Enhancing Multi-Hazard Risk Analysis: Integrating Forensic Analysis, Impact Chains, and Storylines for Time-aware Risk Communication

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Introduction

Navigating the complexities of multi-hazard risk analysis requires innovative methodologies that leverage the strengths and overcome shortcomings of existing approaches. The PARATUS project responds to this challenge by introducing an innovative framework that combines forensic analysis, impact chains, and storylines to unravel the intricate dynamics of disaster risks across diverse geographic contexts.

Using the VAIA storm as a case study, this research used this integrative approach, emphasising the importance of temporal sequencing of a past disaster event through storylines. This methodology facilitates a deeper exploration of cascading impacts and sector-specific risk mechanisms, enhancing understanding of how a disaster event develops over time and facilitating time-aware risk communication. Integrating the three analytical methods to study past disaster events provides a flexible template that serves as a foundation for developing targeted climate change adaptation and risk reduction strategies. This comprehensive approach enables the identification of CCA and DRR measures implemented in the past, and those vulnerabilities still need to be addressed to enhance preparedness for current and future risks.

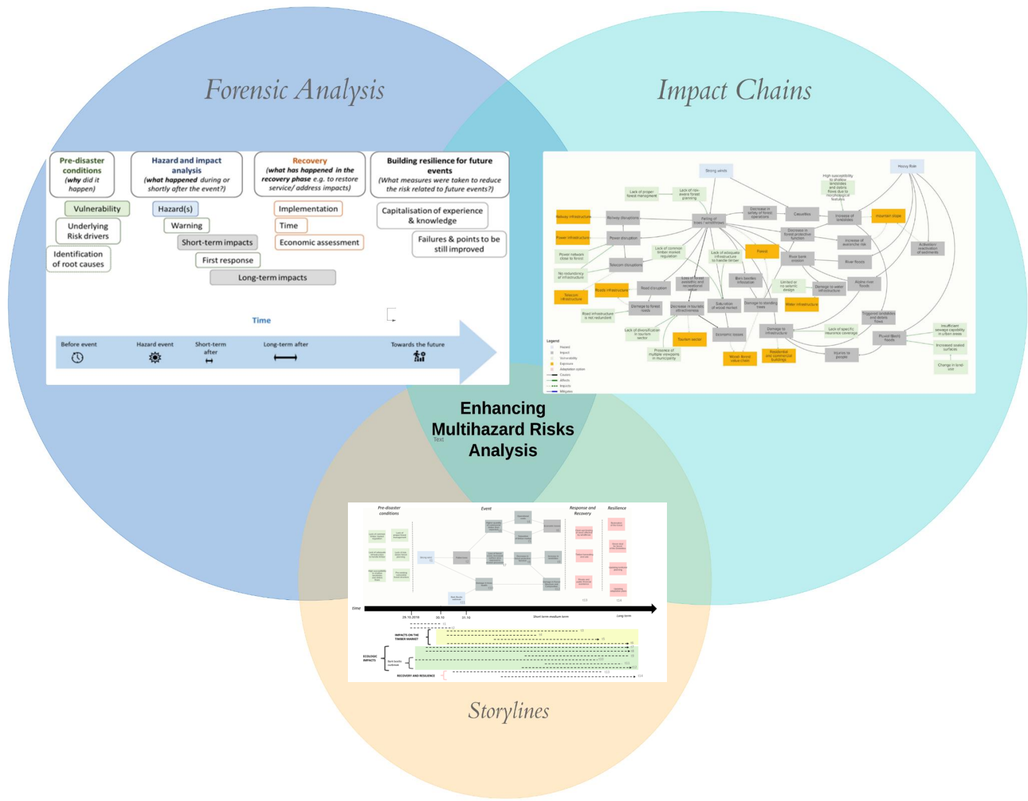
Case Study: Vaia Storm

Vaia is the name of a Mediterranean cyclone that rapidly formed over the Tyrrhenian Sea at the end of October 2018, as noted by the Free University of Berlin. Today, the name also refers to the various hydrological and meteorological events associated with the storm, including windstorms, landslides, floods, and storm surges (Giovannini et al., 2021). The Vaia windstorm affected four administrative units in the Italian Alps—Bolzano, Trento, Veneto, and Friuli-Venezia Giulia—and more than 500 municipalities, with transboundary impacts in Tirol, Austria.
For the analysis, we focus on the provinces of Bolzano and Trento, North Italy.

Photo credits @UNCEM : https://uncem.it/post-tempesta-vaia-aiel-e-uncem-turisti-in-vacanza-hanno-visto-la-piu-grande-catastrofe-delle-foreste-italiane-necessario-fare-il-punto-degli-interventi-con-mipaaft-regioni-enti-locali-imprese/

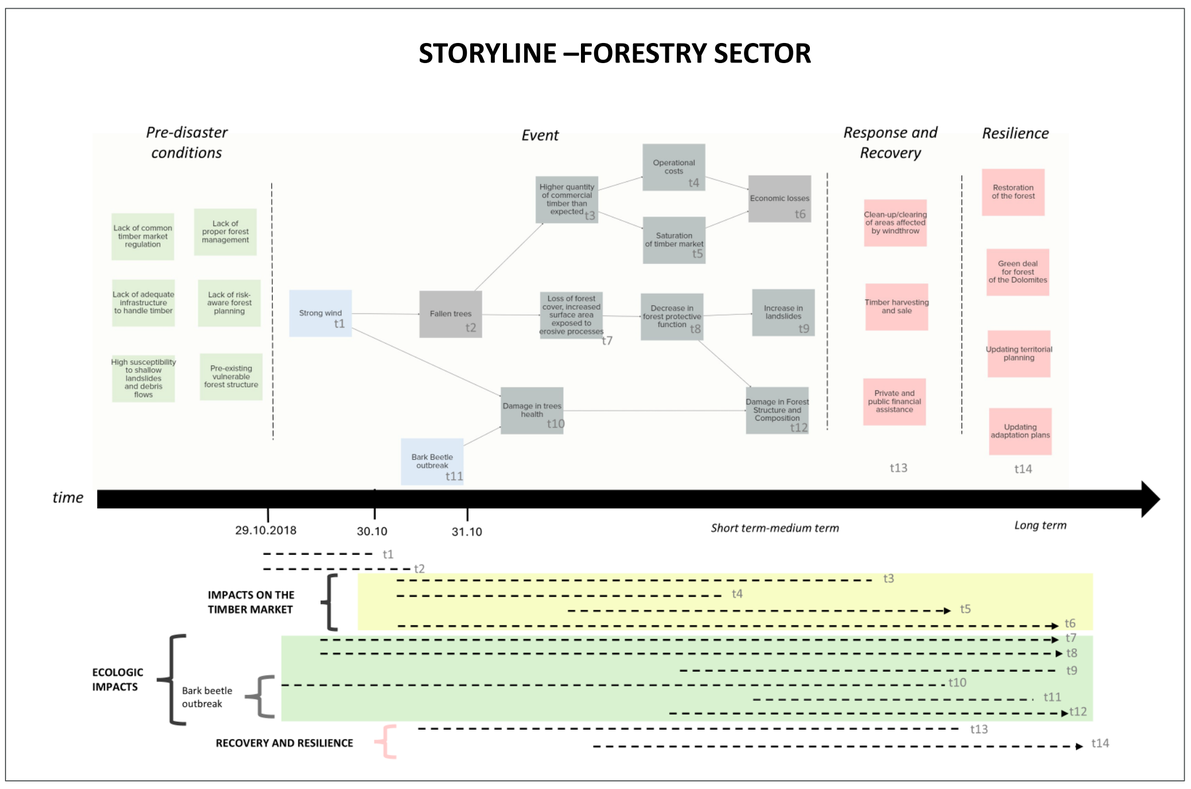
Methods

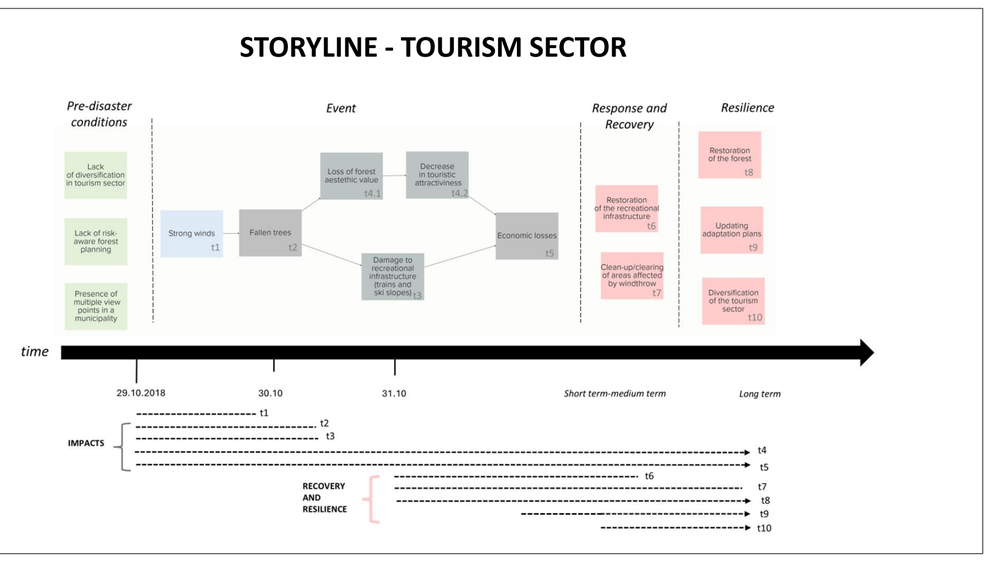
We proposed a risk analysis method that combines the benefits and overcomes the shortcomings of impact chains (ICs), forensic analysis (FA), and storylines (SL) to improve time-aware risk communication. For instance, while ICs provide a comprehensive visualisation and structure of risk, they lack an explicit temporal dimension and can be overly complex. FA, on the other hand, offers a narrative approach to understanding past disaster events but lacks a visual representation. Storylines help bridge these gaps by visually representing the narrative of a disaster event for a specific sector.

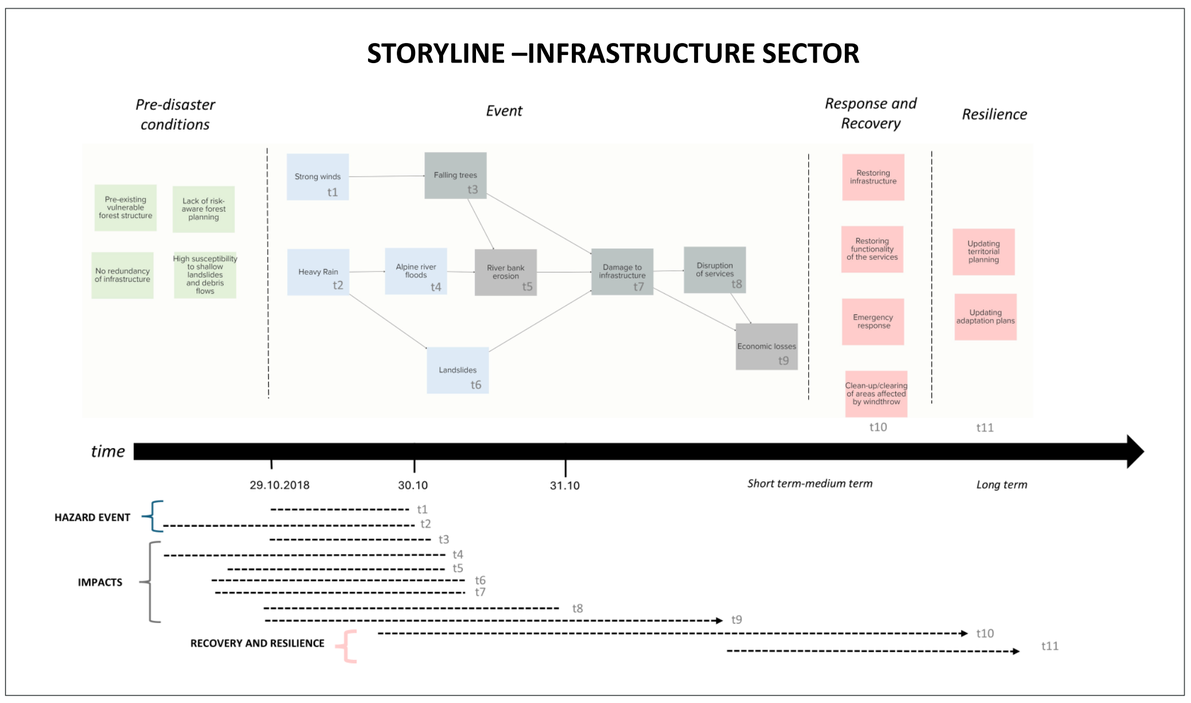


In our approach, we explored storylines traversing different risk pathways within a complex impact chain to create well-defined narrative scenarios incorporating temporal sequencing, which are enriched by the narrative depth offered by forensic analysis. The results focus on the Vaia Storm for the infrastructure, forestry, and tourism sectors.

Results







Conclusion

Within this integrated methodology, storylines enhance the understanding of multihazard disaster risk analysis by incorporating temporal contextualisation of past disaster events, transforming conventional impact chain visualisations into dynamic, chronologically coherent sector-specific narratives, and grounding the analysis through the evidence derived from the forensic analysis.

The VAIA storm revealed synergies and differences regarding the timing of disaster impacts, recovery and resilience phases in the forestry, infrastructure, and tourism sectors in the provinces of Bolzano and Trento.

- The **forestry sector** endured the most significant and long-lasting impacts, affecting its economic and ecological dimensions and cascading into other interconnected sectors such as tourism and infrastructure. The loss of the forest's protective function is of particular concern because it increased the exposure of infrastructure and human settlements to subsequent natural hazards, including landslides and avalanches. This underscores the role of the forest and its management in shaping other sectors' recovery and resilience.
- The **infrastructure sector** experienced short-term and substantial damage and losses during the storm, with economic repercussions extending into the medium and long term. Even though the response required urgent measures, recovery and resilience required medium and long-term efforts. In contrast, the **tourism sector** faced challenges primarily stemming from ecological and aesthetic damage to the forest, which reduced its attractiveness and led to a decline in visitor numbers during the three summers following the storm (Bernardi et al., 2023).

These intertwined impacts emphasise the need for integrated, cross-sectoral strategies that account for cascading effects and operate across temporal scales. Such approaches are essential to enhancing regional resilience to future extreme events and ensuring sustainable recovery and adaptation in all affected sectors.