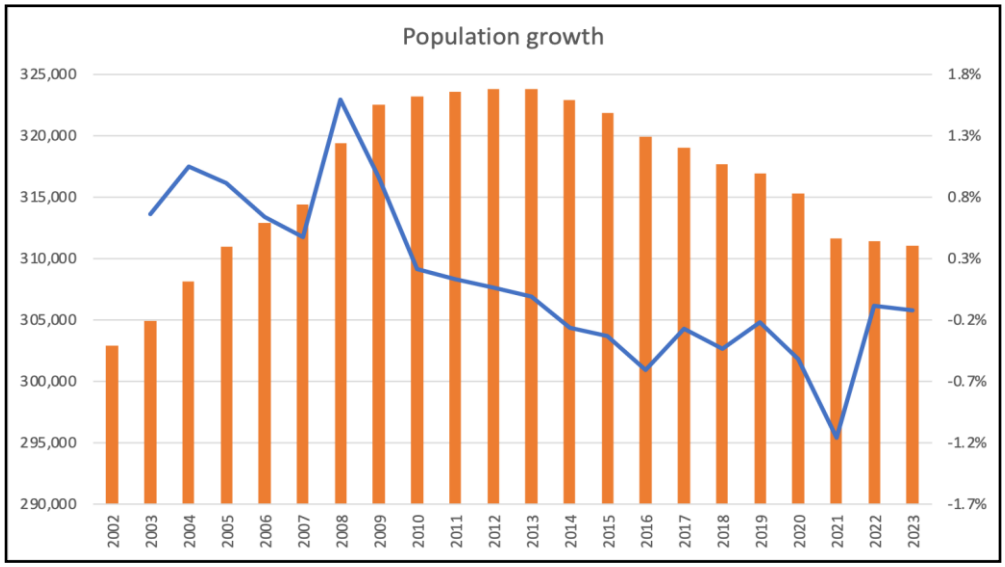

Figure 2: Population growth of the Alpine Convention municipalities within the Metropolitan City of Turin. Source: Authors' creation based on data provided by the Statistical Office of CMTO.

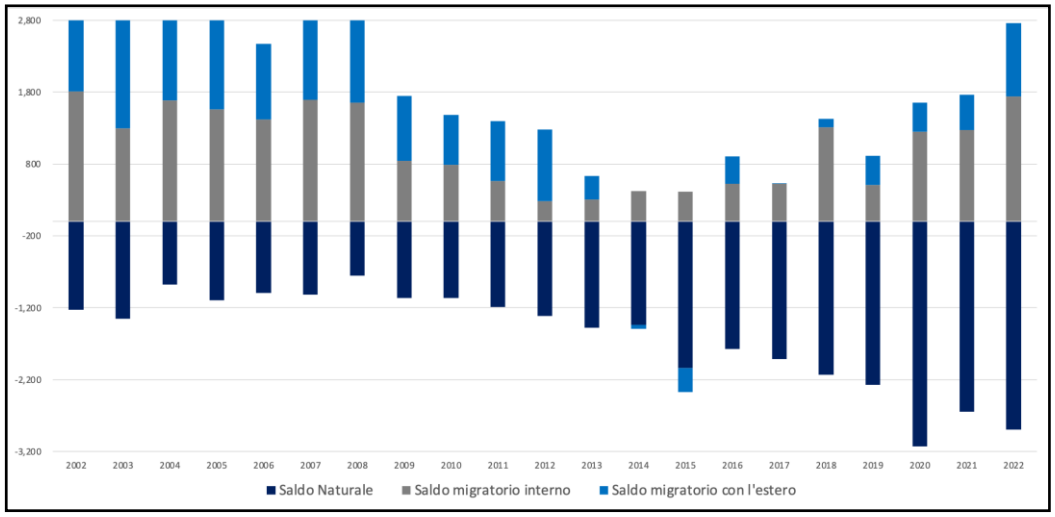

Figure 3: Natural growth and migration balance of the Alpine Convention municipalities within the Metropolitan City of Turin. Source: Authors' creation based on data provided by the Statistical Office of CMTO.

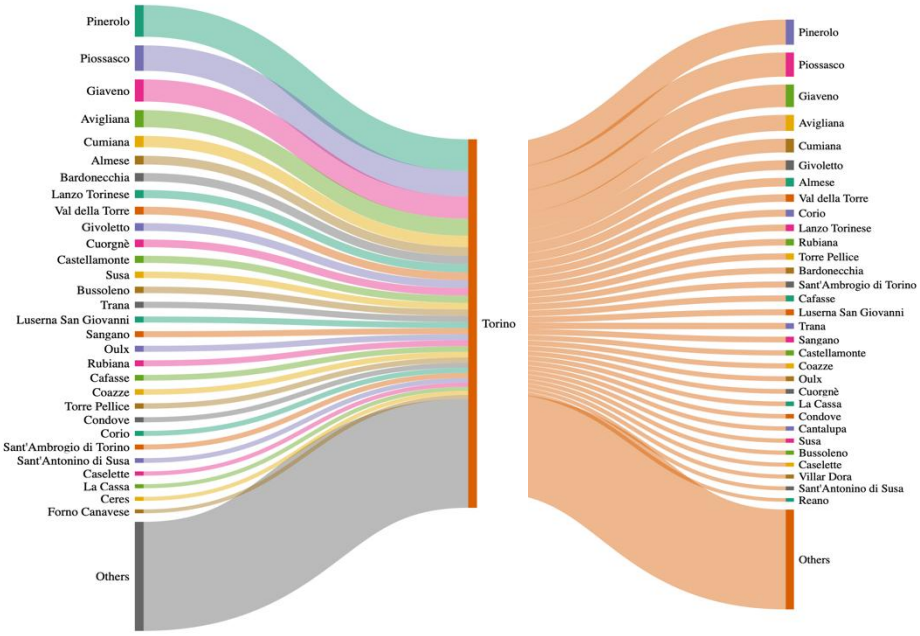

Figure 4: Main origins of new residencies and main destination of residencies cancelled in Turin. Source: Authors' creation based on data retrieved from ISTAT.

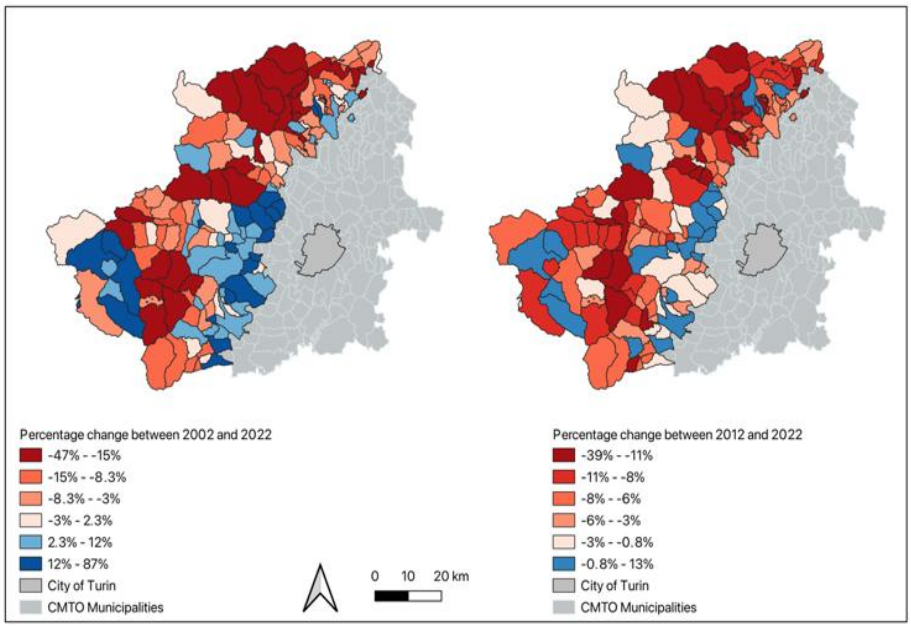

Figure 5: Population changes between 2002 and 2022 and between 2012 and 2022 in the Alpine Convention municipalities within the Metropolitan City of Turin. Source: Authors' creation based on data provided by the Statistical Office of CMTO.

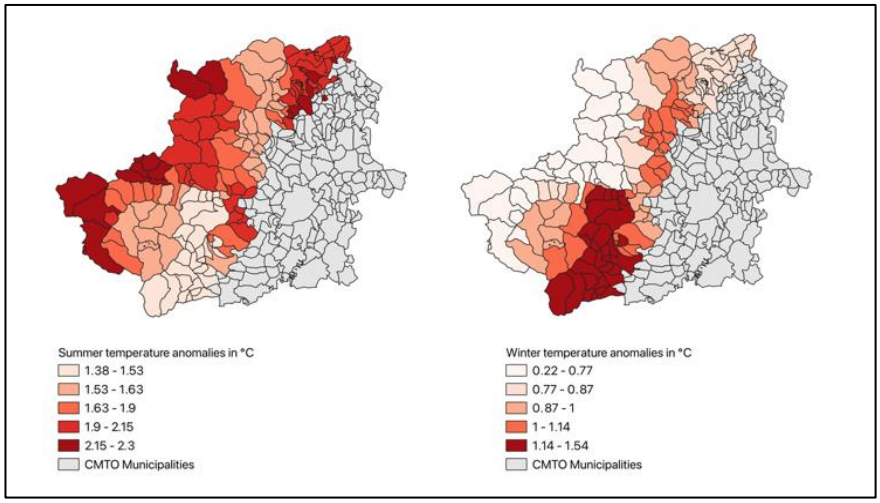

Figure 6: (Skin) Temperature anomalies in Celsius degrees calculated as the difference between 1970-2000 and 2002-2022 for summer and winter seasons. Source: Authors' creation based on data retrieved from Copernicus - ERA5 monthly averaged data on single levels from 1940 to present.

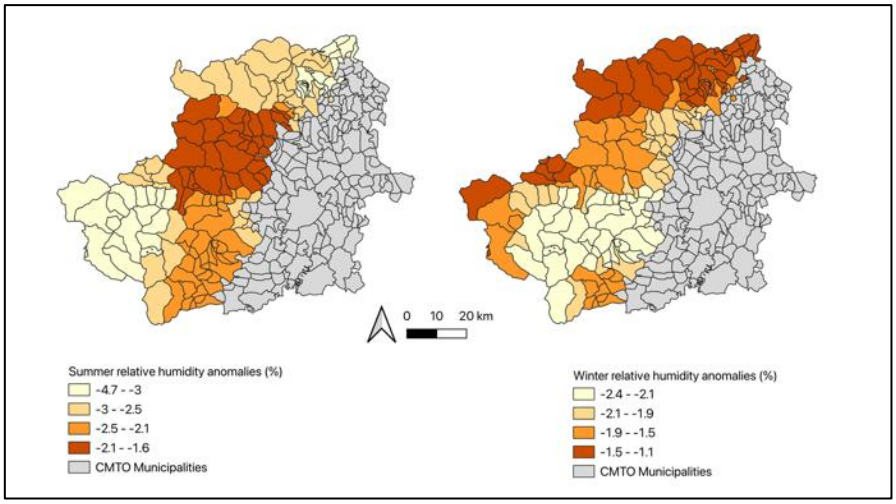

Figure 7: Relative humidity anomalies in percentages calculated as the difference between 1970-2000 and 2002-2022 for summer and winter seasons. Source: Authors' creation based on data retrieved from Copernicus - ERA5 monthly averaged data on single levels from 1940 to present.

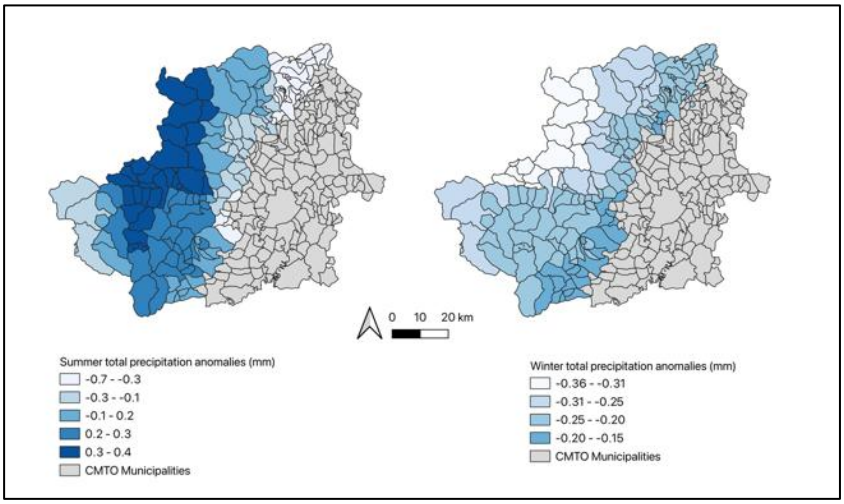

Figure 8: Total precipitation anomalies in millimeters calculated as the difference between 1970-2000 and 2002-2022 for summer and winter seasons. Source: Authors' creation based on data retrieved from Copernicus - ERA5 monthly averaged data on single levels from 1940 to present.

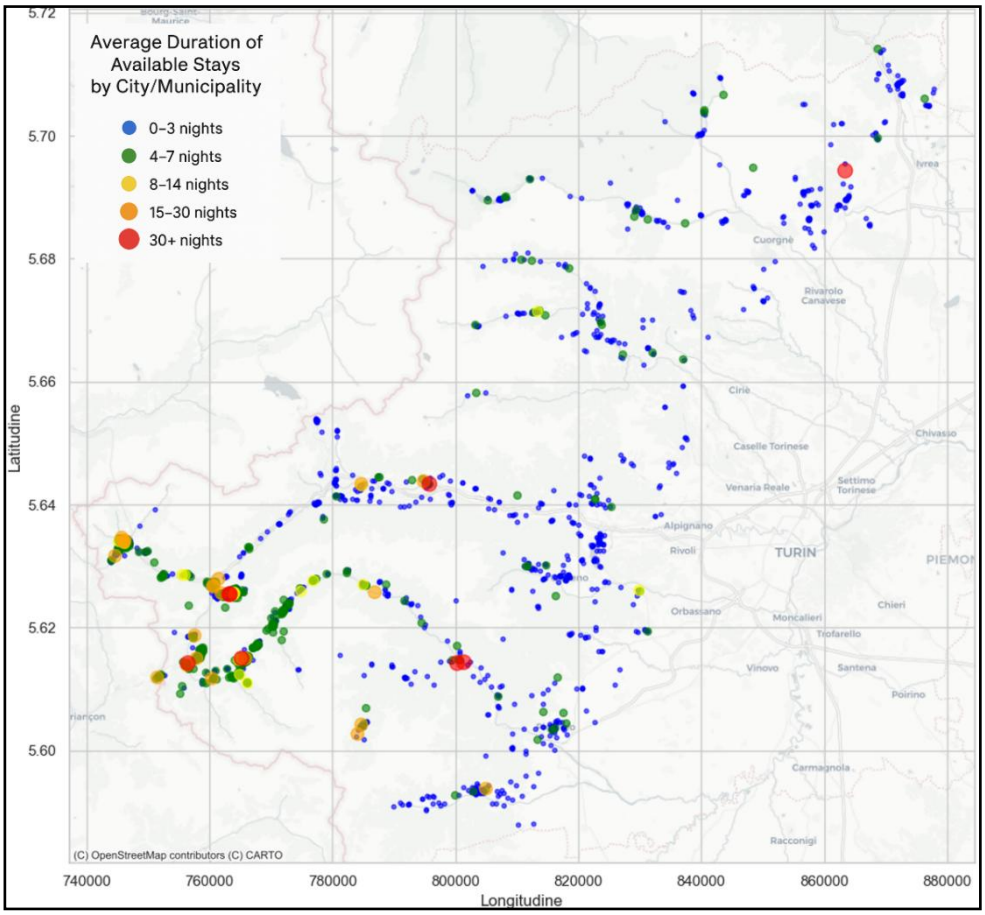

Figure 9: Use of alternative, non-institutional sources regarding tourism flows in the area. Source: Authors' creation based on data retrieved from Inside Airbnb, available upon request.