

Supporting Sustainability: The Case Study of the Abruzzo Regional Sustainable Development Strategy

Federico Falasca(✉), Carmen Ulisse, and Alessandro Marucci

DICEAA, University of L'Aquila, Via Giovanni Gronchi 18, 67100 L'Aquila, Italy
federico.falasca@graduate.univaq.it

Abstract. The concept of sustainable development, catalyzed by global initiatives such as the Millennium Development Goals and the 2030 Agenda's sustainable development goals (SDGs), has reshaped international cultural, political, and social thinking. Recognizing the pivotal role of subnational entities in achieving these goals, there is an increasing emphasis on aligning sustainability objectives with local strategies and actions.

In Italy, the National Strategy for Sustainable Development (NSSD) entails a concerted effort to coordinate national and local initiatives, promoting collaboration across governmental and non-governmental sectors. Nevertheless, one of the main challenges is still the integration of sustainable development principles into regional and provincial planning processes. This study focuses on the analytical and programmatic steps that supported the integration of sustainable development objectives into the Abruzzo regional sustainable development strategy (RSSD). Through projects resulting from different agreements between the Abruzzo region and the Department of Civil, Construction-Architectural and Environmental Engineering (DICEAA) of the University of L'Aquila, a series of tools and guidelines have been developed. Specifically, the main outcomes of the "Review of the system of regional indicators in the context of the implementation of regional strategies for sustainable development" and the "Sustainability, Resilience, adaptation for the protection of ecosystems and physical reconstruction in Central Italy" (Sost.EN.&Re) projects have been deepened.

The result is a regional strategy for sustainable development enriched by the most recent approaches and methodologies in the field of sustainable planning.

Keywords: Sustainable development · Regional strategy for sustainable development · Sustainable planning

1 Introduction

Starting from the'80 (Brundtland report), the sustainable development concept has increasingly affected global cultural, political, and social thinking [1, 2].

The widespread awareness about inequalities, limited resources, and vulnerability of political, economic, and social systems found full application in one of the most important

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international organizations: the United Nations (UN). From this organization, at the beginning of the XXI century, the millennium development goals (MDGs) have been proposed [3]. The MDGs represent 8 points through which address policies of developing countries, to reach security, prosperity, and equality by 2015 [4]. Nevertheless, they didn't find full application in the states' agendas, due to the weak will and the poor resources to implement them [5].

A new drive came in 2015, with the 2030 Agenda. Through this document, the UN member states committed to taking a series of steps to "shift the world to a sustainable and resilient path" by 2030 [6].

To lead the member states through the sustainable development concept, 17 sustainable development goals (SDGs) have been proposed. Together with the SDGs, a set of 169 targets has been provided [7].

In the 2030 Agenda's SDGs, the path traced to reach sustainable development strongly relies on the concept of nature protection and enhancement, brought to the attention of global policies. This goal, first expressed in the MDG 7 "Ensure environmental sustainability", has then been further explored and articulated in the 2030 agenda's SDGs 13 "climate action", 14 "life below water" and 15 "life on land" [8].

Today the objectives set by the MDGs and then by the 2030 agenda can be achieved only through local and regional governments [9, 10]. At the same time, to be achieved, sustainability goals must be translated into actions that take place on a small to medium scale [11].

To be aligned, local government levels must be able to rely on commonly defined procedures and tools, capable of quantifying and monitoring land dynamics. The latter originate within municipal boundaries, although their effects involve multiple local administrations [12].

In Italy, the SDGs have become the objectives upon which the Italian National Strategy for Sustainable Development (NSSD) has been set up. The latter represents an action program to promote the national economic, social, and environmental spheres. Specifically, the strategy coordinates national and local initiatives, promoting collaborations between governmental and non-governmental bodies, and between companies and citizens [13].

The NSSD also envisages the adoption of the regional and provincial strategies for sustainable development (RSSD and PSSD respectively) within 12 months of the approval of the national strategy. Nevertheless, regional sustainable development strategies are still not fully implemented into regional and provincial planning, with a lack of fundamental SDGs-derived concepts [14].

The present contribution traces the steps (analytical and programmatic) that allowed the concept of protection and enhancement of natural capital to converge into the Abruzzo regional sustainable development strategy (RSSD). Through the establishment of national and regional tenders and projects, it has been possible to define, for the Abruzzo region (central Italy), a series of tools that have later converged into the RSSD structure.

Specifically, the "Review of the system of regional indicators in the context of the implementation of regional strategies for sustainable development" and the "Sustainability, Resilience, adaptation for the protection of ecosystems and physical reconstruction in Central Italy" (Sost.EN.&Re) projects have been deepened.

From the Review of the system of regional indicators, a set of indicators to evaluate the correspondence between regional planning and the SDGs has been realized.

The Sost.EN.&Re focused on the realization of the so-called "Planning Tool Mosaic" (PTM) and the ecological network, providing some guidelines useful for implementing them at a regional scale. Together with them, a console of indicators for monitoring the sustainability of transformations has been provided.

All these products have converged into the Abruzzo regional sustainable development strategy (RSSD), deepened in the last section (Fig. 1).

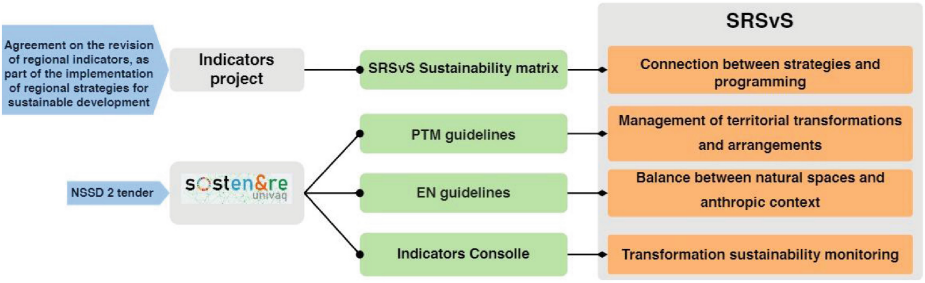


Fig. 1. Agreement, tenders, and project workflow

The paper is structured as follows: Sect. 2 delves the conditions of the study area, providing information about the regional territory. Section 3 sets out the "Review of the system of regional indicators in the context of the implementation of regional strategies for sustainable development" project. Its main product is the so-called Indicators database. Section 4 details the Sost.EN.&Re project, its main objectives, and operational points. Section 5 discusses the operational aspects of the instruments described above, as part of the regional strategy for sustainable development. Section 6 concludes the contribution by exploring the next steps for the full implementation of the Abruzzo regional strategy for sustainable development.

2 Study Area

The Abruzzo region, in central Italy, extends for over 10000 Km^2. It is one of the Italian regions with the highest percentage of protected areas (35.8% of the terrestrial areas and 1.36% of the marine areas) (Fig. 2) [15]. Its history is strictly associated with the protection of the natural environment since the institution of one of the first two national protected areas in 1922: the Abruzzo, Lazio and Molise National Park [16]. After this, several other protected areas were established, reaching the current configuration with a total of 58 protected sites, with an extension of 390,493 hectares.

Nevertheless, the achievement of the objectives set by the 2030 Agenda could not be reached due to the isolation that has characterized these areas over time. In Abruzzo, land consumption shows no signs of decreasing [17]. Furthermore, transformative dynamics driven by private interests do not help to manage problems whose scale of interest goes beyond local borders, which can define fragmentation of the natural matrix [18].

The result is a territorial framework lacking the technologies and information necessary to support a regional strategy capable of defining common methods for achieving sustainability objectives.

Added to this are the most recent calamitous events that have affected central Italy, defining the need for a development paradigm restructuring, directed towards the themes of reconstruction, resilience, and adaptation [19].

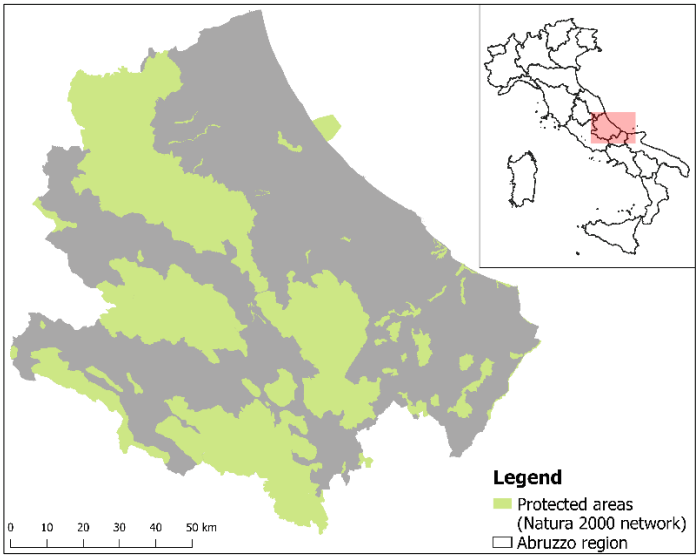


Fig. 2. Study area

3 The "Review of the System of Regional Indicators in the Context of the Implementation of Regional Strategies for Sustainable Development" Project

The systematic use of indicators in the field of environmental and social policies is becoming more and more frequent. Nevertheless, in over half a century of Italian urban and territorial planning, there is still scarce availability of procedures for measuring, monitoring, and analyzing the effects of the various operational tools [20].

Simultaneously, the transformed and potentially transformable territorial matrix must be considered as a priority. Here, land planning can lead to a worsening of the natural conditions [21].

Furthermore, the continuous reference to the 11th and 15th SDGs entails the necessity to face new environmental challenges, through an integrated approach between ecosystem functions, the associated services, and urban resilience [8]. Being the SDGs based on universally recognized principles, it is fundamental to decline regional planning drives, defining the scopes of sustainable planning.

In this regard, the collaboration agreement between the Abruzzo region and The Department of Civil Engineering, construction, architecture, and Environment (DICEAA) of the University of L'Aquila set up the preliminary activities, necessary to fulfill the realization of the regional strategy for sustainable development.

Specifically, the DICEAA undertook to produce the positioning of the regional planning tools concerning the NSSD goals and the 2030 agenda's SDGs.

The correspondence between the SDGs and the regional planning tools has been evaluated through a regional sustainability matrix. The latter identified the links between regional planning and programming, regional investment plans, and the forecasts envisaged by the NSSD.

Contextually, a survey of sustainability indicators already in use by various public and/or private entities nationwide has been undertaken. In this phase, indicators have been retrieved on Italian institutional websites such as ISTAT (National Institute of Statistics) (https://www.istat.it/) and ISPRA (Italian Institute for Environmental Protection and Research) (https://www.isprambiente.gov.it/it).

The reconnaissance process to identify the set of regional indicators started from the parameters already used in the monitoring process. Specifically, the following sectoral tools have been considered:

- Regional landscape plan;
- Flood risk management plan;
- Basin excerpt plan for the hydrogeological structure;
- Flood defense excerpt plan;
- Regional reference framework;
- State maritime plan;
- Coastal defense plan;
- Water protection plan;
- Regional mining activities plan;
- Regional Plan for the Protection of Air Quality;
- Regional integrated waste management plan;
- Regional energy plan;
- Regional hunting fauna plan;
- Gran Sasso and Monti della Laga National Park plan;
- Majella National Park plan;
- Abruzzo, Lazio and Molise National Park plan.

In this phase, through a matrix of coherence, the convergence between the objectives of the regional plans and those of the 2030 Agenda and the NSSD has been verified.

Subsequently, to build the directory of indicators, attention has been focused on the ones coming from the ISTAT and ISPRA institutes, as well as on the indicators retrieved on the websites of private foundations or sector projects, between various public and private bodies (Fig. 3).

The sets of indicators from non-institutional sources that have been used in the subsequent phase of implementation of the RSSD comprehend:

- The Italian Sustainable Development Index, developed by the SusDeF Foundation (Sustainable Development Foundation), is based on environmental indicators relating to impacts – positive or negative – in terms of emissions, consumption of raw materials, etc., according to the Environmental Footprint approach) (https://www.fondazionesvilupposostenibile.org/)
- Indicators on sustainability policies: the 101 municipal indicators identified by the Italian Local Autonomies (ALI) League (https://aliautonomie.it/)
- Indicators on urban regeneration, identified by the Association of Abandoned Urban Areas (AUDIS) (http://audis.it/home)
- Indicators on urban metabolism, consumption of matter and energy, etc., also concerning the fragmentation/compactness/shape/disposition of the urban system, analyzed in the European Project SUME – Sustainable Urban Metabolism for Europe, FP7/2007–2013.

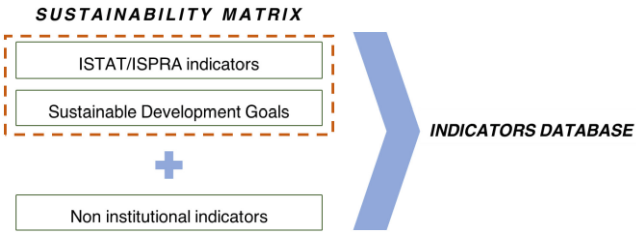


Fig. 3. Indicators database workflow. Through a sustainability matrix, the correspondence between institutional indicators and the sustainable development Goals has been deepened. The next phase of database construction envisaged the implementation of the institutional indicators with the ones coming from private foundations or sector projects.

The research set up 55 indicators linked to the sustainable development goals.

The database will be a useful tool to support local authorities align their plans and programs to the sustainability objectives set by the NSSD and the 2030 Agenda.

As part of the above-mentioned preliminary actions for the implementation of the RSSD, the proposed set of indicators represents a first dynamic and updatable outline of the needs of regional planning, concerning the adaptation to the NSSD. If needed, it will be possible to expand the indicators offer, after a consultation with the competent authorities. The procedure structured through this collaboration allowed to dispose of a tool under which regional planning can update itself, concerning these fundamental themes with an acceptable commitment.

Shortly, the necessary step must be a review of the indicators aimed at defining them not only on a regional basis but also referring to other territorial scales.

4 The Sost.EN.&Re Project

To fulfill the objectives set by the 2030 Agenda, in 2019 the Ministry of the Environment (MITE) promoted the so-called "NSSD2" tender, equal to 3,000,000 euros [22]. The latter has funded 26 projects, divided into two categories:

Category 1: Projects to support the RSSD and PSSD development and implementation. The proposals supported the development of technical contents for the definition of regional and provincial strategies; the development of scientific contributions to support and enhance sustainable development strategies; and the scientific dissemination of the definition and implementation processes.

Category 2: Projects on priority themes for the implementation of the NSSD.

The "Sustainability, Resilience, adaptation for the protection of ecosystems and physical reconstruction in Central Italy" (Sost.EN.&Re) project fits into the first category of the tender issued by MITE, to promote and implement in the Abruzzo region the subsequent SDGs [23]:

- 11 "Make cities and human settlements inclusive, safe, resilient, and sustainable."
- 15 "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss"

The object of formulating a series of guidelines to support the processes for the regional implementation of the National Strategy for Sustainable Development (NSSD) has been articulated into three key points:

1. Drafting of a Technical Mosaicking Protocol for municipal urban planning tools (planning tool mosaic guidelines).
2. Development of a methodology for the inclusion of the Ecological Network (EN) in regional legislation and criteria for evaluating the ecosystem occlusion of infrastructures (ecological network guidelines).
3. Development of a console of indicators for monitoring the sustainability of transformations.

The division into three main operational points arises from the awareness that sustainable development can only be achieved by considering all the actors, synergies, and trade-offs that act on territorial dynamics [24]. A holistic approach requires an analytical panel that characterizes both settlement dynamics and pressures on the environmental system [25, 26]. Such knowledge is fundamental to achieving a structural connection of the portions of territory, each characterized according to its contribution.

4.1 Planning Tool Mosaic Guidelines

A Sustainable development strategy, in addition to focusing its attention on the connections between protected areas, must investigate the forms and dynamics of planning, capable of defining fragmentation and isolation conditions [18]. Here, the interactions between the socio-ecological spheres, the protection of biodiversity, and the associated

ecological functions play a key role in defining the dynamics between a more densely anthropized environment and the areas belonging to the EN [24].

In a country like Italy, where the highest levels of planning have had only rare opportunities to condition decisions at lower levels, there has been an almost total autonomy of municipalities. The latter autonomously manage local transformations, without superordinate strategic control [27]. The consequence is a condition in which each of the 7896 municipalities transforms its territory, without having adequate awareness of what is happening (or is expected) in the neighboring territories [28]. It is also impossible to understand what will happen on the territory, in the geographical dimension that transcends the single municipality. Furthermore, many Italian municipalities have planning tools approved several years ago. Here, the forecasts have been sized based on social and economic evidence, certainly different from today [29].

These conditions do not favor the adoption of measures aimed at improving environmental and urban quality, whose implementation must take place in the upper planning levels and at scales that go beyond municipal boundaries [28].

At the same time, several objectives of the territorial sphere, such as the zero-land take by 2050, or the decrease of anthropogenic pressure in protected areas, now require adequate levels of knowledge. It is necessary to allow potential transformation trajectories to be traced both geographically and in quantitative terms [26]. By doing this, it will be possible to develop appropriate policies to contain potential negative effects.

To support the enhancement of such conditions, the Sost.EN.&Re project established a technical device called the "Planning Tools Mosaic" (PTM). The PTM is a standardized and homogeneous framework for municipal planning tools contents (i.e. the zoning, the related legends, and the technical standards that define urban planning loads) [27]. It consists of digitalization and attribute table population operations in GIS environment. Following the guidelines provided by the Sost.EN.&Re project, the information to be put into the single municipal planning tool are: i) Name of the municipality, ii) National municipal ID code, iii) type of planning tool, iv) the year since which the tool is in force, v) zonal typology related to the single area (polygon), iv) technical implementation standards, which defines the in force standards for each zone. Subsequently, in the "zoning" column a standardization of the zoning, referring to the ministerial decree 1444/68 [30], has been realized (Fig. 4). The presence of the original zoning allows to deepen the actions envisaged by the single municipality. Simultaneously, the standardized zoning classes allow to properly compare different municipalities, disposing of a regional, standardized database.

This kind of system is easily implementable and provides not only error reporting but also the corrective actions to be applied. This different approach would have numerous advantages in the medium and long term, but it is resource-intensive in the initial stages, requiring training courses for technical staff. Once fully operational, the platform will enable the pursuit of planning effectiveness and flexibility, with notable simplifications such as reducing the number of procedures and decreasing the time required for instrument approval procedures [31].

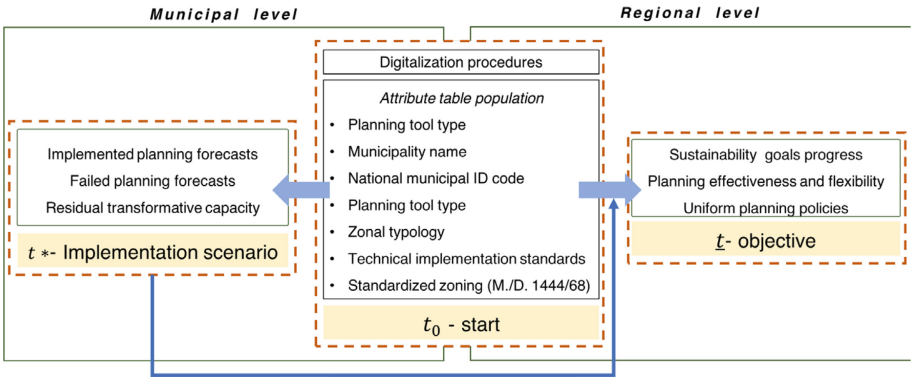


Fig. 4. Planning tool mosaic workflow. The digitalization procedure is the core of this tool. The information to be put in this phase will be functional to make the single planning tool comparable and updatable. Through this tool, it will be possible to compare different territorial scopes (municipalities), as well as to quantitatively assess failed, residual, and implemented planning forecasts.

4.2 Ecological Network Guidelines

During the nineties, Ecological Networks (EN) began to establish in Europe as a central topic of environmental policies. One of the first important initiatives has been the EECONET program (1990) (The European Ecological Network)[32]. EECONET aimed to promote the valorization of biodiversity through the implementation of a European ecological network, to guide the evolution of protected and rural areas policies [33]. In 1996 the European Council promoted the Pan-European Biological and Landscape Diversity Strategy (PEBLDS) [34], to implement the convention of biological diversity (CBD) [35]. A PEBLDS key element was the development of the Pan European Ecological Network (PEEN), which is composed of central areas, corridors and buffer areas, and, where necessary, restoration areas. The PEEN was articulated into three projects, corresponding to central-eastern, southeastern, and western Europe [36, 37].

In Italy, a fundamental contribution to the ecological networks came from the National Ecological Network Project (REN) [38]. The objective of the REN was to locate a network, based on the national areas with different priorities of conservation. The REN also paid specific attention to the connections between protected areas (PAs), to minimize habitat fragmentation [39].

From these projects, the common take-home message is that the EN tool must be projected towards a scenario that allows the protection of key areas, to support and maintain high biodiversity values and the connection between PAs.

Today it is necessary to extend the "classic" theories through which ENs are set up. It is necessary to consider the role that ENs have in improving the conditions of natural capital and ecosystem functions. Specifically, the latter must be protected and enhanced beyond the protected areas and large parks boundaries [40]. For this reason, new EN models cannot disregard the detailed knowledge of the drivers involved in land transformation, which produce and nourish environmental fragmentation [41]. Within the path towards sustainable development, it is necessary to maintain the conditions

that allow biodiversity evolution. To achieve this objective, it is important to ensure the physical and spatial connection between protected areas, which otherwise would be isolated by the outside land dynamics [18].

In this regard, the Sost.EN.&Re project has developed the guidelines for regional EN implementation. Specifically, an evaluation criterion for ecosystem occlusion of infrastructures has been proposed. It is well known that the road infrastructure network can involve a large part of the territory, interacting with the environmental system [42].

Between protected areas, passages that connect different habitats need to be managed with structural interventions. For this reason, the preliminary phase of recognition of large road infrastructures, such as motorways and railways, is fundamental. These elements are to be considered the Main Infrastructural Barriers (BIPs), whose characteristics define landscape fragmentation. Indeed, the highway roadway, together with the railway tracks, often sets a total physical occlusion of the habitat continuity. This is due to the continuous side fences, whose presence is aimed at preventing the casual or intentional entry of people and animals [43].

In these cases, habitat connectivity subsists only when the motorway or railway passes through a tunnel or viaduct. For this reason, their location and survey constitute a fundamental step since the early stages of the definition of potential ecological corridors.

At the same time, the BIPs reveal the limits of the "regional macro-districts". The latter represent the functional areas that must necessarily be connected, to fulfill conservation policies.

After identifying priority gaps, the ecosystem occlusion profile (PdO) tool quantifies the impact of infrastructures on ecosystem integrity. The PdO is a diagram that analyzes the degree of interference set by the road along its longitudinal axis [44]. It consists of considering the extent and type of the obstacles that are present both left and right of the roadway (retaining walls, networks, new road dividers jersey, guardrails etc.). Subsequently, it is evaluated the possibility of overcoming the obstacles by appropriately selected species (Fig. 5).

This procedure constitutes a valid method for obtaining information on the permeability of an area crossed by an infrastructure. It provides usable data on a large scale, indicating which are the areas of maximum probability of wildlife passage. On a detailed scale, it is useful to indicate whether and where the infrastructure can be crossed.

The above-mentioned procedure refers to the Road Ecology discipline [45]. Road Ecology analyzes the interaction between organisms, the environment, roads, and vehicles. It explores the relationships between the natural environment and the infrastructural network, seeking solutions that can be applied in the design phase of roads, motorways, and railways, or aimed at mitigating the effects of the already present ones.

Together with a "snapshot" of the actual criticalities set by infrastructures and local planning tools, it is necessary to qualitatively and quantitatively describe urban settlements and the dynamics to which they are subject and which they nourish [26]. This aspect has been deepened in the last output of the Sost.EN.&Re project, the indicators console.

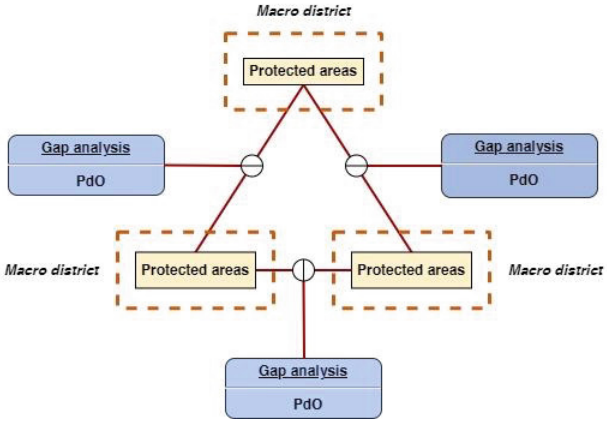


Fig. 5. Ecological network structure. The macro districts, defined by the fragmenting capacity of the infrastructural network, are connected through the so-called "priority gaps". The latter, through the PdO tool, will be deepened, according to the necessary actions to maintain and enhance such connections.

4.3 Indicators Console

Municipal planning tools define different types of intervention on the territory, based on local political and popular will. Without the possibility to quantify the consequences on the territory in the short and long term, local planning tools would lack a real strategic vision.

The indicators engineering can be defined as the operation of designing sets of indicators capable of capturing and describing any changes in land use, assuring interoperability and transparency of information [26].

It can provide wide support to enhance the descriptive capacity of land dynamics. Today various indices are being used both to model settlements and to describe the demographic-environmental conditions that the latter experience and nurture [25, 26].

To monitor the sustainability of transformations, the Sost.EN.&Re project envisaged the creation of a console of indicators.

The indicators console has been set up starting from several experiences that took place in the last decades across the entire national territory, and more limited geographical areas [25, 26]. The parameters listed vary from the simplest and most consolidated ones to more complex indexes concerning the pressure/interference of settlement on the territory and ecosystems. The console contains two macro-categories of indicators:

Settlement Model and Dynamics Indicators: These indicators can provide a summary framework of the settlement system.

Settlement Pressure on Environmental Systems Indicators: These indicators concern settlement pressure/interference on land and ecosystems (e.g., indices of fragmentation and insularity).

The console has been structured to provide key information about the type of indicator, and the scale of application. To support indicators adoption further information about the data and the sources required to calculate them has been realized.

For each parameter, information about the type of indicator (the above-mentioned macro categories), its adherence to the DPSIR (Drivers, Pressure, State, Impact, Response) model, the spatial dimension in which it can be applied (regional, municipal, etc.), and the source of the data necessary to populate it have been considered (Fig. 6).

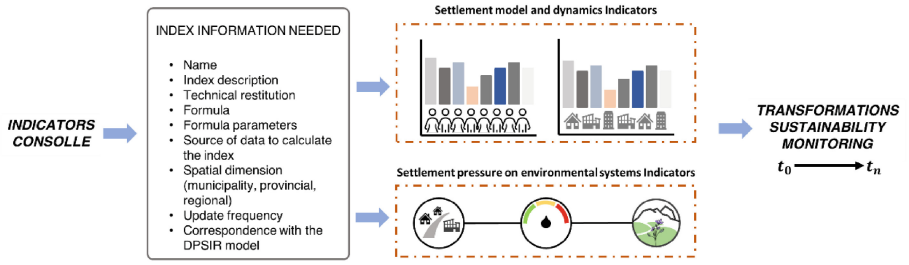


Fig. 6. Indicators console workflow. To put the single indicator into the console several information are needed. Subsequently indicators will be inserted either in the "settlement ond dynamics indicators" or in the "Settlement pressure on environmental systems indicators" classes.

If put together, the settlement model and dynamics Indicators can provide a framework of the settlement system, concerning the implementation of the urbanized territory's current planning. Similarly, simultaneously considering several "settlement pressure on environmental systems" indicators will provide a framework of the current configurations, whose effects could potentially lead to environmental fragmentation and PAs insularization.

Both these categories of indicators can be jointly used to monitor changes in land dynamics in a certain time frame, considering the initial measures as the reference status, and comparing their changes in values during a timeframe.

5 Discussions

The RSSD represents the implementing tool that defines the regional framework for land planning, and environmental evaluation processes. At the same time, the document must ensure coherence with the NSSD and the 2030 Agenda SDGs.

Based on the "abruzzo prossimo" document [46], the RSSD identifies the following specific objectives:

1. Structure a guideline for the integration of the SDGs of the 2030 Agenda into the regional policies, plans, and projects.
2. Increase the resilience of territories regarding extreme events or disasters, focusing on prevention strategies.

3. Guarantee guidance, evaluation, monitoring, and control in decision-making by subordinate entities, and promote the sharing of experiences and technical-scientific information on environmental assessment.
4. Implement, within an organic strategy, regional initiatives to achieve ongoing SDGs.
5. Promote sustainability by facilitating the participation of relevant authorities and the public in the decision-making process.

From an organizational standpoint, in December 2018, the Abruzzo Region signed a Collaboration Agreement with the MATTM (now Ministry of the Environment and Energy Security - MASE) for the definition of the RSSD [47]. The RSSD has seen the establishment of a steering committee, to coordinate activities among the administrative entities involved. Various collaborations have emerged among administration institutes (Regions, Municipalities, etc.), the Environmental Education Centers (CEA), and the University of L'Aquila (Department of Civil, Construction-Architectural and Environmental Engineering - DICEAA).

The first version of the RSSD has been approved in October 2021 [47]. A second Collaboration Agreement with MATTM was signed in April 2020, and the final RSSD was published with [48]. A second Collaboration Agreement with MATTM was signed in April 2020 [49], and the final RSSD was published with [48].

From the review of the system of regional indicators, the recognition of several institutional indicators, and the development of a sustainability matrix allowed the establishment of a multi-level linkage and alignment between Regional Planning, Investment Programs, and National and Regional Strategies. This activity has been later enriched also by non-institutional indicators, to provide the RSSD with a set of indicators useful for evaluating the sustainability of regional planning with the SDGs of the 2030 Agenda.

By doing this, the RSSD will be able to compare its local-scale objectives with those in the sustainability matrix, updating its planning/programming according to the SDGs. This will enable stakeholders to verify the consistency between the 2030 Agendas' SGDs and the regional strategies, as well as the identification of indicators useful for monitoring the actions related to these objectives. Both the matrix and the indicators are dynamic and updatable, according to the needs of regional planning. It will be possible to expand the console of indicators through revision phases and according to the authorities' needs. To maximize interoperability with other territorial and administrative institutes, ISTAT and ISPRA datasets have been used, since the early stages of the Regional Strategy.

From the PTM, the standardization of local planning tools contributes to creating shared knowledge about the potential for territorial transformation. Through the PTM it will be possible to gain an evolving perspective of land dynamics, overcoming the current opacity that characterizes local planning. This will also allow potential interventions through awareness-building, participation, and monitoring actions [27]. Finally, the synthesis into the macro-categories defined by the ministerial decree 1444/68 allows high effective comparability among different municipalities. The zonal standardization further supports the common assessment of local planning tools, highlighting any unrealized transformation, whose effects could potentially lead to increased supra-municipal pressure on environmental systems.

The major challenge in adopting this approach lies in the outdated methods for storing and utilizing information at the local authority level (municipalities). Although GIS

systems can help reduce archiving costs, simultaneously increasing analysis potential, these actions must be preceded by training of the public administration personnel [31, 50]. This aspect should not be underestimated. Indeed, due to its initial costs and difficulties, the reluctance to switch to more effective tools with potentially more complex methodologies could hinder their adoption [51].

In addition, planning forecasts could also potentially lead to environmental fragmentation and the isolation of ecologically sensitive areas [52].

The structure of an effective ecological network, aimed at protecting and improving environmental quality, is therefore based on the interconnection of high ecological value areas.

In this regard, the EN guidelines proposed in the Sost.EN.&Re project aimed to introduce, operationalize, and adopt an interdisciplinary approach that considers pressures and threats resulting from the presence of infrastructures and settlements.

Here, the integration of the ecological network into the regional strategy represents an essential and binding element in driving future sustainable development [53].

6 Conclusions

The proposed tools extend conservation practices on the connections between protected areas. The methodology has been developed to define an effective ecological network, focusing on the corridors considered essential for maintaining habitat continuity [36]. Protecting these corridors will be the responsibility of local authorities, preserving the natural value of the areas involved and improving the conditions of the ecological network [54].

Nevertheless, an assessment of the current situation is not sufficient to ensure high levels of sustainability in the long term. The application of indicator engineering techniques to spatial planning and governance is crucial not only to achieve sustainability goals but also to monitor transformations [55].

In this sense, the proposed console of indicators inside the Sost.EN.&Re project must be considered an investment for the administration. To have significant results, indicators must be able to generate prevailing trends for an adequate period [56].

Finally, the reference set must be sufficiently large to allow an efficient control of the phenomena.

Thanks to the ability to build realistic scenarios and projections of planning policies with the indicators console, it will be possible to verify their alignment with local development needs [57]. It will be also possible to compare planning policies with the historical trends of the main transformation drivers, as well as to assess their potential deviation from superordinate sustainability policies.

In conclusion, the Regional Sustainable Development Strategy for Abruzzo can today dispose of a series of tools useful for Public Administrations, to integrate sustainability principles into their policies, with particular attention to the themes of ecosystem connectivity, and the efficiency and sustainability of territorial transformation processes.

Future actions from the Abruzzo region will need to be aimed at putting in action all the proposed tools, as well as administratively introducing the necessary changes into regional and local planning.

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