The Update of the Provincial Structural Plan of Potenza to Strengthen Climate Change Adaptation Policies in the Governance of Basilicata

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Abstract. The UN's 2050 biodiversity vision aims to achieve thriving ecosystems, reduced species extinction risks, and long-term benefits for humanity. Climate change and biodiversity loss are interlinked global challenges that demand urgent and comprehensive action. Local ecological networks support both climate change adaptation and biodiversity protection by fostering interconnected green spaces that enhance ecosystem resilience. Through targeted policies and nature-based solutions, such as native reforestation and wildlife corridors, these networks mitigate extreme climate events and support species survival. This contribution illustrates the activities of the Province of Potenza in the planning of ecological networks, updating the Provincial Structural Plan as a government tool, seeking strategies for multi-functional development of the territory. With the increase in catastrophic weather events, the identification of new strategies and new tools assumes an important role in adapting to climate change and the challenges that changes in society reflect on the territory. The Province of Potenza is actively involved in European projects promoting participatory governance, territorial resilience, and sustainable ecosystem management, contributing to integrated and lasting environmental transformation.

Keywords: ecological network · governance · climate change adaptation · biodiversity

1 Introduction

Biodiversity is the variety of life on Earth, from genes and bacteria to entire ecosystems like forests and coral reefs. It has evolved over 4.5 billion years, with increasing influence from human activity. Up to one million species are threatened with extinction, many within decades. Important ecosystems such as the Amazon rainforest, are shifting from carbon sinks to carbon sources due to deforestation, while 85% of carbon-absorbing wetlands have vanished [1].

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The Convention on Biological Diversity (CBD), ratified by 196 nations in 1993, aims to conserve biodiversity, promote sustainable use, and ensure fair sharing of genetic resources. It covers ecosystems, species, and genetic resources, extending to areas like biotechnology, education, and agriculture. The Conference of the Parties (COP) meets biennially to review progress and set priorities [2]. While human land use remains the main driver of biodiversity loss, climate change is increasingly contributing by disrupting ecosystems, causing species loss, increasing diseases, and leading to the first climate-driven extinctions [1]. In 2023, many temperature and ice extent records were shattered, with global and North Atlantic sea surface temperatures significantly exceeding their 1991–2024 averages, a trend continuing into 2024. While Antarctic and global sea ice extent has returned to levels seen in previous years, it remains well below the 1993–2024 average. Global daily mean temperatures reached record highs for much of 2023 and 2024 [3] (Fig. 1).

Climate change is a major driver of biodiversity loss, causing species extinctions through habitat disruption, stress, and threats to keystone species. Efforts to address this include climate action, mass reforestation, habitat restoration, and targeted conservation. While progress has been made with increased protected areas, challenges remain in integrating climate policies with biodiversity goals. Nature-based solutions, such as enhancing genetic diversity and leveraging ecosystems for carbon sequestration (e.g., whales' role in marine ecosystems), are vital for resilience. Collaboration, funding, and effective management are essential. The UN's 2050 biodiversity vision aims to reduce extinction risks and ensure long-term benefits for humanity by aligning biodiversity conservation with climate strategies.

2 The European and National Strategies and Plans to Address Climate Change and Biodiversity Loss

Climate change and biodiversity loss are interlinked global challenges that demand urgent and comprehensive action. Europe has taken a leading role in developing and implementing strategies to address these issues, aiming to promote environmental sustainability while ensuring economic and social resilience.

The key initiatives to tackle Climate Change are the European Green Deal, introduced in 2019, is the cornerstone of Europe's climate action plan. This ambitious framework sets forth the goal of achieving carbon neutrality by 2050. To reach this target, the European Union (EU) has prioritized:

- Decarbonization: Transitioning to renewable energy sources, promoting energy efficiency, and phasing out fossil fuels.
- Circular Economy: Reducing waste and encouraging sustainable production and consumption patterns.
- Climate Adaptation: Implementing measures to mitigate the impacts of extreme weather events, rising sea levels, and other climate-related challenges.

Moreover, the Fit for 55 package underscores the EU's commitment to reducing greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. These initiatives are complemented by international cooperation under the Paris Agreement.

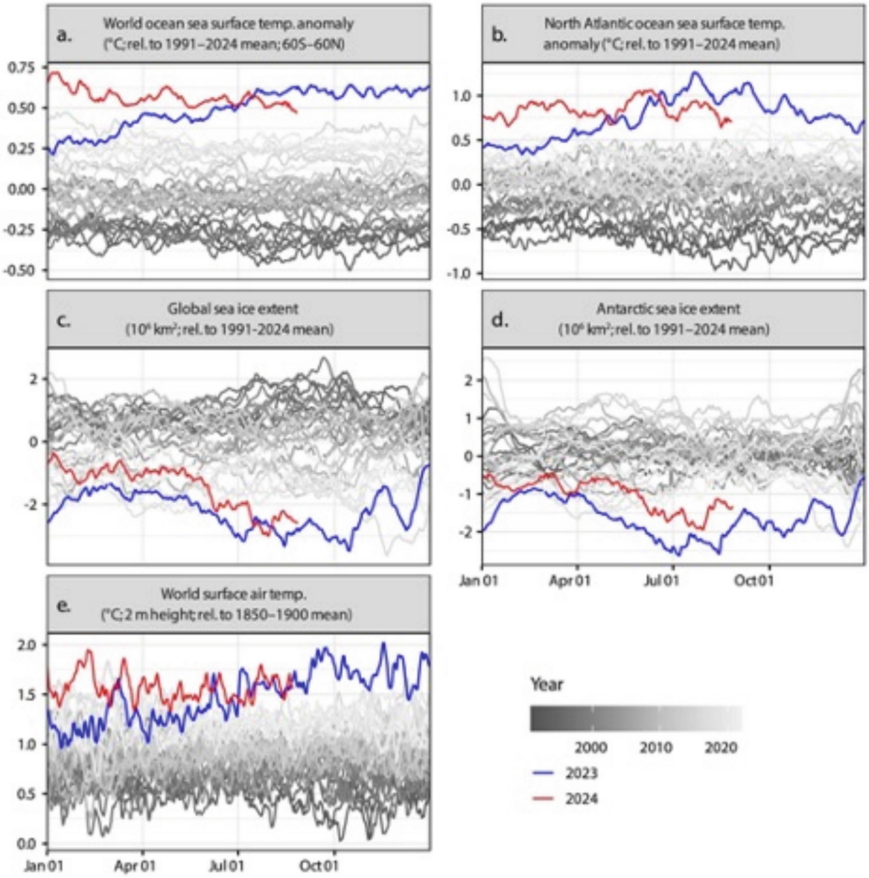

Fig. 1. Unusual climate anomalies in 2023 and 2024. Ocean temperatures (a, b) are presently far outside their historical ranges. These anomalies reflect the combined effect of long-term climate change and short-term variability. Sources and additional details about each variable are provided in supplemental file S1. Each line corresponds to a different year, with darker gray representing later years. All of the variables shown are daily estimates [3].

Biodiversity is essential for ecological balance and climate resilience. The EU Biodiversity Strategy for 2030 outlines critical steps to halt and reverse biodiversity loss, including:

- Habitat Restoration: Restoring degraded ecosystems, such as forests, wetlands, and marine areas, to improve carbon sequestration and protect species.
- Protected Areas: Expanding the coverage of protected land and marine zones to conserve key biodiversity hotspots.
- Sustainable Land Use: Promoting sustainable agricultural and forestry practices to minimize habitat destruction and support ecosystem health.

In addition, the EU Nature Restoration Law sets legally binding targets for ecosystem restoration, aiming for long-term environmental recovery and sustainability.

Integration Strategy integration plays a key role: Europe recognizes the interconnectedness of climate action and biodiversity conservation. The integration of these strategies is evident in nature-based solutions, such as afforestation, which simultaneously reduce carbon emissions and enhance biodiversity. Collaboration with local communities, industries, and global partners is vital for achieving sustainable outcomes.

Through innovative policies and ambitious targets, Europe is addressing climate change and biodiversity loss with a holistic approach. The success of these strategies relies on robust implementation, adequate funding, and cross-sectoral collaboration. As the EU continues to lead global efforts, the preservation of natural ecosystems and climate resilience will remain central to its vision for a sustainable future.

Italy has implemented a range of strategies to tackle the interconnected challenges of climate change and biodiversity loss, aligning its efforts with European and international frameworks.

Regarding the Italian framework on these topics, Italian Climate Change Strategies Italy aims to achieve climate neutrality by 2050, as outlined in its National Integrated Plan for Energy and Climate (PNIEC).

Key measures include:

- Greenhouse Gas Reduction: A target of reducing emissions by 55% by 2030 compared to 1990 levels.
- Renewable Energy Transition: Expanding the use of renewable energy sources and improving energy efficiency.
- Adaptation Measures: The National Adaptation Plan to Climate Change (PNACC) incorporates over 361 actions to enhance climate resilience, including ecosystem-based solutions and infrastructure improvements2.

Regarding the biodiversity conservation issue, the National Biodiversity Strategy for 2030 focuses on preserving and restoring ecosystems.

Key objectives include:

- Protected Areas: Expanding legally protected land and marine areas to cover at least 30% of the national territory.
- Ecosystem Restoration: Restoring degraded ecosystems, such as forests and wetlands, to enhance carbon sequestration and biodiversity.
- Sustainable Practices: Promoting sustainable agriculture and forestry to minimize habitat destruction.

Italy's ecological transition strategy emphasizes the integration of climate and biodiversity goals. Collaborative governance frameworks, involving local communities and private stakeholders, are essential for effective implementation. Funding can be sourced from national budgets, EU programs, and private investments.

Italy's comprehensive approach to addressing climate change and biodiversity loss reflects its commitment to sustainability. By aligning national strategies with European and global goals, Italy is working towards a resilient and biodiverse future.

3 Programmatic Framework: Policies and Strategies of the Province of Potenza

The Province of Potenza (PPZ), through the adoption of its Provincial Structural Plan in 2013, has outlined, developed, and strengthened territorial development policies under the #weResilient strategy. This initiative focuses on disaster risk reduction and integrates environmental sustainability, territorial safety, and climate change mitigation, leveraging extensive local experience in civil protection and territorial safety.

Since 2014, Potenza has actively contributed to the UNDRR "Making Cities Resilient" (2010–2020) initiative, fostering a network among 100 municipalities to implement a shared territorial development strategy at both urban and local scales. A multi-stakeholder platform has been established to engage public and private institutions, citizens, and interest groups in institutional activities.

In 2015, PPZ adopted the Strategic Framework to Combat Climate Change, followed by joining the Covenant of Mayors as regional coordinator in 2016 to support and coordinate territorial initiatives.

Additionally, PPZ turned its enrolment as a supporting authority to the UNDRR MCR2030 (2020–2030), advocating for local resilience enhancement through knowledge-sharing, technical expertise, and collaborative governance.

PPZ's commitment aligns with global strategies such as the Sendai Framework, and its efforts have led to recognition as a UNDRR Resilience HUB in 2022 and as a key partner in European initiatives supporting the Green Deal and Climate Adaptation Strategy.

Potenza Province has introduced tools like the "House of the 100 Municipalities" for real-time information sharing and the Resilience HUB, a coordination structure for education, collaboration, and stakeholder and communities' engagement.

A key element of the strategy is the active engagement of communities in local decision-making for territorial policies, including sustainable development, disaster risk reduction, and climate change adaptation/mitigation. This involves coordinating actions with municipalities and establishing permanent platforms to promote community resilience, ensuring inclusivity across social groups. The goal is to strengthen the capacity of individuals and communities to pursue sustainable development by raising awareness of biodiversity conservation and involving them in relevant policy decisions. The participation of institutional stakeholders further enhances this process [16, 17].

4 The Provincial Structural Plan from Approval to Date

After many years of elaborations and analyses, the PPZ adopted its territorial policy instrument in 2013. Providing, for the first time, knowledge frameworks on environmental, demographic and urban issues to support the definition of a territorial project within the four strategic territorial areas, directing the local territorial government through the action of municipalities and their own governance instruments.

The plan in recent years has worked as collector of organized data and information from different territorial authorities, in support of the only instrument of territorial governance approved in Basilicata, that is the PSP - Provincial Structural Plan.

Over the years, the provincial government has introduced new themes into the local urban planning landscape, such as addressing actions to adapt to climate change or adopting good practices aimed at territorial resilience.

The measures and strategies for adaptation to climate change and land protection, implemented in the Provincial Structural Master Plan (PSP) have been an experience that in recent years allowed to safeguard the qualities trying to intervene on environmental criticalities through the protection of the ecological network in competition with the Italian landscape and environmental legislation.

In the spatial planning of Basilicata, the Ecological Network project of the PPZ's (REP) represented an element that made it possible to recognize an environmental system consisting of protected areas and ecosystems characterized by an intrinsic quality not protected but equally important to guarantee the diffuse environmental quality (core areas), the residual elements and habitats of passage of living species (stepping stones), the corridors of river and land interconnection and areas of poor environmental quality where to direct improvement actions (restoration areas).

The identification of a network of interconnections between habitats of territorial importance represented the first step in an environmental restoration project that was carried out with the contribution of actors and stakeholders who actually act on the territory. The REP has set itself the objective of guaranteeing the high degree of naturalness that has historically characterized the territory, ensuring the preservation and improvement of the most valuable areas and improving the connections between the different habitats with actions that guarantee the efficiency of ecological corridors and territorial security climate change.

The guidelines provided by the project represent a fundamental step to be implemented with specific interventions by local actors in order to improve quality and to intervene on criticalities increasing the detail of the information and the possibility of interventions punctual.

The contribution of PPZ through this instrument has mainly aimed to ensure the interconnection between habitats through the improvement of ecological corridors identified by ensuring territorial security with actions improving officiousness hydraulic.

The regional territory of Potenza, described through the ecological network, is characterized by large areas predominantly forested distributed from north to south along the mountains of the Southern Apennines. These areas, through less extensive and more fragmented woodlands, find a greater spatial continuity of the terrestrial ecological corridors, mainly along mountain ridges and hills, also thanks to the abandoned pastures that slowly evolve towards the forest (Fig. 2).

The blueways have been identified within rivers protected by national landscape legislation (D. lgs. 42/2004 art. 142 lett. c), as considered the most correct criterion by virtue of the scale of representation and the characteristic of representing watercourses with a permanent and non-episodic water regime.

The most critical areas identified relate to the most populated areas, with reference to the rural context, where urban, agricultural and industrial development has been concentrated, due to the northern territory with widespread urbanization and intensive agriculture that has depleted the naturalistic components of the agricultural landscape.

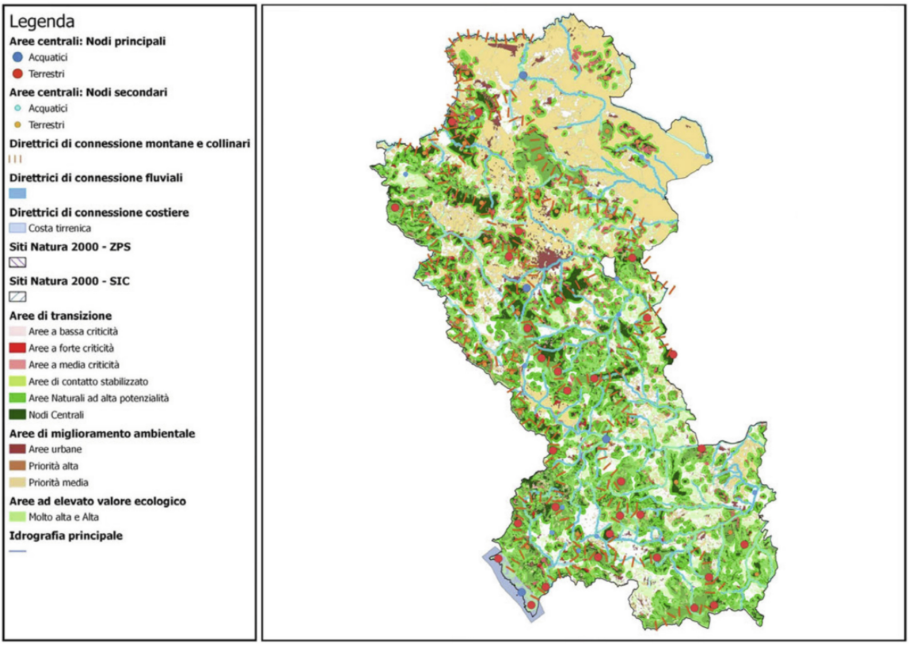

Fig. 2. Provincial Ecological Network. Source: Provincial Structural Plan of the Province of Potenza (PSP)

The PSP in these areas provides, through special provisions for the common guidelines for the implementation of green ways along the paths, in order to enhance the historical landscapes and introducing elements for soil protection such as hedgerows rows and trees able to increase connectivity but also to protect soils from the risk of erosion by carrying out a windbreak action and providing organic material for the land. This type of strategy seeks to repair the environmental connections put to the test by the excessive functionalization of intensive agriculture. In this respect it should be noted that the contribution of the office has been to identify priorities for intervention aimed at environmental improvement based on the degree of anthropogenic pressure suffered. Through the identification of transition bands (buffer areas) have been highlighted the dynamics of pressure on the areas of greater environmental value, preparing different actions according to the pressure in place, For example, by protecting and managing the spontaneous re-naturalisation of pastures and fallow crops, or where high-level criticalities have been identified, medium or low, mitigation or containment measures have been suggested to which the municipal administrations will have to respond at the planning stage (Fig. 3).

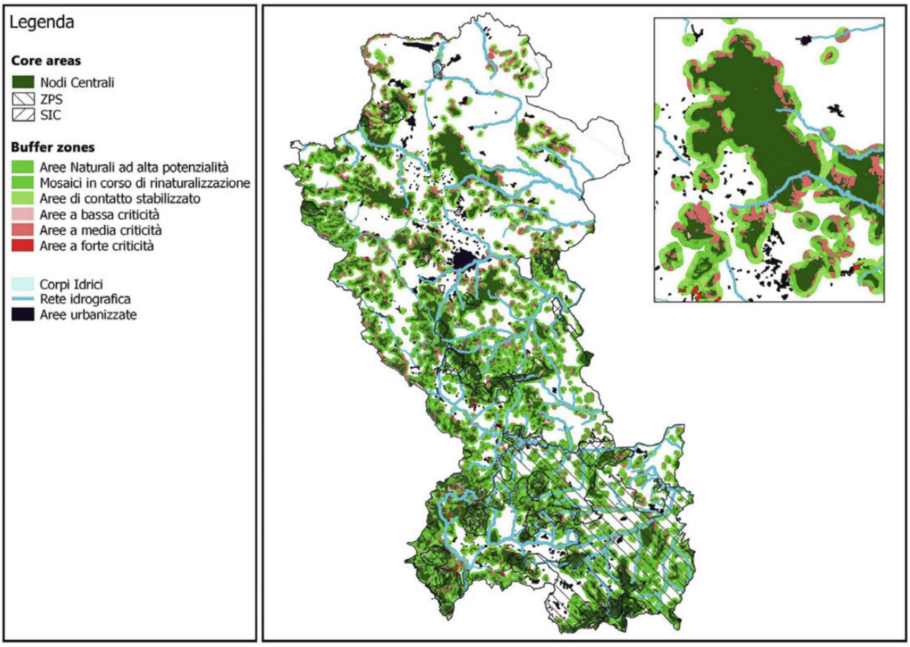

Fig. 3. Core and Buffer Areas of the Ecological Network of the Province of Potenza. Source: Provincial Structural Plan of the Province of Potenza

5 New Approaches and Challenges for the Provincial Ecological Network (REP)

After more than fifteen years since the publication of the Regional Functional Ecological Scheme, which was the methodological structure from which the Provincial Ecological Network was developed, the Basilicata Region through the Regional Landscape Plan (PPR) has redefined a methodology and an approach, adopting that of the National Strategy for Biodiversity and that is to get out of the rigid distinction between territory with high natural value and territory with low or no value.

Also in the National Strategy for Biodiversity (MATTM 2010) and in particular of the work area "Species, habitat and landscape" are highlighted the strong criticalities for biodiversity identified in the abandonment of the countryside, the progressive closure of open areas in favour of shrub and tree formations, the general simplification of agro-ecosystems (mostly in hilly and lowland areas) with the elimination of traditional elements of the agricultural landscape (hedges, rows, pools, fountains), the spread of invasive alien species, and it is recognized the urgency to develop and implement conservation and restoration policies in which the design, construction and maintenance of "ecological networks" Large-area can be the operational tools for this desired synergy between landscape policies and biodiversity conservation.

This new approach in the regional vision finds its implementation in the introduction already in the Landscape Plan with the publication of the guidelines for the design by the municipalities of the Local Ecological Network.

The identification of elements of the ecological network at municipal level, the improvement of the ecological relations between nature and the built environment aims to strengthen contact with ecological elements on a larger scale, in particular ditches, trees, corridors connecting with the Ecological Network at regional scale.

The ultimate goal is to preserve the residual nature in the urban centres, but also to reconstruct a new ecosystem scenario oriented to the model of contemporary sustainable city, in which greater emphasis is placed on human-environment with the idea of the designers that this choice can prove to be an added value for a traditionally agricultural territory rich in excellent agri-food products. The experimental, didactic and educational value of this vademecum will make it possible to see small local actions of great ecological-landscape significance in the search for the possible balance between man and nature.

The ecological network has a strategic importance both from the technical point of view, and from the planning decisions point of view, because it allows to "design" in an integrated way the territory starting from the contact areas between nature and man's work.

In this way, ecological networks represent the moment of redevelopment of natural space in built and artificial contexts of local urban planning, and regulate issues such as land use, territorial fragmentation, the sustainability of settlement development, territorial reputation, quality of life.

This new approach, while breaking with previous ecological network models, represents a more ecosystem-based vision of the territory, beyond conservation measures for protected sites, and also recognizes a value to natural elements of the territory that in a scientific approach might not be considered recognizable in a network as an interconnected system of core areas.

As can be seen from the methodology published with the PPR, the natural elements of the territory assume a connective or centrality function according to the scale in which they are observed, from the regional to the corporate scale.

The regional project provides that starting from a regional project, through methodological guidelines, each municipality can represent its own ecological network, through a look at the current, the implementation/improvement policy of the network is identified with ecological improvement guidelines. For example:

- Re-naturalization of native species reforestation
- Restoration of streams and ditches
- By pass for wildlife on transport infrastructure
- Establishment of plant mitigation bands
- Urban green with native plants peculiar to the area
- Creating green walls to mitigate within the urban perimeter
- Remediation and restoration
- Crop wastage for wildlife
- Grass bands in the presence of extensive monocultures.

What can be the support of the Provincial ecological network in this new methodological vision?

The Provincial Ecological Network, as in general the contribution of the PSP, being at an intermediate level between regional and municipal planning, can assume a coordinating role towards a shared vision of the territory, for its administrative functions.

PPZ can certainly give a vision of the projects to be carried out to realize a network of connection through green infrastructures, multifunctional green ways and blue ways that enhance a new use of the naturalistic landscape. The role that the new REP will have to undertake is therefore to repair natural areas by intervening also with Nature Based Solutions in fragile contexts characterized by hydrogeological hazards or going to intervene in urban and peri-urban area for the reduction of flooding and a more careful management of rainwater.

6 Actions to Improve Blue Infrastructure

The rivers of Basilicata Region constitute a special and important ecosystem to be protected, preserved and enhanced not only for natural and landscape aspects, but also for tourism and sustainable development of the territory. This heritage, as already mentioned above, can become a critical because of the continuous emergency situations, given by increasingly violent weather events able to create huge damage to the populations.

From these considerations arise the actions implemented by the PPZ consisting, essentially, in the implementation of maintenance activities of the hydrographic grid, with the consequent reduction of the hydrogeological risk and redevelopment of the territorial system (both environmental and landscape).

The maintenance activity stems from a regional programming initiative and has, in fact, as its general objective that of revaluing the water courses, returning to the Lucanian rivers the historical and multipurpose role of sources of life, wellness, wealth and security; of energy and productive sources in agriculture and industry; generators of quality urban, agricultural and natural landscapes, cultures, lifestyles with a crucial qualitative function for the territory.

In more detail, on a technical level, the strategic objectives, in line with those set by the PPZ, within the framework of the government policies of its territory are:

- the mitigation of hydraulic risk,
- the structural and functional upgrading of the ecological network and environmental systems,
- the qualitative and quantitative protection of water,
- sharing of information.

The poor and sometimes total absence of maintenance of watercourses has as its effect an intense proliferation of uncontrolled infesting vegetation, briers and dense bushes in riverbed that, in some cases, generates both widespread and localized obstructions, Causing rise of the water shackles and, consequently, the risk of disastrous floods.

The interventions affect many sections of the provincial river network, which coincides with the ecological river corridors of the REP, and they also bring considerable benefits from the point of view of the redevelopment of sites.

In the context of the works, a key role is occupied by the functional recovery of existing hydraulic works and the restoration of the hydraulic officiality of the lights of

crossings, bridges and manholes, in many cases dangerously obstructed by vegetation, from debris and other material trapped in it.

Obviously, the interventions guarantee the maintenance of the ecological functionality of the river ecosystem and safeguard, where possible, the conservation of plant species that permanently colonize the sheltered habitats.

The knowledge of detail that is being acquired can allow the development of programmes and action systems, for the full sharing of information and for the dissemination of information, Encouraging and enabling, soon, the full participation of citizens in initiatives aimed at the development, protection and rational use of water resources. In this way, the foundations are laid for hypotheses of connection of open spaces of river environments, through the realization of historical-ecological routes (green infrastructures) that allow to travel rivers from their sources to the sea, in a green network that includes river-relevant areas, protected areas and existing parks with the aim of creating an ecological network that is multifunctional, able to ensure the connectivity of all living species, including humans.

7 Conclusions

The approach based on local/provincial ecological networks can harmonize climate change adaptation and biodiversity protection by fostering interconnected green spaces that support both ecological resilience and species survival. The provincial policies for preserving and restoring habitats, such as wetlands, and forests, are based on these networks that can act as natural buffers against climate impacts like floods, heatwaves, and soil erosion, while simultaneously providing safe havens for diverse species. Integrating climate-smart conservation strategies, such as planting native and climate-resilient vegetation, enhances ecosystem stability and carbon sequestration. Connecting fragmented habitats through wildlife corridors ensures species mobility, enabling adaptation to shifting environmental conditions. The ecological networks create a synergistic approach, where biodiversity thrives and ecosystems better withstand the effects of climate change [18–22].

In the pursuit of these important objectives and using direct European funds, PPZ is currently engaged in several project and actions and, amongst the most relevant:

- it is leading the CIBIOGO Project “Citizen Participation in Biodiversity Governance”, within the “INTERREG EUROPE” 2021–2027 Program. The general objective of the project consists in improving policy-making tools to increase biodiversity governance and sustainable management of ecosystem services and will have to be implemented within the initiatives conducted by the Resilience HUB of the PPZ capitalized in the broader MCR2030 initiative on territorial resilience;

- it is a partner in the Project “DesirMED”, “Demonstration and mainstrEaming of nature-based Solutions for clImate Resilient transformation in the MEDiterranean”, within the Operational Programme “HORIZON EUROPE” 2021–2027. The Project is based on the idea that climate change (CC) represents a growing threat on a European and global scale, affecting social stability, public health and well-being. Adapting to the demands of CC requires a radical shift from fragmented strategies and approaches to transformative approaches, supporting the development of policies at all levels and promoting transversal and multi-level governance solutions. Nature-based solutions (NBS)

to preserve and restore ecosystems, increase climate resilience, sustainably manage the environment, while providing broader long-term socio-economic benefits, are at the core of the goal of the Adaptation Plan of the European CC Adaptation (CCA) mission to be supported globally and of which PPZ is part;

- it is partner in the NBS4RESILIENCE Project within the Interreg IPA ADRION Programme. The Project addresses the complex issue of various negative climate events and presents several NBS suitable for the problem to increase climate resilience, territorial security and to improve the overall state of the environment in the IPA ADRION Programme region. The main objective of NBS4RESILIENCE is to co-create and transfer into policy choices and planning actions the conditions for the widespread use of NBS for climate resilient territories.

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