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Case Studies

Ecological transition and territorial regeneration: repopulation strategies in the "Crater Area"

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Abstract. The paper is based on the belief that the ecological transition processes must pay particular attention to the most vulnerable areas, especially those affected by disastrous events. The case of the "Crater Area" aims to highlight how appropriate measures can regenerate a region prone to disasters. The earthquakes of 2009 and 2016 that severely struck and damaged the regions of central Italy, has prompted the government to regenerate the area not only restoring damaged building but also by providing tax incentives and subsidized mortgages to attract resident, including foreigners. Since many retirees from abroad have joined the initiative, it will be attempted, though the use of algorithms, to outline future scenarios in order to be able to meet the need of these new population and business for long-term economic and social development.

Keywords: Crater Area, ecological transition, repopulation, tax incentives, sustainable development.

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1. INTRODUCTION

The ecological transition is a critical process for mitigating the effects of environmental disasters and building resilience in natural systems and communities. An effective ecological transition involves restructuring economic and social models to promote sustainable practices, which can reduce the human impact on the environment and mitigate vulnerability to extreme events (Scordato & Gulbrandsen, 2024).

Among the extreme events linked to human activities are earthquakes. Although they are caused by the geological movement of tectonic plates, their damages are amplified by human choices and practices, such as intense urbanization, the lack or inadequate implementation of seismic building codes, and the use of substandard materials and the indiscriminate deforestation. The destruction of vegetation and landscape alterations can change geological conditions and either trigger or intensify the devastating impacts

of seismic events on buildings, infrastructure, and, most importantly, on human lives (Tierney, 2014).

Italy, located at the convergence point of the African and Eurasian tectonic plates, is one of the most seismically active regions in Europe (INGV, 2024) and has historically been affected by earthquakes with significant social and economic consequences for its population (Barbini, 2021; Boero, 2021). In recent decades, the country has experienced one of the most tragic events, the earthquake of 2009 that struck L'Aquila and its surrounding areas, causing widespread destruction and the loss of over 300 lives. In 2016, another catastrophic earthquake hit central Italy, destroying buildings, infrastructure and claiming human lives, particularly in the towns of Accumoli and Amatrice in the province of Rieti, within what is now known as the "Crater Area."

The term Crater Area, previously used to describe a specific geological and volcanic feature of the region, is now associated with the recent destructive earthquakes, which drew international attention to the seismic vulnerability of this area. Today, the Crater Area serves as an example of how equitable and sustainable development can be pursued in fragile territories through revitalization, repopulation, and the revival of the traditional economic activities.

This article will focus on the strategies implemented to repopulate the area, with the goal of attracting new residents, including foreigners. The belief underlying these actions is that only by rebuilding a cohesive community can sustainable economic recovery be ensured in the post-earthquake territory, in accordance with the principles of ecological transition.

The Crater Area, in its newly defined meaning, refers to the municipalities affected by the seismic events of 2009, with the epicentre near L'Aquila. Most of these municipalities (Acciano, Barete, Capestrano, Caporciano, Carapelle Calvisio, Castel di Ieri, Castelvecchio Calvisio, Castelvecchio Subequo, Cocullo, Collarmele, Fagnano Alto, Fossa, Gagliano Aterno, Goriano Sicoli, Lucoli, Navelli, Ocre, Ofena, Ovindoli, Pizzoli, Pog-

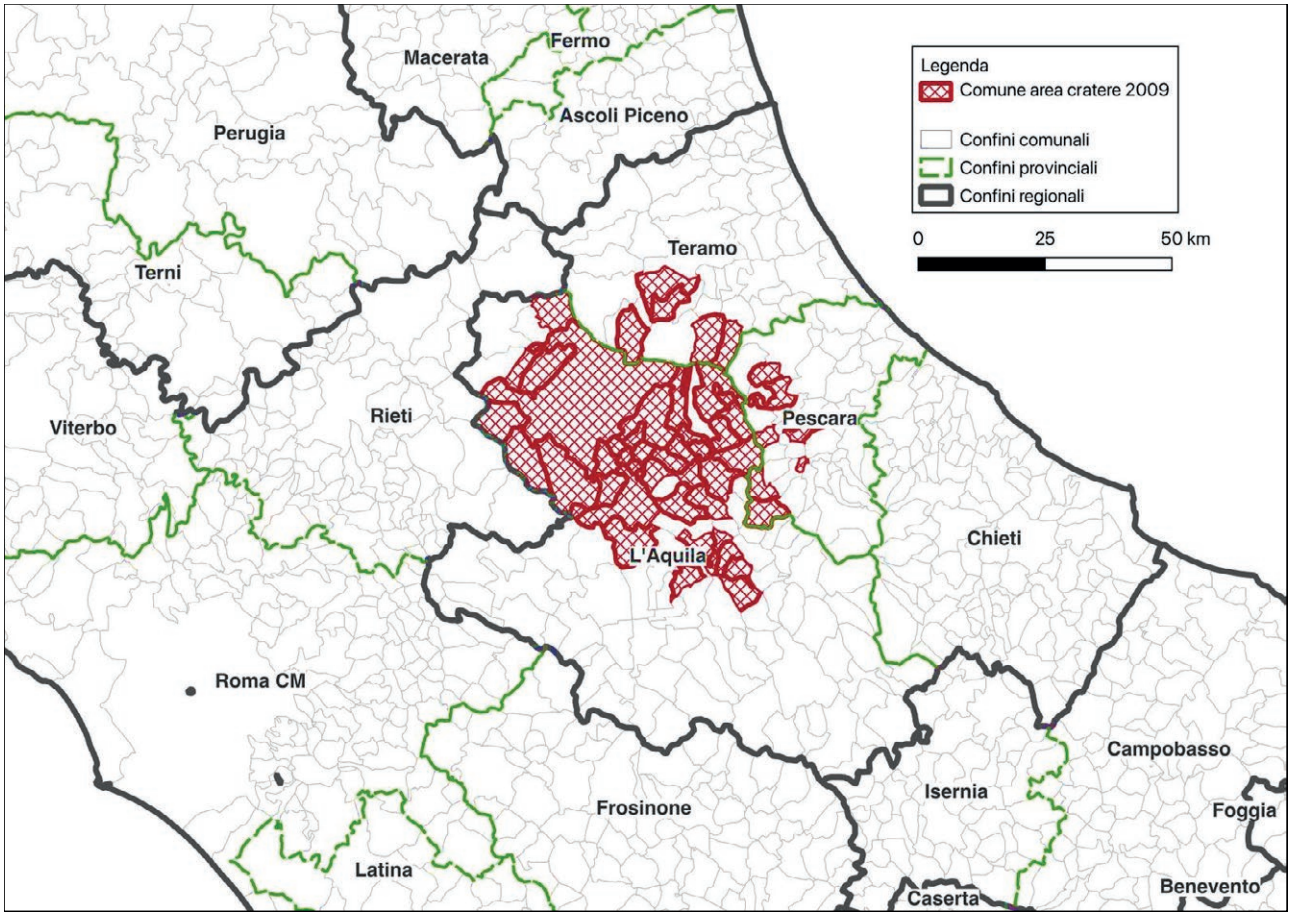

Figure 1. The Crater Area of 2009. Source: Authors'personal elaboration.

gio Picenze, Prata d'Ansidonia, Rocca di Cambio, Rocca di Mezzo, San Demetrio né Vestini, San Pio delle Camere, Sant'Eusanio Forconese, Santo Stefano di Sessanio, Scoppito, Tione degli Abruzzi, Tornimparte, Villa Sant'Angelo, and Villa Santa Lucia degli Abruzzi) belong to the Province of L'Aquila, including the provincial capital itself, shaping a territorial context endowed with heritage and community, deeply connected to their history, culture, and traditions.

In the province of Teramo, the Crater Area includes the municipalities of Arsita, Castelli, Montorio al Vomano, Pietracamela, and Tossicia. The municipalities of Brittoli, Bussi sul Tirino, Civitella Casanova, Cugnoli, Montebello di Bertona, Popoli, and Torre de' Passeri, in the province of Pescara, are also included in the area declared affected by seismic events (INGV, 2018).

Later, with Decree No. 11 of 2022, eight more municipalities were added to the Crater Area: Bugnara, Cagnano Amiterno, Capitignano, Fontecchio, and Montereale in the province of L'Aquila; Colledara, Fano Adriano, and Penna Sant'Andrea in the province of Teramo (Governo Italiano, 2022).

To regenerate the territory, the Italian government has implemented various actions. In addition to declaring a state of emergency and devising plans for the reconstruction of residential properties, public buildings, and damaged infrastructure, a primary goal is to encourage repopulation in the area. Several measures have been developed to attract people, including those from abroad, through tax incentives and subsidized mortgages for purchasing homes (Law 229 of December 14), particularly targeting young people who choose to move to the earthquake-affected municipalities (Law No. 205 of December 27, 2017).

Furthermore, the 2019 Budget Law and its subsequent amendments introduced tax incentives for individuals with pension incomes provided by foreign countries, applying a substitute tax rate of 7% on all income for those who transfer their residence to municipalities within the Crater Area, similar to the tax regime in southern Italian municipalities (Gazzetta Ufficiale, 2019).

These incentives have already yielded encouraging results, implying a positive trend in the coming years. As one can see on the Table 1, between 2019 and 2023, in regions such as Abruzzo and Marche, which benefit from a 7% flat tax alongside Sicily and Sardinia (Informazione Fiscale, 2023) and other incentives, there has been an initial rise of residents from abroad. Abruzzo, in particular, has recorded a upward trend, with the number of new residents rising from 17 in 2019 to 115 in 2023. It is worth noting that this migration flow is predominantly composed of individuals receiving pensions from foreign countries. (Epasto & Lucia, forthcoming).

Table 1- Immigrants from abroad from 2019 to 2023 in regions benefiting from tax incentives.

Region	2019	2020	2021	2022	2023
Abruzzo	17	46	88	110	115
Marche	n.a	n.a	7	45	15

Source: Authors' personal elaboration on ISTAT.

This trend highlights the potential of tax incentives, which could be expanded not only to foreign individuals and pensioners but also to other groups such as real estate operators, agencies, families, and businesses interested in establishing themselves in the Crater Area.

Based on what has been discussed, it is clear that, while there is still much to be done to achieve a complete and sustainable recovery, the measures implemented have already begun to contribute to the repopulation and economic recovery in the Crater Area.

To complete the analysis of this case study, the following section will introduce an experimental methodological framework which can be useful for forecasting future scenarios and developing effective policies to manage them.

2. ADDRESSING FUTURE SCENARIOS: A METHODOLOGICAL PROPOSAL

To forecast future scenarios, algorithms such as Prophet, Random Forest, and ARIMA were employed, aiming to provide tools that can anticipate the evolving behaviours and needs, particularly those of the elderly population. In fact, the tax incentives designed to repopulate the earthquake-affected area have attracted a significant numbero of foreign retirees (Censis, 2021).

Using the Prophet algorithm, historical data on the number of foreign retirees relocating to Italy was analysed to predict future migration trends. Random Forest was applied to estimate consumption forecasts, while ARIMA enabled projections regarding the elderly population in various regions based on birth rates, mortality, and migration.

The graph generated by the Prophet model highlights a clear upward trend in the number of foreign retirees choosing as a destination Abruzzo and Marche, two region of Crater Area (Figure 2). With the right incentives, such as tax benefits and the promotion of local natural and cultural resources, these retirees may contribute to the revitalization of the municipalities within the Crater Area, thus triggering local development processes.

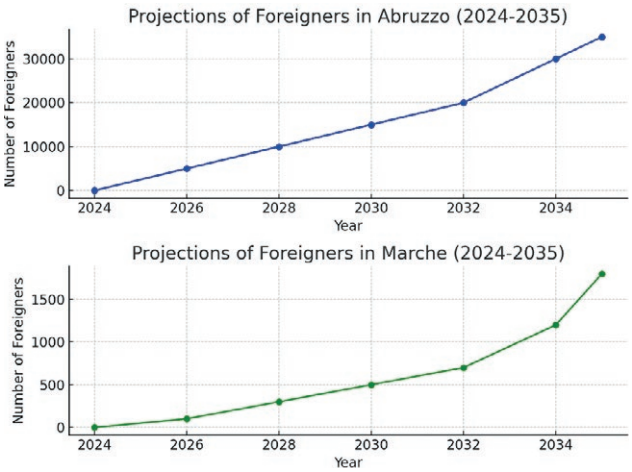

Figure 2. Results of Prophet for time series forecasting.

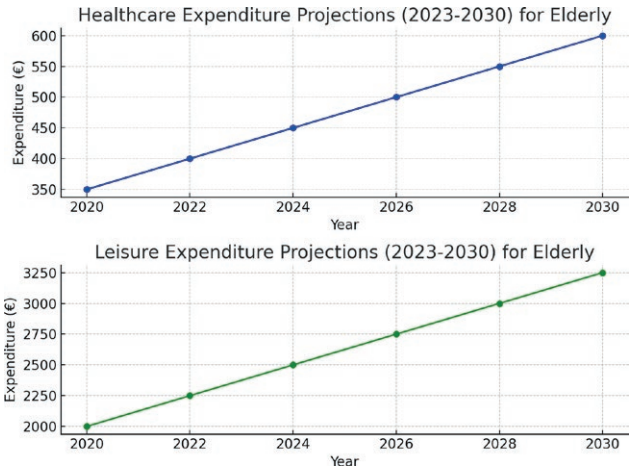

FIgure 3. Random Forest for Consumption Predictions.

The Random Forest model was trained on data related to elderly consumption to evaluate spending trends in key sectors such as healthcare and leisure. The use of Random Forest, a machine learning algorithm, enables precise and reliable predictions, leveraging the model's ability to manage large volumes of data with many variables.

In the forecast graph produced with Random Forest, the consumption predictions, clearly indicate the investments needed to address the demand for vital services, such as from healthcare and leisure, for the elderly population (Figure 3).

Finally, the use of ARIMA, combined with autoregression, integration, and moving average, allows for outlining future population trends. The forecast results show that in 2024, the number of foreigners in Abruzzo will be approximately 187, while in Marche it will be around 23. For 2025; a significant increase is expected, with 303 foreign retirees in Abruzzo and 34 in Marche. In the following years, a continuous upward trend is expected in both regions, aligned with the trend at national level as illustrate in Table 2.

The results show a steady increase in foreign retirees choosing Italy as new residence partly due to the 7% flat tax, who might favour areas like the Crater Area, drawn by the scenic beauty and tax incentives. Considering the estimates outlined by the methodological framework, the Crater Area has promising prospects for repopulation. As has been stated involving the earthquake-affected area in the ecological transition, requires that regeneration be based on the principles of seismic event prevention in the construction of homes and infrastructure, while also respecting the morphological characteristics of the regions.

Table 2. Forecasts of the Resident and Foreign Population in Italy (2025-2034).

Year	Projected Resident Population	Projected Foreign Population	Total Projected Resident Population
2025	58,989,384	6,192,843	65,182,227
2026	58,988,769	6,378,628	65,367,397
2027	58,988,154	6,569,987	65,558,141
2028	58,987,540	6,766,086	65,753,626
2029	58,986,925	6,968,069	65,955,093
2030	58,986,310	7,175,112	66,161,422
2031	58,985,695	7,388,365	66,374,060
2032	58,985,080	7,607,916	66,592,996
2033	58,984,466	7,833,968	66,818,434
2034	58,983,851	8,066,627	67,050,478

Source: Authors' personal elaboration.

3. CONCLUSIONS

The repopulation of the Crater Area represents a significant opportunity to promote the ecological transition, with the aim of achieving a sustainable development model based on eco-friendly practices. In this context, adopting organic practices and using sustainable building materials can play a key role, not only in attracting new residents but also in encouraging investment in the region. For instance, eco-friendly construction can provide modern homes built with sustainability criteria, contributing to reduced energy consumption and minimizing environmental impact. Earthquake-affected areas, physically devastated but still rich in environmental resources, culture and traditions, are ideal settings for experimenting with development models that integrate ecological transition and territorial regeneration.

Despite the progress made, many challenges remain to ensure a full and sustainable recovery. While tax incentives have helped attract new residents, it is essential to broaden attraction policies to engage not only retirees but also young families and new businesses. These groups can contribute to economic diversification and job creation, strengthening the socio-economic system of the area.

The repopulation of hilly and mountainous areas must be accompanied by targeted policies to ensure favourable living conditions in the long term. Among these policies, improving infrastructure and public services is crucial to make these regions attractive again for a stable resident population. Equally crucial is enhancing the resilience of local communities by promoting a culture focussed on seismic prevention and investment in advanced modern technologies for building safety and seismic monitoring.

The case study of Crater Area clearly shows the complexity of the ecological transition, which must consider a wide range of factors, highlighting the need for a holistic approach that merges regeneration with prevention. Revitalizing the economic and social context of the Crater Area requires not only the implementation of seismic prevention principles, but also, in addition to the flat tax, more favourable fiscal policies especially for families and businesses.

To revitalize hilly and mountainous areas, which were already experiencing depopulation prior to the 2016 earthquake, it is essential to adopt long-term and structured policies aimed at ensuring favourable living conditions for all demographic groups. This approach is the key to developing a stable and sustainable environment where ecological transition and repopulation can coexist and mutually enhance each other, promoting enduring regeneration in the affected areas.

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