

# Mapping the potential territorial impact of railways

## High speed rail and territorial sensitivity of Italian regions

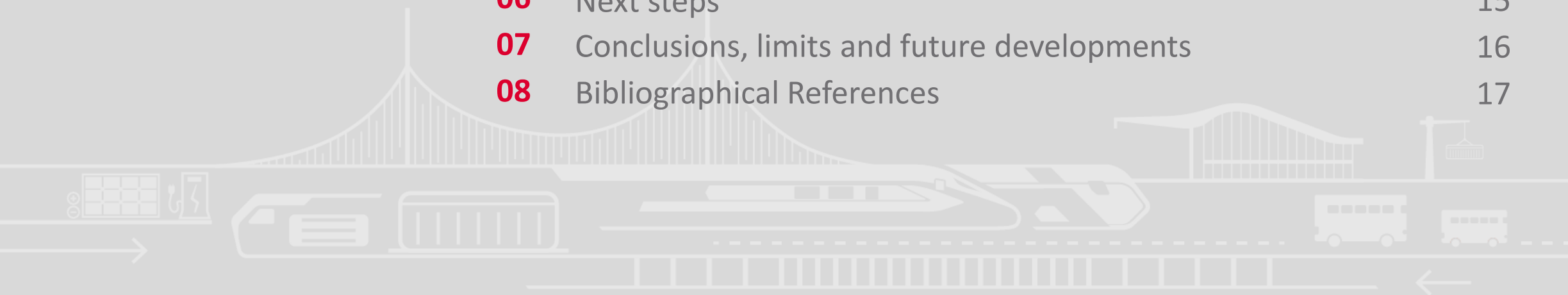
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# INDEX

<b>01</b>	Research question	3
<b>02</b>	State of the art	4
<b>03</b>	Goals and methodology	5
<b>04</b>	Territorial Impact Assessments Indicators' Framework	6
<b>05</b>	Sensitivity of Regions	7
<b>06</b>	Next steps	15
<b>07</b>	Conclusions, limits and future developments	16
<b>08</b>	Bibliographical References	17



# 01. Research question

## The Sustainability Report



**Assessment of the socio-economic impacts of the infrastructures**, with specific reference to

- the promotion of **social inclusion**,
- the **reduction of inequalities** and territorial differences
- Improving the **quality of life** of citizens



Contribution to territorial cohesion

**Assessment of any significant contributions to at least one or more of the following environmental objectives**, as defined in the context of the same regulations, taking into account the life cycle of the work to

- climate change mitigation;
- adaptation to climate change;
- sustainable use and protection of water and marine resources;
- transition to a circular economy
- prevention and reduction of pollution;
- protection and restoration of biodiversity and ecosystems;

### References

#### PNRR Guidelines

for the elaboration of the technical and economic feasibility project to be considered at the base of public work tenders of the National Recovery and Resilience Plan and Complementary National Plan

#### New Italian Procurement Code

With the publication in the Official Journal of Legislative Decree No. 36 of March 31, 2023, the new Public Procurement Code is applied to public tenders for works, services, and supplies launched from July 1, 2023.

# 02. Territorial Impact Assessment Methods

## The State of the art

### An Integrated Approach for the Territorial Impact Assessment of High-Speed Railways



Chiara Ravagnan, Arianna Fittipaldi, Franco Stivali, and Mario Tartaglia

**Abstract** The growing attention to the impacts that transports policies and infrastructure projects have on sustainability and territorial cohesion has been strengthened by the progressive inclusion of these goals among the main objectives of the European Union. In particular, as stated by the Green Paper on Territorial Cohesion, the concept of territorial cohesion “builds bridges between economic effectiveness, social cohesion and ecological balance, putting sustainable development at the heart of policy design.” These goals have been fostering research and experimentation paths for the many companies of the Italian Railways Group (FS Group); in this framework, territorial cohesion and sustainability are the topics of a partnership between the FS Research Centre and the Italferr Sustainability Unit, with the aim of updating the methodological frameworks for the assessment of the territorial impacts of railways. The study is rooted in the institutional and scientific debate on territorial cohesion, interpreted as the “territorial dimension of sustainability” (Camagni, *Rivista di Economia e statistica del Territorio* 3:37–62, 2006a), and is anchored to the methodological references developed for the evaluation of economic, cultural, social, environmental, and governance impacts. To this end, the paper proposes a theoretical and methodological framework of indicators to assess the territorial impacts of high-speed railway projects, arising from a research pathway consisting of 4 phases: the illustration of the literature review on territorial cohesion; the focus on Territorial Impact Assessment methods and indicators; a comparison of the indicators with the Envision Protocol for infrastructures; the proposal of a multidimensional framework of indicators for the territorial impact assessment related to High-Speed Rail.

**Keywords** High speed rail · Territorial impact assessment · Territorial cohesion

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F. Pagliara (ed.), *Socioeconomic Impacts of High-Speed Rail Systems*, Springer  
Proceedings in Business and Economics, [https://doi.org/10.1007/978-3-031-53684-7\\_16](https://doi.org/10.1007/978-3-031-53684-7_16)

335

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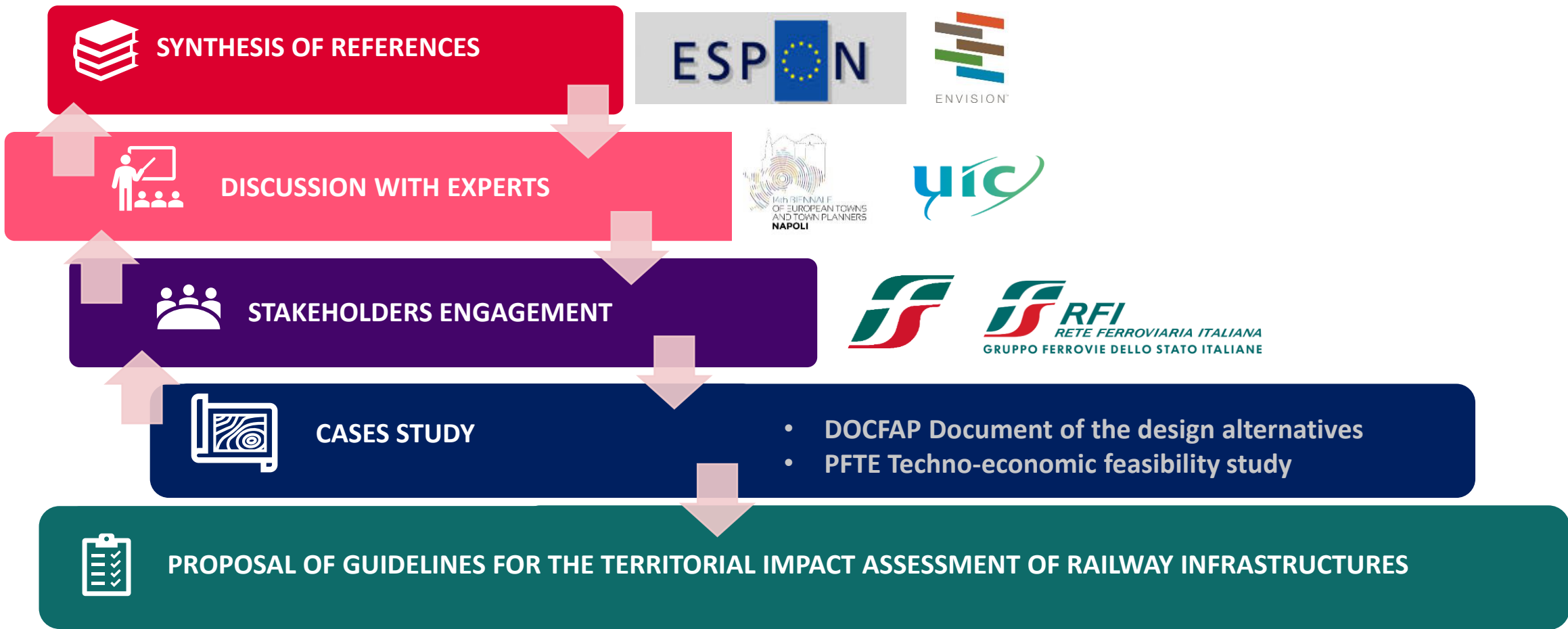
Medeiros, E. (2021), *Territorial Impact Assessment*, Springer.

Prezioso M. (2021) *Territorial Impact Assessment (TIA). Una rassegna della letteratura e dei documenti sul tema*, Università degli studi di Roma “Tor Vergata”

Prezioso M. (ed), (2020), *Territorial Impact Assessment of National and Regional Territorial Cohesion in Italy. Place evidence and policy orientations towards European Green Deal*. Bologna: Patron Editore.

# 03. Goals and methodology

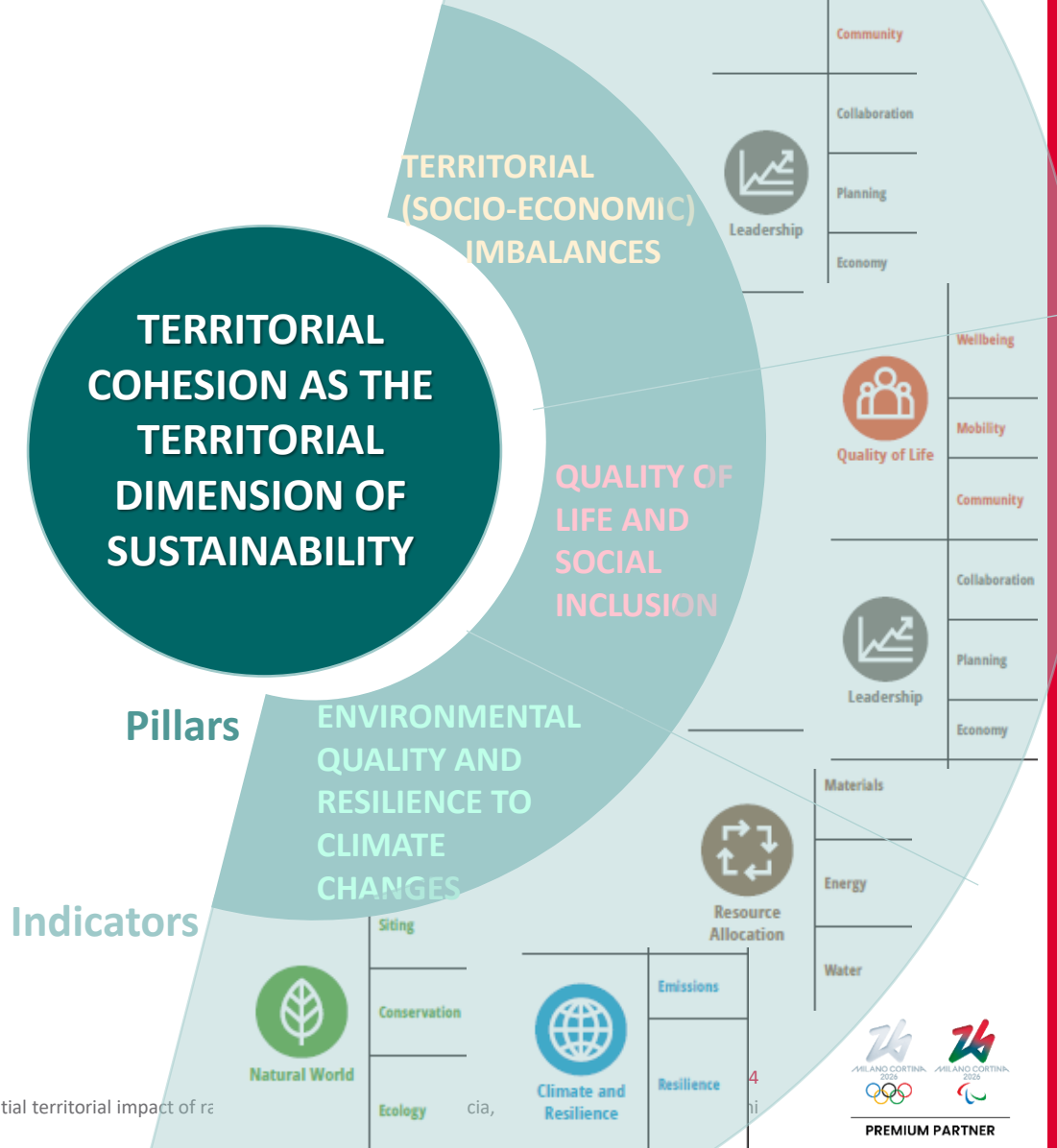
## The Path toward the Guidelines for the Territorial Impact Assessment of Railways



# 04. Preliminary proposal of references for the HSR TIA

## The Indicators' Framework for the Evaluation of the contribution to Territorial Cohesion

SUSTAINABILITY REPORT (MIMS, 2021)	STEMA DETERMINANTS AND INDICATORS (Prezioso, 2018)		TEQUILA COHESION PILLARS AND INDICATORS (Camagni, 2006)		INDICATORS		METRIC
	PILLARS	INDICATORS	PILLARS	INDICATORS			
REDUCTION OF TERRITORIAL IMBALANCES	SUSTAINABLE GROWTH	Risk	Territorial Efficiency	Risk Reduction	Railway infrastructure safety (reduction of interference)	Rail crossing reduction (n.) Pedestrian crossings addition (no.)	
		Multimodal accessibility		External accessibility and interregional integration	External accessibility (to national and international infrastructure nodes)	Reduction of access times to HS stations, Ports and Airports (minutes)	
				General accessibility	Infrastructural equipment	Increase of railway equipment per capita (km of railways per inhabitant)	
		Life expectancy		Relative share of public transport and absence of congestion	Safety of people (reduction of accidents)	Modal shift (Additional % of railway modal share in relation to car share)	
		Unequal distribution of regional income		Development of regional GDP and reduction of income inequalities	Expense for work purposes	Value of the increase in traffic for work reasons due to the additional business expense (euro/year)	
	INCLUSIVE GROWTH	Cultural opportunities	Territorial Identity	Visibility and enhancement of cultural heritage and landscape resources	Accessibility an enhancement of historical-cultural and naturalistic heritage	Reduction of distances from HS stations to regional and national parks or Natura 2000 network (km) Reduction of distances from AV stations from archaeological areas (km) Reduction of distances from high-speed stations, cycle paths and cultural and tourist itineraries (km)	
				Development of territorial "vocations" and "visions".	Territorial leadership and stakeholder engagement	Compliance with the objectives shared by the Regional Planning/Programming in terms of sustainable infrastructure (n. doc or goals) Activation of integrated local development projects (Memoranda of Understanding, Shared Projects)	
		Cultural opportunities	Territorial Quality	Quality of life and access to public facilities	Increase in spaces for collective use	New spaces for social uses (n. or sqm) Regeneration of abandoned or degraded spaces to communities (n. or sqm)	
					Accessibility to urban and metropolitan services	Reduction of access times at urban and metropolitan levels (minutes)	
					Mitigation of the effects on climate change	Climate-changing gas emissions avoided (tCO2e)	
SUSTAINABLE GROWTH	CO2 emissions	Territorial Quality	Protection, saving and regeneration of environmental resources	Air quality	Reduced polluting emissions (t)		
	Air			Use of renewable energies	Percentage of energy used from renewable sources (%)		
	Self Sufficiency Energy			Saving and reusing resources	Volumes of excavated land reused (mc) Rainwater reuse (%)		
	Waste				Energy savings resulting from the modal shift (%) Renaturalisation and/or reclamation of soil and vegetation (sqm)		



# 05. Territorial Sensitivity

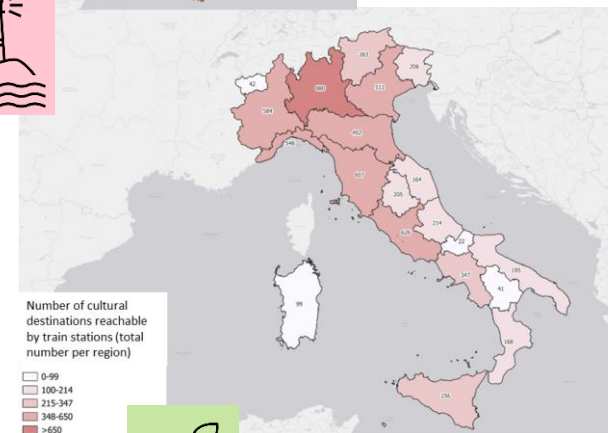
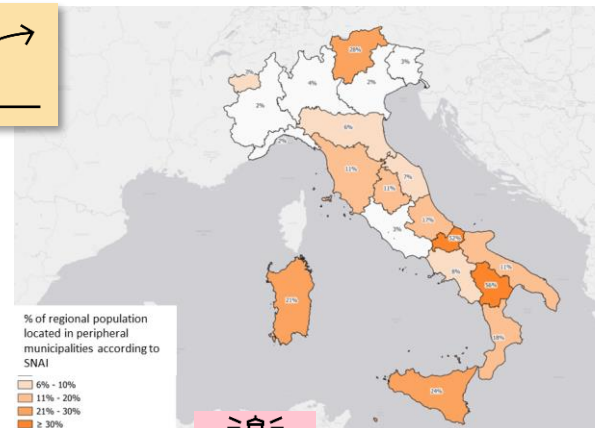
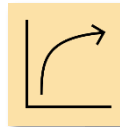
## A proposal

### Territorial (regional) sensitivity

can be described as the degree to which a territory (region) is directly and indirectly affected, either adversely or beneficially by change, in relation to **“how single territories/regions are subject to specific fields, due to their socio-economic and geographical characteristics and to the social values and territorial stakeholders they are likely to show”**, taking into account possible benefits of infrastructure on functional organization, environment and communities (ESPON, 2012).

$S_{r,c}$  = regional sensitivity to the criteria/indicator  $c$   $0 \leq S_{r,c} \leq 1$

>>> Articulation in 5 ranges



# 05. Territorial Sensitivity

## A proposal

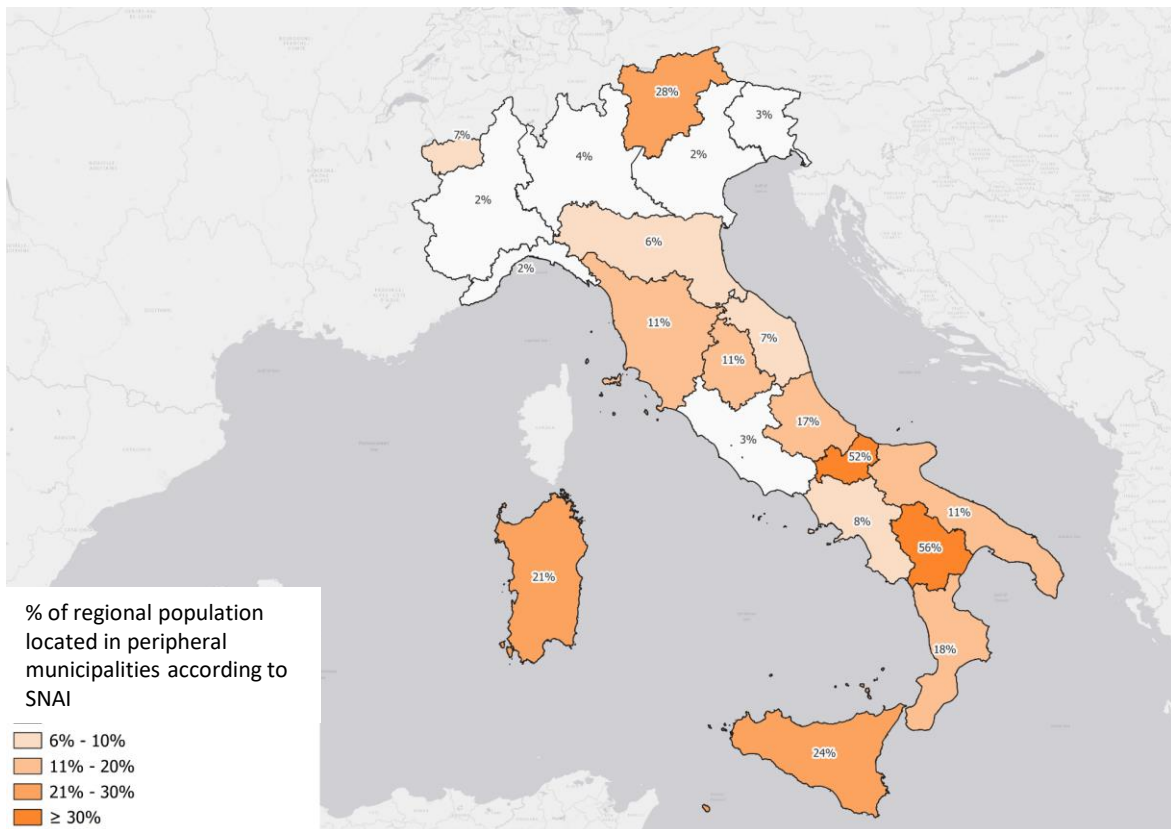
SUSTAINABILITY REPORT (MIMS, 2021)	PILLARS	INDICATORS	METRIC	TERRITORIAL BENCHMARKS/SENSITIVITY PARAMETERS (regional value)	Sources
REDUCTION OF TERRITORIAL IMBALANCES	Territorial Efficiency	Railway infrastructure safety (reduction of interference)	Pedestrian crossings addition (no.) Rail crossing reduction (n.)	Deaths in railroad crossings (number)	RFI - Rete Ferroviaria Italiana
		External accessibility (to national and international infrastructure nodes)	Reduction of access times to HS stations, Ports and Airports (minutes)	Number of inhabitants in peripheral municipalities according to National Strategy for Inner Areas (n. of inhabitants per Region)	Agenzia Nazionale per la Coesione
		Density of Infrastructural equipment	Increase of railway equipment per area (km of railways per km <sup>2</sup> )	Regional railways density per area (km/km <sup>2</sup> )	RFI - Rete Ferroviaria Italiana Eurostat
		Safety of people (reduction of accidents)	Modal shift (Additional % of railway modal share in relation to car share)	Regional motorization rate (cars/inhabitants)	Eurostat
		Expense for work purposes	Value of the increase in traffic for work reasons due to the additional business expense (euro/year)	GDP per capita (euros/inhabitant)	ISTAT - Istituto Nazionale di Statistica
		Expense for tourism purposes	Value of the increase in tourist traffic due to the additional tourist expense (euro/year)	Tourism expense per year (euros/year)	CNR - Consiglio Nazionale delle Ricerche
PROMOTION OF SOCIAL INCLUSION AND IMPROVEMENT OF THE QUALITY OF LIFE	Territorial Identity	Accessibility an enhancement of historical-cultural and naturalistic heritage	Reduction of distances from HS stations to regional and national parks or Natura 2000 network (km) Reduction of distances from AV stations from archaeological areas (km) Reduction of distances from high-speed stations, cycle paths and cultural and tourist itineraries (km)	Number of natural parks, cultural sites and itineraries reachable by train stations (number)	RFI - Rete Ferroviaria Italiana
		Development of sustainable and resilient territorial visions	Compliance with the objectives shared by the Regional Planning in sustainable infrastructure (n. doc or goals)	Mobility demand in Sustainable Strategies (level of demand)	Regional Strategies for Sustainable Development
REDUCTION OF POLLUTION, MITIGATION AND ADAPTATION TO CLIMATE CHANGE AND TRANSITION TOWARDS A CIRCULAR ECONOMY	Territorial Quality	Increase in spaces for collective use	New spaces for social uses (n. or sqm) Regeneration of abandoned or degraded spaces to communities (n. or sqm)	Access to services (BES range)	ISTAT - Istituto Nazionale di Statistica
		Accessibility to urban and metropolitan services	Reduction of access times at urban and metropolitan levels (minutes)		
		Mitigation of the effects on climate change	Climate-changing gas emissions avoided (tCO2e)	Regional CO2 emissions per capita (tCO2/inhabitant)	I4C - Ispra - Life
		Air quality	Reduced polluting emissions (t)	Air Quality - PM2.5 (BES range)	ISTAT - Istituto Nazionale di Statistica
		Energy saving and renewable energy	Percentage of energy used from renewable sources (%) Energy savings resulting from the modal shift (%)	Use of renewable energies (% of tot. consumption)	Open Polis
		Soil	Volumes of excavated land reused (mc) Renaturalisation and/or reclamation of soil and vegetation (sqm)	Soil consumption per area (km/km <sup>2</sup> )	Ispra



# 05. Territorial Sensitivity

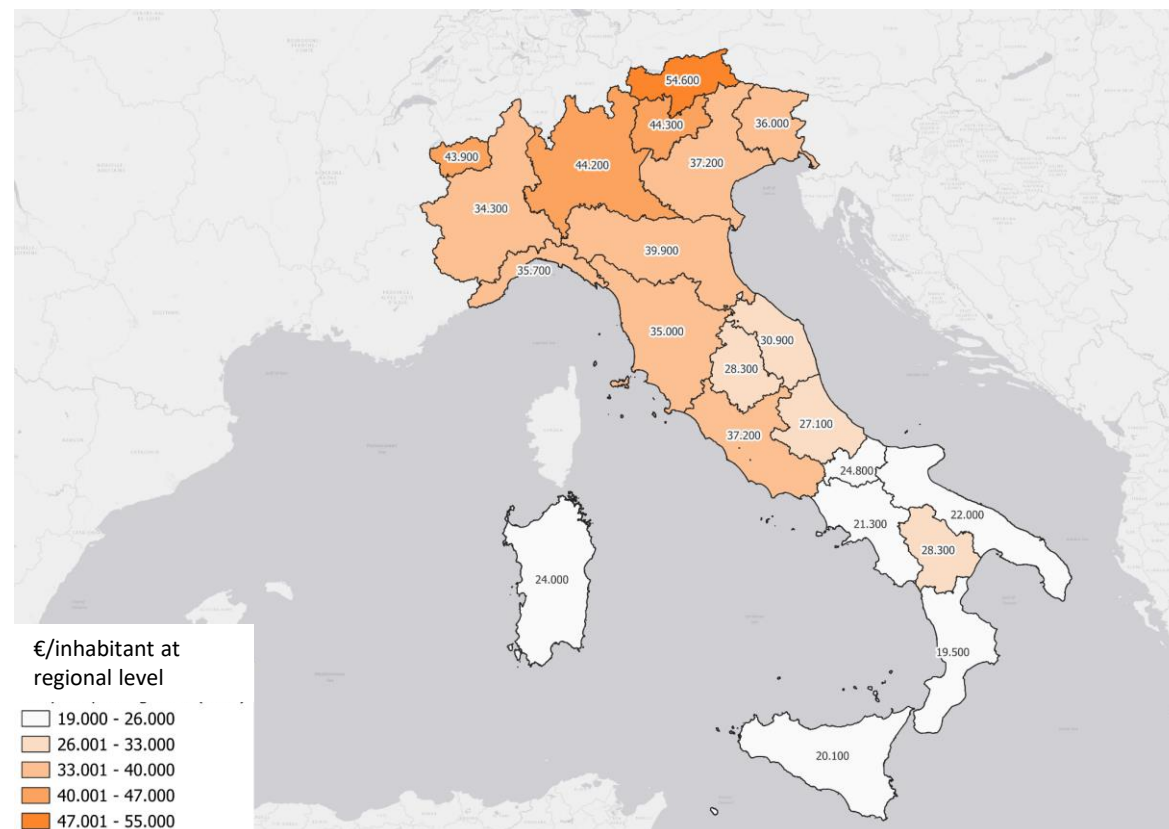
## A proposal

**Inhabitants in peripheral municipalities according to SNAI (% of inhabitants)**



Graphic Elaboration: Martina Madau, Italferr

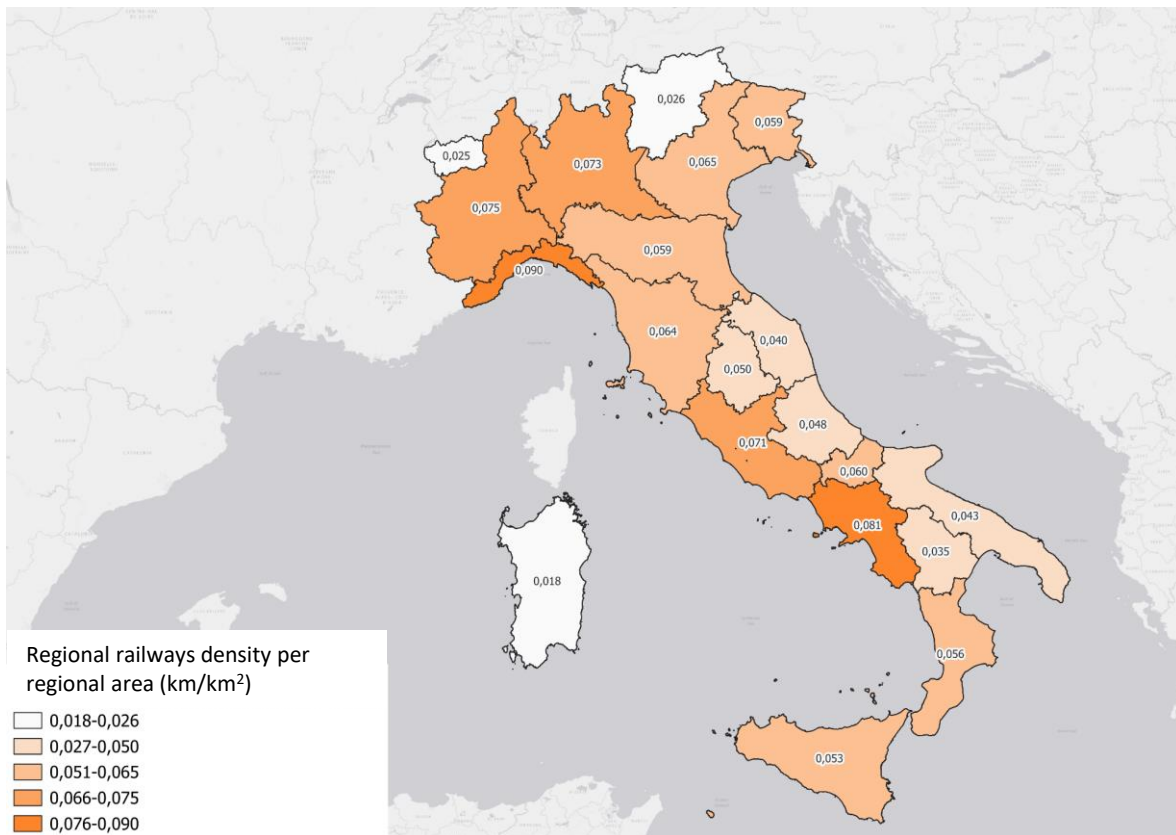
**GDP per capita (€/inhabitant)**



# 05. Territorial Sensitivity

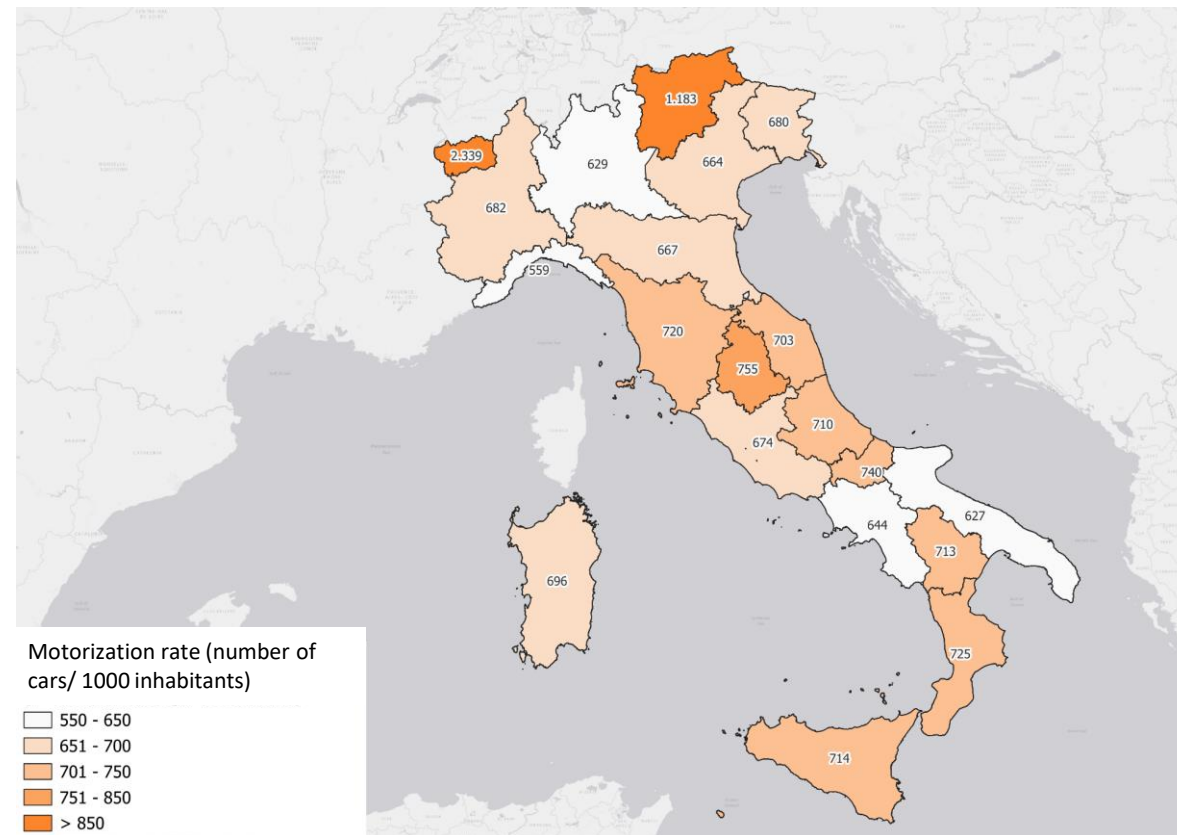
## A proposal

Regional railways density (km/km<sup>2</sup>)



Graphic Elaboration: Martina Madau, Italferr

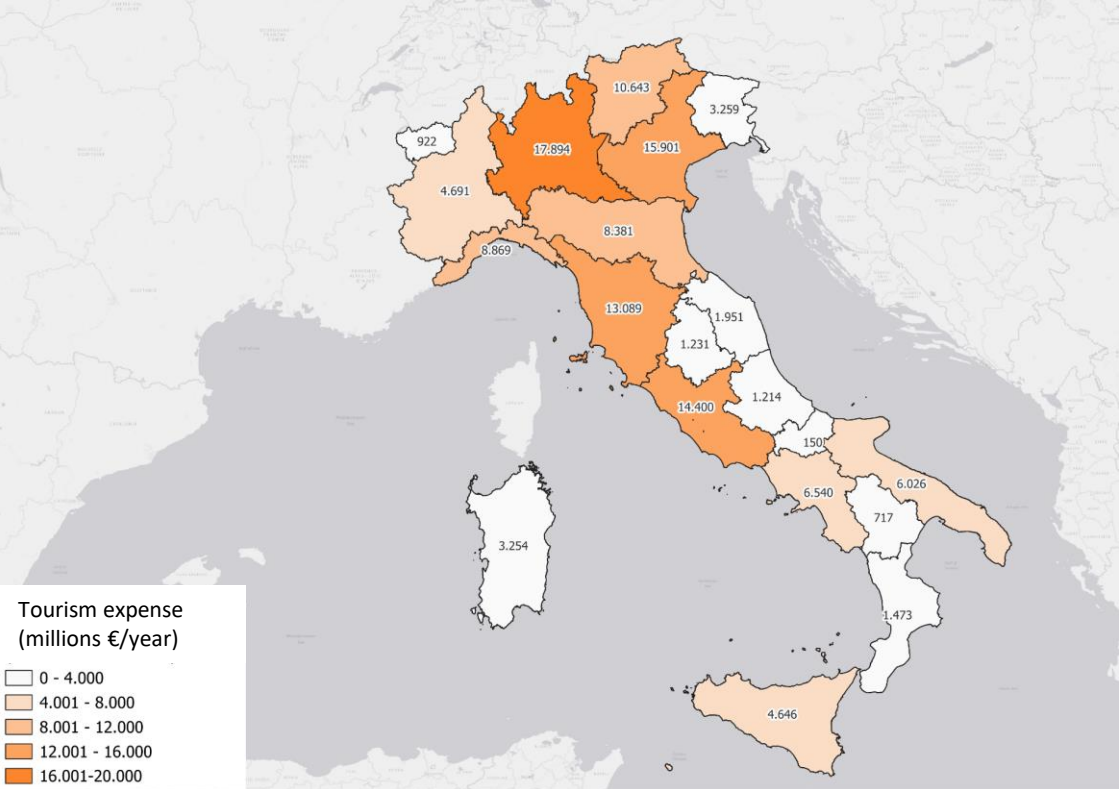
Motorization rate (cars/ 1000 inhabitants)



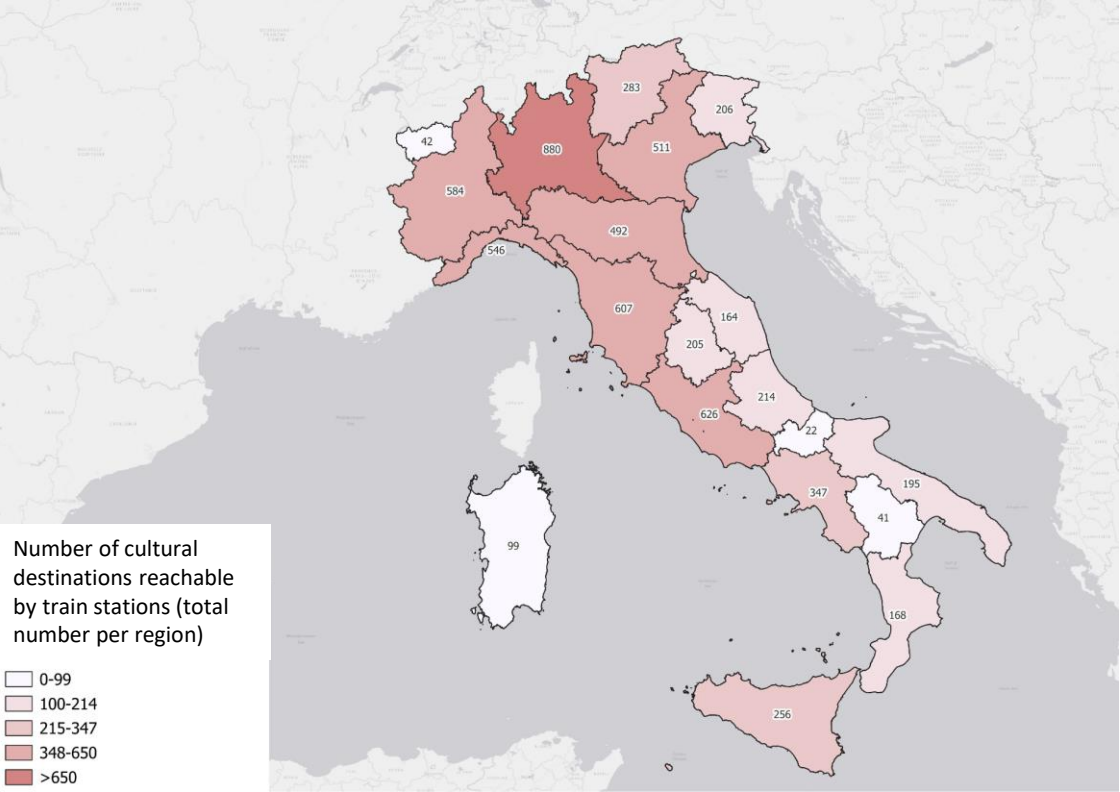
# 05. Territorial Sensitivity

## A proposal

Annual tourism expense (€/year)



Number of natural parks and cultural sites reachable by train stations (number)

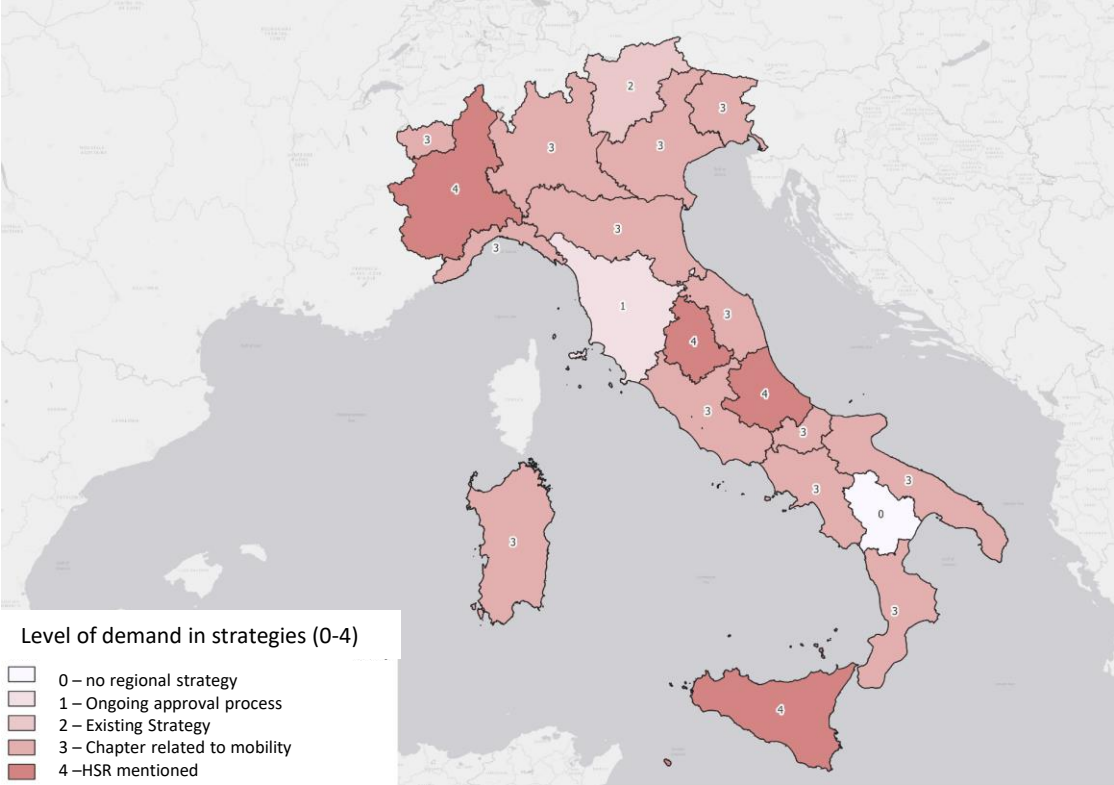


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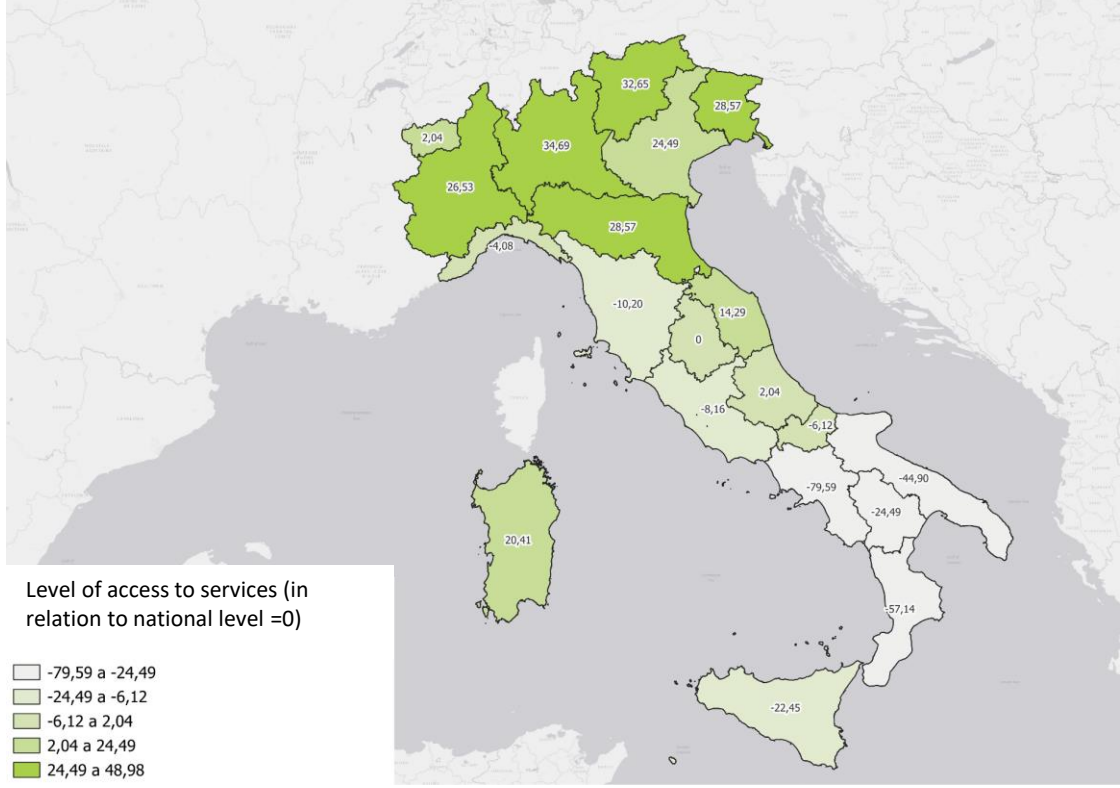
# 05. Territorial Sensitivity

## A proposal

Mobility demand in Sustainable Strategies (level of demand)



Access to services (level of access to service in relation to national level)

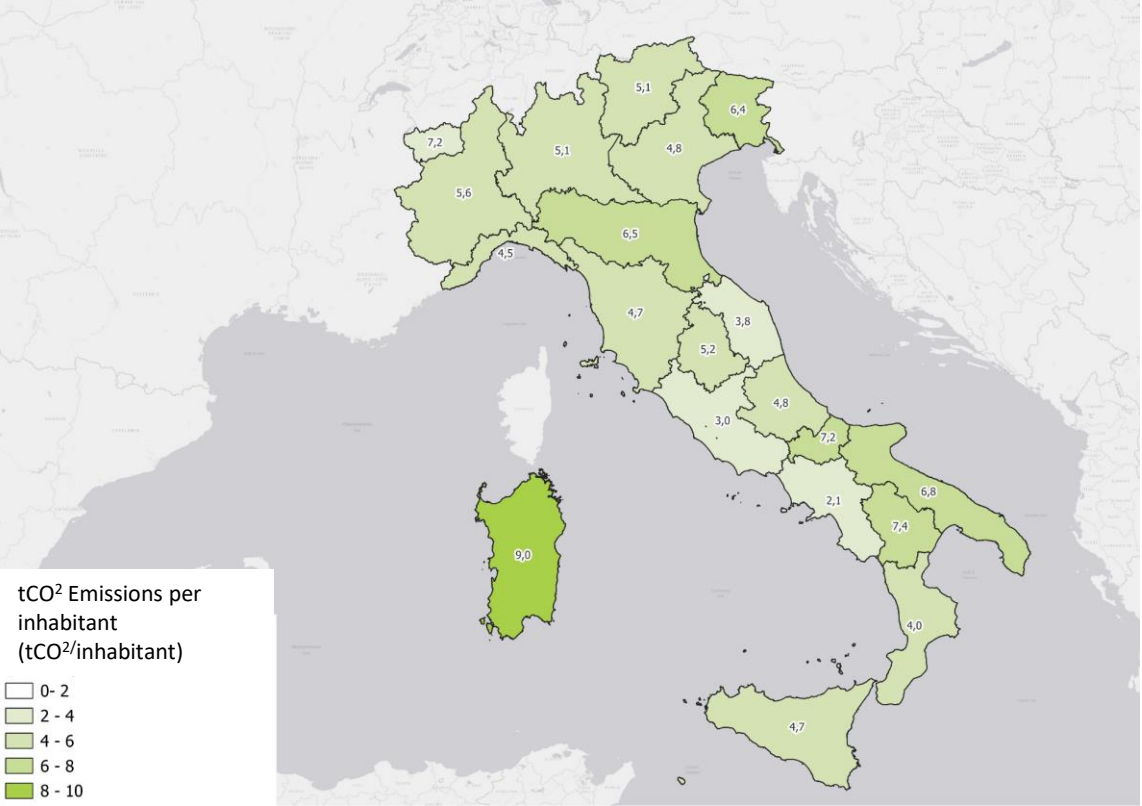


Graphic Elaboration: Martina Madau, Italferr

# 05. Territorial Sensitivity

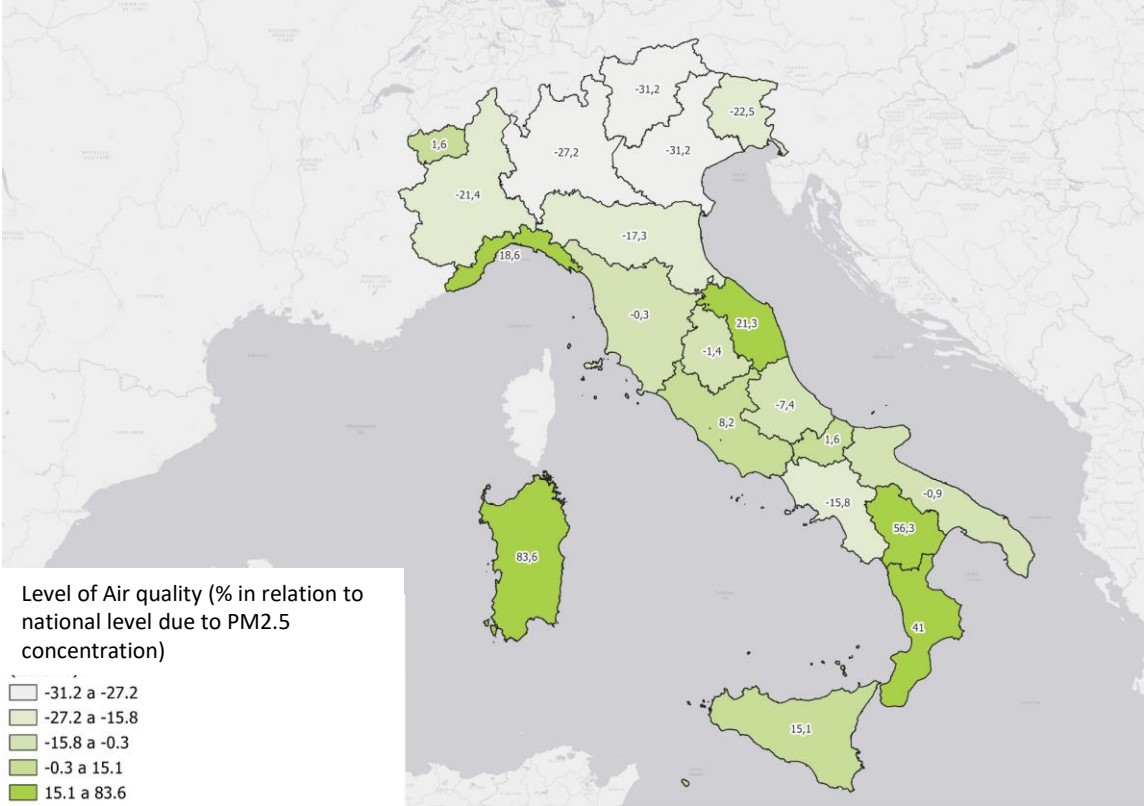
## A proposal

Regional CO<sub>2</sub> emissions per capita (tCO<sub>2</sub>/inhabitant)



Graphic Elaboration: Martina Madau, Italferr

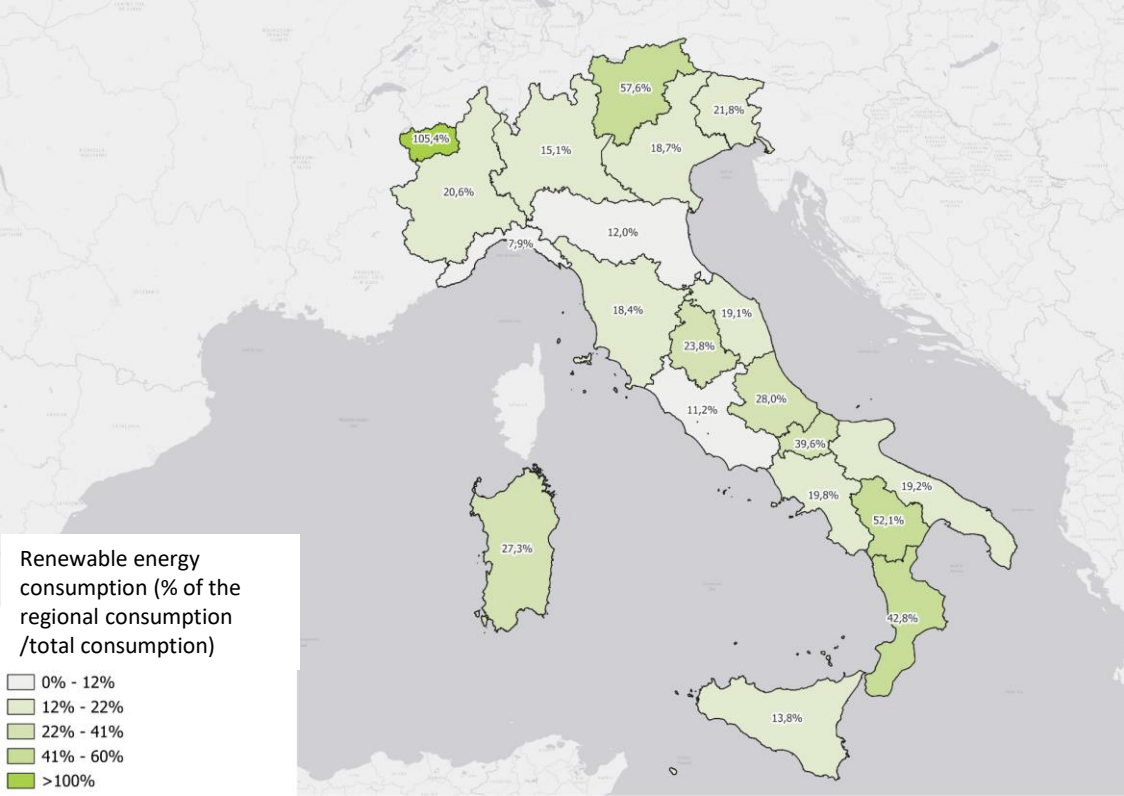
Air Quality (PM2.5) (regional quality air level in relation to national average)



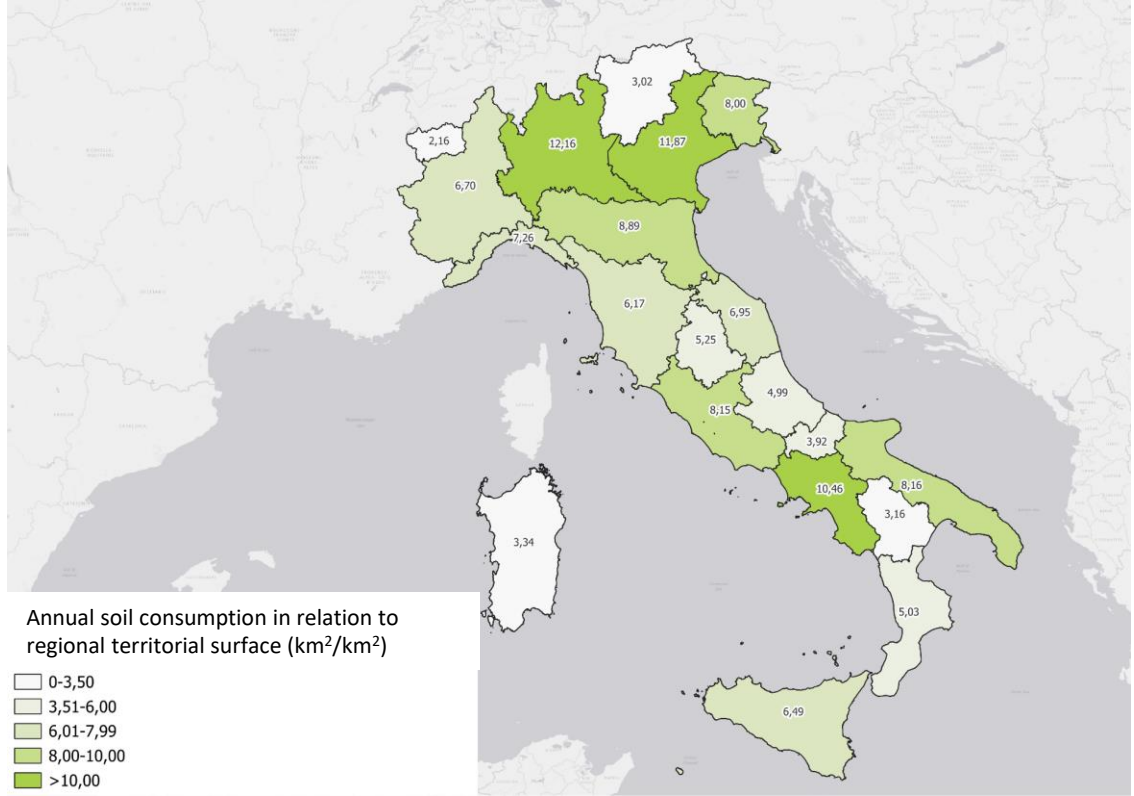
# 05. Territorial Sensitivity

## A proposal

Use of renewable energies (% of energy consumption)



Soil consumption per area (km<sup>2</sup>/km<sup>2</sup>)



Graphic Elaboration: Martina Madau, Italferr

# 06. Next steps

## WSM MCA



Development of the sensitivity of regions and the related impact of railway projects in relation to the specific indicators



Definition of the specific indicators' weight and scope of analysis for the sensitivity parameters



Shared process of the methodology with other Railway Stakeholders



Guidelines for HSR TIA

$$TI = \sum c_i = (\Delta c_1 \cdot \theta c_1 \cdot Src_1) + (\Delta c_2 \cdot \theta c_2 \cdot Src_2) + \dots + (\Delta c_n \cdot \theta c_n \cdot Src_n)$$

$c_{(i=1,2,\dots,n)}$  = All the Criteria/Indicators of the Framework

$\Delta c_i$  = Indicator value Score

$\theta c_i$  = Criteria/indicators weight ( $0 \leq \theta c \leq 1$ )

$Src_i$  = Sensitivity of Regions ( $0 \leq Src_i \leq 1$ )

### Exemple

The territorial impact in term of Territorial Cohesion includes

Pillar: Territorial Efficiency

C1: Density of infrastructural Equipment






$\Delta c_1$ : +0,01 km/km<sup>2</sup> (increase in density determined by the project or specific alternative solution)

$\theta c_1$ : 0,8 (high relevance of C1 in relation to other indicators/criteria Cn)

$Src_1$ : 0,8 (high sensitivity value due to regional railway density – Ex. Low in Abruzzo)

# 07. Conclusions

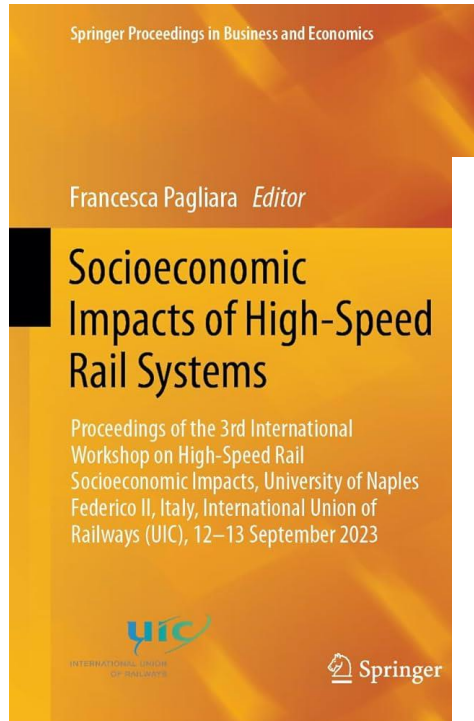
## Limits and future developments

-  Sectoral specification of the evaluation methodologies to railway project is fundamental to improve the sustainability of infrastructure design
-  Territorial aspects must consider different indicators to evaluate the contribution to territorial cohesion
-  The results of the study confirm some hypothesis overlapping the sensitivity parameters of regions
-  Some sensitivity parameters can be refined in presence of data availability and specific research demand
-  The analysis of sensitivity parameters can be adapted and downscaled in relation to research demand
-  The territorial analysis of sensitivity parameters can become a structural and updated analysis framework in the FS SIMS Platform





# 08. Acknowledgment and Bibliographical references



## An Integrated Approach for the Territorial Impact Assessment of High-Speed Railways

Chiara Ravagnan, Arianna Fittipaldi, Franco Stivali, and Mario Tartaglia

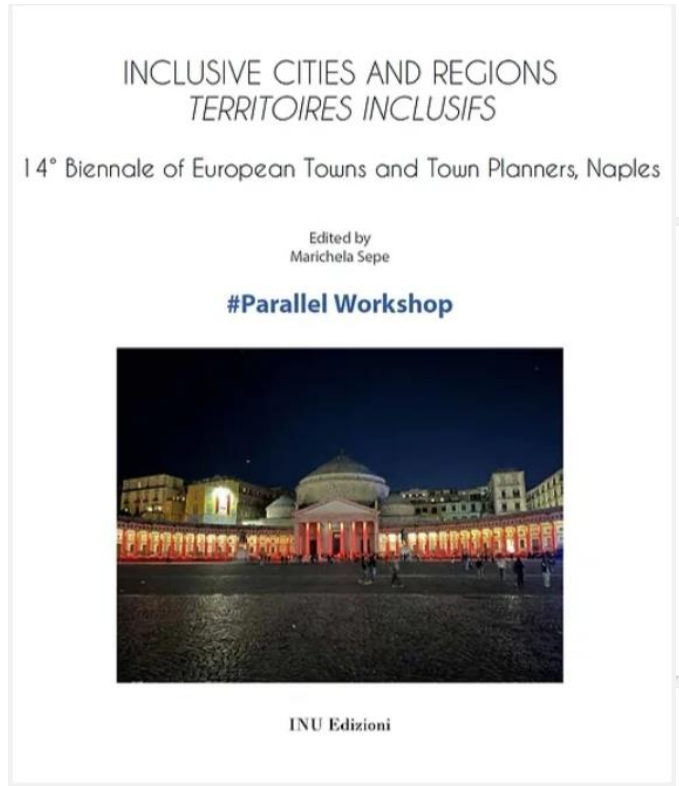
**Abstract** The growing attention to the impacts that transports policies and infrastructure projects have on sustainability and territorial cohesion has been strengthened by progressive inclusion of these goals among the main objectives of the European Union. In particular, as stated by the Green Paper on Territorial Cohesion, the concept of territorial cohesion “builds bridges between economic effectiveness, social cohesion and ecological balance, putting sustainable development at the heart of policy design.” These goals have been fostering research and experimentation paths for the many companies of the Italian Railways Group (FS Group); in this framework, territorial cohesion and sustainability are the topics of a partnership between the FS Research Centre and the Italferr Sustainability Unit, with the aim of updating the methodological frameworks for the assessment of the territorial impacts of railways. The study is rooted in the institutional and scientific debate on territorial cohesion, interpreted as the “territorial dimension of sustainability” (Camagni, Rivista di Economia e statistica del Territorio 3:37–62, 2006a), and is anchored to the methodological references developed for the evaluation of economic, cultural, social, environmental, and governance impacts. To this end, the paper proposes a theoretical and methodological framework of indicators to assess the territorial impacts of high-speed railway projects, arising from a research pathway consisting of 4 phases: the illustration of the literature review on territorial cohesion; the focus on Territorial Impact Assessment methods and indicators; a comparison of the indicators with the Envision Protocol for infrastructures; the proposal of a multidimensional framework of indicators for the territorial impact assessment related to High-Speed Rail.

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**The role of railways toward sustainable and cohesive territories**  
An integrated approach for the territorial impact assessment

Mario Tartaglia<sup>1</sup>, Serena Martini<sup>2</sup>, Chiara Ravagnan<sup>3</sup>, Chiara Amato<sup>4</sup>

The growing attention on the territorial impacts of transports policies and infrastructure projects is fostered by the progressive strengthening of sustainability and cohesion among the great objectives of the European Union. This attention has boosted research paths of the many companies and sectors of the Italian Railway Group (FS Group) to update the methodological frameworks related to the evaluation of the socio-economic and environmental impacts of railways from an integrated territorial perspective. In fact, mobility infrastructures represent a main sector that contribute to the socio-economic, spatial reorganisation and environmental sustainability objectives, both directly, by improving accessibility, and indirectly, with a series of complementary interventions (e.g. public spaces) and indirect impacts (e.g. reduction of travel costs and time). In particular, railways can reduce greenhouse gas emissions, improve the goods traffic, increase the quality of services, and create indirect benefits for all citizens and users. On the other hand, a low transport endorsement and quality, with consequent high transport costs, together with a low competitiveness, can have negative impact on the territorial development (Pezzo, 2020).

In this framework, the Next Generation EU, the NRRP and the Procurement Code in Italy have given rise to new environmental and socio-economic projects assessments, fostering the elaboration of new documents, such as the Sustainability Report, to design multidimensional impacts of projects, including Life Cycle Assessment and Territorial Impact Assessment (TIA).

To this end, in order to evaluate the potential of Transport infrastructures projects on territorial cohesion, interpreted as the “territorial dimension of sustainability” (Camagni, 2006), and in consistency with the scientific debate on TIA methods, the Italferr Sustainability Unit and the FS Research Centre have developed a joint study to propose

a framework of pillars and indicators for the assessment of railways projects territorial impacts. This activity takes into consideration various phases in order to define guidelines for the TIA methodology relating to railways (Fig. 1) (1) the delimitation of a methodological framework of indicators, which is mainly illustrated in the abstract; (2) ongoing discussions with experts and development of the model including the discussion in international conferences; (3) the next steps relating to institutional and local stakeholder feedback; (4) within these phases, the methodology has been experimented in project cases. In particular, the research path presented in this abstract involves phase (1) and (2) and is articulated in 3 steps: (a) the literature review on territorial cohesion that points out the main pillars of the TIA; (b) the literature review on the TIA methods and sustainability protocols for infrastructure projects for the selection of indicators; (c) a proposal of a framework of pillars and indicators for the TIA for railway projects supported by case.

With regards to the literature review (a), territorial cohesion is relatively recent and commonly understood as a concept made up of multiple interconcurrent dimensions (Pezzo, 2020), mainly aimed at counteracting the prevailing tendency of territorial and economic polarisation around the most competitive and populated regions. This concept has been progressively highlighted in several EU emblematic documents, including the ESPD (1999) and the Green Paper on territorial cohesion (2006), which states: “the concept of territorial cohesion builds bridges between economic effectiveness, social cohesion and ecological balance, putting sustainable development at the heart of policy design”. Despite the absence of a unique definition, the literature review points out a convergence on several crucial aspects: reduction of socio-economic disparities, rebalancing of access to services, efficient use of territorial capital, improvement of territorial cooperation and integration, local identity protection, contribution to territorial quality and the efficiency of the environmental resources, as well as mitigation of climate change.

With regards to the studies on TIA (b), many researches (including ESPON) have

