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abstract

Customising training actions by learning from the territory through an applied methodology to improve green and smart competences in vulnerable target groups of European rural areas

Ivan Pistone, Vincenzo De Luca, Maddalena Illario, Antonio Acierno, Erminia Attaianese, Carina Dantas, Mónica Sousa, Mariana Assunção, Mariella Xavier, Vittorio Riponi, Jesús Sanz, Almudena Muñoz, Catalina Martínez Muñoz, María Isabel Pérez Millán

Abstract

Background: Tailoring the training actions for the green and digital transition in Europe's rural areas necessitates evidence-based and context-sensitive methodologies.

Objective: Grounded on the NewEcoSmart (NES) project's pilot studies in Italy, Portugal and Spain, this article presents a structured, place-based approach to improve green and digital competences among adults over 45 years of age from rural areas, to promote job reintegration and accessibility to services in three pilot sites.

Methodology: mixed-methods design has been employed, integrating multi-layered territorial diagnostics using GIS mapping, demographic and labour market data and environmental asset inventories with stakeholder mapping, co-design workshops and recurrent validation loops.

Results: Diagnostic analyses across the three pilot sites revealed site-specific assets and challenges, enabling the co-creation of tailored training modules that embed GreenComp sustainability capacities and DigComp digital skills within local case studies. Initial findings display improved liaison between training content and participants' needs, reinforcing inclusive engagement and practical uptake of green-smart practices.

Conclusion: The methodology's highlight on learning from territory ensures measurability and potential to transfer to other rural contexts, offering policymakers and practitioners an adaptable framework to inform EU rural development and lifelong learning initiatives. By linking policy imperatives with grounded territorial insights, this approach supports sustainable, locally owned pathways for adult upskilling in the habitat sector.

Keywords:

green infrastructure; spatial data model; green competences; digital competences; rural adult learning; territorial diagnostics; co-design; NewEcoSmart approach

Personalizzare le azioni formative imparando dal territorio attraverso una metodologia applicata per migliorare le competenze green e smart in gruppi vulnerabili delle aree rurali europee

Abstract

Contesto: Adattare le azioni di formazione per la transizione verde e digitale nelle zone rurali europee richiede metodologie basate su dati concreti e sensibili al contesto.

Obiettivo: Sulla base degli studi pilota del progetto NewEcoSmart (NES) in Italia, Portogallo e Spagna, questo articolo presenta un approccio strutturato e basato sul territorio per migliorare le competenze verdi e digitali degli adulti di età superiore ai 45 anni delle zone rurali, al fine di promuovere il reinserimento lavorativo e l'accessibilità ai servizi nei tre siti pilota.

Metodologia: Si è utilizzato un approccio metodologico misto, che integra una diagnostica territoriale multilayer basata su mappature GIS, dati demografici e sul mercato del lavoro e inventari delle risorse ambientali con l'individuazione di stakeholders interessati, workshop di co-progettazione e processi di feedback in itinere.

Risultati: Le analisi diagnostiche condotte nei tre siti pilota hanno rivelato le risorse e le sfide specifiche di ciascun sito, consentendo la co-creazione di moduli di formazione su misura che integrano le capacità di sostenibilità GreenComp e le competenze digitali DigComp all'interno di casi di studio locali. I primi risultati mostrano un miglioramento del collegamento tra i contenuti formativi e le esigenze dei partecipanti, rafforzando l'impegno inclusivo e l'adozione pratica di pratiche green-smart.

Conclusione: L'enfasi della metodologia sull'apprendimento dal territorio garantisce la misurabilità e il potenziale di trasferimento ad altri contesti rurali, offrendo ai responsabili politici e agli operatori un quadro adattabile per informare le iniziative dell'UE in materia di sviluppo rurale e apprendimento permanente. Collegando le esigenze politiche con conoscenze territoriali concrete, questo approccio sostiene percorsi sostenibili per il miglioramento delle competenze degli adulti nel settore dell'habitat.

Parole Chiave:

infrastrutture verdi; spatial data model; competenze green; competenze digitali; apprendimento rurale degli adulti; diagnostica territoriale; co-progettazione; approccio NewEcoSmart

Customising training actions by learning from the territory through an applied methodology to improve green and smart competences in vulnerable target groups of European rural areas

Ivan Pistone, Vincenzo De Luca, Maddalena Illario, Antonio Acierno, Erminia Attaianese, Carina Dantas, Mónica Sousa and Mariana Assunção, Mariella Xavier, Vittorio Riponi, Jesús Sanz and Almudena Muñoz

1. Introduction

The European Union supervenes a resolute roadmap to orient the member states towards a twin transition which focuses on the green and digital aspects and reinforces such actions as part of the post-pandemic recovery and resilience structure (European Commission, 2020). European Green Deal constitutes the core of this endeavour, fortifying the position of the EU regarding climate neutrality as of 2050, focusing on dismantling economic growth off resource use while guaranteeing that no site and individual will be left behind (European Commission, 2019). Digital Education Action Plan 2021–2027 adjunctly strives to incorporate digital solutions within training and education perspectives, which incentivises high-quality, inclusive and accessible digital education to reinforce the citizens with the capabilities deemed vital for a gradually digitising society (European Commission, 2021a). Such prominent modi operandi gained practicality via the five-year European Skills Agenda, which was formed in 2020 to provide reinforcements regarding improving and actualising talents on individual and corporate levels by harnessing the Upskilling Pathways concept for adults and improved Vocational Education and Training (VET) plans (European Commission, 2020).

EU-wide rural territories confront perpetual difficulties such as the decline in demographics, relatively low per capita Gross Domestic Product (GDP) against urban territories, incompetence in digital connectivity and in accessing education and public service means (European Commission, 2021b). Not surprisingly, such a toll creates an unbalanced effect on vulnerable target groups -older adults, low-skilled workers, the long-term unemployed and socially or digitally excluded groups- since their inclusion into public training services is negatively affected by physical remoteness, financial barriers, limited technological exposure and reduced mobility (Cedefop, 2022). Solving such a multilayered equation on fragility demands holistic methodologies that surpass standard concepts.

The intertwinement of environmental sustainability and digital innovation delivers the notion of green smart competences, which can be interpreted as a compact ensemble of knowledge, skills and practices guiding people towards thriving in low-carbon practices and harnessing digital means for ensuring process optimisation and innovation. The GreenComp framework, as an EU approach, voices twelve vital capacities for sustainability, ranging from systems thinking to futures literacy, for

approaching ecological and social challenges (European Commission, Joint Research Centre, 2022). Concurrently, DigComp 2.2, the Digital Competence Framework for Citizens, also articulates five capacity areas with eight-stage proficiency: information and data literacy; communication and collaboration, digital content creation; safety, and problem-solving; and is also designed in a way to ensure a solid reference for digital education practices (Ferrari, Punie, & Redecker, 2021).

1.1. The NewEcoSmart project

In response to such a policy framework, the NewEcoSmart (NES) project (August 2023 – July 2025) stands as a prominent medium for targeting social innovation and digital empowerment, focusing on adults over 45 in rural areas, aiming to equip them not only with the skills to adeptly navigate green and digital transitions in their professional capacities but also to explore new vocational avenues in the Habitat sector (NewEcoSmart, 2023). Concurrently, it fosters social entrepreneurship skills, crucial for adopting innovative production and consumption methodologies aligned with Circular Economy principles, resonating with contemporary business paradigms (NewEcoSmart, 2023). It also aligns with the European Union's Green Deal and Digital Single Market strategy, aiming to strengthen employability in burgeoning economies, and aspires to contribute long-term to creating safer, more economical, and healthier solutions, including digitally and energy-efficient infrastructures. Such an innovative approach breeds circular and socially responsible practices within habitat-related micro-enterprises with the responsive approach of boosting communities and promoting social inclusion, coherent with the European Pillar of Social Rights (CETEM, 2023). In this comprehensive framework, this article contemplates on place-based learning theories (Lave & Wenger, 1991; Gruenewald, 2003) and propounds a “learning from territory” methodology operating as a systematic determinant of natural, infrastructural, and socio-economic assets and challenges in the territories and functions as an auxiliary for designing training content with stakeholders to develop green and smart competences. The methodology is practised within a NES pilot process and aspires multiple aspects like i) developing a multi-layered determination structure for territories through incorporating GIS-based connectivity maps, demographic data, labour market indicators, and environmental asset inventories; ii) engaging relevant local actors from municipalities, NGOs, business settings in inclusive workshops to determine the gaps and challenges and collaborate in the development of training priorities, iii) designing and practising tailored training modules and blending GreenComp and DigComp elements with territory-specific case studies, iv) ensuring the validation and refinement of the approach through recurrent feedback loops, jointly considering process metrics and learning outcomes.

The NewEcoSmart project ambitiously targets social innovation and digital empowerment, focusing on adults over 45 in rural areas, aiming to equip them not only

with the skills to adeptly navigate green and digital transitions in their professional capacities but also to explore new vocational avenues in the Habitat sector. Concurrently, it fosters social entrepreneurship skills, crucial for adopting innovative production and consumption methodologies aligned with circular economy principles, resonating with contemporary business paradigms.

Complementary to the authenticity of holistic sources scrutinising the adult learning concept in urban or sectoral settings, a relatively low number of studies examine the liaison of green competences, and rural fragility the number shrinks pertaining to analysing the abbreviatory effect of territorial diversity on training uptake and impact (Education and Training Monitor 2024). Furthermore, policy considerations frequently dissociate sustainability and digital frameworks and tend to overlook their synergies in promoting green and smart competencies. This study proposes a multilayered, operable methodology within the NES project to collaborate in the determination and creation processes and ensures liaison between policy frameworks and hands-on practice and suggests an iterative pattern for policymakers and practitioners in this field.

The project aligns with the European Union's Green Deal and Digital Single Market strategy, aiming to strengthen employability in burgeoning economies, and aspires to contribute long-term to creating safer, more economical, and healthier solutions, including digitally and energy-efficient infrastructures.

1.2. Objective and structure of the contribution

This article subsequently tracks the very efforts within the broader framework of the EU strategy and articulates the European Green Deal, Digital Education Action Plan, Skills Agenda and Rural Vision (European Commission, 2019, 2020a, 2021a, 2021b). Such an endeavour is complemented with the elucidation of the theoretical and conceptual cornerstones and instils the GreenComp (Bianchi et al., 2022) and DigComp (Riina et al., 2022) frameworks and the pedagogical rationale regarding place-based adult learning. Consecutive sections point to the methodological influx, including multi-vector territorial data collection, stakeholder mapping and profiling, inclusive co-creation workshops, and recurrent feedback loops. Empirical results from three pilot sites are also presented, along with territorial diagnostics, mapped capacity gaps, and elaborate examples of tailored training modules. The article contemplates the policy implications, the potential of transferring the concept to other rural contexts and methodological limitations. The asserted, broad vision is concluded with recommendations for prospective studies and suggestions regarding the integration of learning from the territory" approach into conventional policies on EU rural development and lifelong learning practices.

The purpose this article is to develop a methodology for the framework analysis underpinning a customised training matrix that is grounded on the evidence available for three pilot sites in different rural areas of Italy, Portugal and Spain. In this contribution,

we present the methodology for the framework analysis of the legal and deontological framework for Information and Communication Technology (ICT) research and development, including its application to the pilots and to more fragile target groups. It also includes a part dedicated to ethical and professional conduct principles in the design, and deployment of Innovative approaches and ICT tools applied to NES use cases, as well as an overview of the legal considerations and recommendations on data collection, monitoring, storage and security of personal data for NES use cases. Moreover, this paper presents an overview of the results emerging from the application of the methodology to the pilot sites is provided. The limit of this approach lies in the availability of complete data sources for some specific items, that may depend upon the collection at local level. Finally, recommendations on the data collection required to apply NES methodology and on the subsequent implementation of targeted green and digital transition training approaches for rural areas are discussed.

The effort of the proposed approach is to contribute to address as much as possible the complexities influencing the evolution of the local ecosystem towards the green and digital transition through customized training plans. This article propounds the robust NES structure advanced through the alignment of EU-wide policy imperatives with factual territorial analyses and secures a measurable, context-sensitive model for reinforcing the most fragile rural communities in Europe with green and smart competences to accommodate the breakthrough in EU vision for an interregional, inclusive and fair transition.

2. Background

The approach we implemented was based on a mixed methodology where we integrated a data search and analysis grounded on available sources with evidence emerging from the interaction with the local community stakeholders (Fig. 1).

NES project is grounded in the SHAFE concept – Smart Healthy Age-Friendly Environments -, aiming at developing, validating, and implementing an innovative and sustainable approach to strengthen digital and green skills and competences of over 45 in rural areas. The SHAFE community has been supporting the SIRENE project (www.sirene.eu) for the elaboration of a workable framework for investment and the broad adoption of high-quality smart living solutions, combining the housing sector, green and ICT infrastructure. The framework also includes a Blueprint examining validated good practices on responsive, inclusive, smart, age-friendly living environments that were categorised under six main topics - Policy and Funding, Social Innovation, Health and Social Sciences, Community Intervention and Care, ICT for independent living, Information technology, Urban transformation, Housing, Architecture and Design - taking inspiration from the eight domains of the WHO Age-friendly environments approach and identified as key to comprehensively address the expertise and areas of intervention that are relevant to the field of SHAFE. The transversal analysis of the six

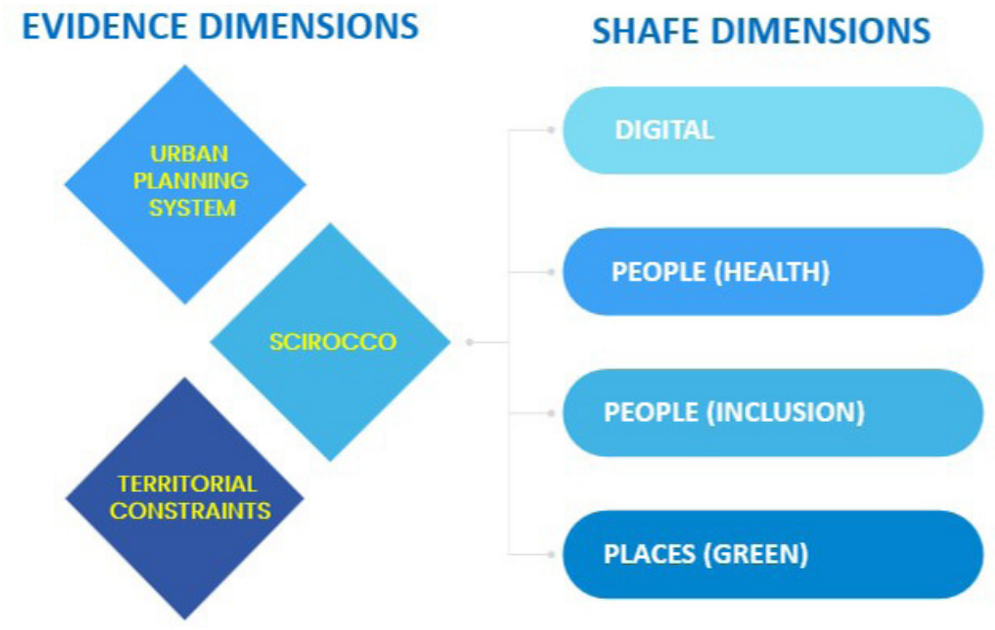

Fig. 1 - Evidence-based approach to a green and digital training matrix

domains that was also carried out in the Blueprint highlights the ones that appear as key features of good practice in the field of SHAFE.

In particular, the application of an assessment tool for NES, provided an overview of the three pilot sites, which differ in terms of maturity, showing a heterogeneous sociocultural context that influences the training approach for supporting the transition towards a green and digital ecosystem.

The analysis of the three case studies focused on the collection of socio-demographic data and questionnaires addressed to the local stakeholders. The aim was to identify the composition and social characteristics of the local communities, highlighting their demands. It was essential to integrate this mainly social analysis with research on the physical conditions of the territories involved, to understand the criticalities and development opportunities linked to morphological, hydrographic, vegetational, agronomic, infrastructural, regulatory and planning assets. The local development of the analysed territories and, consequently, the training programmes that constitute the final objective of the project, are closely linked to the transformability conditions determined by the existing material resources and by the normative framework that regulates land use, ranging from integral protection to conservation and valorisation. In a context of vulnerable inland regions, characterised by the outflow of the inhabitants and the economic and social criticalities caused by the abandonment of agriculture and land care, it is essential to understand the current transformative trends. The challenges of the areas examined in the case studies are mainly depopulation and the demographic ageing resulting from the lack of job opportunities and housing deprivation, accentuated by the scarcity of essential services. In addition to these socio-economic problems, there are also issues linked to a physically fragile territory, widely marked by hydrogeological risk, due to poor soil maintenance caused by the abandonment of agricultural activities

and natural reforestation. NES project refers to the concept of "habitat" in terms of preferred or usual surroundings of the natural and anthropic places where human activities take place and develop, including the built environment. Within this concept, the observation of local economic sectors includes both landscape and valorisation of natural resources as well as activities relying on human skills and capacities. Such natural resources, coupled with the built environment and related artefacts represent the "habitat sector" present at local level. Indeed, NES territories stand out for the considerable value of their landscape and environmental resources, the quality of their agri-food products and their tourist attractiveness, as well as for their furniture industry. All these important and dynamic sectors count many companies dealing with tourism, wines, footwear, construction materials, furniture, and upholstery, directly and indirectly generate jobs and impact on the entire local economies.

The parallel ongoing processes of de-anthropisation has been igniting a vicious cycle of demographic decline and a progressive decrease in the local supply of services. This situation is the main cause of housing deprivation and one of the main obstacles to development. Consequently, NES pilot sites appear as ambivalent areas, characterised by socioeconomic weakness and environmental fragility on the one hand, and by historical and landscape wealth and agro-productive and manufacturing and tourism potential on the other.

Inland areas in Southern European countries share common problems of imbalance and marginalisation, with high social costs for the provision of essential services such as education, health, and public transport. The unsustainable cost of services in low-density territories is an outcome of marginalisation, feeding a vicious circle. Inland areas in countries such as Italy, Spain and Portugal are crucial for national development due to issues related to the provision of services, increased hydrogeological risk, loss of landscape values, alteration of ecosystem balances and depletion of local culture. Moreover, the limited utilisation of the territorial potential of these vast areas has a negative impact on the national economy. Therefore, focusing attention on internal areas to identify policies that promote local development, in line with European Community guidelines, requires a comprehensive analysis of the physical, functional, and infrastructural characteristics of the territory, in addition to the socio-demographic assessment. The European Community, in pursuing territorial cohesion, has adopted a place-based policy, concentrating actions and strategies on territorial peculiarities, including natural and institutional resources and relational networks, both material and immaterial, of places.

The three different level of maturity, ranging for the minimum score 5 of Pacentro and Maiella Madre (Pilot site 1) to the maximum score of 25 of Adelo Area (Pilot site 3), with Ayuntamiento Yecla (Pilot site 2) which discloses a score of 10, positioning in the middle, were combined with the different layers emerging from the structured data analysis.

Fig. 2 - On the right, the physical accessibility of the Museo dei Portici (Photo edited by Maurizio F. Errigo)

3. 3. Legal framework for ICT research for the habitat sector

Since 2007, the promotion of spatial information infrastructures in Europe has been driven by Directive 02/2007/EC 'INSPIRE' (INfrastructure for Spatial InfoRmation in Europe) (https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32007L0002). According to this directive, Member States are required to develop technologies, metadata, cooperation agreements between authorities, and adopt standards to produce accessible spatial data. The primary goals are to support the decision-making process and ensure environmental sustainability. The implementation of these new tools has enabled network users to collect and publish various types of georeferenced data, including texts, photographs, videos, sounds, or measurements of physical quantities such as atmospheric temperatures, creating extensive archives accessible to other users. This has resulted in an unprecedented growth of real-time information, often referred to as big data.

The applications of these technologies are diverse, ranging from cartography creation (e.g., OpenStreetMap) to real-time monitoring of the effects of disasters and the development of digital archives. Their use in urban planning offers considerable advantages. These include the efficient collection and analysis of demographic, environmental, economic and infrastructure data, the ability to virtually model and simulate cities, foster public participation, efficiently manage resources, and improve urban mobility. In addition, the implementation of smart infrastructures, informed decision-making based on data analysis and operational optimisation all contribute to making cities more resilient, economically attractive and sustainability-oriented. In sum, the integration of ICT in urban planning promotes efficient, sustainable, inclusive, and resilient cities.

In this context, GeoApps play a crucial role in expanding and streamlining the management of spatial knowledge, offering user-friendly tools that are highly valuable for the collection and management of built heritage. The utilization of geographic information systems (GIS) in planning procedures is intricately linked with the evolving goals of spatial planning and governance. Such ICT approaches enable spatial analysis, enabling the efficient assessment of the location of infrastructure and resources. By integrating multiple data such as demographic, topographic and economic data, they offer a comprehensive view of the urban context. Advanced visualisation tools, such as interactive maps, facilitate the communication of planning information in a clear manner. GIS tools also support simulations and future scenarios, helping urban planners assess the impacts of decisions. They simplify resource management, optimising the use of space and improving sustainability. By monitoring changes over time, they provide a valuable tool for assessing the effectiveness of planning policies. With advanced analytical tools, GIS supports informed decisions based on accurate data. In summary, the use of GIS improves the accuracy, efficiency and sustainability of urban planning decisions by addressing urban development challenges in an integrated way.

The evolution of ICT in this context is closely tied to the ethical utilization of open

data. In the European Union (EU), the public sector stands out as one of the most data-intensive sectors, generating vast amounts of data known as public sector information (PSI) or government data. This encompasses various data types such as geographical information, statistics, weather data, research project outcomes, and digitized books from libraries. 'Open' public data refers to PSI that is easily accessible and can be widely reused, often under non-restrictive conditions.

According to the 'European Strategy for Data' (2017), data has become a crucial resource for economic growth, job creation, and social progress. Data analysis facilitates process optimization, decision-making, innovation, and the prediction of future events. This global trend holds enormous potential in various fields, including healthcare, food safety, climate, efficient resource use, energy, intelligent transportation systems, and smart cities. The focus is particularly on improving healthcare, creating safer and cleaner transport systems, generating new products and services, reducing the costs of public services, and enhancing sustainability and energy efficiency.

The adoption of open data ensures that all data available to the organisation is easily accessible to anyone who wants to use it, be it citizens, businesses, other organisations or internal contacts in different areas or services. This has several advantages, including improved organisation and management, avoiding unnecessary costs related to duplication of effort in producing information already shared by other entities. In addition, there is an improvement in the quality of data through a process of homogenisation, which favours the timely updating and completeness of information.

Fig. 3 - The Museum Project Plan

4. Methodology of the framework analysis

In NES project we developed a matrix where the gaps emerging from each pilot community along SHAFE domains have been matched and focused on the identification of the key features of the applicable domains for each of them, thus ensuring that an operational approach towards the green and digital transition is supported at policy and strategic level through a personalised Social Innovation Framework.

Towards this end, the required social innovation concepts, methods and skills has been transferred by NES integrated training tools to support entrepreneurs to identify potential business opportunities, funding, and investment around SHAFE, and creating alliances and synergies between stakeholders and ecosystems towards co-design of policy actions.

This multi-layered approach to training is in line with the features that are explicitly mentioned by the World Health Organisation (WHO) in reference to SHAFE initiatives and require all societal levels to be involved, at community and strategic level: free from physical and social barriers and supported by policies, services and infrastructure that promote health and allow people to maintain their full mental physical capacity throughout their entire life or for as long as possible.

NES matrix model has been elaborated in the effort to provide to policy makers a tool

for the integration of all available evidence that could contribute to define a strategy to reskill and upskill the local workforce for digital and green skills and competences.

The matrix consists of SHAFE dimensions against the evidence dimensions coming from the data available for each pilot site. Through the matrix it is possible to follow the different layers of the digital and green transitions, in the effort of deriving specific training content addressing local needs (Tab. 1).

		SHAFE DIMENSIONS			
EVIDENCE DIMENSIONS		DIGITAL	PEOPLE (HEALTH)	PEOPLE (INCLUSION)	PLACES (GREEN)
Scirocco	Readiness to change	Educational offer	Health promotion	Service Availability and accessibility	Environmental protection
	Structure & Governance	Adoption of smart tools for organisation management	Wellbeing at the workplace	Horizontal and distributed governance models in place	Green priorities clearly identified in strategic planning
	Digital Transformation	Availability of broad wi-fi, smart working stations and spaces, shared databases	Integration of digital tools with hands-on and interpersonal/social activities	Usability and accessibility of digital services	Green city design and transition for built environment and in-between spaces
	Funding	Dedicated funding for the digital and green transitions (ex. environmental certification for industry	Dedicated funding for the digital and green transitions (ex. environmental certification for industry	Dedicated funding for the digital and green transitions (ex. environmental certification for industry	Dedicated funding for the digital and green transitions (ex. environmental certification for industry
	Removal of inhibitors	Strategic planning of actions for multi-stakeholders's social engagement to create systematic feedback loops	Strategic planning of actions for multi-stakeholders' social engagement to create systematic feedback loops	Strategic planning of actions for multi-stakeholders's social engagement to create systematic feedback loops	Strategic planning of actions for multi-stakeholders' social engagement to create systematic feedback loops
	Citizen empowerment	Social engagement for interactive sociocultural and literacy initiatives to action the green and digital transitions at local level	Social engagement for interactive sociocultural and literacy initiatives to action the green and digital transitions at local level	Social engagement for interactive sociocultural and literacy initiatives to action the green and digital transitions at local level	Social engagement for interactive sociocultural and literacy initiatives to action the green and digital transitions at local level
	Innovation management	Creative Hubs for innovation	Creative Hubs for innovation	Creative Hubs for innovation	Creative Hubs for innovation
	Stakeholder Capacity Building and Development	Interdisciplinary and multistakeholders training	Interdisciplinary and multistakeholders training	Interdisciplinary and multistakeholders training	Interdisciplinary and multistakeholders training
Urban Planning system	Territorial urban plans	Implementation of large-scale territorial information system	Elaboration of strategic environmental assessments	Interviews with representatives of institutions and the establishment of living labs on ecological themes	Creation of a large-scale ecological network
	Sectoral urban plans (landscape, risks...)	Creation of an information database on ecological and cultural risks and potentials	Assessment of sectoral risks related to landscape and environmental elements	Inter-municipal workshops to educate the population on vulnerability and territorial values	Definition of multidisciplinary studies and actions aimed at reducing environmental risks
	Local plans	GIS digitalisation of urban spaces	Study of the impacts of urban actions on the social fabric	Dissemination of questionnaires related to local and sub-local level issues	Geodesign interventions to involve society in green design
Territorial constraints	Hydrogeological risk	Digital risk monitoring	Evacuation plans	Dissemination actions and communication to the community on hydro-geological risks	Interventions to secure the territory
	Landscape and environmental protection	Digital database of landscape elements	Monitoring stations for environmental indicators	Dissemination actions and communication to the community on environmental risks	Actions to enhance and protect ecological networks
	Landscape and cultural assets	Mapping historical and cultural characters	Enhancement of cultural ecosystem services	Living labs with local users and institutional bodies	Development of strategic plans for heritage defence
	Rural-natural environment	Digital adaptation of land-use map	Enhancement of environmental ecosystem services	Dissemination events on agricultural qualities of the territory and local products	Creation of a green infrastructure linking the agri-food sector and high value natural areas
	Anthropic environment	Implementation of a municipal-scale geodatabase	Enhancement of basic services	Collection of socio-demographic data related to the city's functional areas	Urban regeneration of critical areas
	Degraded areas	Digital mapping of critical urban issues	Functional rehabilitation of abandoned spaces	Co-design workshops with citizens	Actions to revitalise degraded assets and rehabilitation of quarries
	Mobility system	Identification of existing driveways and cycle paths	Removal of architectural barriers on the road	On-site questionnaires to establish critical points according to local users	Implementation of sustainable road systems linking local and supra-local points of interest

Tab. 1 - The matrix integrating SHAFE dimensions with locally relevant evidence

4.1 NES regulatory-planning framework

The collection of digital data presupposes an in-depth knowledge of the reference territory and the instruments through which it is governed and planned. For this reason, a guide sheet has been drawn up to interpret the different levels of territorial planning and governance at different scales, considering the regional/district (macro), supra-municipal (meso) and municipal (micro) levels. This is crucial as it is impossible to adapt a spatial analysis without a clear and precise picture of the regulatory instruments governing the area under study.

		SCALE		
		Regional/district	Supra-municipal	Municipal
RURAL-ENVIRONMENTAL SYSTEM	Landscape protection	Regional Landscape plans (Piano Paesistico) District urban plan (PTC L'Aquila)	Territorial constraints (punctual laws, buffer zones)	-
	Land use	Corine Land Cover, specific regional or district tools	Territorial land use plan	Local land use plan (from municipal urban plan)
	River basin	Regional water and risk management plan	Main river basins recognition	-
	Enviromental network	Protected national and regional parks recognition, Natura 2000's SCI and SPA, natural-rural elements' system	Green Community studies	Local rural and green public areas (municipal urban plans)
ANTHROPIC SYSTEM	Cultural-landscape heritage	Regional protected sites	Recognition of relevant cultural and landscape elements	-
	Regeneration areas	District tourist-environmental regeneration areas	-	Local transformability areas, renewable built heritage
	Community facilities	Provision of territorial services (hospitals, universities...)	-	Local services and infrastructures
	Tourist facilities	Cultural and hospitalities facilities, district tourist routes	Territorial system: tourist facilities	Areas for hospitality and recreational activities
MOBILITY SYSTEM	Train-airport mobility	Regional and district mobility plans	Territorial intermunicipal connections	-
	Car mobility	Mobility system plan	-	Existing and planned mobility
	Slow mobility	-	Eventual cycling lane plans	Cycling lanes/sustainable mobility plans

Tab. 2 - NES regulatory-planning framework useful to analyse various assets in the governance system (elaboration of I. Pistone and A. Acierno)

The objectives of the NES regulatory-planning framework are as follows:

- Provide a picture of the existing planning tools at different scales;
- Integrating land use data from sources for a clear territorial interpretation;
- Highlight the existing relationship between distinct aspects of the rural-urban fabric;
- Identify the possible lines of planning-normative implementation with an ecological approach.

The analysis will also be split into specific study areas, relating to the natural-rural system, the anthropic system and the mobility system.

4. 2. Guidelines for data collection through the NES spatial data model

ITo obtain comparable data across diverse geographical locations, it is essential to establish a common spatial data model that serves as a standardized framework for consistent research. This geographical approach involves defining specific data categories with precise descriptions, enabling the retrieval of relatable information across various contexts and enhancing our understanding of the territory. The primary goal of the proposed spatial data model framework is to analyse existing legal constraints, the planning system, the rural and natural environment, anthropic elements, and mobility connections. This entails defining the morphological and functional characteristics of the case studies.

The objective of the spatial data model is basically to localise in space information

linked to single elements in space or to the distribution of a specific phenomenon over the territory, in order to characterize and map spatial features in relation to the uses and interests of society, analysing the ecological and social elements of territory at various scales and highlight their potential, in an ecological, economic, tourist and social perspective (Neteler & Mitasova, 2004). This allows to produce maps and measurements of various site-specific elements to know better the territorial assets and benchmark different study cases (Sharma, 2021).

The implementation of the spatial data model should consider the spatial accuracy of the collected information. In the research process, digitization is necessary for redrawing elements from source images in raster format, requiring high-resolution files to ensure effective decoding of the coastal interface in the compared case studies. Introducing the concept of the minimum mapping unit (MMU), which represents the smallest reliably identifiable element within a map, becomes crucial (Buckley, 2008). This parameter plays a significant role in both data collection and actual map production, facilitating a skimming process among the analysed and produced data based on the scale of the final output. Given that scale influences geographic data analysis, spatial analysis needs to evaluate scale components through minimum mapping units, as they determine the level of information provided on the studied characteristics and established interrelationships at different scales. In the proposed spatial data model, aerial photographs of the study area typically form the reference base, allowing for the consideration of medium to high values of MMUs. This approach facilitates the integration of a comprehensive open data framework describing various elements of the territory, thereby identifying the primary assets of the urban green infrastructure.

	LAYER	DESCRIPTION	ATTRIBUTES	GEOMETRY
Basic layers	Aerial photograph	Most recent and accurate ortophoto to analyse the terrytory	/	/
	Georeferenced topographic maps	Base maps describing landscape elements (topography, built environment, roads, etc.)	/	Line
Legal constraints	Landscape constraints	Regional or territorial constraints to protect areas with relevant lanscape value	/	Polygon
	Hydro-geological risks	Areas where different degrees (very high-high-medium-low) of natural hazard insist	*Landslide hazard *Flood hazard	Poligon
	Buffer zones	Filter zones between a landscape asset or specific infrastructure (e.g. roads) and the surrounding area	/	Polygon
	Punctual constraints	Regulatory constraints protecting an asset in the territory	/	Point
Rural-natural environment	Protected areas	Natural parks and protected zone according to regional, national or supranational regulations	*SCI-SPA *National parks *Regional parks	Polygon
	Vegetated surfaces	Areas with various kind of vegetation, both private and public, used for agricultural or community scopes	*Rural areas *Fruit trees *Public gardens or parks *Urban forestation	Polygon
	Water areas	Basins that are connected to the study areas and could be valorised in an integrated way	*Rivers *Lakes *Underground rivers	Polygon Line
Anthropic environment	Functional zoning	Land use of the areas within the urban fabric of reference	*Residential areas *Productive areas *Commercial areas *Hospitality areas *Mixed areas	Polygon
	Cultural elements	Various components of the cultural system of the area, both exposed or underground sites	*Historic centres *Archaeological remains or sites *Relevant buildings	Polygon
	Public facilities	Buildings that are intended for community uses and that can be managed by public bodies but also private users	*Universities *Schools *City Hall *Public libraries *Museums *Social centres *Hospitals *Parking spots	Point Polygon
	Degraded areas	Zones or specific buildings that could be regenerated and reintegrated for public utility purposes	/	Polygon
Mobility system	Train links	Rail connections inside and outside the municipal boundary	*Municipal lines *Extra-municipal lines	Line
	Road links	Connections for cars with different speed limits	/	Line
	Soft mobility	Electric tramway and cyclo-pedestrian routes	*Electric tramway *Cycle lanes *Pedestrian routes	Line

Tab. 3 - Framework for the NES spatial data model: each layer represents a specific kind of data to gather (elaboration of I. Pistone and A. Acierno)

5. Results

5. 1. Pilot study 1: Pacentro and Majella Madre Community (ITALY)

According to the town planning of Pacentro, the Guiding Vision aims to promote the practical implementation of the National Strategy of Green Communities. This initiative takes advantage of the inherent wealth of the municipal environment, characterised by abundant forest and water resources. Pacentro, with its unique characteristics, has the potential to serve as a valuable testing ground for strategic analysis, potentially extending its influence to a wider inter-municipal context and strengthening other locally significant economic sectors. At its core, the overarching idea is to articulate a strategic planning perspective in line with the principles of the European Green Deal (European Commission, 2019). This involves seizing the opportunities outlined in the National Strategy for Green Communities and translating them into actions that are consistent with a multifunctional policy of territorial enhancement. This comprehensive policy takes into account various interrelated aspects, including hydraulic and hydrogeological impacts, landscape, environmental and ecological values, activities, pressures, infrastructures and elements to be protected and enhanced. These include sustainable tourism, recreational activities and quality agricultural production.

Approximately 86% of the territory of Pacentro, or 6,209 hectares out of a total of 7,217 hectares, is within the Maiella National Park, as provided for by Article 12 of Law 394/91. It is also subject to the provisions of the existing Regional Landscape Plan (2004). In addition, there are areas within the Natura 2000 network, located within the boundaries of the Park, designated as Special Protection Areas (SPA) and Sites of Community Interest (SCI). Each site has a comprehensive framework that includes geographical and administrative details, a general overview of its characteristics and a list of habitats and species of Community interest, complete with assessments of their conservation status and the main threats to the site. Anyway, the overall vulnerability of the territory of Pacentro is underlined by the provisions of Royal Decree no. 3267/1923, which places 90% of the municipal territory under hydrogeological and forestry restrictions.

The rural-natural environment of the Pacentro region has a crucial role in the development of the whole area, considering its wide surface in the municipal and territorial context. In terms of land distribution, the agricultural areas, which include arable land, temporary crops, olive groves, pastures and complex plots of land, together with areas with important natural spaces, cover a total of 2,689 hectares, or about 37% of the total area of the municipality. Wooded and semi-natural areas, ranging from forests to scrubland, including extensive coniferous and other small pine forests that encroach on the urban fabric, cover about 4,478 hectares, or about 62% of the municipality's territory. In particular, most of the woods, pastures and permanent grasslands are owned by the town of Pacentro, accounting for about 77% of the municipal territory, or about 5,061 hectares out of a total of 7,210 hectares.

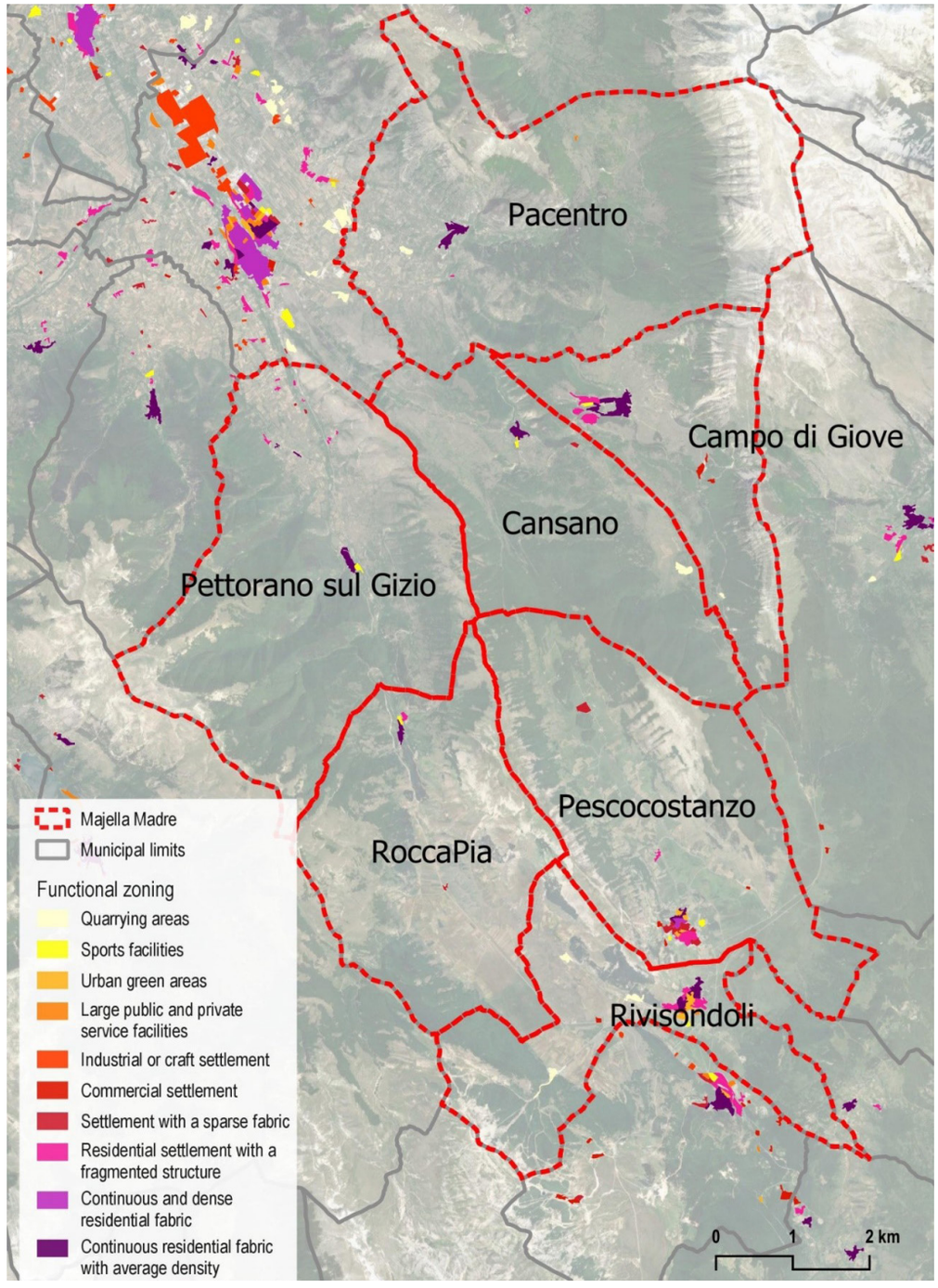

Fig. 2 - Very few zones are actually urbanised in the Majella Madre territory (elaboration of I. Pistone and A. Acierno)

The anthropic environment mainly revolves around the urban centre of Pacentro, while numerous scattered residences dot the agricultural landscape, particularly along the cultivated terraces facing the Peligna valley. The Maiella and Morrone mountains remain largely uninhabited, with the exception of the Passo San Leonardo ski resort, which is contrasted by numerous abandoned dry-stone huts, tangible remnants of the historic sylvo-pastoral use of the mountain slopes. The state of many

of the buildings in the historic centre of Pacentro reflects the situation in various Apennine regions. Many privately owned buildings are abandoned, in a state of disrepair, with outdated systems and significant structural deterioration. Identifying the rightful owners is often impossible, as they may be deceased, relocated or simply uninterested in carrying out essential renovation or maintenance work. This poses a significant challenge to local authorities, resulting in a significant decline in urban quality and risks to public safety and hygiene. Overall, the surface occupied by settlements is minimal compared to the extensive agricultural and sylvo-pastoral areas, accounting for less than 1% of the municipality's territory.

The mobility system is concentrated on the SS 487, which starts from Caramanico Terme and Sant'Eufemia a Maiella, crosses the San Leonardo Pass, reaches Pacentro and then joins the SS 17 at Sulmona. In the area at the foot of the Maiella, near the San Leonardo Pass, the Fonteromana provincial road 54 joins the state road 487 to link up with the municipality of Campo di Giove. At Pacentro, the SP12 Frentana connects the SP487 to Cansano and Campo di Giove. Finally, to the north, the provincial roads 112 Ancinara and 13 Morronese connect Pacentro to Sulmona.

The Pacentro area focuses mainly on agriculture and artisanal activities in the territory. The crisis of the industrial development model, which over the years has affected all the inland areas of Abruzzo and, more generally, the whole of the Apennines, has gradually raised awareness of the possibility of a new economic trajectory based on tourist flows with an accentuated environmental and historical-cultural dimension. The creation of the Maiella National Park has also contributed to this awareness. As a matter of fact, the productive settlements in the area are basically outside the perimeter of Majella Madre: only a few scattered poles of commercial, rather than productive, matrix are located in the south-eastern areas of the district.

5. 2. Pilot study 2: Montemor-o-Velho (Portugal)

The municipality of Montemor-o-Velho, situated within the Centre Region and Baixo Mondego sub-region, is involved in the ongoing establishment of the Coimbra Metropolitan Area. This area encompasses 14 municipalities, Abrunheira, Arazede, Carapinheira, Gatões, Liceia, Meãs do Campo, Montemor-o-Velho, Pereira, Santo Varão, Seixo de Gatões, Tentúgal, Verride, Vila Nova da Barca and Ereira. The area covers an area of 229 km2, ranging from predominantly urban areas like Arazede and Carapinheira to predominantly rural areas such as Abrunheira and Tentúgal.

The legal framework at urban level is based on PMOTs (Planos Municipais de Ordenamento do Território) and on the PDM (Plano Director Municipal). The latter establishes the spatial structure model of the municipal territory, constituting a synthesis of the local development and planning strategy, integrating national and regional indications with the local project axes, limiting the impacts exerted on the relative region.

As part of the research conducted by the National Institute for Environment and Water (INAG) in order to conduct a process of analysis and revision of the list of vulnerable zones, a total of 60 underground aquifer systems were examined with regard to the risk of agricultural contamination. Of these, 15 areas considered to be at potential risk were identified as vulnerable zones. Of these, three fall within the municipal territory of Montemor: Verride, Aluviões do Mondego and Tentúgal.

The municipality of Montemor-o-Velho possesses a very significant range of heritage values. In addition to fortified settlements, churches, chapels, manor houses, farms, traditional houses, among others, there are also a number of interesting sites and complexes that have the potential to become a resource and tourist attraction in the municipality. Indeed, the municipality is home to substantial traces of its architectural and archaeological past, dating back to the Neolithic period, despite the presence of poorly planted settlements that have greatly altered the original status of the area's settlements.

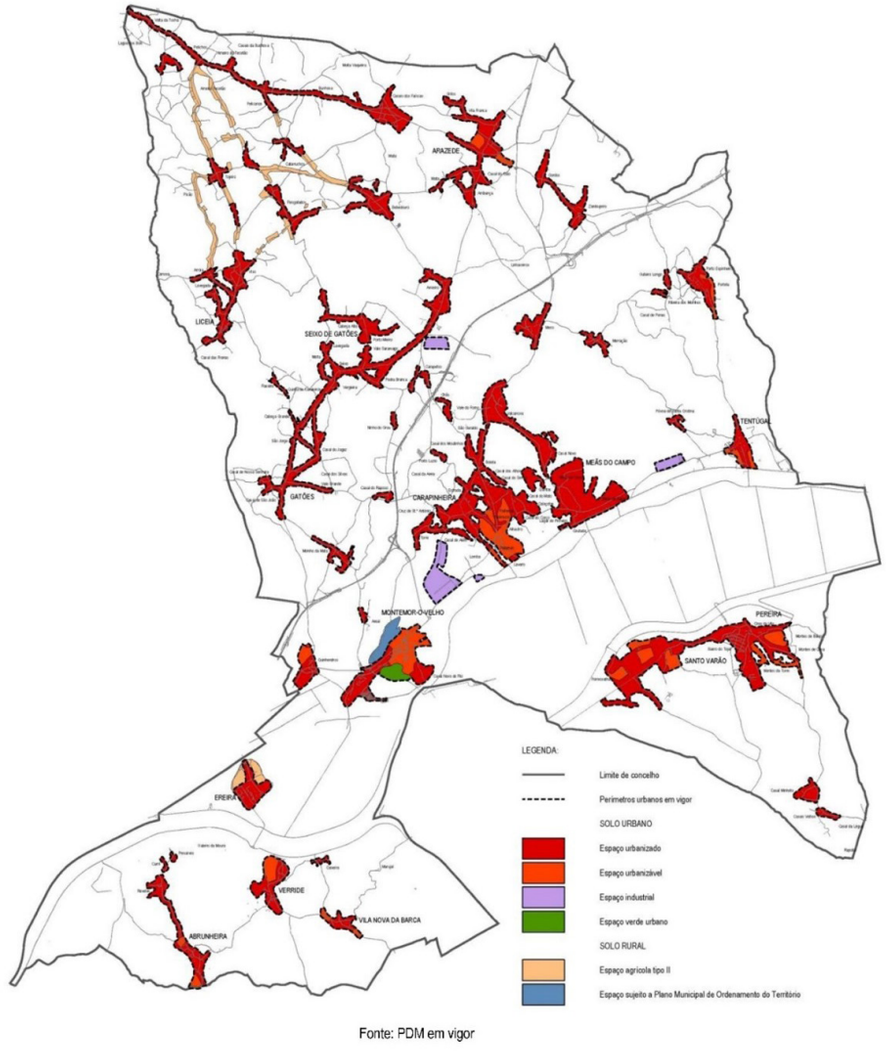

Fig. 3 - Productive and rural use of the Montemor-o-Velho area (source: Montemor-o-Velho website)

In the municipal sphere, there is a growing awareness of the importance of defending the cultural and built heritage, with not only occasional interventions, but also with the safeguarding of complexes and sites with a value of their own or a frame value. This municipality has a long agricultural and livestock history, with family farms and a prevalent polyculture practice.

In summary, the municipality has a strong agricultural tradition, but infrastructural changes have created tensions between farmers and institutions, highlighting the need for greater diversification of agricultural activities and investment in sustainable alternatives. In the Baixo Mondego sub-region, maritime pine forests predominate, occupying about two thirds of the territory, followed by eucalyptus and oak. In Montemor-o-Velho, maritime pine also dominates, constituting the species with the greatest spread. We also find mixed stands of pine and eucalyptus, as well as stretches of oak and other broadleaf trees, although less frequent.

In more recent times, the residential fabric of the municipality of Montemor-o-Velho has been impacted by the attraction of the surrounding large urban centres, which has inevitably caused a demographic decline and contributed to the abandonment of many dwellings. The dwellings in the municipality are mainly of the conventional type, accounting for 99.5% of the total, while non-conventional dwellings make up an insignificant share.

With regard to the geographical distribution of public facilities, it should be noted that the best quality facilities are located in the central part of the municipality, with the Abrunheira area being the second best equipped, followed by Arazede, Pereira and Verride. Overall, Montemor-o-Velho has a good endowment of public facilities in relation to its demographic size, but there are still areas that need to be adapted to respond more effectively to the current and future needs of the resident population.

At the local level, the road network of the municipality of Montemor-o-Velho is basically composed of three hierarchical levels, differentiated according to their respective administrative category. These are the roads integrated in the National Fundamental Network -

Main Road (IP) - according to the PRN2000 in force; the former National Roads (ex EN), downgraded according to the PRN2000 (or through a protocol that transfers them to the Municipality), which become part of the Municipal Network; finally, the remaining Municipal Network, composed of roads and routes (EM, CM and unclassified roads).

The industrial structure of Montemor-o-Velho presents itself as rather fragile, with an overall limited economic impact on the municipality. Despite this situation, the sector has slightly increased its importance in terms of employment, involving approximately one third of the active workforce. According to the most recent data, among the various activities in the secondary sector, manufacturing is the main source of employment, with a focus on the food industry and the production of non-metallic mineral materials, followed by construction. Between the transition from the old to the new millennium, there was a significant growth in employment in the secondary sector, mainly attributable to an increase in workers in the construction sector. There are ongoing

projects to develop an alternative commercial zone in Pereira/Santo Varão and to optimise the existing industrial area in Tentúgal. These initiatives, if completed, would not only improve working conditions and support infrastructure for businesses, but also respond to the growing demand for better environmental and urban living standards.

5. 3. Pilot study 3: Ayuntamiento Yecla (Spain)

The urban planning system in Yecla is based, at the municipal level, on the PGMO (Plan General Municipal de Ordenación). At a regional level, the following have been considered:

- Strategic Plan of the Region of Murcia (2007-2013)
- Industrial Plan of the Region of Murcia 2008-2013
- Guidelines and Territorial Planning Plan of the Region of Plateau

At the municipal level the current PGMO has established the following strategies based on a main territorial model.

The important ecological and landscape values of the municipality of Yecla make it necessary to actively enhance an important proportion of the municipal area, proposing the limitation of urban uses and betting on the preservation of these soils. On the other hand, maintaining the economic dynamism of Yecla implies the need to foresee significant residential and industrial growth. Making these factors compatible requires a territorial model with significant growth around the current urban center of Yecla, continuing the traditional compact model that has characterized the city, and that allows work along the lines of urban sustainability.

A very relevant part of the municipality's land is protected with some figure of a higher nature than the PGMO itself, although this aims to resolve the discontinuities that occur between these high-value spaces. It is important to highlight the risk of flooding, which has a very important effect on the northern area of the municipality, with the intention of preserving the risks that this may pose to the population. The model assumes the maintenance of the main positive features of the current territorial model: concentration of urban areas in the central area of the municipality, preservation of landscapes and valuable rural spaces subject to some type of risk with special attention to the risk of flooding in the northern and southern areas of the core, and consolidation of the city of Yecla as an attractive industrial enclave specialized in its immediate surroundings.

The risk of flooding is considered very important in the municipality of Yecla due to its extension but of a low type in relation to its attendance. These usually occur as a consequence of rainstorms and storms associated with “cold drop” phenomena. The cause of the large occupation of flood-prone areas is because they are basins endorheic with very wide channels with a very small height of the water table. This has as a consequence the damming of water masses by the enclosures of homes dispersed,

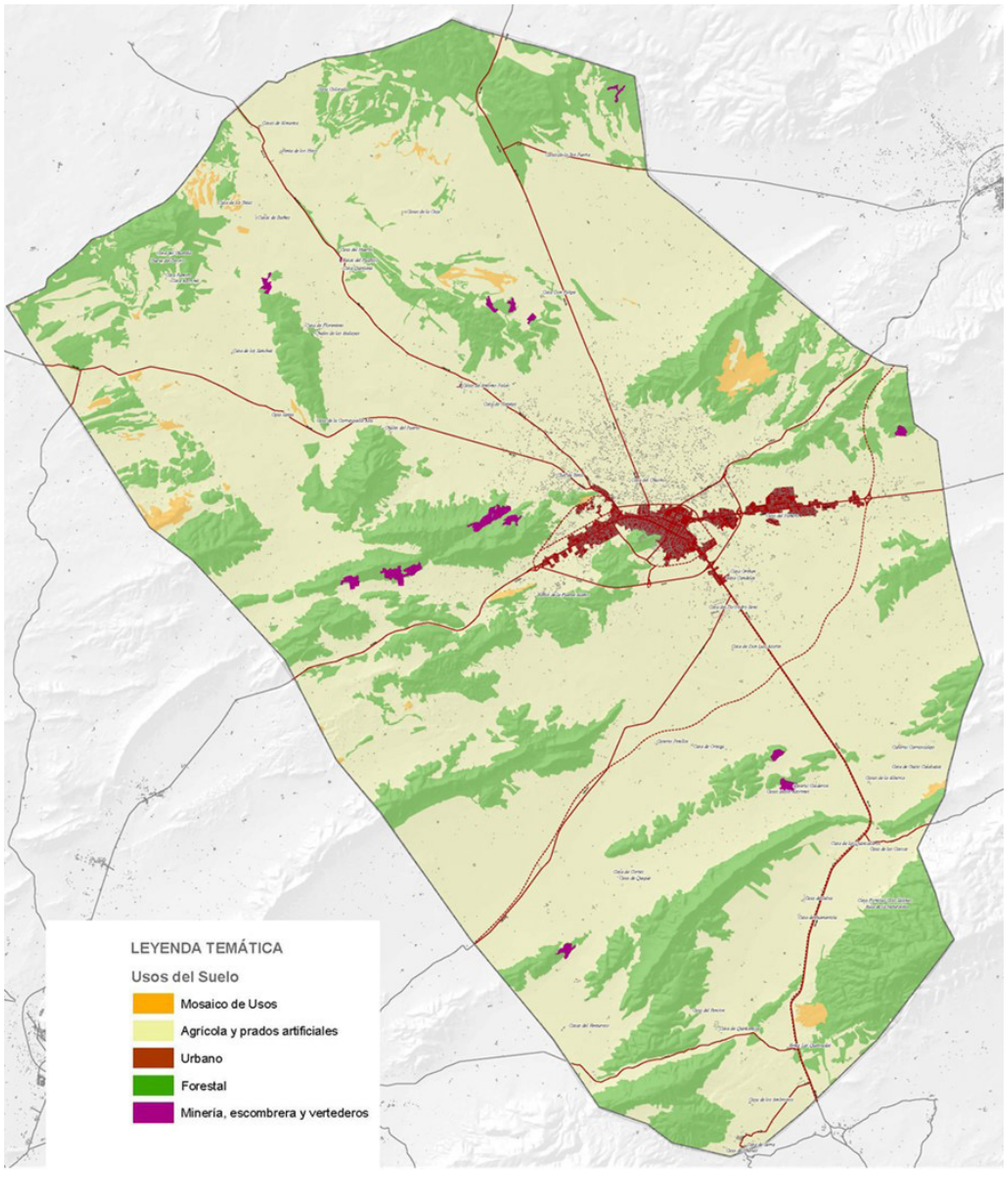

Fig. 4 - Land use of Yecla. The main part of territory is agricultural (80%) with some forestall and often protected areas. In the urban center are concentrated the residential and commercial activities while in the east and west of it are located the industrial ones. Moreover with purple color are showed the mining activities, waste dumps and landfills (source: Ayuntamiento Yecla website)

causing local avalanches of water due to the overturning of fences and walls, and flooding ground floors and basements.

Protected areas constitute the main network of places with natural and cultural values that require protection, and measures have been or are being adopted for their conservation.

The analysis of the Physical Environment shows the high landscape, agricultural and cultural value of the municipal area of Yecla. This richness of the Yecla landscape requires treatment careful with regard to the implementation of new urban growth, infrastructures and activities. The high dynamism economic of the municipality, and especially the agricultural modernization of the two recent decades, has not profoundly altered the coherence of the adequacy of the agricultural and forestry uses to the physical structure of the landscape.

The 2001 Census of the National Institute of Statistics shows for the municipality of Yecla, which currently has a stock of 12,592 homes, a high level of empty homes (18%). In rural areas, where there are 478 registered homes, the percentage is similar (19%). The typologies of collective housing with common free spaces (block with patio) and in open blocks are scarce. There are few buildings with more than six floors. The majors concentrations of commercial and office premises are located around the Town Hall and the main streets. A regular urban fabric of small dimensions, where the blocks have an average dimension of fifty meters on their shortest side, and 120 on the long side, which coincides with the horizontal development of the hillside on which they are located.

There are no degraded areas in the municipality except for some mining areas out of the urban center. There are some quarries out of the urban center.

The Interurban Road Network in the municipality so far includes only one national highway, the National N-344, which connects Valencia and Almería through the Murcian plateau. This becomes a ring road around the center of Yecla (T-424). Likewise, the road network is completed with three first-level regional roads that extend outside the limits of the Autonomous Community. They are the R-424, which connects with Pinoso, and the R-425, with Villena, both municipalities in the province of Alicante; and the R-426, which connects with Almansa, in the province of Albacete. The network is completed radially with three third-level regional roads (Fuente Álamo, Montealegre del Castillo, and RM-A26 roads). In the future, a state highway (A-33) is planned, included as a high-performance road in the 2004 PEIT, following a route parallel to the N-344, which will connect the A-30 Madrid–Murcia highway and the A-31. Madrid-Alicante, to Fuente La Higuera, also connecting with the A-35 highway to Valencia inland. This connection will improve intercity connections significantly.

The municipality has a population structure clearly concentrated and polarized around the center of Yecla with 35,052 inhabitants as of 2021. In recent years there has been significant population growth, due to the growth of the labour market and the increase of immigration, although currently this growth trend seems to be decreasing. The economic activity of the municipality is concentrated on the main axes of Commerce/Repair and Manufacturing Activity. The two activities appear closely linked to the furniture industry, a characteristic of the local economic fabric. Agricultural activities extend over 80% of the Yeclan territory. The main agricultural use is the vineyard, accompanied by olive groves, cereals and fruit trees. The daily residence-work relationships clearly show the role of the municipality as an attraction for labour in its environment, while in contrast the proportion of the local population that works in neighbouring areas is small. Then main 2 industrial areas of Yecla are located on the east and west of the urban center along the main roads.

6. Recommendation on implementation of targeted green and digital transition for rural areas

NES methodology builds on the availability of open data platforms and the results of its application to NES pilots in Italy, Portugal and Spain has been highlighting the limits

due to the data gaps existing at local level. The **first recommendation** is to strengthen the dataflows entering open platforms from rural areas, to ensure that targeted analysis can be carried out across different layers to support evidence-based planning towards the digital and green transitions.

Social norms and ethical values differ across countries and cultures. Considering the very nature of the rural areas in terms of sociocultural context and digital maturity is pivotal to ensure social value and equitable implementation of the green and digital transitions.

The **second recommendation** is to define context-sensitive approaches to ensure that pilot activities for example in terms training for of green and digital skills is targeted towards all the stakeholders that are relevant to ensure adoption and scale-up in the medium and long term. Reskilling and upskilling especially for older adults require cross cultural cooperation and exchange of good practices in innovation ecosystems.

The **third recommendation** is ensuring that potential barriers to cross-cultural cooperation overcome possible cultural mistrust by managing different cultural values. General legal and ethical frameworks for digital technologies should be embedded and operationalised in local pilots through stakeholders engagement.

7. Conclusions

Rural areas differ in terms of both geographical and sociocultural context and for their digital maturity. In order to ensure social value and equitable implementation of the green and digital transitions, and evidence-based approach is very important. The definition of context-sensitive approaches are pivotal to ensure that pilot activities for green and digital skills are adopted and scale-up in the medium and long term. Indeed, potential barriers to cross-cultural cooperation are overcome only taking into account different sociocultural values.

NES methodology for evidence-based training pilot design builds on the information provided by local stakeholders combined with information available open data platforms. Its application to NES pilots in Italy, Portugal and Spain has been highlighting some potential emerging priorities that could be considered at local level to develop comprehensive training strategies.

The dataflows entering open platforms from rural areas ensure targeted analysis that can be carried out across different layers to support evidence-based planning towards the digital and green transitions. The accuracy level of such analysis depends upon the quantity and quality of available data at different scales, hence the need to feed open platforms the best way possible.

The applied methodology here presented, provides the ground to identify adequate tools to address both common and specific training needs expressed by NES pilots in the framework of the habitat sector towards the selected trainees, for strengthening their capacity on digital and green skills and ignite locally valuable dynamics for sustainable development.

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Ivan Pistone
Department of Architecture - University of Naples 'Federico II'
ivan.pistone@unina.it

Architect and research fellow in Urban Planning, Ivan Pistone holds a PhD in Urban Planning from the University of Naples and a PhD in Geography from Aix-Marseille Université. His research activity mainly concerns sustainable approaches to planning, with a focus on green-blue infrastructures and coastal management, studied through socio-participative and geographic-spatial techniques.

Vincenzo De Luca
Department of Public Health - University of Naples 'Federico II'
vinc.deluca@gmail.com

Vincenzo De Luca is a Researcher at the Department of Public Health of Federico II University. His research path is directed towards the study of the determinants of frailty in older adults and digital innovation in the health and social care sectors. From 2015 to 2025, he worked at the Research and Development Unit of Federico II University Hospital, where he contributes to the coordination of the Campania Reference Site of the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA), and the management of several collaborative research projects and innovative procurements on adoption of innovative digital solutions for Healthcare and Active and Healthy Ageing.

Maddalena Illario
Department of Public Health - University of Naples 'Federico II'
maddalena.illario@unina.it

Maddalena Illario is an Associate Professor at the Department of Public Health of Federico II University of Naples. Since 2013, she has been coordinating the Campania Reference Site of the European Partnership on Active and Healthy Living, fostering participation of local stakeholders to many collaborative activities with international partners. She is currently chair of the Active and Healthy Living Reference Site Collaborative Network. She coordinates the Unit for Innovative Approaches to Lifestyle and Integrated Treatments for Chronic Diseases at Federico II University Hospital. She is an expert in prevention and health promotion, integrated care, and digital health.

Antonio Acierno
Department of Architecture - University of Naples 'Federico II'
antonio.acierno@unina.it

Architect and urban planner, Ph.D, associate professor of Urban Planning. Coordinator of the Master in Territorial Urban Landscape and Environmental Planning at the University Federico II; Head of the Interdepartmental Research Center on Urban Planning “A. Calza Bini”. Scientific editor in chief of the international urban planning journal TRIA. His main interests are theory and innovation in Urban Planning and Design, urban safety, green infrastructure, urban regeneration, urban and landscape planning.

Erminia Attaianese
Department of Architecture - University of Naples 'Federico II'
erminia.attaianese@unina.it

Erminia Attaianese is an Associate Professor of Technological and Environmental Design of Architecture at the University of Naples Federico II, Dept. of Architecture (DiArc). An architect by training, she teaches Executive Architectural Design, Applied Ergonomics, and User-Centered Design. Holding a Ph.D. in Building and Environmental Recovery, she is a Certified European Ergonomist (EurErg) and an expert in Human Factors. She serves as President of the Center for the Registration of the European Ergonomist (CREE), and Chair of the "Ergonomics in Design for All" Technical Committee of the International Ergonomics Association (IEA).He is the Scientific Director of the Italian Journal of Ergonomics and co-editor of the book series Oltre l'accessibilità (FedoA). She has authored over 230 scientific publications on Ergonomics and Human Factors related to the built environment, with a particular focus on human-environment-centered design of spaces, products, and systems aimed at health protection, accessibility, and inclusivity in living and working contexts in the framework of the sustainability.

Carina Dantas
SHINE 2Europe, Coimbra, Portugal; ICBAS, University of Porto, Porto, Portugal
carinadantas@shine2.eu

CEO of SHINE 2Europe, leading international initiatives in health, ethics, social innovation and digital inclusion. With over 20 years of experience, she has coordinated numerous EU projects promoting age-friendly, smart, and inclusive environments, and serves as an expert for the European Commission, CEN/CENELEC and multiple advisory boards. She has also more than 30 publications in conferences and high impact conferences.

Mónica Sousa
Associação de Desenvolvimento Local da Bairrada e Mondego (AD ELO), Cantanhede, Portugal
m.sousa@adelo.pt

Psychologist and an effective member of the Portuguese Association of Psychologists, holding the title of Specialist in Clinical and Health Psychology. Since 2015, Mónica has worked at AD ELO as project manager, where she coordinates innovative projects such as VirtuALL Project, recognized as a Good Practice by the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA).

Mariana Assunção
Associação de Desenvolvimento Local da Bairrada e Mondego (AD ELO), Cantanhede, Portugal
m.assuncao@adelo.pt

Psychologist with a Master's in Organizational Psychology from the University of Coimbra. Senior Technician at AD ELO, involved in projects such as VirtuALL, NewEcoSmart and CLDS 5G. Experienced in project coordination and community support initiatives.

Mariella Xavier
CEIPES, Centro Internazionale per la Promozione dell'Educazion, Palermo, Italy
mariella.xavier@ceipes.org

Political sciences and international relation degree. She is Project Implementation Office Coordinator in CEIPES, managing and supporting the project managers of the organisation in the different implementation phases of the projects. She has experiences in developing education paths and training activities for different target groups.

Vittorio Riponi
CEIPES, Centro Internazionale per la Promozione dell'Educazion, Palermo, Italy
vittorio.riponi@ceipes.org

Project Manager at CEIPES with expertise in EU project design and implementation. Holds a Master's in International Affairs from the University of Turin and a specialization in European Project Management. Experienced in public policy, strategic thinking, and international cooperation.

Jesús Sanz
Technology Centre of Furniture and Wood of the Region of Murcia (CETEM), Yecla, Spain
j.sanz@cetem.es

Industrial and Design Engineer. He has a master's in business administration in Knowledge Economy and currently works in projects related to business and innovation systems. He has experience in areas related to quality assurance and production management. Related to EU Projects, he has experience in administrative and technical support to the project team, exploitation planning, financial reports and as project coordinator.

Almudena Muñoz
Technology Centre of Furniture and Wood of the Region of Murcia (CETEM), Yecla, Spain
a.munoz@cetem.es

Bachelor's degree in Chemistry and Master of Innovation and Digital Transformation with honors. She is currently doing a PhD program in Business and Administration topic. She has extensive knowledge in R&D national and international projects and related to innovation and disruptive technologies. She has more than 15 publications in scientific-technical journals and several communications in national and international congress.

Catalina Martínez Muñoz
Ayuntamiento de Yecla, Yecla, Spain
cati.martinez@yecla.es

Director of Local Development Agency of Yecla City Council, whose purpose is to design, develop and manage the areas of employment, economic promotion and training of Yecla. Their daily work focuses on putting resources of the city in value, to stimulate the development of economic activity and employment.

María Isabel Pérez Millán
Ayuntamiento de Yecla, Yecla, Spain
misabel.perez@yecla.es

Councillor responsible for New Technologies, Economic Development and Promotion, Youth and Tourism. She manages training employment and community resources, performs project management tasks or processing of grants; also, the management actions of Professional Guidance for Employment and Self-employment.