ESPON

EUROPEAN UNION

Co-financed by the European Regional Development Fund

Inspire Policy Making with Territorial Evidence

APPLIED RESEARCH

# ESPON-TITAN Territorial Impacts of Natural Disasters

## Final Report

Applied Research // June 2021

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# Abbreviations

| | |
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| CBA | Cost-benefit analysis |
| CCA | Climate Change Adaptation |
| DRM | Disaster Risk Management |
| DRMKC | Disaster Risk Management Knowledge Centre |
| EC | European Commission |

# Glossary

- **Adaptive capacity:** The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC, 2014).
- **Climate Change Adaptation (CCA):** In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2014).
- **Coping capacity:** "The ability of people, organizations and systems, using available skills and resources, to manage adverse conditions, risk or disasters. The capacity to cope requires continuing awareness, resources, and good management, both in normal times as well as during disasters or adverse conditions. Coping capacities contribute to the reduction of disaster risks (UNISDR: UN, 2009, 2016).
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- **Damage:** Total or partial destruction of physical assets existing in the affected area[1].
- **Damage function:** Damage functions are used to translate the magnitude of a (natural) hazard into a quantifiable damage on infrastructure, economic assets, ecosystems, etc.
- **Damage Distribution Matrix (DDM):** DDM is a matrix in which each element (one number in the matrix) represents the distribution (or weight) of the total costs among the affected NUTS3 areas and among the five capital stocks for each NUTS3 region, i.e., it gives you the weight of the cost per capital stock for a specific event level.
- **Disaster:** a "serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure and vulnerability, leading to human, material, economic and environmental losses and impacts" (UNISDR, 2009).
- **Disaster impacts:** It is the total effect, including negative effects (e.g., economic losses) and positive effects (e.g., economic gains), of a hazardous event or a disaster. The term includes economic, human and environmental impacts, and may include death, injuries, disease and other negative effects on human physical, mental and social well-being (UN, 2016).
- **Disaster risk:** "the potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period" (UNISDR: UN, 2009).
- **Disaster risk assessment**: "A qualitative or quantitative approach to determine the nature and extent of disaster risk by analysing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment on which they depend" (UNISDR: UN, 2009).
- **Disaster risk information**: "Comprehensive information on all dimensions of disaster risk, including hazards, exposure, vulnerability and capacity, related to persons, communities, organizations and countries and their assets" (UNISDR: UN, 2009).
- **Disaster Risk Management (DRM)**: Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses (UN, 2016).

- **Economic Loss:** Monetary value of total or partial destruction of physical assets existing in the affected area[1].
- **Exposure:** "The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas" (UNISDR: UN, 2009).
- **Hazard**: "A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation." (UNDRR, 2018).
- **Impact Pathway:** It is a conceptual model that will define the link between a natural hazard and its direct and indirect economic impacts.
- **Natural hazard:** "process or phenomenon that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation" (UNISDR: UN, 2009).
- **Risk:** "the result of the interaction of a hazard (e.g., flood, hurricane, earthquake, etc.) and the vulnerability of the system or element exposed (Birkmann, 2013). Risk is estimated by combining the probability of a hazard occurrence, and the potential scale of consequences (e.g., injury, damage, and loss) that would arise if the event strikes society or exposed elements".
- **Risk governance:** The system of institutions, mechanisms, policy and legal frameworks and other arrangements to guide, coordinate and oversee disaster risk reduction and related areas of policy (UN, 2016).
- **Sensitivity:** The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct or indirect (Adapted from IPCC, 2014).
- **Vulnerability (risk concept):** "The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards" (UNISDR: UN, 2009, 2016).
- **Vulnerability (climate change vulnerability concept):** The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014).

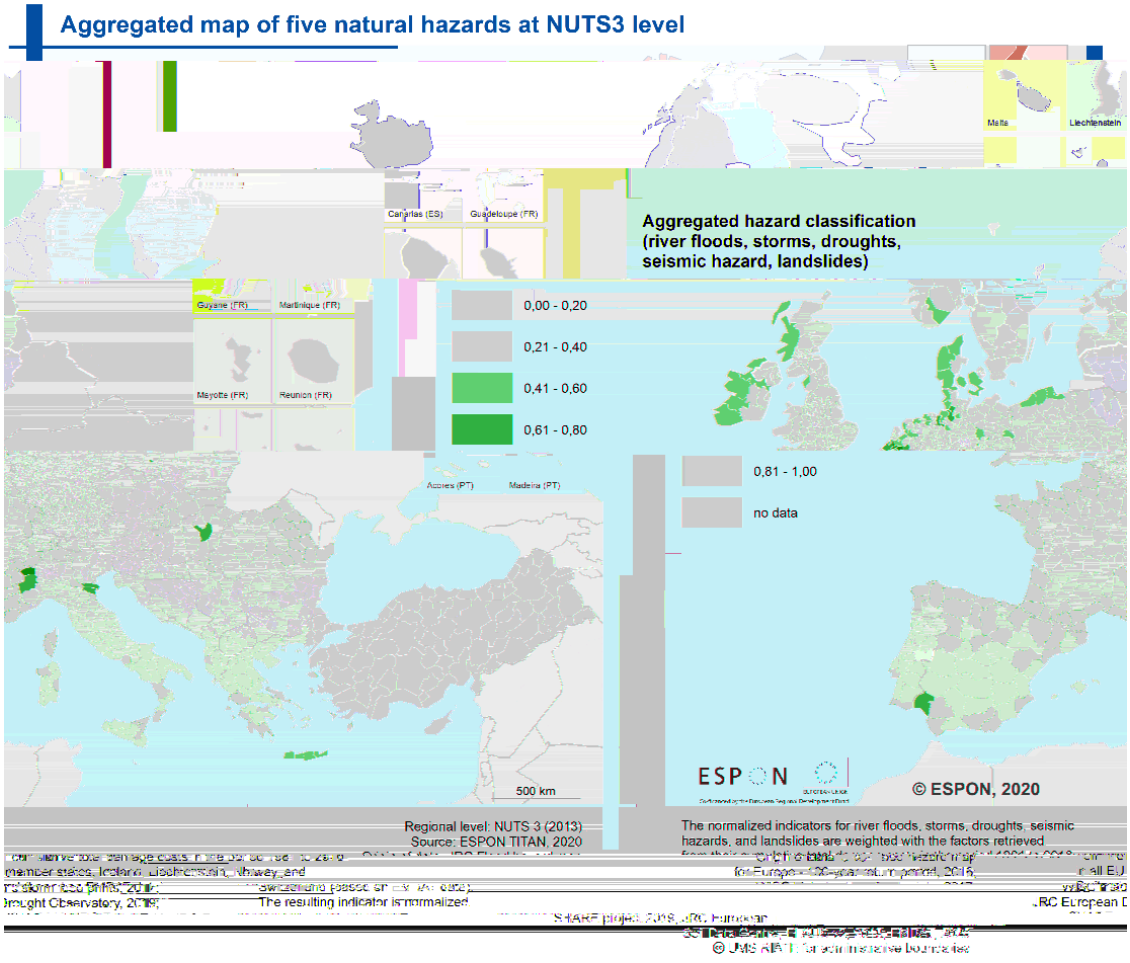
[1] https://www.unisdr.org/files/45462_backgoundpaperonterminologyaugust20.pdf

# 1 Introduction

ESPON-TITAN – Territorial Impact of Natural Disasters, uses innovative approaches and methodologies, to provide analysis of the distribution and territorial patterns of the economic impacts of the natural hazards across Europe – both direct and indirect – , as place-based evidence to support the identification of the most vulnerable regions. Moreover, the project identifies existing effective measures on Disaster Risk Management (DRM) and Climate Change Adaptation (CCA) instruments at different policy levels, that should be mainstreamed into integrated spatial planning and territorial development policies, reinforced by the analysis of eight selected case studies. Based on those ESPON-TITAN scientific findings, as well as on the related place-based evidences identified at regional and local levels, a set of policy recommendations are proposed, framing the political debate on how the territorial impacts of natural hazards affect the territory and what the consequences of having coherent policies implemented may be, at the same time reinforcing the need of integrating DRM and CCA strategies into territorial planning instruments.

# 2 Main results of ESPON-TITAN

In ESPON-TITAN, four main natural hazards, which most heavily affect the European territory, are analysed, to be mentioned: (river) floods, windstorms, drought, and earthquakes. The distribution of aggregated hazards (Map 2.1) is based on the combination of normalised hazard indexes weighted with their cumulative damage costs in the period 1981-2010[2]. Floods and windstorms have contributed to nearly 76% of the damage and losses, followed by droughts and earthquakes (24% both). On the aggregated hazard map, the high intensity of windstorms is visible in exposed coasts, coinciding in many cases with low-lying flood prone areas. High aggregated hazard values are also resulting from the combination of other important hazards, such as floods or droughts (e.g. Eastern Romania). Some considerations regarding the interpretation of this map are that (i) the map do not assess flood protection measures and therefore, also do not assess the effective risk, (ii) droughts are represented in NUTS0, which may partially lead to strong contrasts at national borders, and (iii) the weighting of the aggregation is derived only from economic damage and losses (not including human fatalities or damage and losses that cannot be expressed in monetary values) (see Annex 1 for a detailed description of the methodology and analysis).

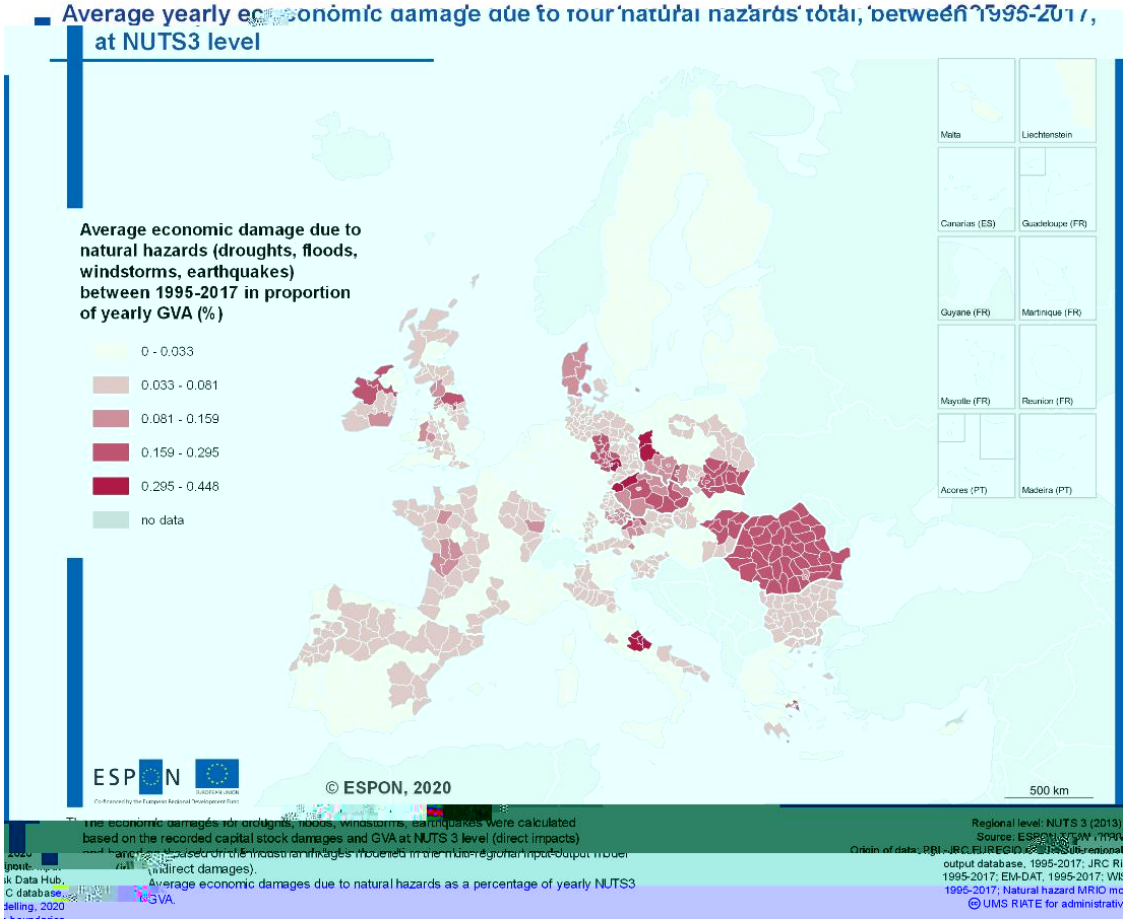



Map 2.1 Aggregated hazard map

[2] Up the end of 2020 the period 1981-2010 was the standard reference period as defined by the World Meteorological Organization (WMO). By referring to this period, the ESPON TITAN results are comparable to a wide range of currently available climatic data.

Innovative methodologies have been developed to deliver the analysis of economic impacts and territorial vulnerability assessment. The approach used to calculate the economic impacts is based on self-developed damage-distribution matrices and Input-Output (I/O) tables to measure, in a monetized value, how the territory is affected by different types of disasters. The analysis revealed that indirect economic impacts induced, in specific regions, by a disruption of economic activities in other ones, tend to be almost as large as direct impacts. Direct impacts are those damage and losses resulting from a natural hazards directly affecting a region (geographically happening there, and damaging the capital stock of the region), while indirect impacts are resulting from the analysis of I/O tables and the derived linkages of economic sectors across regions and countries. The ratio of indirect impacts to direct impacts falls between 60% and 90% across all the period analysed. To illustrate this, in 1999 (when calculated economic damages of all the yearly hazard events have been the largest in aggregate terms, reaching EUR 14 billion), the damage volume was largely attributed to regions in France that were hit by windstorm (together accounting for almost 50% of total damages across the whole European area), and in this case indirect reached over 65% of the direct damages.

The spatial distribution of the economic impacts (based on data of the period 1995-2017) indicates that Central, Southern and Eastern European countries tend to be relatively more affected by these natural hazards, in economic terms, than most of the rest of the European territory. This implies that those countries are recommended to develop place-based measures to reduce the effects of these events in the future. Map 2.2 shows yearly average relative economic damage and losses (as the ratio of economic output drop and the GVA) due to the four natural hazard types, for the period 1995-2017 at the NUTS3 level for the ESPON area (where data was available). Besides Central, Southern and Eastern countries, certain NUTS3 areas of the UK and Ireland, Denmark, France, and Spain (mostly coastal) are also heavily affected, in economic terms, by one or more natural hazard types. (see Annex 2 for a detailed description of the methodology and analysis).



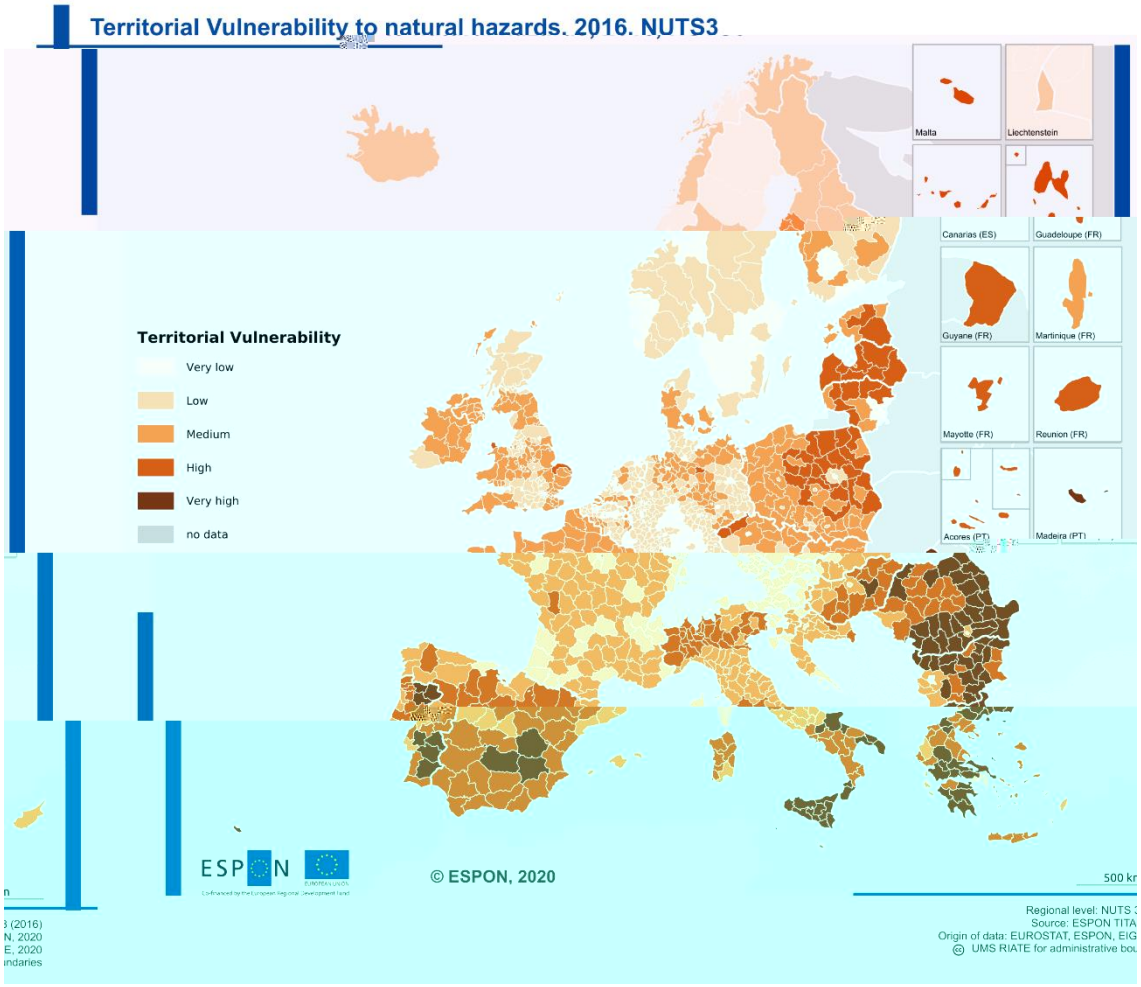

Map 2.2 Economic damage due to the four natural hazard types, yearly average 1995-2017, at NUTS3 level

The economic impact analysis has also included a pilot local analysis with a detailed methodology in two of the eight ESPON-TITAN case studies (namely Nouvelle-Aquitaine and Prague). In those the results of the global methodology (based on top-down information) was compared with the results of the local methodology (based on bottom-up information). The comparison showed that the local methodology evidenced higher damage costs per event, due the inclusion of detailed information of actual incurred events in the region. The local methodology also allowed a deeper understanding of key drivers of economic impacts through qualitative research. It is therefore recommended that the global methodology should serve a pre-screening purpose, in the sense that it should be best used to sense-check where further analysis is needed (i.e. events with initially high damages reported or events that have heavily affected certain sectors), for targeted place-based policy development.

Additionally, a territorial vulnerability assessment was developed at a European level. The methodology is based on principal component analysis (PCA), considering indicators related to susceptibility and coping capacity. New indicators were included in comparison to previous projects (e.g.: ESPON-CLIMATE[3] or RESIN[4]), such as governance, social capital, gender, risk perception, among others. Map 2.3 shows territorial patterns of the vulnerability assessment and clearly shows that Easter and South Europe areas are the most vulnerable. Beyond the territorial distribution of different levels of vulnerability, results were also interpreted in relative terms to the exposed population, showing that 22% of European population lives in territories with high vulnerability levels, especially in Romania, Italy, Bulgaria and Greece (see Section 5.1 for detailed description and analysis).

[3] ESPON-CLIMATE Project, Climate Change and Territorial Effects on Regions and Local Economies in Europe. ESPON (https://www.espon.eu/climate)

[4] RESIN Project, Climate Resilient Cities and Infrastructures. H2020 (https://resin-cities.eu/home/our-aim/)




Map 2.3 Territorial vulnerability to natural hazards, 2016, NUTS3

ESPON-TITAN illustrated the abovementioned findings through eight representative case studies (Andalusia-ES, Nouvelle-Aquitaine-FR, Rotterdam-NL, Po river basin-IT, City of Pori-FI, Prague-CZ, Dresden region-DE and Alpine Region) with a multiscale perspective, that encompass transnational, national, regional and local scales, with differentiated characteristics – e.g. special consideration to one particular type of hazards, existence of operational cooperation and collaboration between involved entities, etc. Good practices were distilled from the case studies analysis, as a supporting pillar of the final policy recommendations elaborated in ESPON-TITAN. (see Annex 5 for a detailed description of the methodology and analysis).

Besides stakeholders from the case studies, a wider range of external experts, institutions and networks (EEA – European Environment Agency, JRC – Joint Research Centre, National and Regional administration representatives, ESPON support team) were engaged in different ESPON-TITAN activities, sharing experiences and insights about the methodology and the results. The involvement of actors from different scale in the discussions (European, cross-border, national, regional and local), as well as from a wide range of backgrounds, has led to a rich variety of perspectives and contributions. Experienced institutions, such as EEA and JRC, have been part of the debate on methodological approaches and results at different stages of the development of the project, giving a valuable input and guaranteeing that the development in place is coherent and perfectly aligned with a European transversal vision on disaster risk and vulnerability matters. Existing ESPON project results have also given some insights and base for comparison and decision on the definitive approach to follow, as for example, ESPON-HAZARDS[5], ESPON-CLIMATE and ESPON-GRETA[6] – GReen infrastructure: Enhancing biodiversity and ecosysTem services for territoriAl development.

[5] ESPON-HAZARDS Project, Spatial Effects on Natural and Technological Hazards. ESPON Project 1.3.1. (https://www.espon.eu/programme/projects/espon-2006/thematic-projects/spatial-effects-natural-and-technological-hazards)

[6] ESPON-GRETA Project, Green infrastructure: Enhancing biodiversity and ecosystem services for territorial development. ESPON (https://www.espon.eu/green-infrastructure)

# 3 ESPON-TITAN Policy Messages and Recommendation

The results of ESPON-TITAN project provide insights that support recommendations on how governments should cooperate to ensure the efficiency and coordination of adaptation and mitigation measures related to disasters, at European, national, regional and local levels. Both the scientific outcomes on natural hazards distribution, economic impact analysis and vulnerability assessment (Annexes 2, 3 and 4), as well as the case studies conclusions (Annex 2 and 5), are translated into a set of tailored policy recommendations (Annex 6), having into account the existing instruments on DRM and CCA and their relation with spatial planning (Annex 4).

The ESPON-TITAN policy recommendations (Table 3.1) are structured around the different stages of the policy process: (i) problem identification and agenda setting, (ii) formulation and adoption, (iii) implementation and evaluation (Howlett and Ramesh, 1995; Jordan, 2001; Burke, 2020) and compiled in three groups. The most relevant recommendations were selected according to the potential role that the EU and its institutions can play in formulating specific actions (e.g. initiating policies, establishing directives, creating databases, etc.). Highlighted in orange are some relevant ESPON-TITAN policy recommendations that are detailed in this section, while in green are the methodological-related ones, included as recommendations for future research (Section 4).

Table 3.1 Overview of ESPON-TITAN policy recommendations

| | |
|---|---|
| (A) Methodologies for calculating economic costs and impacts of disasters and natural hazards | A-1: Harmonisation of concepts and methods for risk assessment and risk evaluation |
| | A-2: Further development of appropriate damage functions for different types of hazards including the calculation of uncertainty parameters |
| | A-3: Research on indirect losses and impacts should increase |
| | A-4: Support methodological innovations in risk assessments regarding the spatial and temporal dimension of risk |
| | A-5: Conceptualisation of criticality as a basis for contributing to the evaluation of risk |
| | A-6: Support regions and the local level in using research and cooperation projects more strategically for DRM and CCA |
| | A-7: Research on how to consider human losses as additional impact of natural hazards, on their inclusion in decision-making processes |
| (B) Improve data availability on economic losses from disasters and natural hazards at local and regional levels | B-1: Development of a framework for the collection of the necessary data at the local level across Member States/authorities |
| | B-2: Disaster-related damage data and reporting should be more granular, including the distinction between direct and indirect damages to avoid double counting in economic modelling |
| | |
| (C) Link measurement of economic losses with the development of DRM and CCA measures | C-1: DRM and CCA measures and plans should always account for the total economic impacts of the occurring natural hazards, including both direct and indirect losses as well as risk aversion factors |
| | C-2: Support a paradigm shift towards a spatially oriented risk assessment and management by including the spatial (cross-sectoral, multi-risk perspective) and temporal (risk dynamics, emerging risks) dimension of risk |
| | C-3: Conceptualisation of criticality and consideration of critical infrastructures (CI) in the evaluation of risk (systemic risk/criticality perspective) |
| | |
| (D) Mobilise European funding mechanisms to further support DRM and CCA at territorial levels | D-1: Focused promotion of a pro-active and prevention-oriented design of EU funding instruments in combination with quality objectives regarding funding of reconstruction |
| (E) Cooperation and coordination of regions, | E-1: Develop cooperation structures between regions, cities and local governments but also between different experts based on a balanced set of formal and informal elements |

| | |
|---|---|
| cities and local governments | E-2: Establish a clear coordination structure for DRM and provide it with leadership qualities |
| (F) Integration of DRM and CCA into legislative frameworks and territorial development | F-1: Support DRM and CCA issues during amendment processes of EU Directives |
| | F-2: Mainstreaming climate change adaption in territorial development policies |

## 3.1 Group 1. Policy recommendations related to economic impacts (focused on methods and data)

This first block of policy recommendations relates to economic impacts (focused on methods and data), where a general question permanently emerges: the trade-off between high resolution and local/regional accuracy of data on the one hand and, on the other hand, the comparability and homogeneity across all regions and statistical units across the ESPON space. Although there is not an easy-to-achieve solution, this issue is addressed by suggesting standards for the collection of comparable data and transparency in methodological approaches.

**(A-1) Harmonise concepts and methods for risk assessment and risk evaluation**. Methodological harmonisation is necessary and possible, whenever reliable cross-regional and/or cross-national comparisons/evaluations are required (although not questioning the need of context-specific risk evaluations as normative judgements, and basis for risk management actions). Given that, as a specific action, aligned with the recommendations from Poljanšek et al. (2021), EC could announce a proposal for a regulation of a harmonisation of concepts and methods for risk assessment and risk evaluation, in order to achieve comparable and comprehensive standards to support DRM policies at European level, e.g. for the further development of the EU Solidarity Fund or for defining funding criteria for supporting infrastructure investments in the Member States. This should be based on an earlier communication of the EC (Commission Staff Working Paper “Risk Assessment and Mapping Guidelines for Disaster Management”, EC 2010) and on experiences collected since 2017 in the JRC-RDH (under the Disaster Risk Management Knowledge Centre – DRMKC). The JRC efforts in this regard should be further extended (several hazards are not yet covered), and the methodological approach, sources used, and constraints could be more transparently described. Further, the accessibility of this information should be improved, which supervision could be assumed by the EC (including JRC) through, for example, DG-ECHO. Indirectly, also the Member States could contribute to the harmonisation process by applying the assessment and evaluation criteria, and providing proper data.

**(B-1) Develop a framework for the collection of the necessary data at the local level across Member States/authorities**. This recommendation aims at increasing the comparability of results (complementing the previous one). This includes standardised data collection at the local scale in terms of disasters and natural hazards, allowing the consideration of implicit local knowledge. The importance of gathering these data resides in the fact that they are risk components, based on which management measures could be implemented. As a specific action, EC could discuss and evaluate different approaches for developing such a framework. On the one hand, the existing JRC-RDH could act as a motivation engine for Member States contribution with comparable data. On the other hand, EUROSTAT could extend their data entry forms, regarding the collection of hazard, risk and damage data, towards the LAU level. Also, the INSPIRE Directive could be amended regarding Annex III, by renaming theme 12 “Natural risk zones” to “Zones of natural hazards and past economic damages”, and thus in charge of providing this additional geospatial data. For data provision, the EC should further foster cooperation with insurance and re-insurance companies.

## 3.2 Group 2. Policy recommendations related to the connection between economic losses and appropriate DRM and CCA measures

This second block presents a policy recommendation related to the connection between economic losses and appropriate DRM and CCA measures. As a central issue for linking them, a paradigm shift towards a more systemic and holistic view on impacts and the evaluation of risk seems to be indispensable. The inclusion not only of direct but also indirect losses describes this overall principle which is described in the policy recommendation below. More information regarding the interconnected issues of the spatial (cross-

sectoral, multi-risk perspective) and temporal (risk dynamics, emerging risks) dimension of risk, as well as criticality as an additional issue to evaluate risk is included in Annex 6.

**(C-1)**

**(E-1) Develop cooperation structures between regions, cities, and local governments, but also between different experts based on a balanced set of formal and informal elements**. Long-lasting, sustainable, and effective cooperation, and successful contribution to DRM, has to be built on formal agreements, but can only be filled with life in an atmosphere of personal connections, mutual trust, as well as open-mindedness to share experiences and learn from others. As specific action we recommend that in the field of DRM and CCA, formal EU/Community funding of transnational cooperation (INTERREG Programme) or cooperation among the Member States themselves, should be further supported. Especially the joint work on specific projects where results and data have to be shared on a regular basis, help to foster cooperation structures. However, the findings further suggest to organise cooperation-oriented expert groups that are characterised by a continuity of topics and personnel in order to build knowledge and trust between group members, and at the same time have the opportunity to work independently from funding guidelines and reporting requirements. Such expert groups could be installed for a certain transnational or transregional area that is characterised by a specific hazard or risk profile. Experts from public authorities and different territorial levels could cooperate for a medium-term period (e.g. in accordance with the 7-year EU funding periods) in order to establish long-term cooperation structures that last even beyond the funding period.

**(F-1) Support DRM and CCA issues during amendment processes of EU directives**. EU directives (especially WFD and FRMD) can have a huge impact on establishing and implementing certain and especially new issues at all administrative levels. Their implementation helps to support arguments in controversial discussions about certain DRM or CCA related actions. As specific action we recommend that the Commission, and especially the Directorate Generals, check the potentials to support DRM and CCA and consider these during amendment processes of EU Directives. Some attention to DRM and CCA has already been paid in those framework directives which have a territorial dimension. In some cases, DRM and CCA issues were not included from the beginning, but introduced in later amendments of the Directives.

# 4 Recommendations for future research

Most of the presented recommendations are related to methodologies and based on the research performed in ESPON-TITAN, that includes some shortcomings and challenges that need to be addressed. They are presented in detail in Annex 6, and summarized here:

**Further development of appropriate damage functions for different types of hazards including the calculation of uncertainty parameters**: To improve the methodologies that distribute economic damages among sectors, there is a need for further research into damage functions for earthquakes, droughts, and windstorms, so that indirect economic impacts could be properly calculated.

**Research on indirect losses and impacts should increase**: Given that different natural hazards give rise to different indirect impacts, there are ample opportunities to explore indirect losses and thus increase the accuracy of the estimation of total economic losses of disasters and natural hazards.

**Support methodological innovations in risk assessments regarding the spatial and temporal dimension of risk**: Spatial planning must adopt a multi-hazard approach in order to appropriately deal with risks and hazards in a spatial context, which is inherent whenever natural hazards are addressed. Further, countries, regions and cities are not static but in a permanent change if not under transformation, and scenario-based approaches that consider uncertainties are needed for risk assessment.

**Conceptualisation of criticality as a basis for contributing to the evaluation of risk**: To further operationalise the spatial dimension of systemic criticality, a normative judgement (considering results of sectoral criticality assessment) is required to determine the worthiness of protection of specific network elements as in the case of the European Council's regulations.

**Support regions and the local level in using research and cooperation projects more strategically for DRM and CCA**: provide especially research projects with follow-up implementation phase (better permanent positions that further support DRM and CCA) in order to transfer the results/findings into practice.

**Research on how to consider human losses as additional impact of natural hazards, on their inclusion in decision-making processes**: the (potential) losses to human lives are often under-estimated because of ethical and methodological reasons, so research should be broaden to consider human losses as additional impact of natural hazards, as well as to further discuss how this issue can be considered in decision-making processes.

# 5 Lessons learnt from regional and local case studies

The policy recommendations generated from ESPON-TITAN scientific findings are focused mainly on EU specific actions, which set is centred on topics that cover the different stages of the policy process, as well as methodological issues. These same topics were covered on the analysis of the eight ESPON-TITAN case studies (Chapter 7), of which some lessons learnt were extracted, based on practical experiences of regional and local stakeholders, that were, in most of the cases, technicians, policy- and decision-makers.

The investigation of these case studies was based on going through an exhaustive analysis of, not only the natural hazards that mainly affect each region and their economic impacts, but mainly on the DRM and CCA instruments in place in terms of legal framework, assessment and management. Special attention was put into their integration of these practices into spatial and sectoral planning, including cooperation and coordination dynamics.

From the analysis, some lessons learnt were identified in relation to the good practices on integrating DRM and CCA into spatial planning. Given that the selected case studies are representative from different regions across Europe, those lessons learnt may constitute a good reference for other regional and local administration. The following conclusions and lessons learnt were reach from the case studies analysis:

**Territories should focus more on risk prevention activities rather than response/reaction, as it has a relevant cost but is worth it**. Nowadays, even if climate change causes more intense events, and anthropic pressure becomes harder, there are fewer damages as a consequence of an event than in the past, as shown in Prague, Andalusia, Po river Basin, City of Pori and Rotterdam. The Dresden Region and Rotterdam show that authorities should focus on long-term decisions as, because of climate change, the conditions might get worse faster than anticipation and decisions are made, in terms of preventive measures.

**Risk cannot be avoided nor reduced to zero, but they can be managed.** Thus, residual risk should be accepted and managed through a sound preparation and disaster management measures. In this line, it is crucial to create an effective alert and rescue system, as seen on the Dresden Region. Moreover, compensation systems to mitigate the effects after an event are crucial, as seen on the Andalusia case. In the context of emergency management, the importance of the human factor has been highlighted in the Po river Basin.

**Mitigation and prevention are processes that include a whole toolbox of measures.** In these lines, funds for constant maintenance are needed, and the responsible institutions must be clearly identified, as seen on the City of Pori, Po river Basin and Nouvelle-Aquitaine.

**New methodologies must be implemented for risk assessment, providing maps and systems of observation, evaluation and scenarios** (as in Nouvelle-Aquitaine), not only in the long, but also in the middle and short-term, also counting on public participation and education (as in Rotterdam). For instance, flood prevention areas should be designated based on hazard intensity, considering parameters like flow speed and water depth instead of the probability of occurrence, as seen on the Dresden Region. Moreover, the use of return period (historical information) must be completed with methodologies based on scenarios, as seen on the City of Pori, Po river Basin and the Dresden region.

The case studies showed the **importance of binding laws regulating every aspect of DRM.** In this line, the Cities of Pori and Rotterdam highlight the importance of including prevention measures, maintenance periods or update frequency in the law. The Po river Basin is a good example of legal obligation, linking risk assessment to spatial planning. The local level is decisive for a successful DRM strategy, as every administration level must be aware of risks and allocate the necessary resources to manage them, as seen on the Alpine Region, Andalusia, and the Po river Basin. But the legal binding character is not enough, as it should be complemented with support from the other – also informal – administrative instruments. Thus, the regional and national level should offer the local level financial support, guidelines, and knowledge, as reflected in the Po river Basin. On the other hand, a generalized criticism is that local authorities should prioritize risk assessment and management, as seen on the Cities of Pori and Rotterdam, for instance.

Prevention is based on this knowledge, applied to the determination of urban and buildable areas. **Municipal planning must consider risks much more than they do nowadays, because it is the key instrument which regulates land-use.** Authorities should pay special attention to areas where buildings have been installed without much consideration or outdated methods concerning risk management in the past, as seen on the City of Pori, Po river Basin or Nouvelle-Aquitaine. Possible solutions are gradual delocalization, insurance, or urban rehabilitation. In this line, it must be highlighted that the support of urban rehabilitation, along with the "2050 zero land-take" objective of the EU, must consider the climate change impacts and its associated risks, redesigning cities and territories in this direction. Urban planning irregularities were revealed, and are associated with high costs. To protect people's lives and incur the lowest costs, the most effective alternative is to avoid the urbanization of high-risk areas, whose maintenance and future safety can only be ensured if responsibility for them lies with clearly identified officials.

A top-down approach is still predominantly followed, although **vertical coordination and cooperation are very important for DRM and CCA**. Some good examples are the common geographic information platform of the Po river Basin, the role of Civil Protection in Andalusia or the interactive and online tools for DRM enhancing cooperation between the different administrative levels and the inclusion of citizens in the Dresden Region. Concerning CCA, adaptation strategies and action plans developed at the national and regional level should be transferred to the local level through adaptation measures.

**Intersectoral coordination should be improved in all areas of risk management,** as well as in the management of adaptation to climate change. In this context, policies for risk management and CCA cannot remain sectoral, but should be integrated with spatial planning and development programs as seen with several paths on the Dresden Region, in Nouvelle-Aquitaine and in the Netherlands. In the future, cross-sectoral measures should be better integrated with, and promoted, as part of adaptation measures.

A good example of vertical coordination is Rotterdam, in which the national government produces and communicates knowledge, generates policy at this level, and exercises leadership over other governments; and at the local level the spatial planning is mostly developed. The examples from Rotterdam show the need/possibility of rethinking land-uses under areas where flooding is foreseen to suffer changes resulting from climate change.

**A sound strategy for DRM and CCA should involve all the relevant actors of the territory**, as seen on the Dresden Region, City of Pori, Rotterdam and Po river basin. This cooperation and collaboration benefits from their innovation capacity, as professionals, universities, and enterprises are constantly developing new solutions and new skills, as seen on the Dresden Region and Po river basin.

Natural phenomena do not care about administrative borders, so cooperation between regions must be put in place. This cooperation must exist between regions within a country, as seen on the Po river basin, but also between countries, as seen on the Alpine Region and the Dresden Region. Cross border cooperation is key for transnational spatial planning, DRM and CCA. In this line, the Alpine Region showed the importance of transnational programmes, such as EUSALP, and transnational projects like GreenRisk4Alps.

**The supranational level should set common standards for DRM and CCA strategies within the European Union.** The success of the Flood Risk Management Directive 2007/60/EC is a good example of what can be done in the European institutions.

The case studies analysed showed that **in the long-term, sustainable and effective cooperation must be built on formal agreements, but it can only be filled with the human component**. Thus, personal connections, mutual trust and open-mindedness to share experiences and learn from each other is a key factor. In this line, the URBACT and INTERACT programs are good examples of how the European Union can foster this kind of exchanges. By keeping clear subsidiarity and proportionality principles, European dimension is necessary as a common house of benchmarking to help driving common improvements in these fields; by learning from the best practices, but also with decided leadership from Directives for First Pillar Policies and those in which territorial cross-border cooperation demonstrate specially potential and usefulness, as it is the case of DRM and CCA.

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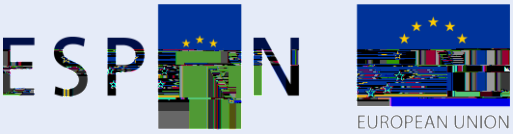


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