

Skill Resilience — 4EU

SkillResilience4EU

**Resilience through re-skilling and upskilling for European labour
markets in transition**

**D4.1 – Transition topology and narrative descriptions for all case
studies**



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Abbreviations and acronyms

Abbreviation or acronym used in this document	Explanation
BOKU	BOKU University
CCS	Carbon Capture and Storage
COVID-19	Coronavirus pandemic
DMO	Destination Marketing Organization
EU	European Union
FHNW	University of Applied Sciences and Arts Northwestern

	Switzerland
HEI	Higher Education Institution
HVL	Western Norway University of Applied Sciences
LSE	London School of Economics
NGO	Non-governmental Organization
NUTS	Nomenclature of Territorial Units for Statistics
UoC	University of Crete
UU	University of Utrecht
UW	University of Warsaw
VET	Vocational Education and Training
WP	Work Package

Glossary

Term	Definition used or meaning in the Acronym project	Reference or source for the definition if applicable
Agency	Purposeful actions of individuals or organizations within institutional contexts, including efforts to create, maintain, or transform institutions.	Emirbayer & Mische, 1998
Events	Discrete occurrences marking meaningful organizational or institutional changes; used as empirical indicators.	Langley, 1999; Strambach & Pflitsch, 2020
Institutions	Shared rules, norms, and expectations guiding behaviour beyond individual actors, including regulative, normative, and cognitive elements.	Scott, 2001
Multi-scalar process	Processes unfolding across multiple spatial or governance levels, with interactions and feedbacks between scales.	Miörner & Binz, 2021
Organisations	Configurations of institutional structures and practices; both shaped by and shaping institutions.	Greenwood & Suddaby, 2006
Process approach	Methodological approach focusing on emergent, evolving phenomena and their interactions over time.	Langley, 1999
Topology visualizer	R-based open-source application that generates transition topology maps from structured case	

	data, allowing users to create, filter, and export visualizations without programming skills.	
Transition topology	Visual maps (directed graphs) that allow the structured analysis of key institutional and organizational changes in a transition process, including their temporal sequencing.	Strambach & Pflitsch, 2020

Executive Summary

Deliverable D4.1 documents the methodology and initial results of Task 4.1, which maps institutional and organizational changes shaping regional labour-market resilience under the twin transition. The aim of the task is to identify and trace regional institutional changes over the last 15–20 years in the form of transition topologies across 13 case studies in five sectors (tourism, food, transportation, energy, agriculture). These transition topologies are complemented by case narratives which describe emerging patterns and guide deeper analysis in subsequent tasks of WP4.

Conceptually WP4 adopts a neo-institutional perspective focusing on institutions, organizations and agency, with organisations linking institutional structures and activities of actors to analyse gradual institutional change across governance scales. Methodologically, a processual, embedded case study design is employed. Based on the “transition topology” approach, the analysis distinguishes “events” (discrete instances of organizational/institutional change) from “activities” (ongoing institutional work linking events), enabling multi-scalar mapping of change dynamics.

As part of a flexible research design, case selection and delineation were developed in sectoral coordination groups. Case delineation followed an embedded design, typically refining the focal spatial scale from NUTS-2 to NUTS-3 (or comparable units) to reduce heterogeneity within broader spatial units while retaining links to state, national and international contexts. Data collection utilized a triangulation of qualitative evidence, integrating narrative interviews with document analysis. For data collection in the case studies, Task 4.1 aligned closely with WP3 on interview procedures and guidelines. WP4 provided a structured workflow and data templates that enabled partners to prepare case datasets and ensured consistent identification and extraction of event information. In the scope of the project, a data visualisation tool was developed, that translated event data into concise transition topologies, serving as a heuristic tool for data exploration and visual analysis. These transition topologies are accompanied with case narratives to describe the processes and patterns that become visible in the maps.

For each case study, the transition topologies provide an initial mapping of institutional change processes, despite varying level of data saturation that will be addressed in the subsequent phase. While differences in data saturation influences the interpretation of cross case patterns, some key observations can already be drawn. Those preliminary observations suggest that greening events generally emerge earlier than digitalization or twin transition events, though patterns vary across cases. Initial findings also indicate that the uptake of skill-related initiatives differs by sector. Further, the preliminary results indicate that events tend to cluster across multiple spatial levels, as seen during the COVID19 pandemic, suggesting that regional transitions may be strongly influenced by interactions across scales and by broader global events. These early findings and the underlying micro-dynamics of institutional changes (including activities linking the events) will be explored in more depth in Task 4.2.

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1 Introduction

1.1 Purpose of the document

WP4 focuses on the analysis of the institutional context for labour market resilience in the regional case studies of the SkillResilience4EU project. Against this background, Task 4.1 aims to identify the most important institutional and organizational changes in regional labour markets related to the twin transition that took place over the last 15-20 years in the case studies. The purpose of this deliverable (D4.1) is to document and present the methodology developed and applied in Task 4.1 of WP4, “Transition topology for institutional contexts” and present the initial results.

Task 4.1 has been led by BOKU with contributions from HVL, FHNW, LSE, UoC, UU, and UW. The deliverable (D4.1) sets out the initial findings from the project’s case studies which have been collected in collaboration with Task 3.1. In D4.1, these results consist of the transition topologies and the corresponding case narratives, for the 13 case studies in five sectors (tourism, food, transportation, energy and agriculture). The transition topologies and the corresponding case narratives provide a foundation for subsequent tasks within WP4.

1.2 Intended readership

The deliverable is directed to a range of audiences. Policymakers at different levels may utilise the report to understand the impact of the twin transition on labour markets and its institutional context. In particular regional and national decision-makers who are engaged with the institutional and organizational contexts of regional labour markets examined in the case studies may be interested in the results presented. In addition, education and VET providers might find valuable insights into how the twin transition shapes the regional institutional context of labour markets and how actors respond to this. Beyond this, it may be relevant to scholars in economic geography, public policy and governance, labour market/VET studies and related fields.

1.3 Structure of the document

The document is structured as follows. Chapter 2 contextualises Task 4.1 within the work package and the overall project. In addition, chapter 2 introduces the conceptual and methodological approach, develops the research design accordingly, and documents the preparatory and implementation steps which ensure clear guidance while allowing flexibility for case study partners. Chapter 3 presents the initial results with regards to the institutional context of the 13 regional case studies, i.e., the transition topologies and their corresponding narratives, organised by sectoral focus. Finally, Chapter 4 concludes the document and outlines the next steps in WP4.

1.4 Relationship with other deliverables

This deliverable builds on the data collected in cooperation with WP3. This includes inputs from Deliverable 3.1 from WP3, which provides the data collection and preparatory desk research required for Task 4.1 and the project’s case studies. The deliverable will inform activities in WP5 and WP6, particularly deliverables addressing the analysis of policy frameworks and education programs (D5.2 and D6.1). Finally, conceptual findings on institutional dynamics in regional labour market resilience will feed back into the conceptual framework of WP1 (D1.4).

In addition, this deliverable provides the foundation for subsequent outputs within WP4. It serves as the basis for D4.2, which conducts an in-depth analysis of the micro-dynamics underlying the institutional transformations depicted in the transition topologies. Together, D4.1 and D4.2 inform the focus group activities in D4.3 and underpin the comparative analysis of regional institutional transition pathways across sectors and regions in D4.4.

2 Methodology and methods

After situating the task within the overall project, this section introduces the conceptual foundations, methodological approach, and research design underpinning the development of transition topologies. Together, these elements establish the analytical basis and procedural steps through which the topological maps presented in the following section (Chapter 3) were developed across the project's cases.

2.1 Task objectives and contribution

The overall aim of the SkillResilience4EU project is to support inclusive and sustainable transitions of regional economies and labour markets under the twin transition, ensuring that regions and actors can adapt to change while minimizing risks of social exclusion.

WP4 contributes to the project's overall aim by investigating the institutional conditions that enable such inclusive, sustainable regional transformations. As part of this contribution, it also analyses how regional actors navigate uncertainty, adapt to or even proactively drive change in the context of macro-level twin transition trends, thereby supporting the resilience of regional labour markets.

In doing so, WP4 complements the quantitative analyses in WP1 and WP2 with a micro-level institutional perspective, the qualitative analyses of labour market dynamics in WP3 by examining their institutional and organizational contexts, and the in-depth analyses of policy frameworks and education programs in WP5 and WP6 by elucidating their actual impacts at the regional level.

In this context, Task 4.1 focuses on mapping institutional changes in the case study regions and producing transition topologies and corresponding narratives, thus providing a solid foundation for subsequent analyses, stakeholder engagement, and cross-case comparisons in D4.2-D4.4.

2.2 Conceptual and methodological approach

Building on the SkillResilience4EU project's view of regional economic resilience as a dynamic, evolutionary concept (Martin, 2012; Boschma, 2015), a neo-institutional approach is a suitable framework for analysing institutional change. While traditional institutional perspectives often emphasise stability, WP4 draws on recent approaches in this literature that examine how institutions themselves change and how they enable or constrain change at the micro-level (e.g., Lawrence & Suddaby, 2006; Greenwood et al., 2008). This focus provides the conceptual foundation for the process-based methodological approach (Langley 1999) applied in this deliverable and allows to systematically capture the micro-dynamics of institutional change that shape regional labour market resilience.

2.2.1 Conceptual approach

The conceptual framework of WP4 rests on three closely interrelated conceptual elements:

- (1) **Institutions:** understood as shared expectations that guide behaviour beyond individual actors, including regulative (laws, formal rules), normative, and cognitive elements (values, norms, beliefs) (Scott, 2001). Institutions form interrelated arrangements whose effectiveness depends on complementarities with other elements (Hall & Soskice, 2001). These arrangements evolve in highly place- and path-dependent ways, generating

substantial variation even at sub-national levels (Hansen & Coenen, 2015; Strambach & Pflitsch, 2020).

- (2) **Organizations:** defined as intentionally created configurations of institutional structures and practices (Greenwood & Suddaby, 2006). Organizations' strategies and practices are shaped by their institutional environments, including isomorphic pressures toward locally legitimate practices (DiMaggio & Powell, 1983). Yet, as goal-oriented actors, organizations both reproduce and transform place-specific institutional arrangements (Strambach & Pflitsch, 2020).
- (3) **Agency:** understood as the purposeful and temporally embedded action of individuals or organizations, exercised within spatially differentiated institutional arrangements and shaped by locally available resources (Emirbayer & Mische, 1998). Institutional work captures the concrete practices through which actors intend to create, maintain, or transform institutions in specific spatial and institutional contexts (Lawrence & Suddaby, 2006).

Hence, while analytically distinct, these three elements are tightly interconnected. Organizations both exercise and enable (individual) agency by providing resources and structures that guide action, even as they are subject to institutional pressures themselves. Changes in organizational structures and practices therefore mirror ongoing processes of gradual institutional change, which may, however, culminate in broader institutional transformations over time (Strambach & Pflitsch 2020).

The regional level is the central arena in which dense formal and informal interactions and negotiation processes shape and transform shared expectations, norms, and coordination mechanisms. It is thus the salient level at which the institutional dynamics of labour markets unfold. At the same time, these dynamics are embedded in, and coevolve with, national and supranational processes: overarching legal and regulatory frameworks (e.g., national laws, EU directives) set the formal "rules of the game" (North, 1990) but they are interpreted, implemented, and co-shaped through local practices.

Accordingly, institutional change is conceptualized here as a multi-scalar process in which transformations arise from cross-level interactions, and dynamics at one scale both influence and are influenced by developments at others (Hansen & Coenen, 2015; Miörner & Binz, 2021). This perspective enables to depict how mega-trends such as greening and digitalisation alter informal norms, routines, and coordination and thereby reshape regional institutional configurations, while locally induced changes can, over time, also prompt adjustments at higher levels.

2.2.2 Methodological approach

The methodological approach of WP4 is rooted in a process ontology, which contrasts with the more common variance-based approaches (Langley, 1999). Instead of focusing on correlations or causal relations between a few variables, a process ontology examines emergent, evolving, or disappearing phenomena and their contingent interactions over time (Cloutier & Langley, 2020). While not strictly capturing causality between events (rather temporal relations), it is thus particularly suited for analysing the complex, multi-scalar processes driving institutional transformations of regional labour markets.

Building on the conceptual framework, organizations are treated as observable links between agency and institutions. Because organizations can be clearly located in time and space, events of organizational change (e.g., the foundation of a new organization or a new department within

an existing organization) serve as empirical indicators to capture underlying micro-dynamics of institutional change, which are otherwise difficult to observe. Institutional change is furthermore operationalized in the form of events, that serve as additional proxies for an alteration of rules, norms or cognitive framings (e.g., the implementation of a new law or a new award incentivising specific types of behaviour). Agency is captured through the activities of actors which connect events (e.g., lobbying for new regulations or raising funds for a new initiative; Strambach & Pflitsch, 2020).

Therefore, methodologically a processual, embedded case study design is adopted (Yin 2018), allowing the analysis of multi-scalar processes across interconnected spatial levels. The approach of transition topology developed by Strambach and Pflitsch (2020) allows to capture such complex processes. This approach combines a rich narrative analysis of actors' activities, strategies, and motivations with a more abstract and replicable visual mapping of key institutional changes. It has previously been applied among others to investigate the role of universities (Pflitsch & Radinger-Peer, 2018), civil society actors (Pflitsch & Strambach, 2018) and international development organisations (Fahimi et al., 2025) in institutional transformations (see Figure 1).

In line with a process-based perspective, the visual mapping as part of the transition topologies includes two main elements: events and activities (Langley, 1999). Events are discrete occurrences, typically represented by boxes or circles, marking when meaningful organizational or institutional changes take place. Activities are the ongoing processes and actions, depicted with lines and arrows, showing how actors mobilize resources, exercise agency, and interact with institutional structures. Together, the narrative and the map illuminate how institutions, organizations, and agency co-evolve across scales and over time, making the cross-level interactions shaping regional labour-market resilience visible.

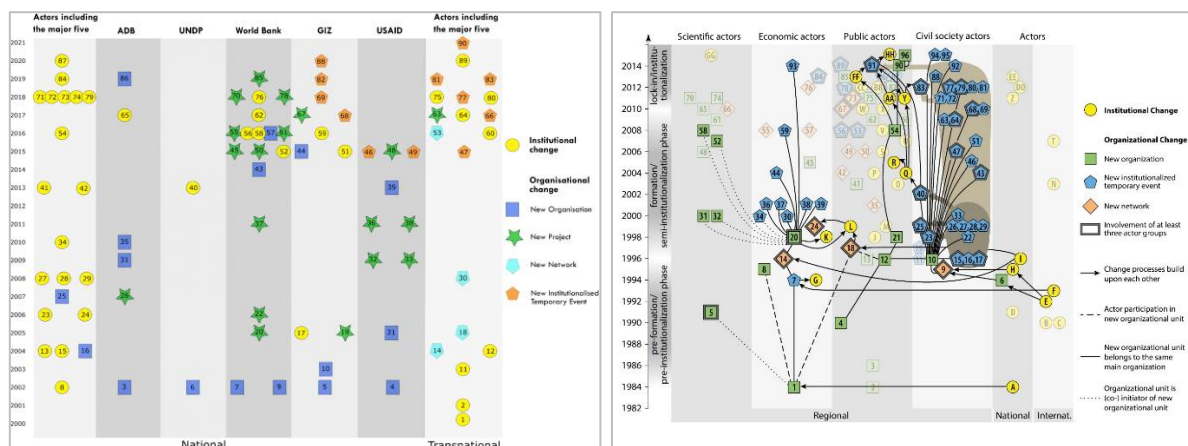


Figure 1: Exemplary visual mappings of a transition topology (Fahimi et al., 2024, Pflitsch & Strambach, 2018)

2.3 Research design and implementation

This chapter translates the conceptual and methodological approach from Chapter 2.1 into a concrete research design and describes the corresponding implementation steps, beginning with a kick-off workshop involving all project partners. It outlines how multi-scalar processes and the interactions between institutions, organizations, and actors were operationalized, and explains the procedures used to collect, process, and analyse qualitative evidence to produce the transition topologies and corresponding case narratives (see Figure 2).

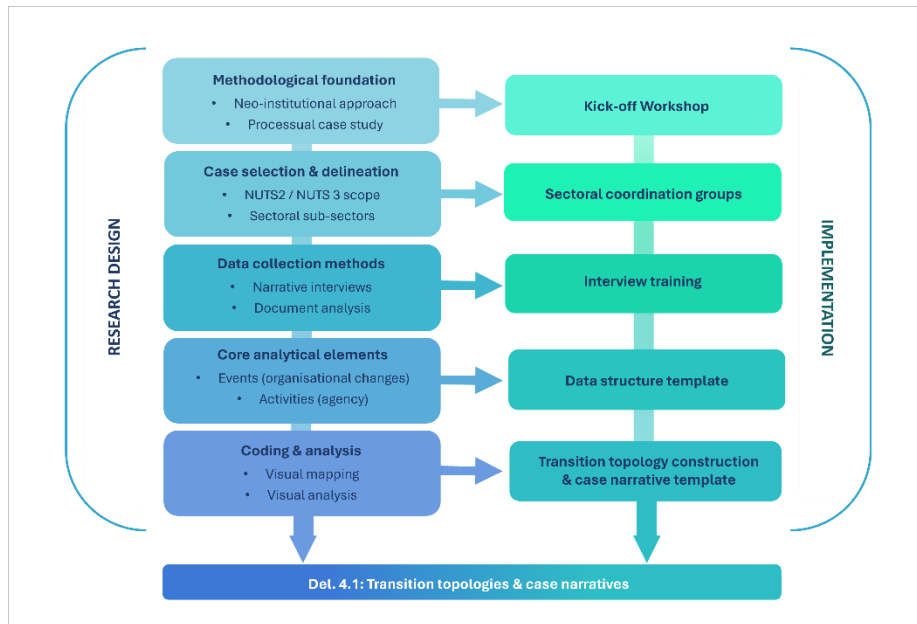


Figure 2: Research design and corresponding implementation steps in Task 4.1

2.3.1 Delivery of internal workshop on WP approach

As outlined in the proposal, an internal workshop held on 11.09.2025 introduced and jointly discussed WP4's theoretical and methodological approach. It served as the formal WP kick-off, provided an overview of WP4's objectives and contribution to the overall project, clarified the conceptual framework and methodological choices, and outlined the research design and respective implementation steps. In this way, partners were informed early on how they would be involved in subsequent research steps, including envisaged data collection and data representation with the analytical tool.

The workshop agenda covered:

- the objectives of WP4 and their linkages to the overall project;
- the theoretical and methodological framework guiding the analysis;
- requirements and examples for data collection based on initial desk research and exploratory interviews;
- the role of the software tool for data visualisation and analysis; and
- key milestones, deliverables, and next steps within WP4.

The workshop was conducted online. Presentations were followed by a moderated discussion and Q&A to address open questions and clarify methodological aspects. Documentation and presentation materials were made available to project partners via the project collaboration platform. Where relevant, feedback from the session informed minor refinements to the planned data collection process.

2.3.2 Case selection and delineation

For Task 4.1, WP4 developed a flexible research design for selecting and delineating cases. This design aligns with the project's spatial and sectoral boundaries, as outlined in the proposal, while allowing methodologically justified adjustments during implementation. It builds directly on desk research conducted by all partners from May to August 2025 under the lead of WP3. This research

included targeted document reviews and informal calls with key actors, and all steps were jointly planned together with WP4.

Initial findings from the desk research suggested that a NUTS-2 scope might be too broad to capture the processes driving institutional transformations in regional labour markets. It was therefore suggested that, in some cases, a more focused spatial unit at NUTS-3 level (or comparable functional units) could serve as the focal unit of analysis, to better capture interactions between actors, institutions, and organizations while reducing within-unit heterogeneity. At the same time, it was recommended that all cases remain linked to wider NUTS-2 and national/supranational contexts where relevant regulatory frameworks apply.

Similarly, a dual principle was suggested for sectoral definitions: where broad sector labels risked obscuring important differences between subsectors (related to actors, technologies, infrastructure, organizational culture, or institutional arrangements), the scope should be narrowed. Where cross-cutting dynamics and interdependencies were central, a broader sectoral scope should be retained.

Based on these suggestions, WP 4 established sectoral coordination groups in September and October 2025 to operationalize the case selection and delineation. Partners consolidated sector-specific decisions, defined the focal spatial scale, and selected sub-units relevant to the twin transition and expected labour-market impacts. Some partners followed the NUTS-3 suggestion, while others retained NUTS-2 due to sector- or country-specific constraints. Similarly, some groups narrowed subsectors for analytical clarity, while others kept a broader scope to capture value-chain linkages.

The coordination meetings also ensured comparability across regional case studies and prepared the first interview round. They were held online, lasted about one hour, involved all partners working on the same sector, and were moderated by BOKU using a common structure. Minutes and materials were documented and shared via the project platform.

An overview of the final sector–region cases, showing the agreed sub sectors or domains within each sectoral coordination group and the regional focus of the respective partners, is provided in Table 1. Interim outcomes of these meetings were presented and discussed with all partners at the project meeting in London on 12 November 2025.

Table 1: Overview of WP4 case studies, showing agreed sub-sectors and partners' regional focus

Sector	Transportation	Energy	Food	Tourism	Agriculture
Scope, Sub-sector or domain	Logistics	Greening & Digitalisation of grid	Food system	Cruise Industry	Greening of production
HVL	Vestland (NUTS 3)	Vestland (NUTS 3)		Vestland (NUTS 3)	
FHNW	Northwestern Switzerland (NUTS 3)		Val Poschiavo (< NUTS 3)		
LSE					Nord-Est Region (NUTS 2)
BOKU			Vulkanland (< NUTS 3)		Styria (NUTS 2)

UU		Groot-Rijnmond (NUTS 3)			
UW		Łódzkie (NUTS 3)			
UoC	Crete (NUTS 2)		Crete (NUTS 2)	Crete (NUTS 2)	

2.3.3 Data collection methods

The data collection for WP4 relies on a triangulation of qualitative evidence (Flick, 2007), combining narrative interviews (Küsters, 2009) and document analysis (Bowen, 2009). This approach was chosen to capture actors' perspectives, interpretations, and priorities (particularly which events and activities they considered central for the region and how they understood the relationships between them), while also gathering contextual information and allowing cross-validation of different perspectives.

Narrative interviews invite participants to recount experiences as stories rather than respond to a rigid questionnaire. Follow-up prompts support comparability across interviews and in the context of this WP can help identify the micro-dynamics crucial for the transition topologies. A narrative interview guide should therefore be structured in a way that balances openness with comparability and ensures the systematic collection of evidence.

Building on this design, the operational implementation was conducted in close coordination with WP3. In particular, two steps were planned and implemented jointly:

(1) Development of the interview guide and workshop materials (co-developed with feedback loops and pre-testing)

With regard to Task 4.1, the aim was to elicit event- and activity-data (including timing, involved actors, and links to the twin transition) suitable for the construction of topologies and case narratives. Therefore, a narrative WP4 module was added to the overall interview guide to capture ordered sequences of events and identify potential turning points. The interview guide module was pre-tested by WP4 and adapted with respect to terminology and narrative prompts employed. While the complete interview guide module can be found in the Annex, the following outlines its main elements:

1. **Introductory / icebreaker question:** to ease the conversation and determine whether green, digital, or both topics were most salient to the interviewee.
2. **Past developments:** narrative stimulus with follow-up questions to clarify details and deepen the story.
3. **Future challenges and opportunities:** narrative stimulus with follow-up questions.
4. **Referral questions:** to identify additional relevant actors.
5. **Closing questions**

(2) Preparation and training of partners for the interviews (led by WP3, with WP4 inputs)

From a Task 4.1 perspective, the goal was to familiarize partners with the specifics of narrative interviewing and to gather feedback for minor adaptations. An online workshop (19.11.2025) was organized, during which the WP4 team provided concrete examples of how an interview sequence

can unfold to elicit events, activities, actor roles, and cross-scale linkages that feed directly into topology construction and case narratives.

In addition to the two steps, regular meetings between WP3 and WP4 helped to align data needs, harmonize documentation standards (per WP3 guidelines), and manage scheduling and communication.

2.3.4 Data preparation and coding

Data preparation followed shared WP3/WP4 protocols to ensure consistency and comparability across cases. Interview recordings were transcribed according to WP3 procedures. The resulting transcripts, together with the documentary corpus, formed the basis for systematically extracting and storing the elements required to construct the transition topologies in line with WP4 guidelines.

Building on the methodological approach of WP4, as outlined in Chapter 2.2, the elements required for the topologies comprise both events and activities. Events capture observable instances of organizational or institutional change (e.g., in this context the establishment or formal recognition of new training programs), while activities represent the ongoing institutional work through which such changes are enacted (e.g., lobbying, coordination, collaboration among actors for new labour market regulations). Yet, in a first step, Task 4.1 focused solely on the identification and systematic categorization of events in the interview transcripts and document corpus. Activities were documented during the data collection process and will be analysed as part of Task 4.2. Classification of events followed deductively derived categories aligned with the analytical framework, including: type of change (institutional/organizational), transition type (green/digital/both), temporal markers (year), spatial scale (regional/national/supranational), and actor groups (public, economic, academic, civic). These codes were introduced in the WP4 kick-off workshop and further defined in a step-by-step presentation provided to all partners. Where warranted by the data, inductive categories were added to capture emergent patterns (e.g., distinct technological pathways or sector-specific developments).

All data identified and extracted in this way were captured and organized in structured case databases, which were created based on flexible data structure templates provided to the partners. These templates reflect the core distinctions and standardized classifications (events and activities; change type; transition type; temporal markers; spatial scale; actor groups), while allowing case-specific adaptations and the addition of inductively derived categories where needed. In particular for cases focusing on the same sector, it was ensured that comparable codes were applied wherever feasible. The resulting consistently structured dataset served as the foundation for constructing the WP4 transition topologies and case narratives, and also allowed partners to include additional information on the activities linking events, providing a basis for Task 4.2. In addition, partners were asked to provide a structured overview of each case, including stakeholder groups, spatial levels, time period, and sector definition.

A step-by-step presentation demonstrated the workflow, elaborating on each category in the template (see Figure 3). This presentation also outlined the use of the templates for the topology visualizer (see Section 2.3.4), as well as the proposed timeline for Deliverable D4.1. Templates and supporting documentation were made available on the shared project platform, and partners submitted their completed templates by 16 December 2025. WP4 reviewed data structure tables and initial classification events of all partners to ensure consistency between cases and provided targeted suggestions for minor revisions.

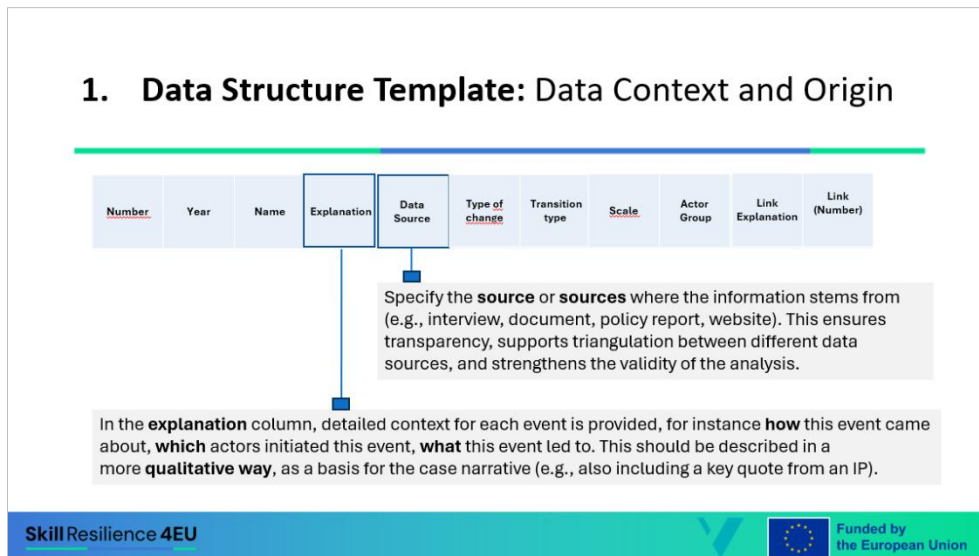


Figure 3: Excerpt from the presentation illustrating the use of the data structure template

2.3.5 Topology construction and visual analysis

Beyond providing a comprehensive illustration and organization of the empirical material, the topological maps were supposed to serve as methodological tools for qualitative visual analysis throughout the research process (Pflitsch et al., forthcoming). By abstracting from raw data through categorization and aggregation, the visual mappings facilitate synthesis of complex processes, making higher-order structures, relationships, and influencing factors visible. Notably, the relationships (which will be displayed in the topologies in form of arrows in D4.2) should be interpreted as temporal rather than direct causal links. They can support in-depth case analysis in Task 4.2 and enable comparison across cases and phases in D4.4. In Task 4.1, the maps also were supposed to allow exploration of alternative configurations and sequences by regrouping events into different categories, supporting the formulation of propositions for subsequent data collection and analysis.

Since no suitable tool existed to automatically generate and flexibly adapt visualisations (i.e., the transition topologies) for this purpose, an external partner (Dr. Max Eriksson) was subcontracted from May – August 2025 to develop the R-based- open-source application. The tool was developed by Eriksson independently, with regular feedback loops with the BOKU team (WP4) to align features and usability. The so-called “topology visualizer” (see Figure 4) has been publicly available since September 2025. The application generates graphics directly from a text-based Excel table, in which events are recorded by year, actor group, and spatial level, including possible connections between events. A user-friendly graphical interface allows users to create, filter, and export visualisations without programming skills. An initial version of the tool was presented and explained to all partners during the internal workshop (see 2.3.1) and further instructions were shared in the detailed presentation already mentioned in 2.3.3.

Upon receiving partners’ completed templates in December 2025, the BOKU team transferred the data into an upload table, developed the transition topologies (or supported partners in doing so), and prepared several visualizations. These were used to discuss initial observations in one-hour meetings with individual partners, with follow-ups as needed to clarify points and iteratively refine the topologies (e.g., through re-categorizations of elements). Based on initial input from

HVL, BOKU then provided a structural template for the case narratives, ensuring comparability across cases. This template specified the scope and boundaries of each case, provided an initial descriptive account of the temporal development of institutional change related to the twin transition, and guided the derivation of open questions or preliminary propositions for D4.2. Feedback focused on aligning transition topologies and case narratives to ensure both outputs were consistently linked.

Together, the transition topologies and case narratives constitute the central outputs of D4.1. They provide descriptive, chronological accounts that contextualize the processes visualized in the topological maps and serve as intermediate devices supporting iterative development of the case studies. The outputs of this process – the transition topologies for each case and the corresponding case narratives – are presented below by sectoral focus.

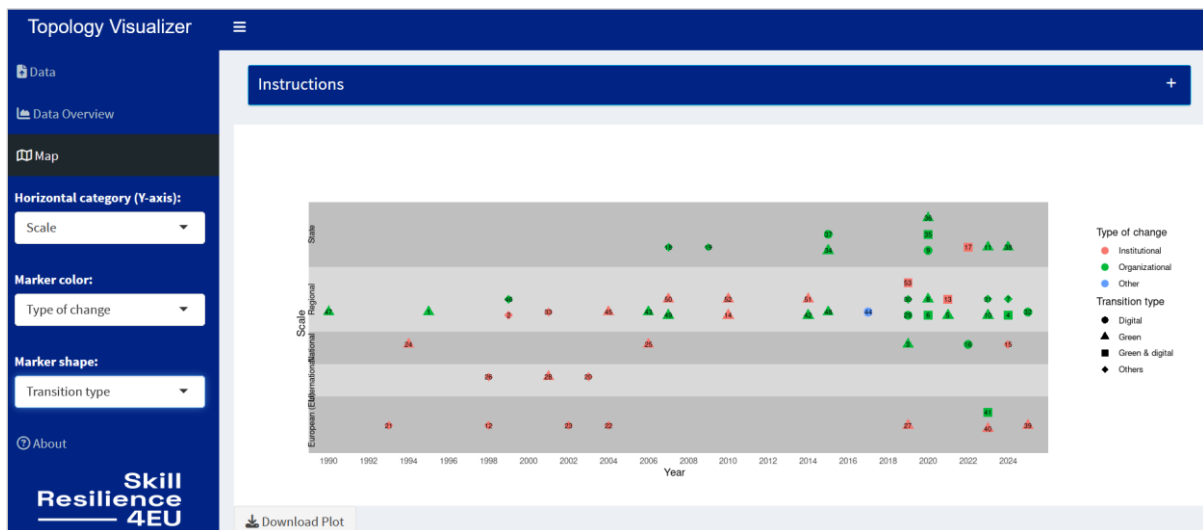


Figure 4: Screenshot of the topology visualizer

3 Results: Topological maps and case narratives

This section consists of the mapping and narrative description of the institutional and organizational change processes related to the twin transition and the transformations of regional labour markets in the case studies. In the following, the results for each case study are presented, structured by sectoral focus. Each sub-chapter entails a short summary of the data basis (see D3.1 for further details) and case delineation, the transition topologies, and the corresponding descriptive case narratives.

3.1 Food Sector

The Food Sector is the focus of three case studies by the partners BOKU, FHNW and UoC. The data basis for the results of Task 4.1 of each partner are summarized below (Table 2):

Table 2: Data basis for Task 4.1 in the Food Sector

BOKU	FHNW	UoC
13 stakeholder interviews - Regional development agency (2) - Academia (3) - VET provider (2) - Public employment service - Firm (3) - Industry service provider - Association	7 stakeholder interviews - Tourism agency - Cultural tourism office - Administrative district - Academia - VET provider - Firm - Association	7 stakeholder interviews - Local government/inter-municipal organisation - Firm/entrepreneur (4) - Academia (2)
Document analysis	Document analysis	Document analysis

3.1.1 Vulkanland (BOKU)

Delineation of the case:

This case looks at the food sector in south-eastern Styria (NUTS 3, AT224) with a focus on the Vulkanland region, embedded within three additional levels: the supra-regional level (Styria, NUTS 2, AT22), the national and international context. The Vulkanland was selected as a predominantly rural yet well-connected region characterised by a dense and highly integrated food production system, a strong regional identity, and close linkages between agriculture, food processing, and tourism, while simultaneously facing persistent structural labour market challenges. Accordingly, the food sector is defined broadly as a complex and interconnected system encompassing food production, processing, supply, and distribution across small-scale producers, larger firms, and service providers. The analysis considers economic actors along the food value chain, public actors involved in regulation, policy, and knowledge production, as well as civil society actors promoting sustainable and regional food systems. The case study focuses on the period from approximately 2000 to 2025, marked by major European and national regulatory changes shaping the sector's transformation.

Institutional changes related to greening and digitalisation across multiple spatial scales

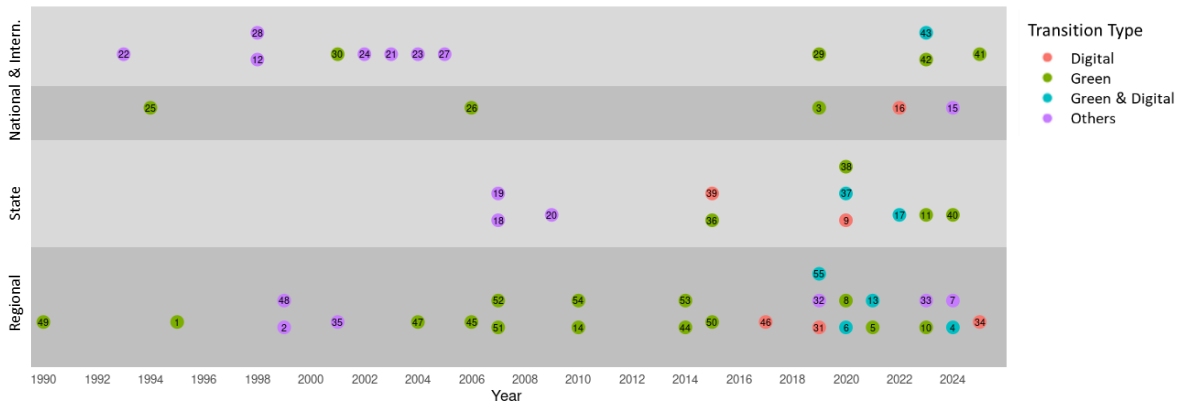


Figure 5: Transition topology depicting institutional changes related to greening and digitalisation across multiple spatial scales in the food sector in the Vulkanland, Austria (1975-2023).

Figure 5 illustrates the temporal development of the institutional transformation process in the Vulkanland related to two ongoing mega-trends, greening and digitalisation, from the late 1990s to the present. It becomes visible that the majority of events take place at the regional level. At the international level several events, which had an impact at the regional level, take place in the early 2000s, followed by a gap between 2006 and 2009. Events at the regional scale appear more continuously from 1999 onwards (with exception of a gap between the years 2011-2013). At the state level events take place infrequently between 2009 and 2024.

Figure 5 also shows which of the two macro-level trends each event is assigned to. Most changes are related to the green transition, while many events identified as relevant through the interviews cannot be clearly categorized to one transition type (especially early events on the international level and regional level). Events related to the digital transition first appear at the regional level in 2015. Especially at the regional and state level, from 2019 onwards, events are increasingly addressing the twin transition, i.e., both trends simultaneously. There is only one event identified at the international level which aligns with the twin transition (event 43).

Evolution of initiatives addressing evolving skill needs and actors across spatial scales

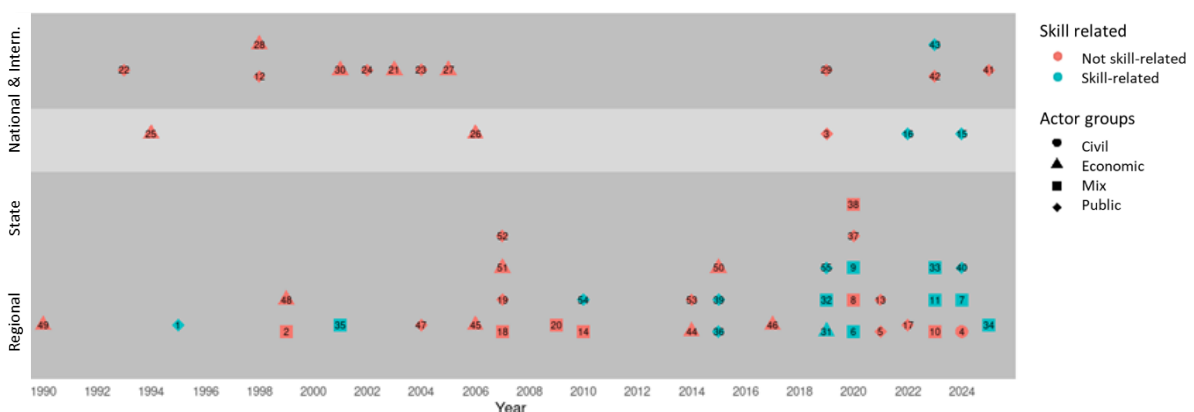


Figure 6: Transition Topology depicting institutional changes related to skill (and non-skill)-related initiatives as well as actor groups across multiple spatial scales in the food sector in the Vulkanland region, Austria (1999–2025).

Figure 6 illustrates the same events as Figure 5, yet, differentiated by their skill-focus (skill- versus non-skill-related initiatives) as well as by the actor groups linked to these changes. In general, events are coded as skill-related if they address demands for re- and upskilling. As for the actor groups, it becomes apparent that economic actors and mixed actors are the primary drivers of

institutional and organisational changes across the whole timespan at the regional level. At the international scale, economic and public actors initiate changes until around 2006. After 2018 events at the international scale are initiated solely by public actors. Notably, in general only one event is associated solely with civil society actors (see event 4).

While there are some early changes in skilling efforts visible (see event 54 and 35), events related to up- and reskilling become more frequent after 2015. The majority of up- and reskilling related events occur on regional level and state level, with only two events identified at the national level (event 15 and 16).

Conclusion and outlook

Based on the transition topologies for the food sector in the Vulkanland (Figures 5 & 6), the following points summarize the key observations and open questions for further data collection and analysis:

- *Temporal pattern:* Regional-scale events occur continuously since the late 1990s, whereas international-scale events peak in the early-2000s
- *Thematic Focus:* Most changes are related to the green transition, events related to the digital transition appear only after 2015
- *Actor configuration:* Most (early) events at the regional level are initiated by economic and mixed actor groups
- *Skills focus:* Skill-related events become more frequent after 2015 and appear predominantly at the regional level

Further data collection and analysis could focus on the following:

- *Explain regional continuity:* Uncover the micro-dynamics that enable the sustained sequence of institutional changes and organisational changes at the regional level. Given the prominence of economic and mixed actors here, further analysis could zoom into the roles these actors played in this process.
- *Analyse co-emergence of digitalisation and skilling:* Do the concurrent increases in digital and skills-related events after 2015 indicate interdependencies and shared drivers?
- *Assess bottom-up dynamics of skilling:* The strong regional concentration of skilling initiatives suggests bottom-up dynamics that should be explored through more fine-grained analysis of these regional events and the activities leading up to them.
- *Trace international-to-regional effects:* How did international developments in the early phase influence the long-term regional transition trajectory?

3.1.2 Val Poschiavo (FHNW)

Delineation of the case:

This case examines the food sector in Eastern Switzerland, Switzerland (NUTS 2: CH05), with a sub-regional focus on Graubünden (NUTS 3: CH056) and a local focus on the Val Poschiavo region. The sector is defined broadly as a connected system spanning production, processing, logistics and distribution, from small producers to larger firms and service providers. Key economic actors include market-oriented companies such as Nicolò Paganini (berries) and Raselli (organic herbs). Public actors comprise the Canton of Graubünden, Regione Bernina (regional development agency), Valposchiavo Turismo and Graubünden Cultura. Civil society organisations such as Bio Grischun and Polo Poschiavo promote sustainable, fair and regional

food systems, while mixed initiatives like Agrischa and Kastanienfest bridge actor groups. The timeframe covers roughly 1990–2025, during which energy transitions and digitalisation have significantly reshaped activities, networks, and competencies across the food value chain.

Institutional changes related to greening and digitalisation across multiple spatial scales

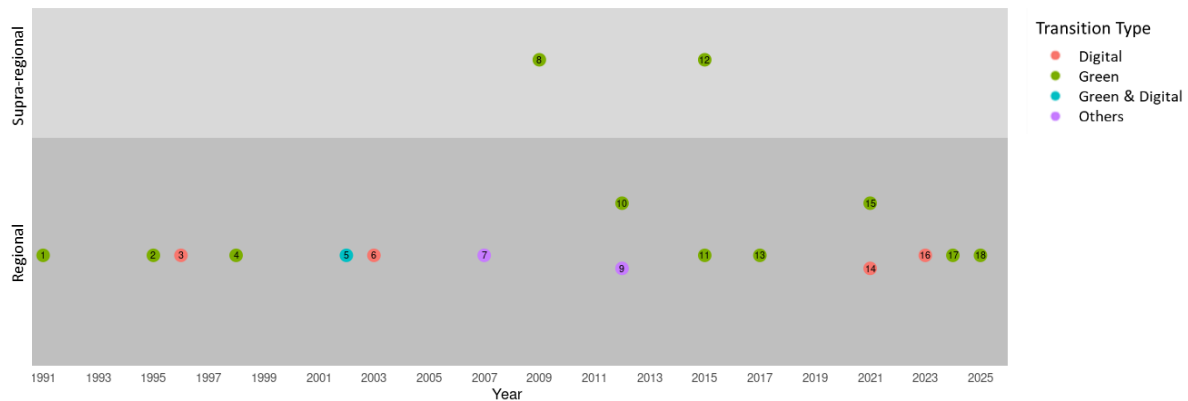


Figure 7: Transition Topology depicting institutional changes related to greening and digitalisation across multiple spatial scales in the food sector in Val Poschiavo, Switzerland (1991-2025).

Figure 7 depicts institutional changes related to two ongoing mega-trends, greening and digitalisation across multiple spatial scales in the Food Industry in Val Poschiavo. At the regional level, events occurred in a continuous manner from 1995 to 2025. No clustering of events at the regional scale is observable. Other scales refer to the supra-regional levels of Ostschweiz and the canton Graubünden, where only two events (2009 and 2015) are shown to have influenced developments related to the twin transition in the regional food sector.

Figure 7 also shows which of the two macro-level trends each event is assigned to. It becomes clear that most events are linked to the green transition. While non-regional events solely address the green transition, there are also a few events related to digitalisation and the twin transition at the regional level over the years.

Evolution of initiatives addressing evolving skill needs and actors across spatial scales

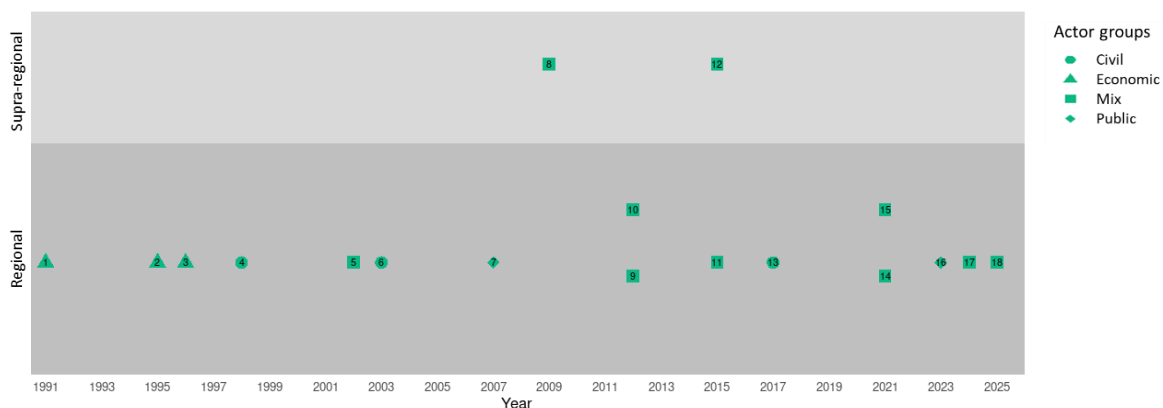


Figure 8: Transition Topology depicting institutional changes related to skill (and non-skill)-related initiatives as well as actor groups across multiple spatial scales in the food sector in Val Poschiavo, Switzerland (1991-2025).

Figure 8 illustrates the same institutional change events as Figure 7, but categorizes them by skill-versus non-skill-related initiatives, actor groups, and spatial scales. The Figure illustrates that in the early phase, events are initiated primarily by economic actors, while mixed actor

constellations become more prominent around 2011. Civil society actors have initiated three events, whereas public actors have initiated fewer events on their own. In Figure 8 it becomes clear that currently no skill-related events can be identified in the topology.

Conclusion and outlook

Based on the transition topologies for the food sector in Val Poschiavo (Figures 7 & 8), the following points summarize the key observations and open questions for further data collection and analysis:

- *Temporal pattern:* Regional events occur relatively continuously from 1995 to 2025
- *Thematic Focus:* Most events align with the green transition, while more infrequently events linked to the digital transition also occur
- *Actor configuration:* Early initiatives are led by economic actors, while mixed actor constellations become more prominent from 2011 onwards
- *Skills focus:* No skill-related events have been identified in the topology.

Further data collection and analysis could focus on the following:

- *Unpacking micro-dynamics of regional event sequence:* Given that the topology shows only a few events outside the region, a closer examination of the micro-dynamics that drive and sustain the continuous regional event sequence is warranted.
- *Interplay between green and digital transition:* The emerging pattern suggests that green and digital transition may be mutually reinforcing, which calls for a closer examination of their linkages.
- *Investigate actor-related shift:* What mechanisms drove the rise of mixed actor constellations from 2011 onward, and how did these coalitions affect the process?
- *Analyse re- and upskilling initiatives:* How should the lack of visible skills initiatives be interpreted? Does it point to a significant skills mismatch or rather indicate alternative qualification pathways (e.g., on-the-job learning, the dual vocational system)?

Yet, given the relatively small number of events and interviews conducted for this case, the robustness of the emerging patterns remains subject to further scrutiny. While this limitation can partly be explained by the small size of the Val Poschiavo region and the focus on finer spatial scales, it primarily points to the need for stronger qualitative underpinning to further contextualise the findings.

3.1.3 Crete (UoC)

Delineation of the case

This case focuses on the food sector in Crete (NUTS 2, EL43). Crete is a predominantly rural yet highly touristic region where agriculture and food processing are tightly interlinked, with olive oil serving as the backbone of the local food economy. The case delineation adopts a broad definition of the food sector spanning primary production, processing, supply, and distribution across small-scale producers and food producing industries. Furthermore, in the scope of analysis are service activities linked to agrotourism, which has expanded rapidly in recent years. Relevant stakeholder groups therefore are economic actors such as olive oil producers, food producing industries, researchers and policy makers. The temporal scope is approximately 2001–2025, a period marked by significant European directives transposed into Greek law during the

2010s, which prompted adaptations in production, processing, and compliance practices across Crete's food industry.

Institutional changes related to greening and digitalisation across multiple spatial scales

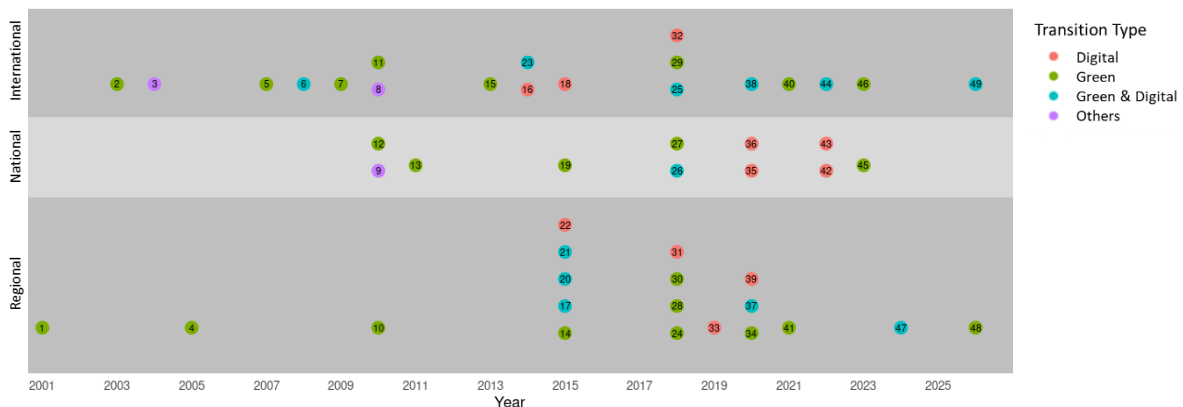


Figure 9: Transition Topology depicting institutional changes related to greening and digitalisation across multiple spatial scales in the food sector in Crete, Greece (2001-2026).

Figure 9 depicts institutional changes related to the two ongoing mega-trends, greening and digitalisation from 2001 to the present across multiple spatial scales in the food sector in Crete. It becomes visible that a substantial number of events that had an impact on the food industry in Crete take place at the international level. At the international level events first appear around 2003 (event 1 and event 3) and then more continuously from 2007 onwards. At the national level, the first events emerge around 2010, with a couple of events occurring between 2015 and 2023. At the regional scale surges of events are depicted in 2015 and 2018, with fewer events occurring afterwards. Across all spatial scales 2015 and 2018 appear to be important moments, in which a clustering of events occurs.

Figure 9 also shows which of the two macro-level trends each event is assigned to. While most changes are related to the green transition, many events are addressing the twin transition, i.e., both trends simultaneously. These events occur relatively early on (see events 6 and 23). At the regional scale, events linked to the digital and twin transition first appear in 2015. Notably, events at the national scale only address the digital and twin transition a bit later, in 2018.

Evolution of initiatives addressing evolving skill needs and actors across spatial scales



Figure 10: Transition Topology depicting institutional changes related to skill (and non-skill)-related initiatives as well as actor groups across multiple spatial scales in the food sector in Crete, Greece (2001-2025).

Figure 10 shows the same institutional change events as Figure 9, yet, categorizes them by skill- versus non-skill-related initiatives, actor groups, and spatial scales. In Figure 10 it becomes apparent that the majority of international events are initiated by public actors. At the regional scale, early events are initiated by public or economic actors. In 2015 events initiated by mixed actor groups emerge. Events at the national scale are mainly initiated by public and mixed actor groups.

With regards to re- and upskilling efforts, events related to skilling initiatives first occur in 2015 and then become more frequent afterwards. First events related to up- and reskilling appear at the regional scale (see events 21 and 20). Between 2018 and 2022 skill-related events also occur at the national scale, while at the international scale only one event in 2018 is categorized as related to up- and reskilling (see event 25).

Conclusion and outlook

Based on the transition topologies for the food sector in Crete (Figures 9 & 10), the following points summarize the key observations and open questions for further data collection and analysis:

- *Temporal pattern:* Event clusters in 2015 and 2018 across scales; events at international scale occur most continuously in comparison with other scales
- *Thematic Focus:* Events are characterized by an early focus on green transition, with the first events related to digitalisation and the twin transition emerging around 2015
- *Actor configuration:* Public actors play a key role at the international scale, at the regional level a shift towards mixed coalitions is notable after 2015
- *Skills focus:* Events related to re- and upskilling emerge only after 2015, particularly at the regional and national level

Further data collection and analysis could focus on the following:

- *Trace international-to-regional effects:* How are continuous changes at the international scale linked to regional events?
- *Analyse co-emergence of digitalisation and skilling:* The simultaneous rise of digital and skills-related events after 2015 warrants a closer examination of potential interdependencies and shared drivers.
- *Examine the involvement of actor groups:* Analyse micro-dynamics at the regional level and focus on the emergence of mixed actors at the regional scale, in particular what triggered and enabled this more intensive cooperation
- *Explore the clustering of events in 2015 and 2018:* To what extent can specific developments account for the accumulation of events in 2015 and 2018 across scales?

3.2 Transportation Sector

The Transportation Sector is the focus of three case studies by the partners HVL, FHNW and UoC. The data basis for the results of Task 4.1 of each partner are summarized below (Table 3):

Table 3: Data basis for Task 4.1 in the Transportation Sector

HVL	FHNW	UoC
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16 stakeholder interviews - Academica (4) - Public transport firm - Association - Public authorities (5)	7 stakeholder interviews - Cluster organisation - Public authority - Logistic firm (2)	4 stakeholder interviews - Public transport firm (3) - Association
Document analysis	Document analysis	Document analysis

3.2.1 Vestland (HVL)

Delineation of the case

This case examines the transport sector in Vestland, Norway. Spatially, the focal scale is Vestland county (NUTS3 region NO0A2), embedded into national and international level developments. This scale has been chosen because counties are an administrative level in Norway, while NUTS 2 regions are not. The sector is defined broadly to include public transport, logistics, shipping and maritime services, and as linked to emerging carbon, hydrogen and ammonia value chains. Key actors include firms like Posten Bring and Skyss, port and municipal authorities (e.g., The Port Authority, Port of Bergen, Bergen Municipality, Øygarden Municipality), the Bergen Chamber of Commerce, Vestland County Authority, and the CCUS Innovation Cluster, alongside civil society organisations such as Kollektivtrafikkforeningen and the Bellona Foundation, as well as joint initiatives like Trainee Vest, which illustrate multi-actor collaboration. The timeframe spans approximately 2005–2025, with most change occurring in the last decade.

Institutional changes related to greening and digitalisation across multiple spatial scales



Evolution of initiatives addressing evolving skill needs and actors across spatial scales

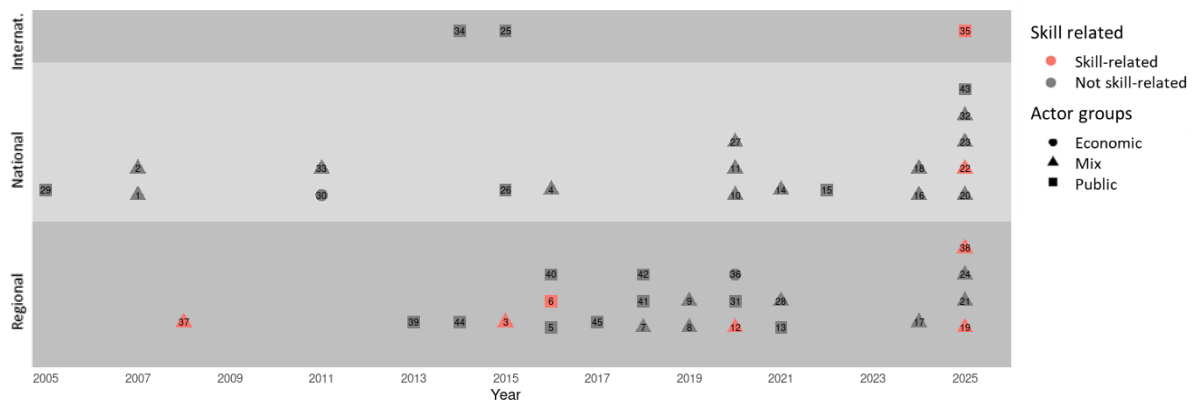


Figure 12: Transition Topology depicting institutional changes related to skill (and non-skill)-related initiatives as well as actor groups across multiple spatial scales in the transportation sector in Vestland, Norway (2005-2025).

Figure 12 shows the same institutional change events as Figure 11, but categorizes them by skill-versus non-skill-related initiatives, actor groups, and spatial scales. Figure 12 shows that, early on, most events, particularly at the national level, are initiated by mixed actor groups (e.g., events 1 and 2). At the regional level, public actors also play a significant role in driving changes. Economic actors have initiated only two of the events depicted.

The topology shows that most skill-related events occur at the regional scale. Initiatives addressing re- and upskilling appear as early as 2007 (event 37). Notably, these events are – when compared with Figure 11 – nearly all related to the digital transition. In 2025, skill-related events also emerge at the national and international levels. As Figure 12 indicates, these initiatives are predominantly led by mixed actor constellations or public actors.

Conclusion and outlook

Based on the transition topologies for the transportation sector in Vestland (Figures 11 & 12), the following points summarize the key observations and open questions for further data collection and analysis:

- *Temporal pattern:* Most events occur at the national and regional scale with a surge of regional events between 2013 and 2021
- *Thematic Focus:* Events initially centre on the green transition, with a growing shift toward digitalisation after 2015/2016 but few events addressing both trends
- *Actor configuration:* Overall, mixed coalitions initiate a substantial number of events from early on, while regional changes are also driven by public actors
- *Skills focus:* Most skill-related events occur at the regional level, begin as early as 2007, and are related to the digital transition

Further data collection and analysis could focus on the following:

- *Explore regional dynamics and cross-scale patterns:* What drives the surge of regional events between 2013 and 2021, and how do national–regional dynamics interact?
- *Examine the lack of twin-transition related events:* Notable is the lack of events which jointly address digitalisation and greening, which calls for a closer examination of interdependencies and barriers for integration.

- *Explore actor roles and related events:* What roles do mixed coalitions play in early phases, and how do the events they initiative differ from those driven by public actors at the regional level?
- *Analyse regional anchoring and digital focus of skills-initiatives:* Why have skills-related initiatives been predominantly regionally anchored since 2007, and why are they predominantly oriented towards the digital transition?

3.2.2 Northwestern Switzerland (FHNW)

Delineation of the case:

This case examines trimodal freight transport in Northwestern Switzerland (NUTS 2: CH03), within the federal context of Switzerland (NUTS 1: CH0) and the cantons Basel-Stadt (CH031), Basel-Landschaft (CH032) and Aargau (CH033). A narrower sector definition is adopted here that focuses on freight logistics across rail, road and inland waterways, excluding passenger transport. This scope reflects the region's unique trimodal infrastructure. Furthermore, the assumption is that skill changes driven by electrification and digitalisation are likely to be transferable across freight and passenger domains. Key economic actors include publicly and privately owned operators and infrastructure managers (e.g., Swiss Federal Railways/SBB Cargo International), logistics companies (e.g., Rhenus Switzerland), and nodal infrastructures such as the Port of Switzerland and EuroAirport. Public actors comprise federal and cantonal authorities (e.g., the Federal Department of Economic Affairs, Education and Research or the canton of Basel-Stadt) and education and research organisations (e.g., the University of Applied Sciences Northwestern Switzerland). Mixed actor coalitions (e.g., Logistik Cluster Region Basel) are channelling lobbying and coordination. Civil society is represented by transport and logistics unions such as SEV or FairLog. The timeframe spans 1994–2025, anchored by the 1994 popular initiative to protect the Alps from transit traffic.

Institutional changes related to greening and digitalisation across multiple spatial scales

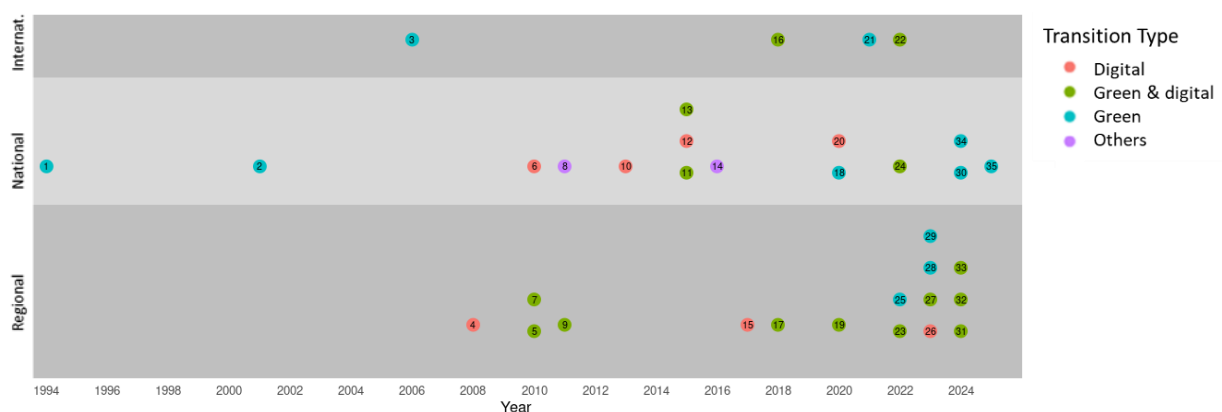


Figure 13: Transition Topology depicting institutional changes related to greening and digitalisation across multiple spatial scales in the transportation sector in Northwestern Switzerland, Switzerland (1994-2025).

Figure 13 depicts institutional changes linked to the two ongoing mega-trends, greening and digitalisation across multiple spatial scales in the freight transportation sector in Northwestern Switzerland. Prior to 2008, events in the sector were infrequent and primarily occurred at the national or international level. From 2008 onwards, changes become more frequent and increasingly occur at the regional level. Between 2012 and 2016, several changes occurred at the

national level, while no regional events were recorded in this period. From 2017 onwards, regional developments resumed, and increased markedly after 2020, alongside events at the national and international levels.

Figure 13 also indicates the macro-level trend to which each event is assigned. Prior to 2008, national and international events are exclusively linked to greening. Notably, regional-level developments begin in 2008, with a focus on digitalisation, and the first events addressing the twin transition at the regional level emerge in 2010. Overall, a substantial number of twin-transition-related events are observed across all scales, particularly in the second half of the timeframe considered.

Evolution of initiatives addressing evolving skill needs and actors across spatial scales

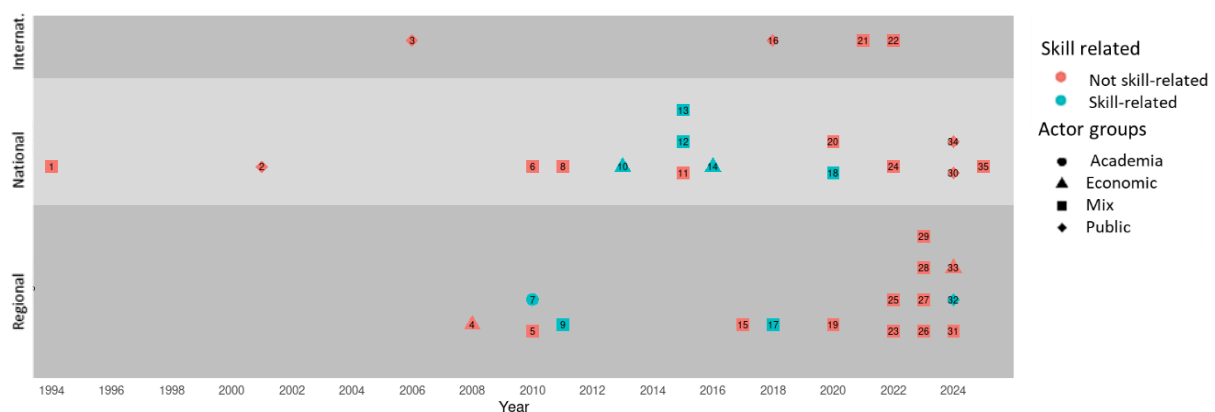


Figure 14: Transition Topology depicting institutional changes related to skill (and non-skill)-related initiatives as well as actor groups across multiple spatial scales in the transportation sector in Northwestern Switzerland, Switzerland (1994-2025).

Figure 14 shows the same institutional change events as Figure 13, but categorizes them by skill-versus non-skill-related initiatives, actor groups, and spatial scales. In terms of actor groups, notably, most events across all spatial levels are initiated by mixed actor constellations. Public actors are primarily involved in national and international events, whereas at the national and regional level, economic actors are slightly more prominent.

The transition topology indicates that skill-related events predominantly occurred between 2010 and 2020. Skill-related events predominantly occur between 2010 and 2020. While non-skill initiatives generally dominate in the freight transport sector, several skill-related events emerge at both national and regional scales. Regionally, the first skill-related events appear in the early 2010s and then again in 2018 and 2024. At the national level, a surge of skill-related events is observable in the period 2012-2016.

Conclusion and outlook

Based on the transition topologies for the transportation sector in Northwestern Switzerland (Figures 13 & 14), the following points summarize the key observations and open questions for further data collection and analysis that can be derived from them:

- **Temporal pattern:** After 2008 changes become more frequent and increasingly appear at the regional level, with an acceleration after 2020
- **Thematic focus:** After an early focus on greening, events related to the twin transition become quite prominent after 2010, alongside events that address either greening or digitalisation alone

- *Actor configuration*: From the beginning, most events are initiated by mixed actor constellations
- *Skills focus*: Skills-related events are concentrated between 2010 and 2020 and occur at both national and regional scales

Further data collection and analysis could focus on the following:

- *Trace cross-scale dynamics*: How do national/international regulations interact with regional developments, and how do they explain the post-2020 acceleration?
- *Analyse sequencing and drivers of digitalisation and greening*: What drivers explain the post-2010 rise of twin-transition events, and how do they relate to the earlier greening-first trajectory?
- *Examine the involvement of actor groups*: The early involvement of mixed actor groups, warrants a more fine-grained investigation into the role and involvement of different actor groups in these initiatives
- *Look into drivers and alignment of skills initiatives*: What drivers explain the 2010-2020 concentration of skills-related initiatives, and how are national initiatives connected to regional events?

3.2.3 Crete (UoC)

Delineation of the case

This case concerns the transportation industry in Crete (NUTS 2, EL43), positioned within the island's regional context and the national and EU and international environment. It focuses on the logistics segment of the industry, covering both marine and ground transportation, reflecting Crete's role as a major tourist destination and logistics hub connecting island and mainland flows. Within this segment, a broad definition is adopted to include freight and passenger logistics, fleet operations, dispatching, and road transport companies, as well as self-employed taxi drivers. The analysis concentrates on economic actors — marine and ground transportation firms and taxi drivers as well as public actors. Civil society actors are not a primary focus in this case. The temporal scope is the last 15 years (approximately 2007–2025), a period marked by EU legislation that increased requirements for digital monitoring and the reduction of CO₂ emissions.

Institutional changes related to greening and digitalisation across multiple spatial scales

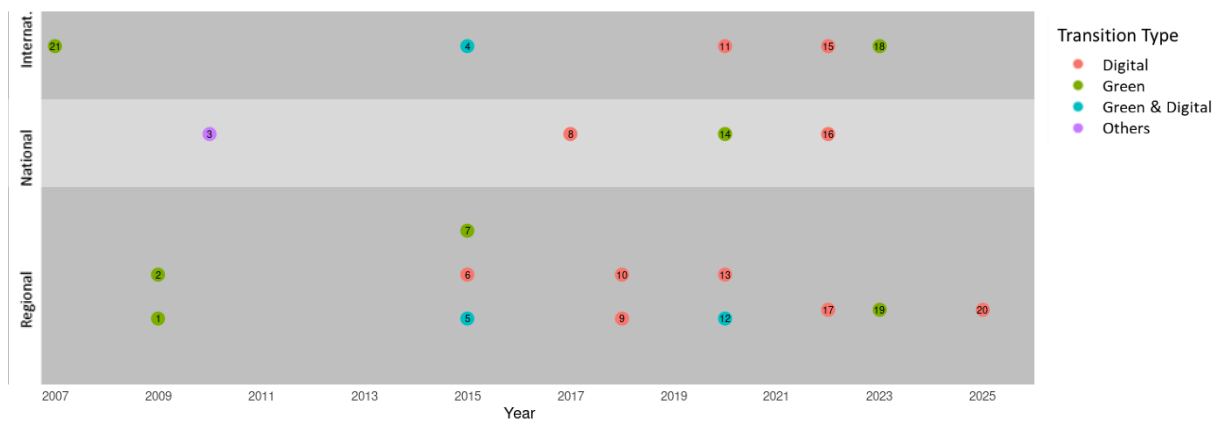


Figure 15: Transition Topology depicting institutional changes related to the greening and digitalisation across multiple spatial scales in the transportation sector in Crete, Greece (2007-2026).

Figure 15 shows institutional developments in Crete's transportation sector from 2007 to the present across various spatial scales in relation to the two continuing mega-trends, digitalisation and greening. In Figure 15 most institutional and organizational changes occur at the regional scale, beginning in 2009 and accelerating after 2015. Changes at other scales are more sparsely distributed and it can be observed that national events frequently occur temporally subsequent to changes at the international level.

Figure 15 also illustrates which of the two macro-level trends each event aligns with. It becomes apparent that early events in the late 2000s primarily targeted the green transition at the regional and international levels. Around 2015 the focus shifts towards digitalisation and the twin transition (i.e., changes combining a digitalisation and greening agenda). For instance, most changes at the regional scale occurring after 2015 are related to the digital or twin transition. Notably after 2017 no national and international events directly address the twin transition.

Evolution of initiatives addressing evolving skill needs and actors across spatial scales

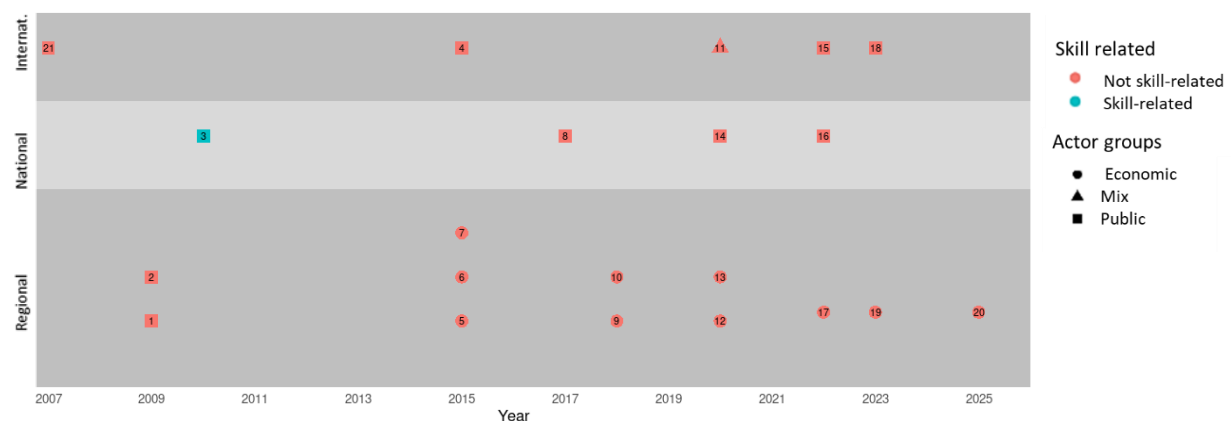


Figure 16: Transition Topology depicting institutional changes related to skill (and non-skill)-related initiatives as well as actor groups across multiple spatial scales in the transportation sector in Crete, Greece (2007-2025).

Figure 16 shows the same institutional change events as Figure 15, yet, categorizes them by skill-versus non-skill-related initiatives, actor groups, and spatial scales. The figure shows that most regional-scale events are led by economic actors, with only two exceptions early in 2009 that were initiated by public actors (events 1 and 2). By contrast, at the national and international scales, changes initiated by public actors predominate, while across all levels mixed actor constellations play only a minor role in the depicted institutional transformation process.

Regarding re- and upskilling, only a single skill-related event appears at the national scale in 2010 (event 3). Notably, this initiative – although identified as relevant for the transformation of the transportation sector in the context of the twin transition in Crete – is not directly linked to this mega-trend or either strand of it (i.e., greening or digitalisation).

Conclusion and outlook

Based on the transition topologies for the transportation sector in Crete (Figures 15 & 16), the following points summarize the key observations and open questions for further data collection and analysis that can be derived from them:

- *Temporal pattern:* Most events occur at the regional scale, with an acceleration of events after 2015
- *Thematic focus:* Early events have a focus on greening, whereas for later events (around 2015) the focus changes towards combining greening and digitalisation agendas
- *Actor configuration:* While regional level events are initiated predominantly by private actors, public actors are main drivers of changes at the national and international level
- *Skills focus:* Currently only one event addressing re- and upskilling demands has been identified in the topology

Further data collection and analysis could focus on the following:

- *Explore micro-dynamics at the regional scale:* Which developments triggered the increase in events at the regional level after 2015
- *Trace cross-scale effects:* The patterns of events detected at the international and national scales call for further investigating the linkages between transition dynamics across scales
- *Analyse emergence of events related to digitalisation and twin transition after 2015:* Are there areas of the sector where digitalisation events tend to occur separately and others where they serve as further drivers of greening?

Yet, given the small number of interviews conducted so far, additional data collection is warranted to critically assess the robustness and validity of the emerging patterns, particularly in this case.

3.3 Tourism Sector

The Tourism Sector is the focus of two case studies by the partners HVL and UoC. The data basis for the results of Task 4.1 of each partner are summarized below (Table 4):

Table 4: Data basis for Task 4.1 in the Tourism Sector

HVL	UoC
7 stakeholder interviews – Private employer/firm (3) – DMO – Employer organisation – Academia – Policy	9 stakeholder interviews – Private employer/firm (2) – Entrepreneur – Academia (2) – VET providers (2)
Document analysis	Document analysis

3.3.1 Vestland (HVL)

Delineation of the case

This case describes the tourism sector in Vestland, Norway. Spatially, the focus is Vestland county (NUTS3 region NO0A2), embedded into national and international level developments. Since tourism spans multiple segments such as transportation, accommodation, restauration, experience providers and travel services, green and digital transitions can play out in diverse ways. A rather broad delineation of the sector is adopted here to capture this diversity. Vestland is one of Norway's most tourism-intensive regions. Yet, because key actors (e.g., the employer/industry association) operate nationally, and the sector is shaped by international institutional changes, national and international levels are included alongside the regional focus. The actor groups identified as relevant (and forming the basis of the data) are economic actors (from large cruise services and hotel chains to small independents and port spin-offs), public actors (Vestland County Authority, DMOs, and ports), education actors (upper secondary schools and HEIs), and mixed actors (e.g., NHO Reiseliv and larger ports like the Port of Bergen). The time frame centers on the period from 1997 to 2025.

Institutional changes related to the greening and digitalisation across multiple spatial scales

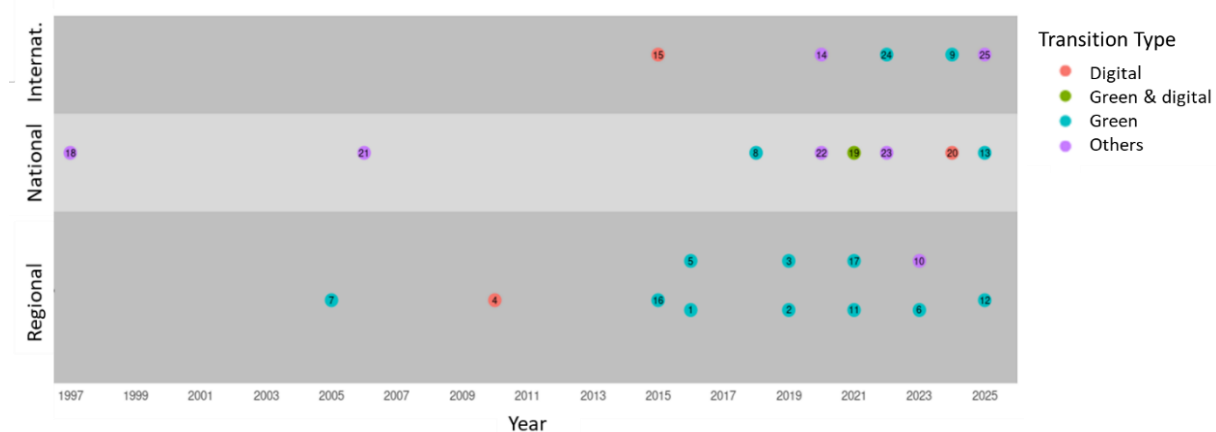


Figure 17: Transition Topology depicting institutional changes related to greening and digitalisation across multiple spatial scales in the tourism sector in Vestland, Norway (1997-2025).

Figure 17 depicts all important institutional and organisational changes related to the greening and/or digitalisation that had an impact on the tourism sector in Vestland across the three spatial scales defined above. First, it shows how the events are distributed across time and space. While there are a few events at the national and regional levels between 1997 and 2015, most changes occur after 2015. In particular, there is a large number of events taking place at the regional level.

Figure 17 also shows which of the two macro-level trends each event is assigned to. It indicates that most changes are related to the green transition. Few changes are linked to the digital transition or the so-called twin transition. There is only one event at the national level which aligns green transition goals with digital technologies in 2021 (see event 19), and three linked specifically to the digital transition (see events 4, 15, 20).

Evolution of initiatives addressing evolving skill needs and actors across spatial scales

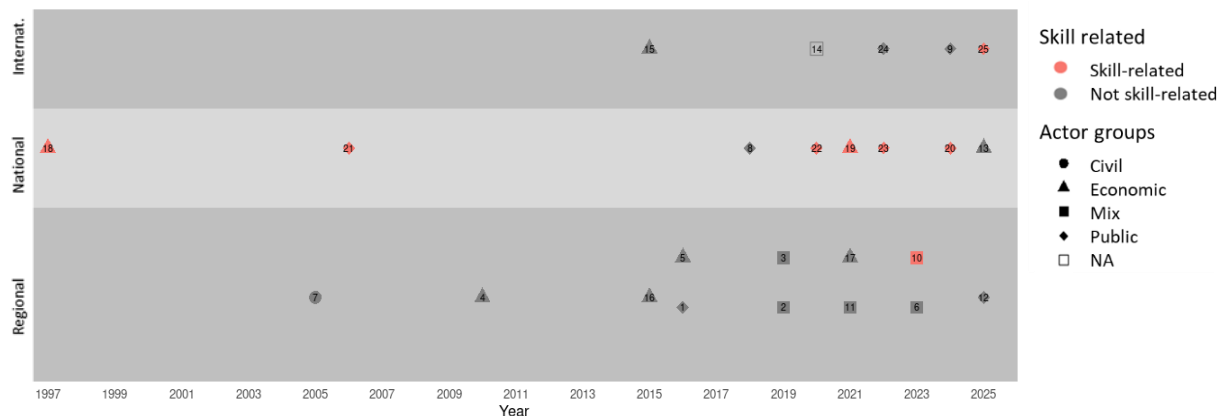


Figure 18: Transition Topology depicting institutional changes related to skill (and non-skill)-related initiatives as well as actor groups across multiple spatial scales in the tourism sector in Vestland, Norway (1997-2025).

Figure 18 shows the same institutional change events across the three spatial levels as Figure 17 yet, categorizes them by skill versus non-skill-related initiatives as well as actor groups.

As for the actor groups, economic actors are the primary drivers of institutional and organisational changes early on at the regional level. From 2019 onward, mixed actors become more prominent. Notably, no events are associated solely with education actors. Overall, there are relatively few skill-related initiatives, and most of them occur at the national level (see events 18-23). Some happen relatively early (1997 and 2005), but several appear only after 2019. At the regional level, there is only one skill related initiative in 2023 (event 10).

In addition, Figure 18 indicates that initiatives addressing evolving skill needs involve a diverse set of actors spanning economic, public, and mixed actor groups. At the national and international levels, public actors primarily drive these initiatives (see events 20-23). Again, education actors do not appear as sole actors in these initiatives.

Conclusion and outlook

Based on the transition topologies for the tourism sector in Vestland (Figures 17 & 18), the following points summarize the key observations and open questions for further data collection and analysis:

- *Temporal pattern:* Most mapped changes across all three spatial levels occur after 2015.
- *Thematic focus:* The green transition dominates in particular at the regional level, while digital and twin transition related changes are comparatively sparse.
- *Actor configuration:* Regional dynamics shift from predominantly economic actors to mixed actors after 2019. Academic actors do not appear as sole initiators.
- *Skills focus:* Skill-related initiatives are few and are concentrated at the national level, largely driven by public actors.

Further data collection and analysis could focus on the following:

- *Explore cross-scale dynamics:* The accumulation of regional greening-related events after 2015 indicates cross-scale dynamics, warranting closer analysis of international-to-regional linkages in transition dynamics.
- *Analyse drivers of skill-related events:* Why do the visible skill initiatives cluster mostly at the national level and how are they connected to what happens within the region?
- *Explore actor roles:* What explains the absence of education actors as sole initiators of events and are they maybe more present as partners in mixed configurations?

- Do digital and twin transition developments occur more continuously (and thus appear less as discrete events), or are they genuinely less frequent in this case?

However, given the relatively small number of events identified and interviews conducted for this case, the robustness of the emerging patterns remains subject to further analysis. While this limitation can partly be attributed to the high fragmentation of the tourism sector in Vestland, a robust qualitative underpinning to contextualise the findings is necessary.

3.3.2 Crete (UoC)

Delineation of the case

This case examines the tourism sector in Crete (NUTS 2, EL43). Crete is a mainly rural major tourism destination. The case delineation adopts a broad perspective that includes core services and supporting activities, as well as education and research linked to workforce reskilling and upskilling. Key economic actors are training and education providers such as the Lifelong Learning Center and the European Sustainability Academy. Public actors include tourism-focused researchers, the Crete Development Organisation (OAK), which manages roads and water supply, and the Intermunicipal Solid Waste Management Company (DEDISA). At the current stage formal civil society were not identified in the mapping. The time frame centers on the period from approximately from 2000 to 2025, focusing on the rapid expansion of tourism and the evolving skill demands in relation to greening and digitalisation.

Institutional changes related to the greening and digitalisation across multiple spatial scales



Figure 19: Transition Topology depicting institutional changes related to greening and digitalisation across multiple spatial scales in the tourism sector in Crete, Greece (2003-2025).

Figure 19 depicts institutional changes related to the two ongoing mega-trends, greening and digitalisation from 2003 to the present across multiple spatial scales in the tourism sector in Crete. It becomes visible that the majority of events take place at the regional level. The earliest events take place at the regional scale between 2003 and 2007 (see event 1, 2, 3), with multiple events mapped in 2010, 2015 and between 2021 and 2023. At the international level, key events cluster around 2009, 2019 and 2022. National events are less frequent, with 2010/2011 and 2022 emerging as important dates. Across scales, there is a noticeable gap in events between 2016 and 2018.

Figure 19 further illustrates which of the two macro-level trends each event is assigned to. Most changes concern the green transition across all spatial scales. Around 2010, early events at the regional and international scale are linked to digitalisation and the twin transition, i.e., both trends simultaneously (events 5, 6, 8, 10, 11). While events less frequently address these trends during the 2010s, after 2021 events increasingly address the twin transition, particularly regionally.

Evolution of initiatives addressing evolving skill needs and actors across spatial scales



Figure 20: Transition Topology depicting institutional changes related to skill (and non-skill)-related initiatives as well as actor groups across multiple spatial scales in the tourism sector in Crete, Greece (2003-2025).

Figure 20 shows the same institutional change events as Figure 1, yet, categorizes them by skill-versus non-skill-related initiatives, actor groups, and spatial scales. As for the actor groups, at the regional level most early events are initiated by economic actors, whereas after 2021 the focus shifts toward public actors driving changes. Mixed actor coalitions appear around 2010 and 2015 but are not prominent at the regional scale. At the international and national scales, mixed actor groups are more prominent in initiating events.

In Figure 20 it becomes apparent that most skill-related events take place at the regional scale. Initial skill-related green and digital events focusing on up- and reskilling emerge at the regional scale already around 2010 (see event 5, 8 and 11). Around 2015 another accumulation of skill-related events is observable at the regional scale. After 2020 skill-related events become more frequent at the regional level, in parallel with skill-related events also emerging at the national level. Early skill-related events are mostly initiated by economic actors or mixed actor-groups, while public actors play a more prominent role in the 2020s.

Conclusion and outlook

Based on the transition topologies for the tourism sector in Crete (Figures 19 & 20), the following points summarize the key observations and open questions for further data collection and analysis:

- *Temporal pattern:* Events occur continuously at the regional scale since the early 2000s, with a surge of events across scales after 2020
- *Thematic Focus:* Most early changes are linked to the green transition, events related to the twin transition emerge around 2010 and accelerate after 2021
- *Actor configuration:* At the regional level, early changes are initiated by economic actors, with public actors increasingly driving change after 2020

- *Skills focus*: Events related to re- and upskilling emerge around 2010 at the regional level and become more frequent since 2020

Further data collection and analysis could focus on the following:

- *Investigate regional dynamics and cross-scale patterns*: What explains the increase in regional events after 2020 and how do national/international regulations interact with regional dynamics?
- *Explain regional continuity*: Identify the micro-dynamics that sustain the ongoing sequence of institutional and organisational changes at the regional level. Given the prominence of economic and public actors, further analysis should zoom in on the roles these actors have played in this process.
- *Examine actor roles*: The limited involvement of mixed actor groups at the regional scale warrants in-depth analysis of what has hindered collaboration between actor groups.
- *Analyse co-emergence of digitalisation and skilling*: Do the parallel increases in twin transition- and skills-related events after 2020 suggest interdependencies and shared drivers?

3.4 Energy Sector

The Energy Sector is the focus of three case studies by the partners HVL, UU and UW. The data basis for the results of Task 4.1 of each partner are summarized below (Table 5):

Table 5: Data basis for Task 4.1 in the Energy Sector

HVL	UU	UW
16 stakeholder interviews - Academia (6) - Firm (5) - Public authority (3)	0 stakeholder interviews	12 stakeholder interviews
Document analysis	In-depth Document analysis	Document analysis

3.4.1 Vestland (HVL)

Delineation of the case

This case describes the energy sector in Vestland, Norway. Spatially, the focus is Vestland county (NUTS3 region NO0A2), embedded into national and international level developments. The energy sector is deliberately delineated broadly here to encompass both energy production and infrastructure, including the power grid and trading, CCS and hydrogen projects, offshore wind, and the digital services that underpin these activities. Relevant actors who are shaping the transformation of the energy sector in Vestland, include: Economic actors, encompassing electricity producers and traders, digital service providers, and firms and suppliers in the oil and gas industry, such as Equinor, BP, and Shell. In CCS and hydrogen, both O&G companies and clusters like CCUS Norge play prominent roles. On the public side, grid providers and several regional and national authorities as well as funding agencies shape development through regulation, funding, and infrastructure investments. From civil society, the Bellona Foundation acts as a catalyst for climate-related innovation. In addition, mixed, often public-private constellations connect market actors, policy, and technology development, acting as intermediaries across these spheres. The time frame focuses on the last 25 years.

Institutional changes related to the greening and digitalisation across multiple spatial scales

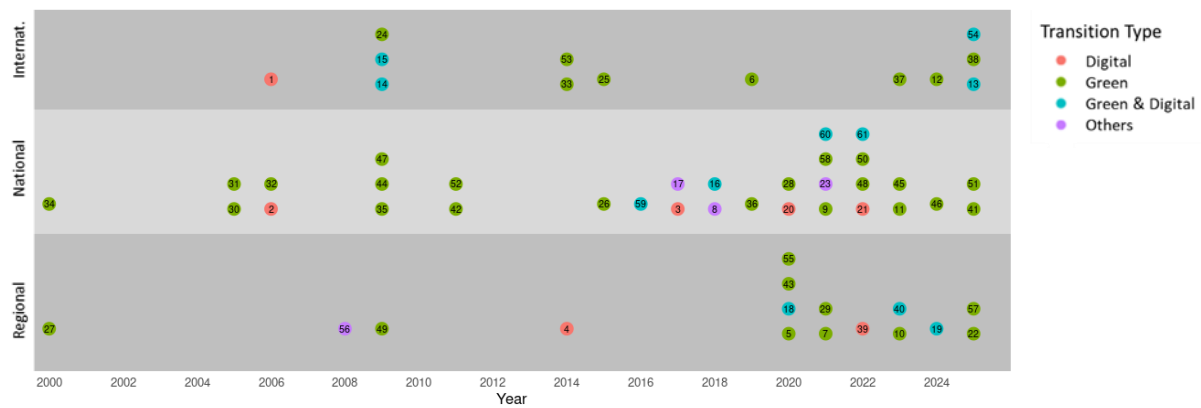


Figure 21: Transition Topology depicting institutional changes related to greening and digitalisation across multiple spatial scales in the energy sector in Vestland, Norway (2000-2025).

Figure 21 depicts institutional changes related to the two ongoing mega-trends, greening and digitalisation from 2000 to the present across multiple spatial scales in the energy industry in Vestland. It becomes visible that the majority of events that had an impact on the energy sector in Vestland occurred at the national level. Additionally, most events between 2000 and 2019 are identified at the national and international level. Regionally there are few events mapped before 2019, with an increase of events after 2020. This surge of regional events is accompanied by an accumulation of events at the national scale. Internationally, time periods with clusters of events occur in 2009, 2014 and 2025.

Figure 21 also shows which of the two macro-level trends each event is assigned to. It shows that most changes are related to the green transition. While early events related to the digital and twin transition can be found in the late 2000s, events related to the digital transition become more common after 2014/2016. In the region most events are linked to the green transition, with fewer events related to the twin or digital transition.

Evolution of initiatives addressing evolving skill needs and actors across spatial scales

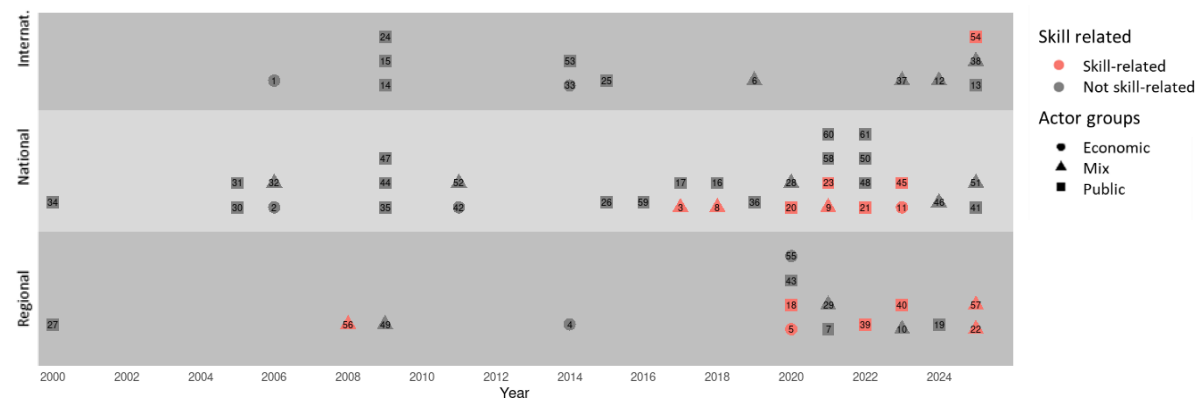


Figure 22: Transition Topology depicting institutional changes related to skill (and non-skill)-related initiatives as well as actor groups across multiple spatial scales in the energy sector in Vestland, Norway (2000-2025).

Figure 22 includes the same institutional change events as Figure 21, but categorizes them by type (skill vs. non-skill), actor group, and spatial scale. In Figure 22 it becomes visible that a substantial number of events is initiated by public actors across all spatial scales. Mixed actor coalitions become more frequent around 2017. Overall, economic actors more seldomly appear to initiate changes.

Events are coded as skill-related if they address demands for re- and upskilling. Most early events do not have an explicit skill focus. The majority of skills-related events take place at the national level, with a smaller number occurring at the regional level. Skill-related initiatives become more frequent only after 2020 and are predominantly initiated by economic and mixed actor groups.

Conclusion and outlook

Based on the transition topologies for the energy sector in Vestland (Figures 21 & 22), the following points summarize the key observations and open questions for further data collection and analysis:

- *Temporal pattern:* Before 2019, changes occur mainly at national and international scales; regional events surge after 2020 alongside a national accumulation
- *Thematic Focus:* Events are characterized by a focus on green transition, with events related to digitalisation and the twin transition increasing after 2016
- *Actor configuration:* Public actors initiate the majority of events across scales, while a shift towards more mixed actor coalitions is notable after 2017
- *Skills focus:* Events related to re- and upskilling increase after 2020, particularly at the regional and national level

Further data collection and analysis could focus on the following:

- *Explore regional dynamics and cross-scale patterns:* The increase of changes at the regional level after 2020, calls for further investigating the linkages between cross-scale dynamics.
- *Trace different pathways:* Does the analysis of different technology pathways (CCS, Hydrogen) reveal additional patterns between transition dynamics across scales?
- *Examine the involvement of actor groups:* Focus on the surge of mixed actor constellations after 2017, in particular what triggered and enabled more intensive cooperation.
- *Analyse temporal patterns:* What caused the gap of events between 2011 and 2016 in at the national scale?

3.4.2 Groot-Rijnmond

Delineation of the case

This case examines the energy sector in Rijnmond, the Netherlands. Spatially, the focus is on the NUTS 3 region Groot-Rijnmond (NL366), which includes the municipality of Rotterdam and the port of Rotterdam. The case is embedded into the province of South Holland (NL36) and the national context. The sectoral delineation is broad in this case, covering resources critical to the development and deployment of clean energy technologies, as well as on the enabling technologies that facilitate the energy transition, such as carbon capture and storage and digital technologies. The relevant actor groups include economic actors involved in production, processing, logistics and innovation across the energy sector (e.g. RWE, Shell, ExxonMobile) and public actors responsible for policies, regulation, funding, labour market measures and knowledge development. While civil-society actors are not out of scope, they have not been identified at this stage of the mapping. The time frame centres on the period from 2001 to 2025.

Institutional changes related to the greening and digitalisation across multiple spatial scales

Figure 23 depicts key institutional and organisational changes related to the greening and digitalisation that had an impact on the energy sector in Groot-Rijnmond across the aforementioned spatial scales. First, the figure shows how these events are distributed across time and space. The earliest events occur at the national scale, beginning in 2001, followed by few events in the period between 2011 and 2013. Institutional changes at the state level emerge around 2014 and occur continuously afterwards. Around 2016 first events take place at the regional scale, with a notable co-occurrence of events in 2021.

Evolution of initiatives addressing evolving skill needs and actors across spatial scales

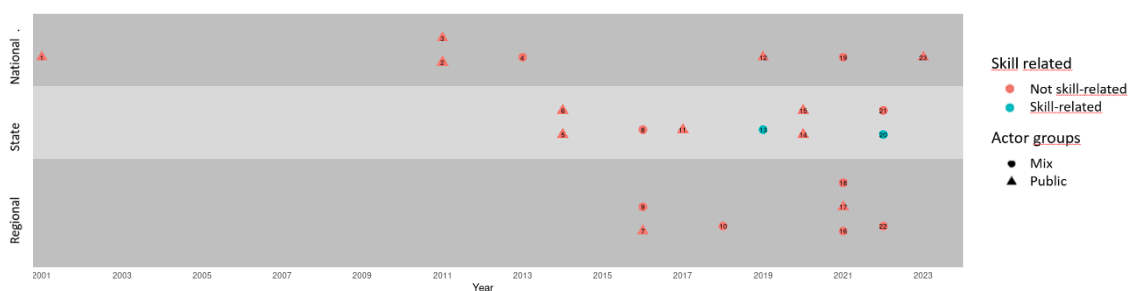


Figure 24 shows the same institutional change events across the three spatial levels as Figure 23, but categorises them by skill versus non-skill-related initiatives as well as actor groups. With respect to actor groups, early events at both the national and state level are initiated by public actors. However, mixed actor coalitions driving changes jointly appear early across all spatial scales. Overall, initiatives led by public actors and those driven by mixed actors alternate across the three spatial levels.

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Conclusion and outlook

Based on the transition topologies for the energy sector in Groot-Rijnmond (Figures 23 & 24), the following points summarize the key observations and open questions for further data collection and analysis:

- *Temporal pattern*: momentum builds from 2011 onwards, with continuous changes at the state level from 2014 and regional changes setting in in 2016
- *Thematic focus*: Early events focus on the green transition, while events linking greening and digitalisation already emerge around 2013
- *Actor configuration*: Many early changes are initiated by public actors, but mixed actor coalitions emerge relatively early in 2013
- *Skills focus*: Skill-related initiatives are few and are concentrated at the state level

Further data collection and analysis could focus on the following:

- *Trace cross-scale dynamics*: The temporal patterns observed might indicate top-down diffusion, calling for an analysis into the linkages between changes at different scales
- *Identify international influences*: To what extent have international developments, which are currently not depicted in the topology, influenced regional events?
- *Evaluate the limited skill focus*: Determine whether the scarcity of skills-related events signals a skills mismatch or reflects qualification processes not yet captured in the topology
- *Analyse actor roles*: Why are there no changes driven primarily by economic actors or civil society initiatives depicted in the topology?

As the current data collection relied primarily on documents, additional data collection in the form of interviews is needed to refine the selection of relevant events and contextualize the emerging patterns that become visible in the topologies. In addition, they might enable to capture key international events which have influenced the regional transition.

3.4.3 Łódzkie (UW)

Delineation of the case

This case examines the energy sector in Łódzkie (NUTS 2: PL71), with a local focus on Bełchatów, where coal phase-out impacts are most acute. The sector is defined broadly to encompass both how the green and digital transitions, including the end of lignite extraction from the open-cast mine and the progressive phase-out of the coal-fired power plant, new activities in renewables (RES), hydrogen and energy efficiency, and related services such as smart-grid digitalisation, cybersecurity, advisory and energy audits, drive shifts in competencies (e.g., from miner to RES installer or automation specialist). Key economic actors in this process include conventional companies (such as PGE Mining and Conventional Energy), as well as firms implementing PV and heat pumps, and technology providers offering smart-grid and cybersecurity solutions. Public actors comprise the Marshal's Office of the Łódź Voivodeship, Bełchatów District authorities, labour offices, universities and vocational schools. Civil society actors include trade unions of miners and energy workers, environmental NGOs and associations supporting reskilling. The chosen timeframe for this case is approximately 2004–2025, aligned with intensified EU climate policy and employment restructuring away from coal.

Institutional changes related to greening and digitalisation across multiple spatial scales

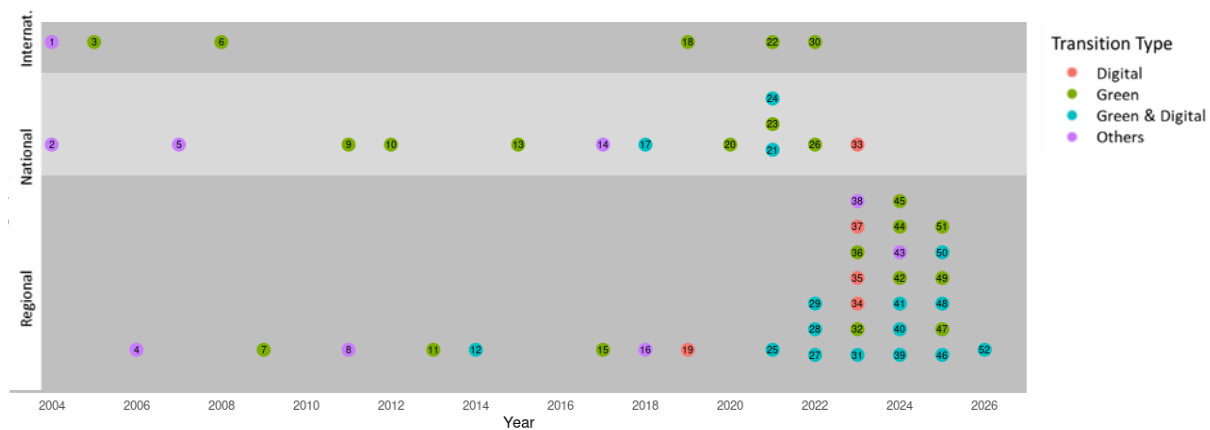


Figure 25: Transition Topology depicting institutional changes related to greening and digitalisation across multiple spatial scales in the energy sector in Łódzkie, Poland (2004-2025).

Figure 25 depicts institutional changes linked to the two ongoing mega-trends, greening and digitalisation across multiple spatial scales in the energy sector in Łódzkie. Between 2000 and 2020, key events unfolded in parallel at the international, national and regional levels, reflecting a multi-level governance dynamic. At the regional level, events occurred in a scattered but continuous manner from 2006 to 2020, followed by a surge after 2022. Nationally, changes were continuous from 2004 to 2020, with a minor cluster of events around 2021. At the international level, fewer events were identified as relevant for the regional transition, concentrated in 2004–2008 and 2019–2022. Notably, no relevant events were identified at either the international or national scale after 2023.

Figure 25 also shows which of the two macro-level trends each event is assigned to. It demonstrates that most developments are associated with the green transition, especially at the international level. Digital and twin-transition events (combining greening and digitalisation) first appear in 2014 and 2018, respectively. At the regional level, changes increasingly relate to the twin transition after 2021, alongside events which primarily relate to the green transition.

Evolution of initiatives addressing evolving skill needs and actors across spatial scales

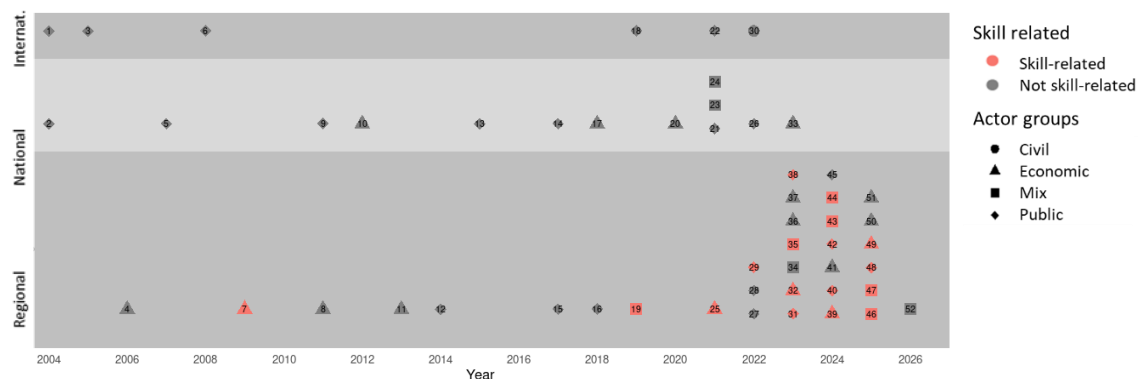


Figure 26: Transition Topology depicting institutional changes related to skill (and non-skill)-related initiatives as well as actor groups across multiple spatial scales in the energy sector in Łódzkie, Poland (2004-2025).

Figure 26 shows the same institutional change events as Figure 25, yet, categorizes them by skill-versus non-skill-related initiatives, actor groups, and spatial scales. In Figure 26 it becomes visible that most international events are initiated by public actors. Similarly, the national level is characterized by events led by public and economic actors, with an exception in 2021 when mixed actors initiated two events (events 23 and 24). At the regional scale, early changes are

initiated by economic actors, however after 2014 public actors also begin to initiate events. From 2022 onward, the landscape becomes more diverse as mixed actor groups initiate events.

The figure further illustrates that skill-related events relevant to the region occur only at the regional scale. An early skill-related event appears at the regional scale in 2009 (event 7). A marked increase in such initiatives can be observed after 2021, from which point the majority of regional events address re- and upskilling aspects. These skill-related initiatives are initiated by public and economic actors, with mixed actor groups also playing a role.

Conclusion and outlook

Based on the transition topologies for the energy sector in Łódzkie (Figures 25 & 26), the following points summarize the key observations and open questions for further data collection and analysis:

- *Temporal pattern:* Parallel developments across scales before 2021, afterwards concentration of events at the regional scale.
- *Thematic Focus:* Events are overall characterized by an early focus on the green transition, with an increasing focus towards the twin transition after 2021, in particular at the regional level
- *Actor configuration:* Early on changes are initiated by both public and economic actors, with more mixed coalitions emerging after 2021 at the national and regional levels
- *Skills focus:* Events related to re- and upskilling occur only regionally and especially after 2021

Further data collection and analysis could focus on the following:

- *Explore the clustering of regional events after 2021:* The post-2021 surge in regional events warrants closer examination of its triggers and the possible role of cross-scale dynamics (noting the sequences of events that already become visible at the regional and national levels beforehand).
- *Analyse co-emergence of digitalisation and skilling:* With the regional shift toward the twin transition after 2021 and skills initiatives occurring only regionally (surging post-2021), the simultaneous rise warrants a closer examination of potential interdependencies and shared drivers.
- *Investigate actor roles:* What mechanisms triggered and enabled the rise of mixed actor coalitions at the regional level from 2022 onward?
- *Look into re- and upskilling initiatives:* Why have skills-related initiatives emerged predominantly regionally, and what is the role of different actor constellations in them?

3.5 Agriculture Sector

The Agriculture Sector is the focus of two case studies by the partners BOKU and LSE. The data basis for the results of Task 4.1 of each partner are summarized below (Table 6):

Table 6: Data basis for Task 4.1 in the Agriculture Sector

BOKU	LSE
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Figure 28: Transition Topology depicting institutional changes related to skill (and non-skill)-related initiatives as well as actor groups across multiple spatial scales in the agriculture sector in Styria, Austria (1988-2024).

Figure 28 illustrates the same events as Figure 27, yet, differentiated by skill-focus (skill- versus non-skill-related initiatives) as well as by the actor groups linked to these changes. With regards to the actor groups, the topology shows that across the entire observation period, economic actors and mixed actor constellations play a central role in driving organisational and institutional change. Public actors become more prominent after 2022, predominantly at the national scale. Civil society actors appear only once, initiating a single event at the national scale.

Skill-related initiatives become more visible from 2015 onwards, despite some early changes in skilling efforts illustrated in Figure 28 (see event 1, 3, 4). These events related to re- and upskilling take place mainly at the national level, with some events also occurring at the regional level. While events cluster after 2022 at the national level, those changes do not predominantly address re- and upskilling.

Conclusion and outlook

Based on the transition topologies for the agricultural sector in Styria (Figures 27 & 28), the following points summarize the key observations and open questions for further data collection and analysis:

- *Temporal pattern:* Most changes take place continuously at the regional and national scale from the early 2010s, with a cluster of events at the national scale after 2022
- *Thematic Focus:* Events related to digitalisation appear early, beginning in the late 1980s, while green transition dynamics become more visible after the mid-2000s and intensify significantly after 2020.
- *Actor configuration:* Regional transition events are primarily driven by economic and mixed actor groups, with public actors becoming more prominent in later stages
- *Skills focus:* Skill-focused initiatives are concentrated at the national level between 2015 and 2020, with fewer appearing at the regional level.

Further data collection and analysis could focus on the following:

- *Understand regional innovation dynamics:* Further analysis could examine how regional actors and interactions across scales contribute to the continuous emergence of organisational and institutional changes at the regional scale.
- *Trace cross-scale patterns:* How have international events influenced institutional and organizational changes at other scales?
- *Exploring the interaction between digitalisation and greening:* Given that digitalisation-related events precede greening initiatives, further analysis could investigate greening events are connected to earlier digitalisation initiatives.

3.5.2 Nord-Est Region (LSE)

Delineation of the case

This case examines the agricultural sector in the Nord-Est region, Romania. Spatially, the focus is on the Nord-Est region (NUTS 2: RO21), with a county-level focus on Iași (NUTS 3: RO213). The regional developments are embedded into national and international policy context. A narrow sector definition on arable crop production (cereals and oilseeds) on large commercial farms is adopted. The actor groups underpinning the analysis include economic actors (e.g., commercial crop farms, agricultural cooperatives, input suppliers, machinery providers), public actors (e.g., MADR, APIA, county councils and municipalities), education and research actors (universities and research institutes). Furthermore, civil society actors such as farmer associations, rural development NGOs, and LAGs, as well as mixed actor coalitions are influencing transition dynamics. The timeframe spans approximately 2000–2025, marked by Romania's EU accession and CAP integration (2007), successive tech adoption and shocks from COVID-19 (2020) and the war on Ukraine (from 2022) that disrupted costs, supply chains, and markets.

Institutional changes related to greening and digitalisation across multiple spatial scales

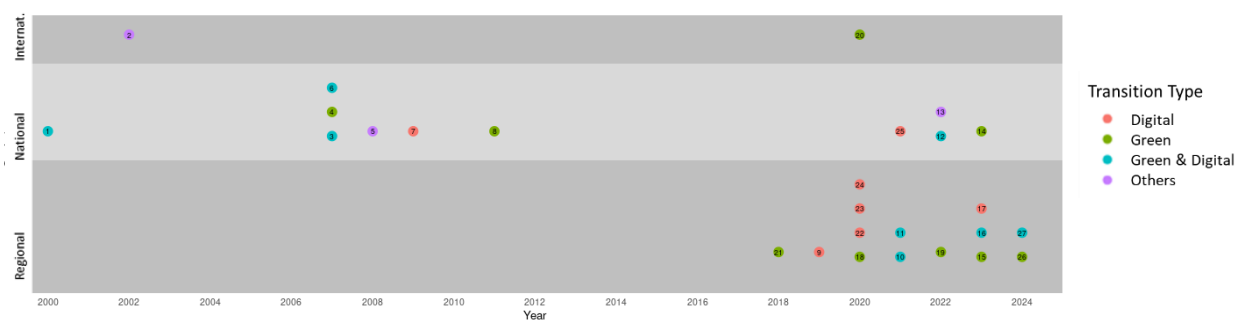


Figure 29: Transition topology depicting institutional and organizational changes related to greening and digitalisation across multiple spatial scales in the agricultural sector in the Nord-Est region, Romania (2000-2024).

Figure 29 shows the temporal development of the institutional transformation process in Styria related to two ongoing mega-trends, greening and digitalisation, from 2000 to the present. While few events take place before 2006, in 2006, three national events occur followed by infrequent changes between 2008 and 2012. Overall, there is a gap of events between 2012 and 2018 visible in the topology. From 2018 onward, the first events appear at the regional level, with a concentration of events in 2020 and continuous changes thereafter. At the national level, a small number of events takes place between 2021 and 2023. Only two events are recorded at the international scale, in 2002 and 2020.

Figure 29 further illustrates which of the two macro-level trends each event is assigned to. Early institutional changes address the green transition as well as the twin transition, i.e., both trends simultaneously. After 2020, an increasing share of events is primarily linked to digitalisation. At the regional scale, events are evenly linked to the green, digital and twin transition.

Evolution of initiatives addressing evolving skill needs and actors across spatial scales

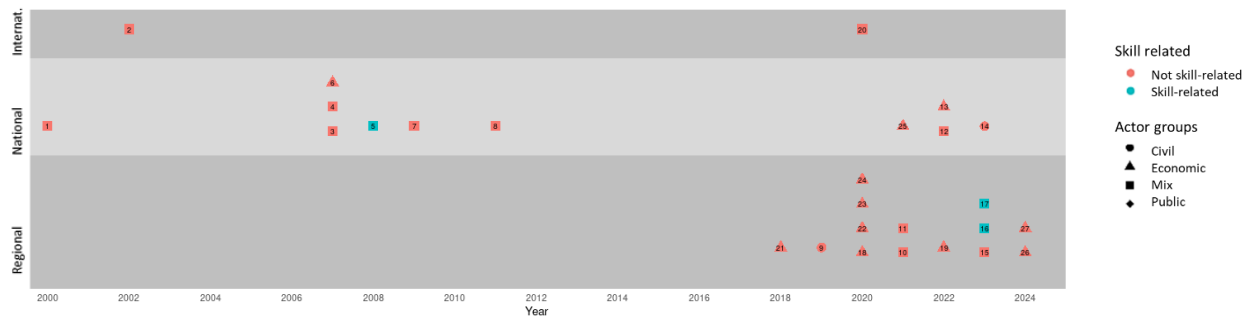


Figure 30: Transition Topology depicting institutional changes related to skill (and non-skill)-related initiatives as well as actor groups across multiple spatial scales in the agriculture sector in the Nord-Est region, Romania (2000-2024).

Figure 30 shows the same institutional change events as Figure 1, yet, categorizes them by skill-versus non-skill-related initiatives, actor groups, and spatial scales. As for the actor groups, at the regional scale the majority of events are initiated by public actors as well as mixed actor constellations. At the national and international level public actors predominate, with fewer events initiated by mixed actor groups at the national level.

Figure 30 further indicates that only three events are related to re- and upskilling. One early skill-related event (see event 5) takes place in 2008 at the national level. Regionally two skill-related initiative occur in 2023 (event 17 and event 16).

Conclusion and outlook

Based on the transition topologies for the agricultural sector in Romania (Figures 29 & 30), the following points summarize the key observations and open questions for further data collection and analysis:

- *Temporal pattern:* Events occur sporadically between 2008 and 2012 at the national scale, followed by a gap from 2012 to 2018, while first regional events appear after 2018
- *Thematic Focus:* Early changes relate to the green and twin transition, after 2020 events increasingly address digitalisation alone
- *Actor configuration:* At the regional level, changes are initiated by public and mixed actor groups, while at the national scale public actors are the main initiators
- *Skills focus:* Only three events related to re- and upskilling are identified in the transition topology

Further data collection and analysis could focus on the following:

- *Investigate cross-scale patterns:* Which specific changes at the national or international level explain the emergence of regional events after 2018?
- *Examine temporal patterns:* What caused the gap of events between 2012 and 2016?
- *Analyse actor roles:* The limited involvement of economic actors merits an in-depth analysis of their involvement in coalitions of actor groups.
- *Assess limited skill-related events:* Does the lack of skill-related events indicate a skills mismatch or are the alternative qualification mechanisms present which are not yet captured in the topology?

4 Conclusions

This section presents some initial interpretations of the findings across cases. Commonalities and differences are discussed along several dimensions, and some preliminary observations regarding sector-specific patterns are highlighted. In addition, the section addresses limitations, primarily resulting from data gaps, and outlines the next steps.

4.1 Main results

Deliverable D4.1 presents the data basis for as well as initial results of WP4, which analyses the institutional change processes associated with the twin transition and regional labour market transformations. The deliverable outlined the conceptual and methodological approach for mapping and analysing the institutional context of regional labour markets shaped by twin transition related macro drivers. Using the transition topology approach, Task 4.1 aims to capture the dynamics of change by mapping key events of organizational and institutional change over time that are perceived as relevant by regional actors. Building on this framework, the report detailed the research design and its implementation, explaining how the transition topologies were jointly developed with the project partners. Each case study partner collected the required data, which BOKU integrated into a common database and subsequently visualised as transition topologies.

This report presented the initial results from the transition topologies mapping institutional change processes in the 13 case studies in five sectors. These transition topologies identify key institutional and organizational changes over the past 15-20 years categorized by transition type, actor group and their linkages to re- and upskilling. The accompanying case narratives describe initial patterns and observations along those categorizations. For the case studies, the transition topologies provide preliminary indications of the interlinkages between institutional change processes of greening and digitalisation.

4.2 Interpretation

While the results of the transition topologies are still preliminary, some initial observations can be derived. General patterns across all cases are presented first, followed by observations on sector-specific differences. A more detailed analysis will follow in Deliverable 4.2.

Commonalities and differences across the cases can be observed along the following dimensions:

Sequencing of greening and digitalisation events

One dimension relates to the temporal sequencing of events concerning sustainability and digitalization. From a twin transition perspective, these events would be expected to occur in close temporal proximity or even be addressed within the same event. The majority of transition topologies show a focus on greening in the early phases of the timeframe depicted, with events linked to the digital or twin transition appearing only later. In many cases events addressing digitalisation emerged between 2015-2020, with some exceptions. While in some cases digitalisation and greening are combined relatively early on, other transition topologies illustrate few events related to the twin transition at all. This raises questions about the extent to which the expected synergies between these two trends can be leveraged at the regional level and what may be constraining their realization.

Dynamics across scales

Another dimension concerns dynamics that do not emerge on a single spatial level but are instead connected across different spatial scales. Some of these cross-scale developments are relatively easy to explain. For instance, across all case studies and spatial levels, we observe a clustering of events during the COVID-19 pandemic, particularly from 2020 onwards. However, many topologies also show an increasing concentration of events already after 2015. Explaining these patterns requires further in-depth analysis of cross-scale dynamics and contextual factors.

Involvement of key actor groups

A further dimension relates to the configuration of key actor groups that drive these developments. The more diverse these groups are, the more likely it is that these developments generate impacts across a wider range of domains. In contrast, more homogeneous actor groups would rather indicate more isolated impacts.

Across the cases, actor group involvement follows distinct patterns. In several cases, early institutional change is driven predominantly by a single actor group (either economic actors or public authorities). Subsequently, in these cases, there is a shift towards mixed actor coalitions in the later phases of the timeframe depicted. In other cases, mixed actor groups initiate changes from the onset, as e.g., observed in the food sector in Vulkanland and the transport sector in Vestland and Northwestern Switzerland. In contrast, mixed-actor initiatives are comparatively rare in Crete's transport sector. These observed patterns point to the need for further analysis to examine the conditions enabling the emergence of mixed-actor coalitions, the specific compositions of those cooperations, and to assess their roles within the observed transition trajectories.

Development of skill-related events

Another dimension captures the extent to which skill-related events are linked to other forms of institutional and organizational change and the spatial levels at which these processes unfold. First, the number of skill-related events can be seen as an indicator of institutional change in the labour market. Second, this change can be expected to be more sustainable when skill-related events coincide with other forms of institutional and organizational change.

While some transition topologies map several skill-related initiatives, in other transition topologies non, or only few events associated to re- and upskilling are observable. When skill-related initiatives are observed they tend to emerge at the regional level. Another notable observation is that skill-related events and digitalisation co-emergence in some transition topologies. This observation raises the question of potential common drivers or interconnections between these developments. However, answering this question more comprehensively requires triangulation with labour market data.

Furthermore, some early observations can be derived regarding sector-specific differences:

Externally vs. locally driven transition dynamics

One dimension here concerns the extent to which organizational and institutional change is driven by regional actors, or whether regions merely adopt developments originating at higher governance levels, such as the national level. The capacity of regions to autonomously adapt to such changes constitutes an important indicator of resilience.

In some sectors international developments appear to be particularly important for regional transition dynamics, while the topologies for other sectors suggest more endogenously driven transitions. For instance, in the energy sector international and national institutional changes occur more frequently and therefore seem to have a stronger influence on regional developments than in other cases. In contrast, in two of the food cases (Vulkanland, Val Poschiavo) regional events tend to occur very continuously from the beginning, indicating a stronger locally-driven dynamic.

Differential uptake of greening and digitalisation

The other dimensions concerns whether transformations are primarily driven by digitalization, sustainability, or by the interaction of these two dynamics. From a twin transition perspective, one would expect that the convergence of these dynamics becomes visible in the topologies through an increased pace of transformation and a larger number of events. However, the empirical picture remains highly heterogeneous.

In fact, sectors differ in their uptake of greening and digitalisation, with some sectors focusing more on greening and others emphasizing digitalisation. Most cases are characterized by an early emphasis on greening, yet changes linked to digitalisation and the twin transition appear more frequently and prominently in some sectors than in others. For instance, the topological maps suggest that events related to digitalisation and the twin transition occur more frequent in the transportation sector than in the food sector.

4.3 Limitations

The preparation of the evidential base for WP4, undertaken in close coordination with WP3, relied on case-level data provided by project partners. By Month 12, not all partners had collected, processed, and transmitted case study data to the extent foreseen in WP3. As a result, the data available for Deliverable D4.1 differs across cases, and can explain differences in data saturation across the transition topologies.

Delays and partial data gaps arose for several reasons. In fragmented sectors such as agriculture and tourism, access to interview partners proved more difficult than anticipated because of the prevalence of small, dispersed firms and limited availability of senior decision-makers. In addition, staffing delays in some teams responsible for case study implementation affected the pace of data collection and preparation. To mitigate these issues, we extended internal deadlines where feasible, coordinated bilaterally with partners to agree on tailored next steps, and provided methodological support in cases of persistent difficulty.

However, some limitations remain. In few cases, data saturation has not yet been reached, particularly where the number of interviews is still relatively low. While our analysis identifies coherent patterns across scales, the evidential base varies by case. We have therefore qualified findings according to data sufficiency, using interview counts and event density as indications, and indicated where observations in the topologies should be considered with particular caution. In such instances, key observations and respective guiding questions should be read less as preliminary findings and suggestions for further analysis, but more as indicators of remaining data gaps or analytical challenges to be addressed in the second data collection round. Moreover, the observed higher density of events in later stages may partly reflect recency bias in interview data. Yet, the patterns that otherwise become visible in the topologies suggest that mitigation efforts, such as careful respondent selection and data triangulation, have effectively counteracted this bias.

In addition, two types of factors that have repeatedly come up in discussion with partners may explain gaps and lead to certain biases in the interpretation of the transition topologies presented above. First, given the complexity of the topic, partner sometimes found it difficult to identify more general institutional or organizational shifts related to the twin transition *and* in addition explicitly probe for skill-related dynamics resulting from these changes, which may have led to their under-representation. Second, some partners expressed the impression that digitalisation is a very gradual process, which, compared to greening, might therefore be less frequently reflected in concrete events. In a similar vein, it was also discussed that, in certain contexts, up- and reskilling initiatives, may not always appear as formal, codified institutional or organizational changes, but rather occur informally. Therefore, these kinds of changes may have been more difficult to identify in the event-focused analysis conducted in Task 4.1 and may be undercounted in the topologies. At the same time, these observations highlight interesting questions that will be examined in more depth in Task 4.2

Further, given sectoral and regional specificities project partners deliberately selected and adapted spatial and sectoral scopes where necessary (see Chapter 2.3.2). Consequently, these adaptations lead to some heterogeneity in units of analysis and limit direct comparability of the respective transition topologies. Yet, a rigid standardization would have risked masking important context-sensitive mechanisms and dynamics the study aims to uncover and ultimately compare. Overall, the observed heterogeneity therefore reflects the tailored and flexible design of the study, which was necessary to meaningfully capture local and sectoral particularities while still allowing cross-case insights of the findings on a more generic level, as planned in Task 4.4.

Overall, however, all cases represent a sufficient evidential base for an initial topological mapping. While the robustness of these maps varies by case and direct comparison between the topologies require some consideration, each supports a first round of cross-case comparison and hypothesis generation.

4.4 Further work

Deliverable D4.1 has laid the data foundation for all subsequent tasks of WP4, which focuses on the in-depth analysis of the institutional dynamics in the case studies, the identification of governance challenges and opportunities and sector comparison. As the analysis advances to the study of micro-dynamics in Task 4.2, a qualitative, in-depth interrogation of the material will complement the topological mapping with more in-depth narrative case accounts. This will ensure that the maps are properly contextualized, that subtler dynamics are surfaced, and that the activities connecting events will be made visible.

Drawing on the initial findings outlined above, particular emphasis will be placed on analysing cross-scale dynamics between the identified changes in national and international institutional environments and regional developments. Furthermore, the influence of broader contextual changes such as the changing perception of climate change, the Covid-19 pandemic, or the financial crisis will be elicited.

The previously mentioned limitations will also be addressed in the next phase of WP4. In preparation for the second data collection round, the need to target identified gaps and potential biases have been emphasized by expanding interview coverage to underrepresented actor groups, refining interview prompts to elicit skills- and digitalisation-related events or more informal or gradual activities, and further triangulating interviews with sectoral policy documents, records from training providers, and other relevant sources.

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Annex 1: Interview guide module WP 4

Structure of the interview:

The interview is divided into two parts. First, we will focus on the past to understand how changes in skill demand caused by digitalization and the sustainability transition were addressed, both within your organization and in the region of XX. Then, we will discuss what this means for the future, focusing on labour market access, such as training opportunities, removing barriers to employment, or supporting disadvantaged groups.

Part 0: Introductory questions:

Icebreaker Question: To start, could you please briefly describe the extent to which - and the ways in which - your (current) role relates to the topics of sustainability and digitalization?

Part I: Past Developments and Milestones

Setting the Scene

As mentioned earlier, we are interested in understanding how changes in skill demand caused by digitalization and the sustainability transition were addressed, both within your organization and in the region of XX, over the last 15–20 years. To gain deeper insight into this process, we would like to reconstruct its development with you by focusing on some key changes that you have implemented in your organization - or together with others in the region. By changes, we mean for example:

- **New rules, standards, or funding schemes** that encouraged more sustainable or digital practices (e.g., new environmental regulations, support programs for digital technologies, or incentives for green investments).
- **New internal policies and strategies**, such as HR recruitment, employer branding strategy, AI use policy, marketing strategies
- **Initiatives and practical measures** such as the launch of training programs, the creation of regional networks, the introduction of pilot projects (AI implementation, automation).

Identifying Key Changes:

To start, could you please briefly outline what you consider to be the most important changes from your perspective, so we get an overview? By important changes, we mean all changes that you consider important; even if these have not led to the desired results. We will then discuss these changes in more detail afterwards. *(Note these changes down in order to come back to them later!)*

Initiating the narrative:

Thank you for this overview. We would now like to discuss each change in more detail with you to understand **1) how it came about, 2) what it was about, and 3) what impact it had.**

Narrative prompt:

Please feel free to start wherever it makes the most sense for you. For example, you could begin with the moment when you first realized you needed to change something, whether that was related to digitalization, greening, or both. (What was the specific change you implemented? In *which year* did this happen?)

Follow-up questions for each named change:

1. Origins and background: How it came about

Q: Can you explain what triggered you to initiate this change?

- Broader Influences (e.g., the COVID-19 pandemic, new EU regulations, shifting expectations regarding sustainability)
- National and Regional Influences (e.g., national regulation, regional changes in demand, founding of new network)

Q: Can you explain who was involved in initiating/realizing this change?

- Key Actors Involved (e.g., regional government, industry associations, collaboration between multiple regional stakeholders)
- Activities of Actors Involved (e.g., lobbying for funding, forming taskforces, conducting needs analysis, researching best practices, engaging in informal talks)

2. Core details: What it was about

Q: How did this change look like and what / whom did it involve / affect?

- Specific actions taken (e.g., designing the training program, selecting participants, collaborating with partners)
- Targeted challenges (e.g., closing digital skill gaps, addressing skill mismatches, supporting workforce transitions)
- Involved/affected groups (e.g., young people, older workers, lower skilled individuals)

3. Impact and significance: What impact it had

Q: Did this change lead to other further changes in your organization or the region?

- New collaboration between actors (e.g., Did it bring actors together that haven't worked together before?)
- Concrete follow-up changes (e.g., Did it inspire new funding schemes, the creation of a new network, or policy changes or did the initial change act as a pilot program for further similar initiatives?)

Thank you very much for elaborating on this change in detail. I'd now like to move on the next change that you mentioned before, namely XY. Again, I'd be interested in understanding 1) how it came about, 2) what it was about, and 3) what impact it had.

Annex 2: The Consortium

Short name	Full name	Homepage	Logo
HVL	Western Norway University of Applied Sciences	https://www.hvl.no/en/	
BOKU	BOKU University	https://boku.ac.at/en/	
LSE	London School of Economics	https://www.lse.ac.uk/	
UoC	University of Crete	https://www.uoc.gr/en/	
UW	University of Warsaw	https://en.uw.edu.pl/	
UU	University of Utrecht	https://www.uu.nl/en	
FHNW	University of Applied Sciences and Arts Northwestern Switzerland	https://www.fhnw.ch/en/	
BFI	Berufsförderungsinstitut Wien	https://www.bfi.wien/	
Simplon	Simplon.co	https://www.simplon.co/	
MOP	Municipality of Platania	https://www.platanias.gr/en/	

Annex 3: Project Summary

SkillResilience4EU - Resilience through re-skilling and upskilling for European labour markets in transition.

The twin transition (defined as the coexistence and interplay of the green and digital transitions) has enormous impacts on European labour markets. Because the green and digital transformations can feed into, facilitate, or hinder each other, it has been difficult to predict how labour markets will absorb and respond to changes and disruptions in employment conditions, skill needs and job availability and mobility. Other ongoing global challenges and macro-economic events, like the COVID-19 pandemic, also contribute to a profound reshaping of labour markets in Europe. New sectors emerge, existing sectors need to adapt and transform. New skills need to be developed or need to be transferred from other industries. Regions and sectors need to narrow labour market and skill mismatches to minimise the costs and to maximise the benefits of job destruction and job creation processes.

Different sectors and regions are affected in varying ways and intensities, either by green or digital transitions, or the combined impact of the twin transition. This unequal distribution of job creation and destruction processes may favour or leave behind places, sectors, and socio-economic groups and may threaten social cohesion and inclusion. The institutional and policy context needs to become more flexible and responsive to cope with the ongoing transformations and narrow down the labour market mismatches. Tailored and cost-effective policies and programmes for reskilling and upskilling, in particular for the most vulnerable and left-behind socio-demographic groups and places, need to be developed together with policy makers, VET providers, unions, public authorities, and other decision makers.

Funded by Horizon Europe, the European Union's Framework Programme for Research and Innovation, SkillResilience4EU will introduce a novel conceptual framework to describe and understand the impacts of the twin transition on European labour markets and will investigate the complex mechanisms, dynamics, and challenges that regions and institutions undergo by exploring selected sectors (tourism, food, transport, agriculture, and energy). The project will develop a management tool for policy makers to support them in managing labour markets in transition with recommendations for policy scenarios. SkillResilience4EU will also map and evaluate educational and training programmes for upskilling and re-skilling and will deliver recommendations and practical resources to support individuals and employers with specific focus on career guidance and development.

To achieve this ambition, the SkillResilience4EU consortium unites higher educational institutions (Western Norway University of Applied Sciences, Utrecht University, London School of Economics, University of Warsaw, University of Natural Resources and Life Sciences in Vienna, University of Crete, North-Western Switzerland University of Applied Sciences) one vocational training institute (BFI), one private training organization (Simplon.co) and a local public authority (Municipality of Platánias). The partners cover a whole range of expertise: economic geography, innovation studies, regional development, sustainability transitions, qualitative research, institutional research, policy research, labour and behavioural economics, education, arts and design, social inclusion, VET and lifelong learning. Coordinated by Western Norway University of Applied Sciences, the project was launched on 1st January 2025 and will run for 3 years.