THEMATIC2GREEN: Strengthening Innovation Capacity for a Place-Based Green Transition in Fragile ADRION Territories

Michele Greco, Francesco Scorza, Biagio Perretti, Francesco Paolo Del Giudice, Alfonso Annunziata, and Beniamino Murgante(✉)

University of Basilicata, Viale dell'ateneo Lucano, 85100 Potenza, Italy
beniamino.murgante@unibas.it

Abstract. Coastal, mountainous, and historically significant territories in the ADRION macro-region face increasing pressure from environmental degradation, climate change, and uneven patterns of economic development. In these areas, small and medium-sized enterprises, public institutions, and civil society organizations must reconcile environmental sustainability with social sustainability while preserving employment and local income opportunities. In response, THEMATIC2GREEN aims to strengthen innovation capacity for green development based on cultural and natural resources. The project adopts a place-sensitive approach structured around three interdependent lines of action: environmental quality management and certification of economic activities, climate change adaptation, and renewable energy production and consumption, including energy communities. Targeting fragile coastal and mountainous regions, the project combines pilot actions, joint solutions, a joint strategy for renewable energy communities, and a permanent cooperation network. Through a quadruple helix model, THEMATIC2GREEN seeks to generate practical, transferable, and territorially adapted solutions for a balanced green transition in the ADRION area.

Keywords: green transition · innovation capacity · fragile territories · sustainable development

1 Introduction

In the coming years, small and medium-sized enterprises (SMEs), public institutions, and non-governmental organizations (NGOs) located in coastal areas, mountain territories, and historic towns of lagging regions will face a common set of major challenges [1, 2]. These communities must reconcile environmental sustainability with social sustainability, while preserving local employment and income opportunities [3, 4].

The first issue concerns the prevention and reduction of degradation of natural resources and cultural heritage caused by economic activities that remain essential for local development. In these territories, agriculture, tourism, and other place-based services provide livelihoods but can also generate environmental pressure [3, 5, 6]. The key

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O. Gervasi et al. (Eds.): ICCSA 2026 Workshops, LNCS 16766, pp. 270–280, 2027.
https://doi.org/10.1007/978-3-032-30539-8_20

issue is therefore to improve the environmental performance of local economic systems without weakening their social and economic functions. A second challenge is the transition away from fossil fuels while improving the efficiency and sustainability of renewable energy production and distribution [7–10]. This issue is particularly complex in marginal areas characterized by low population density and high environmental and cultural value. In such territories, renewable energy systems often involve high production and distribution costs. In addition, renewable sources may also generate significant environmental impacts, including visual impacts on landscapes from wind turbines and solar installations, pressure on air quality and agricultural land from biomass plants, and landscape fragmentation associated with energy distribution networks. As a result, the energy transition in these areas requires solutions that are both technically efficient and territorially sensitive. A third challenge is adaptation to climate change and mitigation of its effects on local economic and social activities. Climate change is already affecting, or is expected to affect in the short and medium term, sectors such as cultural services, cultural and nature-based tourism, non-food agricultural production, and other consumer-oriented services. SMEs, public and private service providers, and local communities will need to adjust production processes, services, and product innovation strategies in order to reduce vulnerability and strengthen resilience [11–20]. At the same time, this context creates important opportunities. These territories are increasingly included in European and macro-regional policy frameworks that support a sustainable transition, notably the European Green Deal and the EUSAIR strategy. In this perspective, the development of environmentally high-quality businesses, innovative systems for renewable energy production and consumption, and stronger local capacities to mitigate and adapt to climate change can generate both local and global benefits, including new employment opportunities. Against this background, the overall objective of THEMATIC2GREEN is to strengthen innovation capacity for green development based on cultural and natural resources, while addressing emerging environmental and social challenges. The project is designed to support territorial development in the ADRION macro-region through coordinated action in three interdependent thematic areas. First, the project aims to enhance entrepreneurial capacity to improve the environmental sustainability of local economic systems. This includes promoting environmental quality, innovation, and certification processes for economic activities rooted in local resources. Second, it aims to reinforce the capacity of public and private actors to identify climate-related threats, assess local impacts, and define adaptation strategies for preserving both economic development and the social sustainability of the green transition. Third, the project promotes the development of renewable energy production, distribution, and consumption, with particular attention to the creation of locally adapted and socially acceptable solutions, including a joint strategy for renewable energy communities. The main expected outputs include pilot actions, joint solutions, a joint strategy for renewable energy community development, and a permanent cooperation network able to continue beyond the project lifetime. The project focuses on coastal and mountainous areas in the ADRION macro-region, which share rich natural resources, diverse cultural heritage, small rural populations, and economies centered on agriculture, tourism, and micro-enterprises. These regions are also highly vulnerable to climate change impacts such as sea-level rise, erosion, and extreme weather. The partnership of THEMATIC2GREEN higher education institutions,

business support agencies, local administrations, and development agencies across the ADRION area. Based on a quadruple helix model, the project integrates academia, public institutions, businesses, and civil society to support the green transition through three lines of action: environmental quality in economic activities, renewable energy systems, and climate change adaptation. Its integrated and place-sensitive approach aims to generate practical and transferable solutions for fragile territories.

2 Organization of the THEMATIC2GREEN Project

2.1 Methodological Approach

THEMATIC2GREEN adopts an integrated territorial approach to foster innovation capacity for green development in marginal coastal and mountainous areas characterized by rich cultural and natural resources. The method is designed to support public institutions and micro-scale public and private businesses, which often operate under limited human resources and therefore face difficulties in addressing green-transition objectives through isolated sectoral interventions. The project addresses three interrelated dimensions in parallel. The first concerns the improvement of environmental quality management in economic activities, particularly those based on cultural and natural heritage. The second focuses on innovative models for renewable energy production, distribution, and consumption, with specific attention to locally adapted solutions such as energy communities. The third aims to strengthen the capacity of public and private actors to identify climate-related risks, assess local impacts, and define adaptation strategies able to preserve economic development and social sustainability.

The methodological assumption is that these dimensions are mutually dependent and should be implemented through an integrated framework. This design is intended to maximize systemic impact, promote synergies among stakeholders, reduce fragmentation in project coordination, and avoid excessive pressure on the limited administrative and organizational capacities of marginal territories.

Operationally, the project combines pilot actions, joint solutions, strategic planning, and network-building activities. In each thematic area, partners co-develop and test solutions tailored to local needs, while also contributing to a joint strategy for renewable energy communities. These activities are supported by the creation of a permanent cooperation network aimed at ensuring continuity beyond the project duration.

The methodological framework also capitalizes on the experience developed in the previous THEMATIC project under the ADRION 2014–2020 programme. THEMATIC2GREEN builds on that experience by reusing knowledge on territorial needs, local potential, and stakeholder networks, thereby strengthening complementarities among partners and consolidating already established cooperation mechanisms.

The method also leverages partners' prior expertise. In environmental management and certification, partners share capacity-building experience and help transfer good practices. For renewable energy, operational knowledge is exchanged on innovative local models like energy communities. Climate adaptation solutions are developed using insights from earlier national and European projects involving multiple partners.

Overall, THEMATIC2GREEN is based on integration, capitalization of previous experience, and collaborative experimentation, with the aim of generating practical

and transferable solutions for a balanced and effective green transition in vulnerable territories.

2.2 Work Plan and Work Packages

The project work plan is structured into three thematic Work Packages (WPs), corresponding to the main dimensions of the green transition addressed by THEMATIC2GREEN: environmental quality of economic activities, climate change adaptation, and renewable energy systems. Across all WPs, the project follows a shared methodological sequence: territorial and needs-based analysis, co-design and implementation of pilot actions, and dissemination and transfer of results. This common structure ensures coherence and supports the progressive strengthening of institutional and operational capacity.

WP1, Promotion of environmental quality certification of public and private services, focuses on improving the capacity of public and private actors in coastal and mountainous territories whose economies rely on cultural and natural resources. Its target groups are SMEs, public institutions, and NGOs involved in cultural services and heritage-related activities. The first action develops a structured analysis of territorial needs and potentials through a transnational working group, surveys, and the identification of support options, leading to a shared white paper. The second action implements a pilot aimed at creating a technical assistance service for environmental management and certification, including a feasibility study, a support platform with models and diagnostic procedures, direct assistance to final beneficiaries, staff training, and a transferable joint solution. The third action addresses communication and awareness raising through workshops, conferences, social media, and video dissemination. The main output is a support platform for environmental management and certification, accompanied by a joint solution for reuse in partner regions.

WP2, Pilot actions for creation of tools for climate change adaptation of vulnerable economic systems, aims to strengthen the ability of public and private actors to assess and respond to climate-related impacts in vulnerable coastal and inland areas. It addresses tourism, cultural services, archaeological and natural heritage, and rural communities. The first action consists of a territorial analysis of expected climate impacts on local economic systems, based on the review of available models, the selection of indicators, and stakeholder surveys. The second action develops a pilot based on the joint design of local-scale forecast models, supported by GIS tools and adapted to partner territories. These models are conceived as decision-support tools for investment planning, territorial management, and innovation. The third action disseminates adaptation options through workshops, video production, and social media campaigns. The main outputs are a forecast platform for local climate scenarios and a joint solution for cooperative adaptation strategies (Fig. 1).

WP3, Pilot actions and joint solutions for energy efficiency in coastal and rural areas, addresses renewable energy development and energy efficiency in low-density, fragile, and seasonally variable territories. The first action combines territorial analysis and stakeholder consultation for the preparation of a Joint Strategy for the promotion of energy communities, while also supporting the formalization of a permanent cooperation network. The second action consists of joint pilot activities on micro-installations

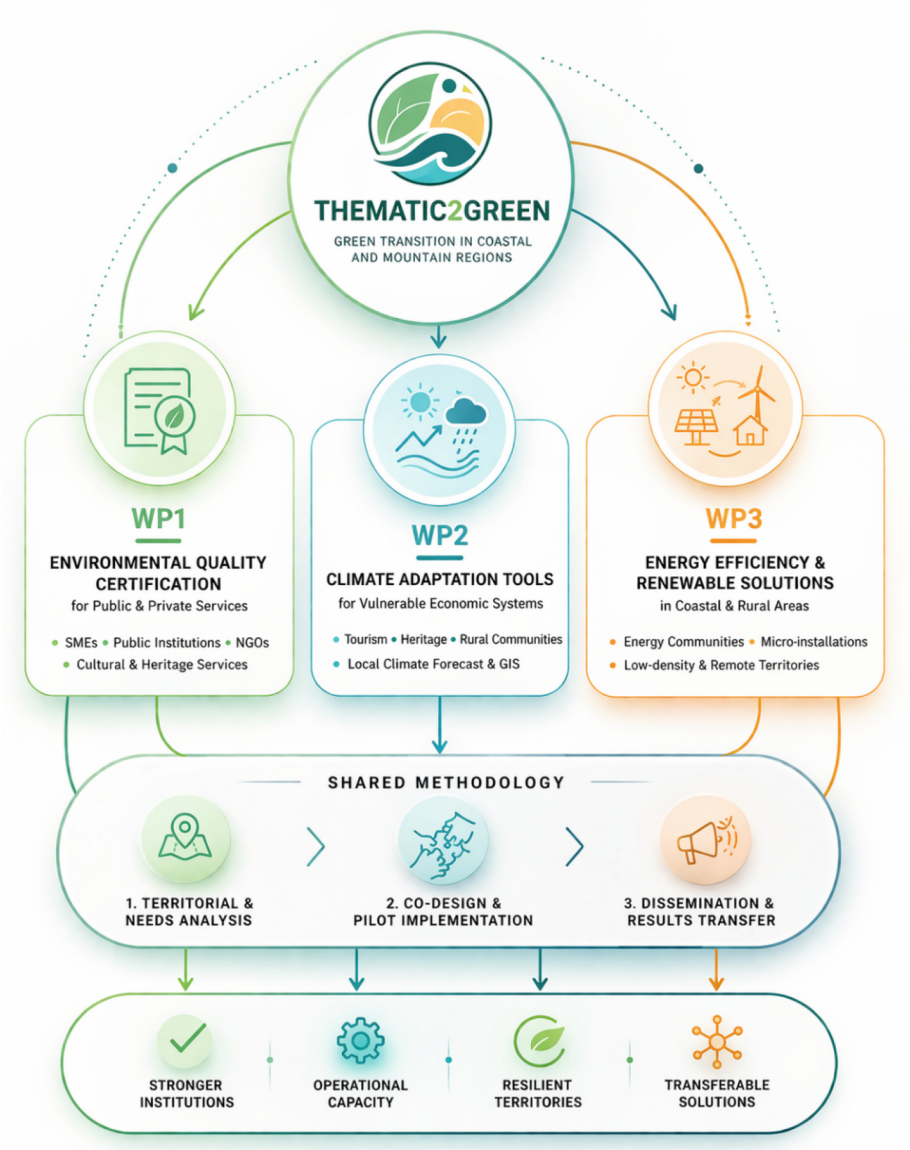

Fig. 1. Project Structure and Articulation into Work Packages

and innovative renewable energy systems in coastal, rural, and remote contexts. The third action promotes awareness raising and mainstreaming through communication campaigns, newsletters, international fairs, and European sustainability events.

Overall, the work plan presents a coherent and methodologically robust design, in which each thematic line moves from diagnosis to experimentation and from experimentation to transferability.

2.3 Structure of the Partnership

The partnership is structured according to the triple helix model, combining research and innovation institutions, public authorities responsible for policy design and implementation, and organizations specialized in business support and promotion. This composition is intended to ensure both scientific rigor and practical relevance in the development of actions for the green transition in the ADRION macro-region. Beyond project outputs, the consortium is designed to generate a lasting impact at both regional and transnational scales by consolidating a network able to support coordinated green development across diverse territorial contexts. A major strength of the partnership lies in the capitalization of experience gained through the previous THEMATIC project (ADRION 2014–2020), in which most partners worked together over a three-year period. That cooperation continued after the formal end of the project through a permanent stakeholder network established by a memorandum of understanding signed in 2021. This network played an important role in the development of the THEMATIC2GREEN proposal and provides a strong institutional basis for the new project. The partnership combines four complementary dimensions: scientific and technical expertise, geographical representativeness, policy-making capacity, and business development experience. Scientific and technical expertise is mainly provided by the academic partner SI-UNIBAS, together with local development agencies and business support organizations. Geographical coverage is ensured by the presence of partners from four ERDF countries and three IPA countries, representing a wide range of environmental, structural, and economic conditions within the Adriatic-Ionian area. Policy-making capacity is provided by local administrations and regional agencies, while business development experience is ensured by national and regional support bodies.

All partners contribute to project activities according to their institutional profile and field of competence. In the work package on environmental quality development and certification, ENTGRE, RDA BKP, and ZRDASER play a leading role, especially in the design and implementation of pilot actions. In the climate adaptation work package, key functions are performed by RUTGRE, SI-UNIBAS, MUNPREK, ZRDASER, BSC KRANJ, REDAH, and ENTGRE, with particular relevance for the development of models and operational tools for vulnerable mountain areas. In the renewable energy work package, leadership is mainly provided by MUNPREK, MUNMED, and BSC KRANJ, while the Municipality of Castelmezzano contributes an established good practice on energy communities in environmentally sensitive territories. All partners also contribute to the Joint Strategy through territorial analysis and feasibility assessment. Overall, the partnership reflects a balanced combination of expertise, territorial coverage, and institutional continuity. This configuration strengthens implementation capacity and enhances the consortium's ability to generate coordinated and durable effects on the green transition in the ADRION macro-region.

3 Objectives and Expected Results

3.1 Common Challenges, Strategic Alignment and European Policy Synergies

The ADRION countries present common sustainability issues despite substantial socio-economic differences. Coastal and inland rural areas face increasing pressure from resource exploitation and climate change, while the economic potential of cultural and natural assets remains unevenly developed across the macro-region. In this context, THEMATIC2GREEN aims to reinforce innovation capacity for a balanced green transition by fostering transnational cooperation on environmental quality management, renewable energy, and climate change adaptation in coastal and rural economic systems. Within this perspective, THEMATIC2GREEN is explicitly aligned with the European Green Deal, the EU Strategy for the Adriatic and Ionian Region (EUSAIR), and relevant national Smart Specialisation Strategies (S3). With respect to the Green Deal, the project contributes to decoupling economic growth from resource use and to a just transition that "leaves no person and no place behind" through actions on energy efficiency, renewable energy systems, energy communities, and environmental quality certification in lagging coastal and rural areas. In relation to EUSAIR, it supports regional cooperation, Western Balkans integration, economic development, and the valorisation of the macro-region's cultural heritage. The project is also designed to reinforce national and regional S3 priorities in partner countries, especially in the fields of sustainable energy, environment, circular economy, tourism, and innovation for green development.

3.2 Expected Results and Target Beneficiaries

The expected results of THEMATIC2GREEN derive from its comparative and transnational approach. By examining structurally similar territories across the ADRION area, the project aims to produce a more accurate understanding of common needs, constraints, and development opportunities. This approach is expected to improve diagnostic capacity and to support the joint development of robust and transferable solutions. In particular, the exchange of good practices among territories with comparable economic structures and environmental conditions should accelerate the capitalization of innovative methodologies in two key fields: environmental quality management for micro-businesses and small-scale renewable energy systems. At the same time, the joint development of models and methodologies for assessing climate change impacts is expected to strengthen the robustness and operational effectiveness of local adaptation strategies. A central expected outcome is the reinforcement of planning and implementation capacity across public authorities. Local authorities in coastal and rural areas are expected to acquire tools for investment planning in climate adaptation, renewable energy, and environmentally sustainable development. Regional authorities should benefit from improved instruments for territorial planning and investment prioritization, supported by the involvement of regional bodies and development agencies and by the capitalization of networks and results from the previous THEMATIC project. The project is also expected to strengthen the engagement of national public authorities, particularly in IPA countries, through closer technical and institutional interaction with European partners.

Sectoral agencies are also expected to play a strategic role as intermediaries between territorial needs and the joint solutions developed at transnational level. Their contribution is essential for translating project outputs into operational support mechanisms and for adapting common methodologies to local governance and market conditions. Higher education and research organizations, in turn, are expected to contribute to the identification and validation of innovative solutions, particularly in relation to renewable energy production and distribution systems suited to coastal areas with seasonal demand patterns and inland territories characterized by low population density and vulnerable ecosystems. Their involvement reinforces the scientific basis of the project and supports methodological rigor in the design of technical solutions.

SMEs represent another key target group. In rural, coastal, and mountain service sectors, the project is expected to increase awareness and practical capacity in environmental quality management, while improving access to environmental certification procedures for activities related to cultural services and the management of cultural and historical resources. The general public is also expected to benefit from greater awareness of energy communities and of their social, economic, and environmental advantages, which is a necessary condition for their wider diffusion.

Overall, the project aims to support a multi-level and transnational learning process for a more coherent and inclusive green transition across the ADRION macro-region.

4 Preliminary Results

Building on the objectives and expected results outlined in Sect. 3, the Metaponto case study provides an initial empirical validation of the project's analytical framework by showing how compound coastal hazards can progressively reconfigure territorial risk in fragile Mediterranean systems. The assessment, based on a multi-scenario approach integrating relative sea level rise (RSLR), vertical land movements (VLM), and storm surge dynamics, identifies a distinctly non-linear evolution of impacts, moving from selective exposure in the short term to accelerated damage in the medium term and systemic risk amplification in the long term.

In the 2030 horizon, impacts remain relatively contained and spatially differentiated. The most exposed component is the drainage network, with interference values between approximately 18% and 25% of its total extent, while protected areas and the road network show lower but still significant levels of impact. By contrast, buildings and accommodation facilities remain only marginally affected in most scenarios. This pattern indicates that early climate-related pressures primarily affect the environmental and functional backbone of the territorial system, particularly regulation and drainage infrastructures, before significantly compromising the built environment and economic assets.

A marked discontinuity emerges by 2050. Under intermediate and high-impact scenarios, damage and interference indicators increase sharply across several territorial components, especially accommodation facilities, buildings, and protected areas, with values entering the 30–40% range. This acceleration suggests progressive saturation of the system's adaptive capacity and reflects the cumulative interaction of sea-level rise, subsidence, and more intense extreme events. In this perspective, 2050 can be interpreted

as the first critical tipping point, beyond which the territorial system loses a substantial part of its capacity to absorb external perturbations without structural and functional reconfiguration.

By 2100, the analysis delineates a clearly systemic risk scenario. Under high-forcing conditions (RCP8.5 combined with VLM), interference reaches about 37.3% for the drainage network, 44.4% for protected areas, 26% for accommodation facilities, 11.3% for buildings, and 12.1% for the road network, while irrigated areas remain comparatively less exposed, although still affected by increasing trends. The inclusion of storm surge dynamics produces a further step change in impact magnitude: interference exceeds 60% for accommodation facilities and approaches 70% for protected areas even under moderate return-time conditions, with peaks close to 80% under the most severe compound scenario (RCP8.5 + VLM combined with a 100-year storm surge event). These results indicate that extreme events do not act as simple additive stressors, but as discontinuity factors capable of triggering rapid transitions toward high-impact states.

Overall, the preliminary results reveal a clear hierarchy of vulnerability. Natural systems and environmental infrastructures act as primary receptors of climate stress, followed by a progressive propagation of impacts toward the built environment and, subsequently, toward economic activities, particularly coastal tourism. This pattern is reinforced by multi-risk interactions, as coastal erosion, flooding, groundwater salinization, and water stress operate in a mutually amplifying way. The Metaponto case therefore illustrates the transition from sectoral vulnerability to systemic risk in Mediterranean coastal territories and highlights the need for timely, integrated, and cross-sectoral adaptation strategies.

5 Conclusions

THEMATIC2GREEN addresses the green transition in fragile ADRION territories through an integrated and place-based framework that combines environmental quality management, renewable energy development, and climate change adaptation. Its methodological value lies in the parallel treatment of these interdependent dimensions through pilot actions, joint solutions, strategic planning, and transnational cooperation. The project is further strengthened by a multi-actor partnership and by the capitalization of knowledge, networks, and operational experience generated in the previous THEMATIC initiative. The preliminary evidence from the Metaponto case study confirms the relevance of this approach. The results show that climate-related pressures in Mediterranean coastal systems evolve from selective and sector-specific impacts to systemic risk configurations driven by the interaction of sea-level rise, subsidence, and extreme events. This finding supports the need for integrated, cross-sectoral, and territorially differentiated adaptation strategies.

Overall, THEMATIC2GREEN provides a structured framework for reinforcing innovation capacity in vulnerable regions and for generating practical, transferable solutions consistent with European and macro-regional sustainability objectives. In this sense, the project contributes both to local resilience building and to broader transnational learning for a balanced green transition in the ADRION area.

Acknowledgments. This study was supported by the European Union through the Interreg IPA Adrion Program within the project "Thematic Innovation capacity toward green development - THEMATIC2GREEN" (CUP: E37F24000020007).

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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