An Evolutionary Tree Framework for a Fair and Inclusive Twin Transition in Europe

Special Session: Twin Transition and its Unequal Geography

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Abstract.

The FITTER-EU project addresses the critical challenge to help ensure that a fair and inclusive twin transition encompassing both green and digital transformation, in Europe is delivered. The project takes a process-oriented approach with the aim to replicate and extend it to multiple contexts/sectors throughout the EU. For benchmarking, the project implements this approach in six use cases - Germany, Hungary, Italy, Ireland, Spain, and Portugal, covering four contexts/sectors - Energy, transport, building, and agri-food/agriculture. This extended abstract introduces an innovative evolutionary tree framework to map the project's developmental stages from data collection to the final policy-relevant outputs, similar to the evolution of a tree through the seasons —Winter (Research inputs and foundation), Spring (Progression and fine-tuning of research towards actionability), and Summer (policy-level decision-making - Influence, Impact, and Guidelines)—each illustrated by distinct figures (Figures 1–3). The fruit-bearing "Summer" season in the FITTER-EU project becomes possible through the development of a Fitter Digital Platform powered by an intelligent decision-support system for policymakers. Thus, the digital platform is the fruit or the manifestation of all the research-heavy work carried out across the preceding seasons, including data gathering, scenario building, vulnerability mapping, along complex operation insights. It is symbolic of the strength of the roots that support the FITTER-EU evolutionary tree and that ultimately help produce the fruit. The digital platform will be used to identify and mitigate risks of social exclusion among vulnerable groups during the twin transition. Preliminary outcomes include the development of quantifiable composite indicators for four sectors (Energy, transport, buildings, and agriculture) that form the basis of scenario building and the corresponding vulnerability mapping process. Further, these findings inform targeted policy interventions and underpin the development of best practice guides. The innovation of this work lies in its potential to drive anticipatory governance and ensure that transition policies do not inadvertently exacerbate existing inequalities.

Keywords: Twin Transition, Evolutionary Framework, Vulnerability Mapping, Digital Platform, Composite Indicators, Inclusive Policy

1. Introduction

Europe's ambitious dual agenda of green and digital transitions—commonly referred to as the twin transition—presents both opportunities and challenges. While these transitions promise economic growth and environmental sustainability, they also risk deepening existing inequalities if vulnerable populations are not adequately protected. Further, the unchecked course of action toward twin transition may produce new vulnerabilities on top of the existing ones. The FITTER-EU project was conceived as a pre-emptive response to this dual challenge, to support a just transition by developing a forward-looking comprehensive ecosystem that integrates risk assessment, mitigation strategies, and policy simulation.

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In this paper, the methodology of this project is presented as "The Evolutionary Tree" framework. This metaphorical construct delineates the project's life cycle in three phases. The Winter phase represents the foundational inputs (data collection, literature reviews, stakeholder workshops), the Spring phase captures the growth of research methodologies and the refinement of key performance indicators (KPIs) through scenario analyses across multiple sectors, and the Summer phase culminates in tangible outputs—most notably, a digital platform that informs policymaking. The "Evolutionary tree" is a perfect representation of the structured yet dynamic roadmap that the project follows for achieving a fair and inclusive twin transition.
The project is further contextualized by its strategic alignment with European policy priorities, emphasizing the need to tailor transition policies to the socio-economic realities of diverse European countries. Together, these concepts underscore the project's motivation: to transform raw data and innovative research into actionable policy tools that protect vulnerable social groups while promoting sustainable growth.

2. Methodology

The FITTER-EU project employs a mixed-methods approach that integrates qualitative and quantitative data, underpinned by the evolutionary tree framework. This metaphor captures the organic growth of the project, starting with data collection and analysis (roots), transitioning into research methodologies and key performance indicators (branches), and culminating in the tangible outcomes (fruits) that help policymakers and stakeholders define laws that integrate disadvantaged groups in society.

The methodology is structured in three sequential phases (Figures 1-3):

1. Winter – Inputs and Foundations
   The project starts with the mobilization of data sources to build a baseline understanding of the twin transition across four sectors: energy, transport, buildings, and agri-food/agriculture. Foundational inputs include literature reviews, surveys, interviews, focus groups, stakeholder workshops, and engagement with sister projects. These projects are the READJUST project, which investigates policies and develops solutions to mitigate unintended negative consequences of the Twin Transition and secondly, and the complementary project, the ST4TE project, which is aimed at providing a comprehensive view of the drivers of the Twin Transition, inequalities that emerge or are widened by it, and a set of policies to build greener, more equal and more productive societies.

This phase also lays the groundwork for identifying vulnerable groups whose needs are at risk during the transition. As the tree prepares for growth, the various task-oriented segments/arms of the project (work packages) emerge as branches, setting the stage for the next phase. The various work packages of the project are shown in Figure 2.

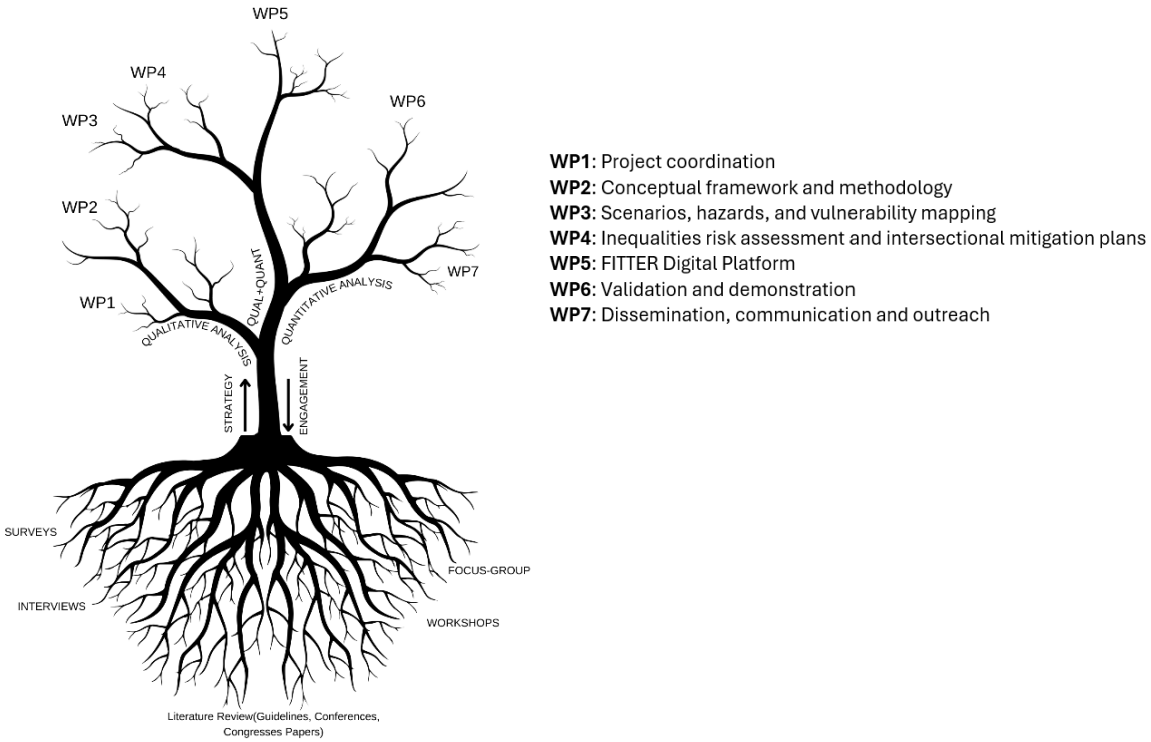

Figure 1. Inputs of the FITTER-EU projects - Step 1 (Winter) and work packages descriptions

2. Spring – Research and Technical Development

The Spring phase symbolizes a result-oriented advancement of the research work (see Figure 2). Sectoral composite indicators are developed to map the potential vulnerabilities, subsequently helping in the modeling of forward-looking scenarios with hazard mapping and risk indices to analyze the potential negative impacts of transition policies. The model is used to conduct sector-specific analyses (energy, transport, buildings, and agriculture) across six European countries (Germany, Hungary, Ireland, Italy, Portugal, and Spain). Both qualitative methods (expert workshops and policy consultations) and quantitative methods (statistical modeling and KPI development) are employed to refine risk assessments. A set of KPIs is developed to capture the essence of policy assessment —influence and impact—ensuring that the developed research model is robust and reproducible. Important quantified indicators and data touchpoints are identified from the available datasets across Eurostat and other national statistical platforms. The available data from these touchpoints will be used in producing results and outputs in season 3.

The strength of the developed research model lies in its thorough and complex intersectional analysis across multiple socio-demographic and socio-economic profiles to identify vulnerable groups; thus, not leaving any stone unturned. Some of the profiles analyzed during the research phase include: a) unemployed / low-income, and low-skilled people; b) People with disabilities; c) Elderly people; d) Ethnic minorities and migrants; e) rural/remote underprivileged communities; f) Young people from peripheral and rural areas; g) People at risk of extreme poverty and social exclusion, including homeless people. In addition, a rigorous analysis is carried out for the possible identification of new vulnerable groups caused by the transition policies and measures, and market forces; Our engagement too with the sister projects only strengthens the outcome of the project.

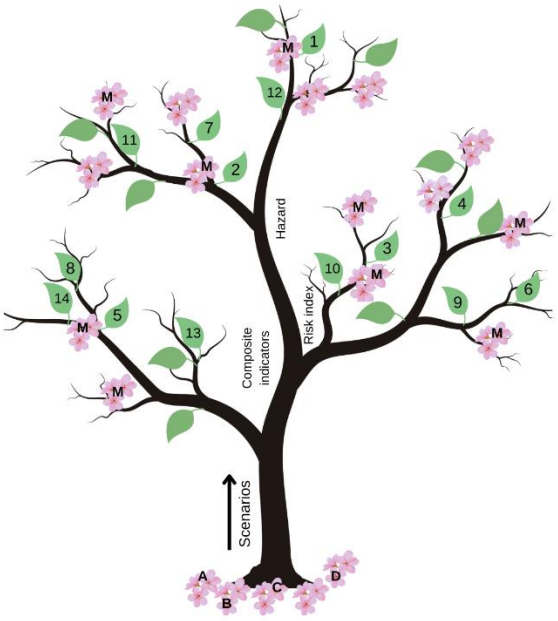

Figure 2. RESEARCH AND TECHNICAL DEVELOPMENT of the FITTER-EU projects - Step 2 (Spring)

The hazard assessment, risk indices, and composite indicators in the research model are represented as structural components of the evolutionary tree. Various operational key performance indicators (KPIs: leaves) track the project's impact through public events, scientific publications, media engagement, and stakeholder interactions, demonstrating the project's maturity represented by blossoms on the tree that are symbolic of the most relevant mitigation measures and the policy best practices formulated through research (M: blossoms), while the blossoms on the ground (A, B, C, D) represent the measures that have been discarded due to their ineffectiveness. The KPIs measure engagement, dissemination, and scientific contributions, ensuring that the project meets its objectives in supporting the twin transition. The table below (Table 1) presents the selected KPIs, categorized into public engagement, digital outreach, and academic impact.

Table 1. FITTER-EU PROJECT KEY PERFORMANCE INDICATORS (leaves)

1- Number of public events for external audiences	8- Total impressions for social media campaigns
2- External events attended representing the project	9- Scientific publications in peer-reviewed journals,
3- Workshops and collective intelligence session	10- Presentations at international conferences
4- Meetings/Presentations	11. N. unique visitors of FITTER-EU website
5- Total social media followers	12- N. of references in other websites
6- News published on the websites	13- Scientific publications as open access
7- Posts published on social networks	14- Persons reached by FITTER-EU project

3. Summer – Outputs and Policy Impact

The final phase, represented by Figure 3, is the culmination of the project's efforts and engagement with the sister projects. In this phase, the outputs of the research are translated into actionable knowledge through a digital platform that functions as an Intelligent Predictive Decision Support System. The tree is now fully developed, bearing fruits symbolic of the various functionalities of the FITTER-EU platform. These outputs provide practical tools and insights for policymakers, represented by a figure collecting the fruits. This project phase delivers tangible resources that facilitate informed decision-making and policy formulation. Key outputs include - a) A user-friendly digital interface that integrates simulation tools for policy-making; b) Best practice guides and mitigation measures aimed at curbing the adverse effects of transition policies on vulnerable populations; c) Policy briefs and actionable recommendations that inform the development of national and regional strategies for a just transition.

The co-creation methodology across the three phases of the project (winter, spring & summer) ensures that stakeholders—including policymakers, academic experts, and civil society organizations—are actively involved throughout the project - from validating the research findings, all the way to refining the functionalities of the digital platform. This participatory approach also enhances the legitimacy of the digital platform and its predictive decision support system.

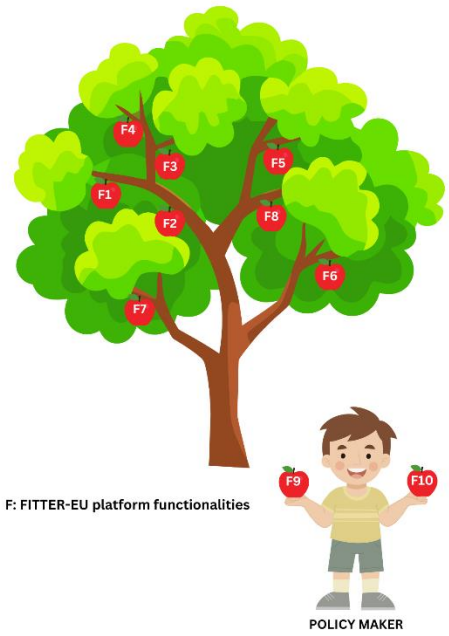

Figure 3. Outputs of the FITTER-EU Project- Step 3 (Summer)

3. Results

The evolutionary tree framework has enabled the systematic identification of critical vulnerabilities across key sectors. Key findings will include:

- **Composite Risk Indicators:** The project has successfully developed composite indicators for assessing energy poverty, transport challenges, and housing vulnerabilities. These indicators integrate quantitative measures (such as the share of renewable energy, energy efficiency indices, and transport accessibility metrics) with qualitative insights from stakeholder consultations.
- **Digital Platform Functionality:** As outlined in the Spring and Summer phases, the co-creation approach has resulted in a robust digital platform that offers simulation tools for policymakers. This platform enables users to predict the potential adverse impacts of transition policies under different scenarios and to explore mitigation measures.
- **Policy Relevance and Engagement:** The integration of expert workshops and policy consultations has enhanced the project's policy relevance through critical feedback that has been incorporated into the refinement of baseline scenarios and vulnerability profiles across the six use cases. This co-creation process not only validates the research approach but also fosters a sense of ownership among stakeholders.
- **Operational Efficiency:** By leveraging the evolutionary tree concept, the project has achieved a streamlined approach to transitioning from data collection (Winter) to policy output (Summer). The clear delineation of phases has facilitated timely progress, with each phase building upon the previous one to generate actionable insights.

4. Discussion

The significance of the FITTER-EU project lies in its ability to integrate complex, multi-dimensional data into a coherent framework that informs policy decision-making through the development of composite indicators that have the potential to serve as standardized metrics for assessing the impact of twin transition policies across Europe. This is particularly important given the diverse challenges faced by different social groups. The project's emphasis on vulnerable populations ensures that policy interventions are both equitable and targeted.
Despite these strengths, the project faces challenges that warrant further investigation. These include the need for continuous data updates, the integration of real-time monitoring systems, and the refinement of composite indicators to capture emerging vulnerabilities. Future work will need to address these issues by incorporating advanced data analytics and machine learning techniques to enhance the predictive power of the digital platform.

5. Conclusion

The FITTER-EU project represents a pioneering effort to address the challenges of twin transitions in Europe. The integration of comprehensive vulnerability mapping, scenario analysis, and a state-of-the-art digital platform offers policymakers an invaluable resource for anticipatory governance.
Key takeaways include:

- The development of composite risk indicators provides a nuanced understanding of energy, transport, and housing vulnerabilities.
- The creation of an interactive digital platform that supports policy simulation and decision-making.
- A robust co-creation process that ensures stakeholder engagement and enhances the practical relevance of the research.

Future work will focus on scaling up the platform, integrating real-time data, and refining composite indicators to adapt to evolving socio-economic conditions. Ultimately, the project's outcomes are expected to contribute significantly to achieving a fair and inclusive twin transition, ensuring that the benefits of the green and digital revolutions are equitably distributed across society.

References

1. J. Andrew Kelly, J. Peter Clinch, L. Kelleher, S. Shahab, Enabling a just transition: A composite indicator for assessing home-heating energy-poverty risk and the impact of environmental policy measures, Energy Policy, Volume 146, 2020, 111791, ISSN 0301-4215, https://doi.org/10.1016/j.enpol.2020.111791 .
2. Verhorst, T., Fu, X. & van Lierop, D. Definitions matter: investigating indicators for transport poverty using different measurement tools. Eur. Transp. Res. Rev. 15, 21 (2023). https://doi.org/10.1186/s12544-023-00596-z , (https://www.sciencedirect.com/science/article/pii/S0301421520305127)
3. Transport poverty: definitions, indicators, determinants, and mitigation strategies - Final Report - European Commission, https://employment-social-affairs.ec.europa.eu/transport-poverty-definitions-indicators-determinants-and-mitigation-strategies-final-report_en, Accessed: 2025-02-16
4. Methodology | FITTER-EU, https://fitter-eu.com/page/methodology, Accessed: 2025-02-16
5. Fair and inclusive twin transitions for a stronger social Europe | FITTER-EU | Project | Fact sheet | HORIZON | CORDIS | European Commission, https://cordis.europa.eu/project/id/101132546, Accessed: 2025-02-16
6. FITTER-EU – Aitec, https://www.aitec-intl.com/fitter-eu/, Accessed: 2025-02-16
7. READJUST – Just transition to a green and digital future for all | READJUST, https://readjust.eu/ , Accessed: 2025-02-24
8. Strategies for just and equitable transitions in Europe | ST4TE, https://st4te.eu/ , Accessed: 2025-02-24