Briefing Note

WEATHER

Weather Extremes: Assessment of Impacts on Transport Systems and Hazards for European Regions

Project to be funded under the 7th Framework Program of the European Union, theme 7: transport including aeronautics

Project Co-ordinator:
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Project duration: 30 months

Project partners:

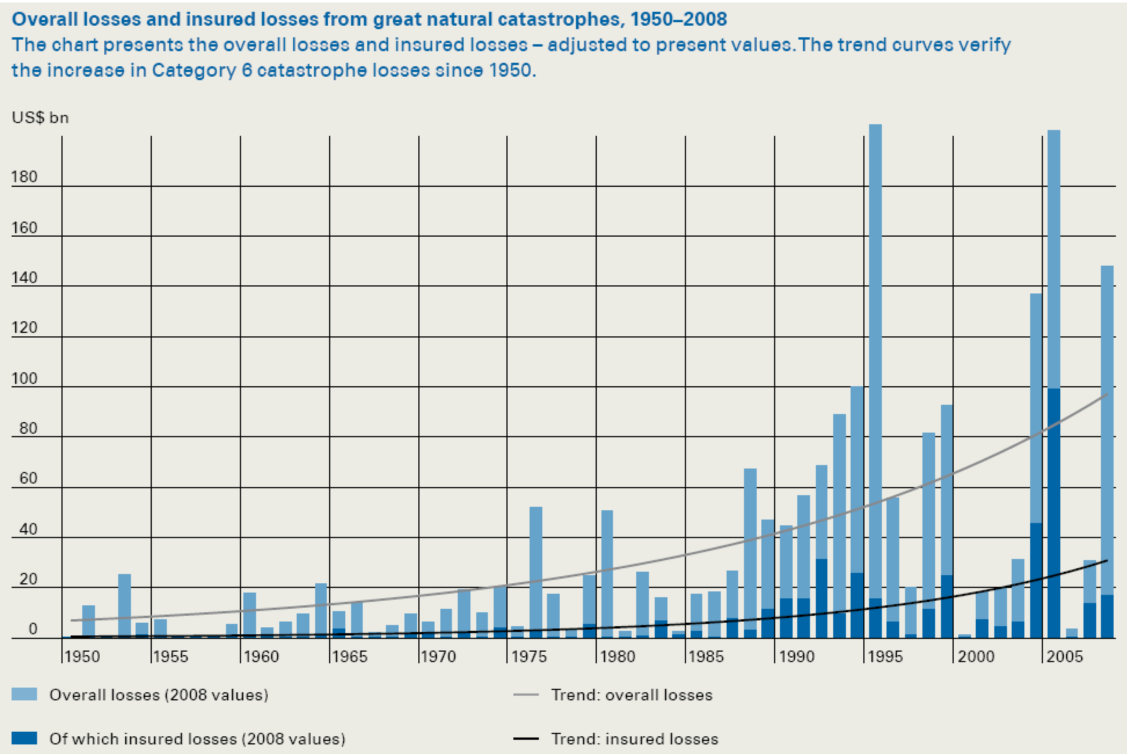
1. Introduction to the Subject

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) and subsequent communications, e.g. the declaration of Valencia, have emphasised climate change is manmade and that there is an urgent need to react. Even restricting global temperatures to rise by 2°C constitutes a huge challenge for policy and technology development. Respecting the IPCC warnings the EU has ratified a 20% reduction of climate gas emissions until 2020 at its 2007 summer summit, and has published the actual state of knowledge in its 2007 Green Paper on adaptation to climate change (EC, 2007). But a formal ratification of the EU climate targets at Member State level is still pending. Eventually, the very emotional scenes at the closing session of the Bali Climate Conference in December 2007 have underlined the strong link between climate policy, economic development and political power.

The effects of increasing global temperatures widely differ by world regions and at small scale level makes climate change appear with different faces. Equatorial countries will generally suffer from more intensive, longer or more frequent dry periods sharpening the problem of scarce sweet water, growing desserts and consequently much more difficult food production. It is thus frequently expected that armed conflicts in the 21st century will rather be on water and food supply than on land, oil or natural resources. While these impacts hit the anyway poor and underprivileged regions on our planet, some regions with cooler climate might even benefit from increasing temperatures. Growing tourism, richer crops or longer availability of arctic ports and shipping routes may, in average, appear for the anyway better-off northern countries in Europe, Asia and North America. The increasing melting speed of the arctic ice and mountain glaciers and the thawing North American and Siberian permafrost soil, however, bring about severe consequences like land subsidence and the loss of ice roads, sometimes being the only access to remote settlements, in these regions.

But in any case and in all world regions, global warming is expected to bring about more extreme weather events. These include hurricanes, storm surges and floods, intense precipitation, extreme heat and dry periods, strong frost phases or combinations of these. But it is not only the development of average environmental conditions over decades, but the rapid turning of weather phenomena which make the impacts of climate change harmful. Looking at the calendar of disasters published annually by the big reinsurance companies suggests an increasing number and severity of climate-driven catastrophic events (see figure). However, the seldom occurrence make statistical distributions fractal and thus long time series would be needed for a sound interpretation of trends.

Figure 1: Overall and insured losses through natural catastropies 1950 - 2008



Source: Munich –Re, 2009

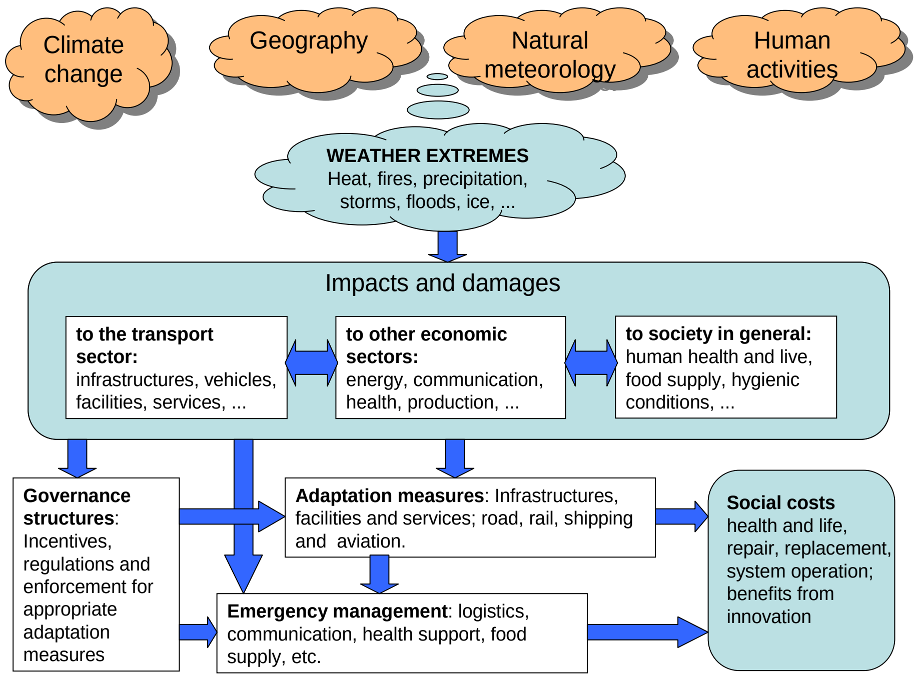
Transport is among the main causes, but can also be a victim of climate change. Heavy rain falls, long dry summers and the melting-off of the Alpine glaciers can cause more days where inland navigation is not possible due to high or low water levels, rising sea levels entail investments at seaports, airlines have to circle storm fronts or delay flights, causing delays and increased operating costs, and storms, heavy rain falls and floods can make roads and railway tracks impassable, deform or even destroy them. The US Transportation Research Board thus concludes that the climate conditions during the past decades are most likely no longer a reliable source for future investment decisions. Besides efforts to mitigate climate change, adaptation gets more and more relevant to ease the adverse effects of climate change. The IPCC defines adaptation as 'the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities'. Various types of adaptation can be distinguished, including anticipatory, reactive, private, public, autonomous and planned adaptation. Adaptive capacity is defined as the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

The cutting off of traffic routes moreover cause problems to emergency and supply services, to human well-being, to production and distribution services and thus to the economy in general. On the other hand, damages to industry or service sectors, e. g. energy supply or telecommunication services can have severe consequences on transport; without electricity electric trains and even modern filling stations will not work. On the contrary, rising average temperatures decrease the number of days with ice and snow, decreasing the costs of winter maintenance, accidents and weather-inflicted delays. The overall consequences of climate change on transport and its related sectors are only poorly investigated as they are possibly small against the social effects and as the system of inter-relationships between the sectors appears rather complex.

2. Motivation of the Study

The motivation for this study emerges from the great and still growing attention paid to the long term impacts of climate change and from the still large uncertainties on social and economic impacts and on options to ease their severity. As one of the major and steady emitters of greenhouse gases, driven by mega trends like globalisation and the growth of megacities, the transport sector deserves special attention. But to our knowledge only few studies have been carried out so far to clarify its role in global warming. In this work we will, however, leave the common perspective of transport being the culprit for climate change and draw our attention to its role as a victim of global warming. Out of the manifold effects climate change imposes on economy and society we concentrate on the short to medium range impacts of weather extremes on transport infrastructures and services. This appears of particular importance as transport has the network for supply of people with food, health services and other basic goods in the case of catastrophic events. Thus, maintaining the functionality of transport services under extreme conditions will ease the negative impacts of such events.

Figure 2: Illustration of systems affected by extreme weather events



A particular motivation of the study emerges from the review of literature on climate change impacts on transport. Most sources describe the general effects and impact chains and report on specific damage cases or catastrophes, but concrete figures of economic or entrepreneurial costs and the likely benefits of adaptation measures can hardly be found. Acknowledging the difficulty and uncertainty of quantifying impacts where even the magnitude of future effects is extremely vague, the study aims at making a step forward in this direction. Our motivation is to support decision-making on economically sound and sensible technical, managerial and political adaptation strategies.

3. Project Objectives

The WEATHER project approaches the topic of extreme events and their impacts on transport systems from an economic perspective. It thus aims at partly filling the gap between greenhouse gas emissions, climate and extreme weather scenarios and their quantification in monetary terms. An important element in this respect is the quantification of costs and benefits of certain abatement measures and of alternative emergency strategies.

In front of this background and out of the motivations formulated above, the core objective of the project can be formulated as follows:

> **Determine the physical impacts and the economic costs of climate change on transport systems and identify the costs and benefits of suitable adaptation and emergency management strategies.**

Behind this overall goal of the study seven sub-objectives, which again contain several aspects and partial goals, can be identified:

1. Develop a dynamic model explaining the causal relations between the severity and frequency of extreme weather events, the functionality of transport systems and related sectors, economic performance and social welfare.

The motivation of this objective is to understand the complex inter-relations between the various economic sectors, including transport, energy supply, telecommunications and food provision and health care. Although special attention is paid to transport, the objective is to understand the complexity of the system to external disruptions as a whole.

2. Identify the vulnerable elements of the transport sector and the specificities of each mode and of intermodal processes with respect to different extreme weather events.

This knowledge shall help to quantify the consequences and the long-run economic costs of climate change on transport, including infrastructures and services. Indirect effects from and to other sectors, e.g. energy supply and telecommunications, will be considered

3. Work out efficient and innovative mechanisms of managing disastrous events with particular emphasis on maintaining the service function of transport networks in an intermodal context.

This objective is motivated from the failures and success stories observed in past natural catastrophes. Building on these experiences, systems of local information / communication as well as crises and emergency management structures will be established.

The co-operation of the transport modes constitutes a central element of the work. The role of innovation processes is considered highly important to install cost efficient and effective systems.

4. Identify appropriate and efficient adaptation strategies for transportation infrastructures and services to ease the impacts of extreme weather events in the future.

The focus of this objective is on technical and operational measures and on planning structures. Special attention is given to new technologies and innovation processes. It thus diverges into several sub-objectives along the type of adaptation measures, e.g. new materials and technologies for infrastructures and vehicles, warning systems, network planning procedures, etc., and along the various modes and types of regions.

5. Clarify the role of governments, companies and industry associations in fostering efficient crises and emergency management measures and adaptation strategies.

The relation between governance structures, incentives, regulation and enforcement measures shall be investigated to establish sound management and adaptation mechanisms looking beyond election periods or business accounting years. Innovative policy design in this respect is considered a key element of installing long-term sustainable adaptation, crises and emergency management structures, and recovery planning.

6. Check the applicability of theoretical concepts of vulnerability assessment, crises prevention and adaptation strategies with practical experiences and local conditions

The core of the project is to develop better strategies to adapt to climate change with practical relevance. Thus, one of the core objectives of the project is to test the applicability of the project findings in real environments in close co-operation with policy, stakeholders and transport managers.

7. Dissemination of project findings to a wider audience to fostering the debate on the costs and implications of more frequent and severe weather conditions on transport systems

Since climate change mitigation and adaptation is a top priority on many policy programs worldwide, the project seeks to contribute to the debate and to disseminate the results found among a wide scientific and practical audience.

The short review of selected publications on vulnerability, adaptation and emergency management research shows, that the picture is scattered and incomplete. Driven by the latest events (Storm surges in the US, heat and floods in Europe) national and international bodies issues studies which are limited to or at least biased by these events. The WEATHER project aims at performing broader and more systematic view of the impacts of extreme weather events on the European transportation sector.

3. Project Organisation

As the time and budget restrictions do not allow for a very detailed engineering analysis of all modes, infrastructures, services, regions and weather events, the project takes a broader perspective. The team mainly consists of economists with profound experiences in each of the transport modes and sectors. But detailed expertise is imported into the project through extensive expert interviews and by conducting three targeted workshops. The addition to current state of know thus is to complete the picture of vulnerabilities in the transport sector across modes and options for emergency management and adaptation and to balance the different effects and sectors where they occur. The project thus shall deliver a priority list of these impacts and options across modes, regions and weather events.

Studies carried out so far have been rather vague on quantitative results. The WEATHER project can not entirely solve the problem of uncertainty of predictions on future weather extremes and the reaction of the transport sector. But by combining vulnerability assessment, infrastructure cost accounting and business accounting frameworks the project aims at making a decisive step forward in assessing the economic costs of climate change's weather impacts on transport.

The main step beyond the current state of knows is, however, to link what happens in the transport sector to the entire economic and social environment. Considered are impacts from other sectors to transport as well as impacts of transport on other sectors. By this approach the vulnerability of transport systems with their major inter-linkages to other sectors will be set into relation to the vulnerability of the economy and society as a whole. This new insight has not been delivered by previous work.

Eventually, the development of advanced adaptation and emergency management strategies in Europe can be of real value for other, poorer, countries in the world, could be of economic success for EU countries by establishing a lead market for such technologies and procedures, and can thus foster the European innovation System. The WEATHER project particularly addresses the last point, which could be a valuable argument for politics to invest in prevention and adaptation strategies although their short-term benefit might be limited. The WEATHER project thus leaves the more technical arena of current adaptation literature and contributes to its practical value in daily business and policy decision making.

4. Toolbox of Scientific Methods

To achieve the wide range of objectives, the WEATHER project applies several methodological elements, each targeted to the specific tasks and goals. The WEATHER toolbox includes:

- Literature review. Each task of the project will review the latest relevant scientific literature and practical applications in the field. Due to the diverse objectives and tasks of the WEATHER project a specific work package on state of the art review across all WPs and Tasks is omitted in order to make best use of the available resources. The reviews will in particular consider experiences at EU border regions and in other world regions with special emphasis on FP7 partner and co-operation countries.
- Workshops with experts, stakeholders and policymakers. The three core work packages will organise targeted events bringing together relevant players from the scientific, operator and policy-making communities to support the competence of the WEATHER consortium. The workshops will be co-ordinated with the parallel EU-funded research projects EWENT and ECCONET and will include worldwide experience.via the "global panel of experts".
- Global panel of experts: Experiences from FP7 partner and co-operation countries will be included by setting up a panel of experts having experience with disasters outside the EU. The nucleus of the panel is the World Conference on Transport Research Society (WCTRS).
- Statistical downscaling and regional climate prediction models are applied to increase the knowledge on climate impacts on specific European regions.
- Model simulations. By applying dynamic models reflecting the interactions between different economic sectors over time the WEATHER project will go beyond a sole inventory of vulnerabilities and adaptation options. Tools considered are the Economic Growth Model NEDyM by SMASH-CIRED and the ASTRA system dynamics platform by Fraunhofer-ISI.

- Infrastructure cost models and business cost accounting will be applied both to capture long-term impacts of disruptive weather extremes on long-life infrastructures as well as their immediate impact on transport and infrastructure operators and state budgets.
- Multi Criteria and Cost Benefit Analyses will support to quantify the vulnerabilities and to select most efficient options to adapt to extreme weather events. By applying these techniques the WEATHER project will add to mainly qualitative statements of current vulnerability and adaptation studies.

These instruments are applied at different stages in the project where appropriate.

4. Structure of Work Packages

The overall work plan of the WEATHER project follows the logic of the project objectives state in Section B.1.1.3. Together with WP 0 on project management the work is thus broken down into 8 work packages (WPs). The logic of the work packages is summarised by the enumeration in turn:

- WP1: "Weather trends and economy-wide impacts" sets the scene by assessing newest available research on climate and weather trends for European regions and by exploring models to assess their impact on economy and society. The assessment of regional extreme weather trends starts form large scale climate models and zooms into selected smaller geographical units. Similarly, the assessment framework reviews state-of-the-art models, including the various inter-relations between economic and societal sectors like energy supply, production, health care, food and water supply and transport, and selects the one suiting best the needs of the WEATHER project.
- WP2: "Vulnerability of transport systems" targets the analysis of WP1 to the transport sector by identifying the weak points of transport systems of all modes and of inter-modal connections with respect to natural disasters. With the help of the event forecasts in WP1 and the case study experiences the work package will estimate the likely costs to transport infrastructure owners and managers, service operators, passengers and freight forwarders in case no specific adaptation activities are undertaken. Impact levels considered are direct costs to transport system operators, indirect impacts on other economic sectors, and impacts on third parties (social effects). The work package will invite stakeholders, operators and engineers from the transport sector to support the expertise of the WEATHER team and to go

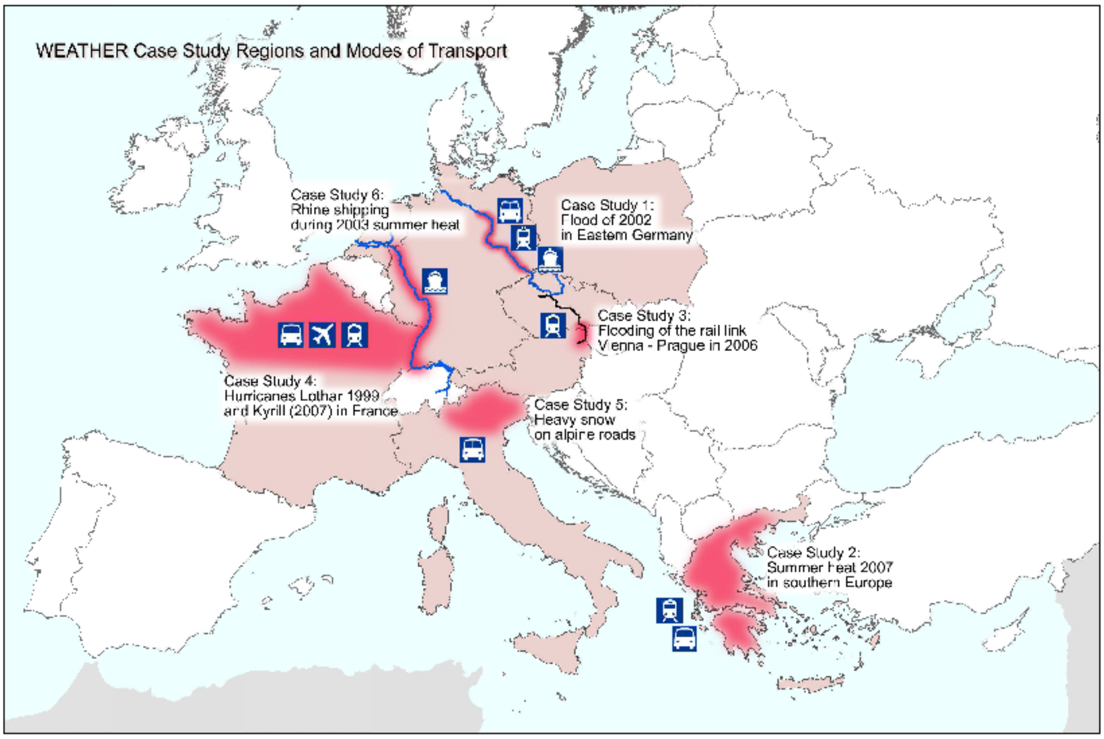
into detail where major impacts are uncovered by the proceeding desktop analysis.

- WP3: "Crisis management and emergency strategies" addresses the objective how the negative impacts of extreme weather events can be eased by installing suitable crisis and emergency management systems and system recovery mechanisms. Based on the experiences made in past disasters, particularly including WP6 case studies, best practice strategies to handle peoples' food, water supply and health services through keeping transport systems working will be collected and analysed. Through literature reviews and targeted workshops the understanding of the inter-relationship between policy structure, new and innovative technologies and transport system characteristics will be deepened. Outputs are a report on methods and findings and policy guidelines on the transferability of best practice crises management strategies.
- WP4: "Adaptation options" deals with technical and organisational options to make transport infrastructures, services and intermodal connections less vulnerable to impacts of extreme weather events. Included are technical measures at infrastructures, vehicles and terminals, as well as organisational schemes. There will be a strong link to WP3 as adaptation also includes the installation of systems and mechanisms relevant in the emergency case. Means of innovation research will help to identify the emerging technologies and support literature review and intensive stakeholder and policy-maker consultations. Outpupts are a report on methods and findings and policy guidelines on the transferability of best practice adaptation strategies and technologies.
- WP5: "Governance structures and incentives" will draw on the requirements for innovative system changes identified in WP3 and WP4 and analyse the appropriateness of current legal and managerial frameworks to support their implementation. Through multi-criteria analyses, work shops and actor analyses with policy makers pitfalls and limitations to long-range decisions will be identified. Ways to overcome them, including incentives, regulation and enforcement, will be explored.
- WP6: "Case studies" considers a number of real cases of extreme weather events and their impacts on transport and society. The case studies are classified into three types: (1) ex-post cases verifying the general findings in the past WPs and enriching them with specific data and experiences, (2) ex-ante cases analysing implementation plans, costs and benefits of best practice measures in real environments, and finally (3) case studies embracing

the ex-post and the ex-ante perspective. The case studies have been selected to cover all modes, weather phenomena and geographical structures in Europe. They closely interact with the analytical work packages by (1) providing initial inputs on experiences and requirements and by (2) testing the evaluation guidelines developed by WPs 3 and 4.

- WP7: "Policy conclusions and final conference" seeks to summarise project findings and to communicate them to policymakers, transportation officials and managers and to the scientific community. The work package will thus produce, besides a detailed final report for publications, brochures and journal articles highlighting results or particular interest for particular stakeholder groups. The work package further includes a final seminar and the participation at relevant conferences on transport and climate change.

Figure 3: Location of WEATHER case studies

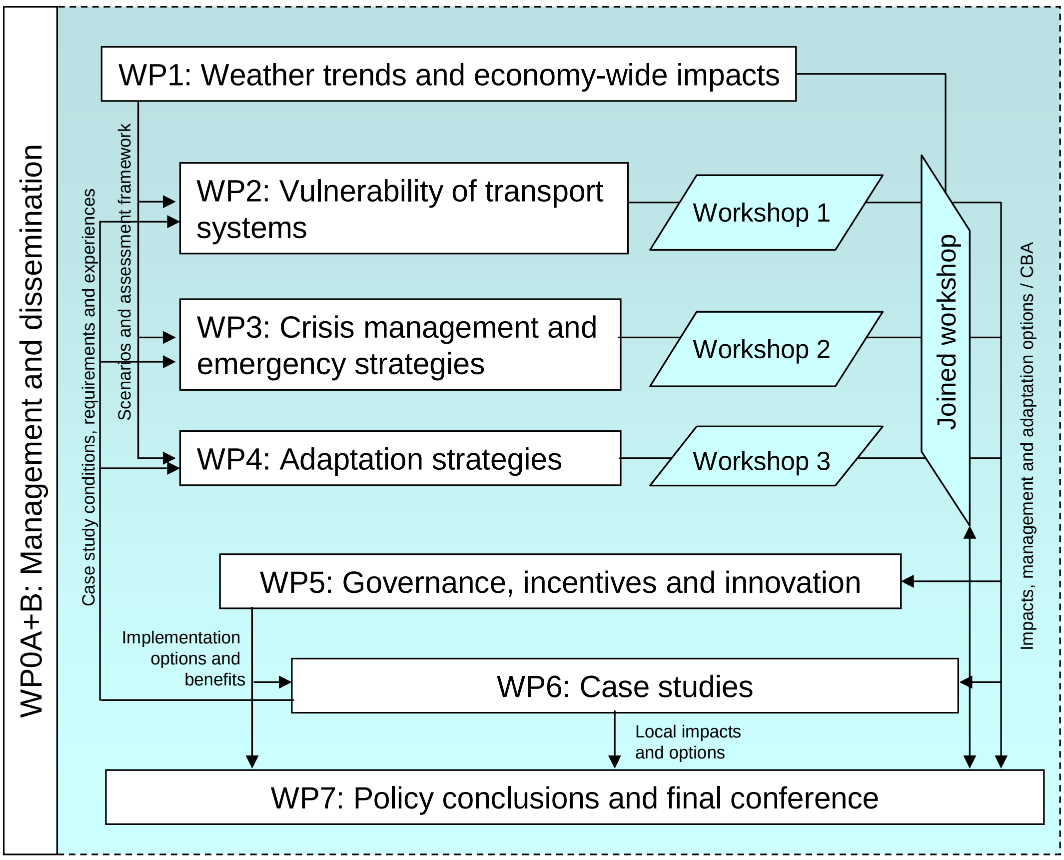


The project structure reflects a series of dimensions:

- Weather extremes: These include severe storms, heavy and durable rainfalls, floods, excessive heat periods, etc.
- Transportation systems: road, rail, shipping and aviation infrastructures and respective services
- Types of activities: Emergency actions in the damage case, technical prevention or adaptation measures and organisational and policy adaptation strategies including all modes and transport sectors (passenger and freight).
- Time scale: The general time horizon of the WEATHER project is 2020. Nevertheless, the analysis will incorporate long-term impacts and measures which can be identified within a certain level of confidentiality.

These dimensions are partly reflected in the sequence of work packages and partly in an implicit way within the work packages. The WPs and the information flow between them are presented by the following chart.

Figure 4: Work package flow chart



5. Dissemination activities

The project seeks to spread its activities and findings among a large group of interested institutions and individuals. This involves steady dissemination throughout the entire life time of the project and beyond, and through a final conference at the end of the project. The continuous dissemination activities include the production of presentation material, a project website, a project newsletter and scientific publications.

1. Dissemination material: The project team will produce information materials, such as brochures, posters, press releases and a project CD-ROM to be used in the project events as well as in other dissemination activities.

2. WEATHER Newsletter: 4 to 6 issues of a project Newsletter will be produced each after the achievement of important project milestones, disseminating facts, key results the key results and findings of the project and the activities to follow. The newsletters will be written in a journalistic style and layout to reach a wide as possible target group.

3. WEATHER website: A website will be set up at the beginning of the project dedicated to the provision of up-to-date information on the progress and the achievements of the project. The website will be the main focus for providing up-to-date information on the progress and the outcomes of the project; it will introduce into detail the objectives, activities and outputs of the project. The project deliverables will be available for downloading on the website, as well as all dissemination material to be produced.

4. Scientific publications: The project team will seek to publish key findings in conference papers and journals. Therefore, the WEATHER website will contain a calendar of related events and interesting journals.

6. The WEATHER consortium

The consortium is composed out of eight legal entities from six EU Member States (Germany, Italy, Greece, France, Austria and the Netherlands). Out of these, the Fraunhofer-Society is participating with two institutes (ISI located in Karlsruhe and IVI located in Dresden).

The WEATHER partners mainly comprise of transport economics research and consultancy units reflecting the broad perspective of the WEATHER project on the problem of increasing extreme weather events. The proposal includes the wide spectrum from weather scenarios over economic impact chains, incentives and policy measures, emergency management, and modal aspects of vulnerability and adaptation. The list of partners is given below.

Table 1: List of WEATHER project partners

No.	Beneficiary name	Country
1	Fraunhofer-Gesellschaft (FhG), Represented by its Institutes for Systems aind Innovation Research (ISI) and for Transportation and Infrastructure Systems (IVI)	Germany
2	Centre for Research and Technology Hellas, Helenic Institute for Transportation	Greece
3	Société de Mathématiques Appliquées et de Sciences Humaines - International research Center on Environment and Development	France
4	Karlsruhe Institute of Technology, Institute for Industrial Production (IIP) and Centre for Desaster Management (CEDIM)	Germany
5	Institute of Studies for the Integration of Systems	Italy
6	Herry Consult GhmH	Austria
7	Agenzia regionale per la Prevenzione e l'Ambientedell'Emilia Romagna	Italy
8	NEA Transport research and training	Netherlands

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7. Contact

The WEATHER project is co-ordinated by the Fraunhofer-Institute for Systems and Innovation Research (ISI), located in Karlsruhe, Germany. Contact details:

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