D2.3. System Dynamics Models

Regions 4Climate

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List of Acronyms

CLD	Causal Loop Diagram
EU	European Union

IP/s	Innovation Pillar/s
JTI/s	Just Transition Indicator/s
NGO	Non-Governmental Organization
SD	System Dynamics
TOE	Tonnes of Oil Equivalent

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Keywords list

- Just Transition Indicators.
- Causal Loop Diagrams.
- System Dynamics
- Stakeholder Engagement.
- Resilience Quadruple Helix.
- Social Equity.

Disclaimer

Executive summary

This document outlines a unified approach for SD modeling across pilot regions using Just Transition Indicators (JTIs). This approach aims to aid decision-making by constructing Causal Loops Diagrams (CLDs) to evaluate and help to select optimal actions for a just transition, emphasizing resilience and the integration of a "quadruple helix" framework involving stakeholders from different sectors. Key activities include:

- Workshops: to facilitate a collaborative, informed, and pilot adapted approach to the implementation of JTIs, ensuring that the selected indicators are practical, relevant, and effectively integrated into regional planning and decision-making processes for sustainable transitions. These workshops are: (a) designed to suit each regional context; (b) conducted in the local language; and (c) facilitated by regional experts previously and particularly trained.

- Results of the workshops: aimed to provide not only the quantification of the selected JTIs, but also the quantification of the interrelations among these JTIs, thereby providing a solid foundation for data-driven and participatory regional planning for just transitions. All results are translated into English and shared on the R4C portal, helping define key elements like levels, flows, variables/constants, and feedback loops for SD modeling (when possible).

- Methodology: both top-down and bottom-up approaches are used to address system dynamics, offering a comprehensive analysis, and facilitating diverse, complementary scenarios.

This document essentially focuses on facilitating a pilot region-specific and stakeholder-inclusive approach to transition towards sustainability and social equity, fostering a collaborative environment for shared comprehensive decision-making and long-term planning.

The unified but flexible modeling approach introduced promises to significantly advance the knowledge and implementation of resilience strategies across Europe, aligning local actions with global sustainability goals. By respecting regional nuances and fostering stakeholder collaboration, it sets a precedent for future initiatives aiming to combine systemic thinking with adaptive regional planning.

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1. What is the Just Transition?

Just transition is a concept originated in the field of environmental and labour policy. It refers to the idea that the transition to a more sustainable economy and society should be fair and equitable, ensuring that no one is left behind.

In the context of modelling the regional social-ecological-technical-economic-political systems in the R4C project, just transition to climate resilience implies maximizing the social and economic opportunities of climate action, while minimizing the risks.

The framework for just transition was developed in T2.2 in alignment with the methodology for resilience pathway definition generated by the projects funded under call topic HORIZON-MISS-2021-CLIMA-02-02. Craft an adaptable framework for socially just transition to climate resilience (D2.2) considers the specificities of R4C demos.

Just transition and "climate change adaptation" are related concepts, but they have distinct focuses and goals: just transition primarily addresses the social and economic dimensions of transitioning to a low-carbon economy, while climate change adaptation focuses on minimizing the negative impacts of climate change and increasing resilience to its effects.

1.1 Resilience, quadruple helix and just transition

On one hand, resilience refers to the ability of the pilot-regions to absorb and recover from the impacts of climate-related events while maintaining its essential functions and structure.

On the other hand, the quadruple helix is an extension of the triple helix model, which describes the traditional collaboration between academia, industry, and government in driving innovation and economic growth. The quadruple helix model adds a fourth dimension, namely, civil society or the public, to the collaboration. It emphasizes the importance of including citizens, communities, non-governmental organizations (NGOs), and other stakeholders in the innovation process. The goal is to foster more inclusive and participatory approaches to innovation, where diverse perspectives and knowledge are integrated into decision-making processes.

The link between the quadruple helix perspective and the just transition lies in their shared emphasis on inclusivity, participation, and fairness to create a more sustainable and equitable future. By incorporating civil society and diverse stakeholders into the innovation process, the quadruple helix perspective seeks to ensure that the benefits of innovation and sustainable development are more widely distributed. It promotes the idea that the innovation actions to be implemented by pilot-regions during R4C should address societal challenges and contribute to social, economic, and environmental well-being.

Similarly, the just transition framework aims to ensure that the transformation to a sustainable economy considers the needs and interests of workers, communities, and vulnerable groups. It advocates for measures embedded into specific metrics such as retraining and reskilling programs, social inclusivity, job creation in new industries, and community development initiatives (among others) to support those affected by the transition.

By combining the quadruple helix perspective with the just transition there is a greater likelihood of achieving sustainable and equitable outcomes. The involvement of the pilot-regions' stakeholders in the innovation process can help identify potential social and environmental impacts early on, leading to more inclusive and socially responsible solutions. Additionally, the just transition framework provides a guiding principle to ensure that the benefits of innovation actions are shared fairly and that the costs and burdens of transition are minimized for vulnerable groups.

Resilience is rooted into the just transition modelling framework, due to the fact that pilot-regions are faced as robust and adaptable systems that not only mitigate the adverse impacts of climate change, but also ensure that vulnerable populations are supported and empowered throughout the process. This holistic approach fosters social cohesion, enhances environmental sustainability, and promotes economic stability, leading to a more equitable and resilient future traceable with the 9 indicators proposed in section 3.

2. How to model it?

The question raised is: what are the conditions favouring the just transition in each pilot?

System Dynamics (SD) is the appropriate technique to face complex situations, featured by an uncertain number of indicators sometimes difficult to quantify, supporting management-oriented models (NOT PREDICTIVE MODELS) pointing out "**what would happen if**".

A key pillar for modelling is to get a series of quantifiable, reliable and suitable indicators that the pilots are able to provide in the best possible way. A list of 9 potential tailor-made indicators is specified as starting point. They are so called JTI: Just Transition Indicators (agreed among CARTIF, VTT and DRI).

Defining these JTIs as differential is essential for tailoring, measuring, and effectively implementing a just transition for every pilot region in a way that truly benefits their communities as they are undergoing social, economic and environmental transformations. The inference of these transformations towards a just transition is the object of SD modeling, but not the pilot region's innovation actions to be implemented during R4C by themselves (which are monitored through alternative complementary KPIs). This represents an important innovation in itself resulting from the project.

The list of JTIs is common for the 12 pilots of the project. They will decide which ones apply according to their representativeness and the innovation actions they are implementing during R4C.

Pathway to SD modelling

- **Pilots ('guinea pigs')**: JTIs assessment and additions (Milestone 10).
- **CARTIF & VTT**: JTI fine-tuning and optimization. Final list.

Timing	Allocation
M10-M13	WP5 (CS1,2,3)

- **Pilots (all)**: Define local facilitators to conduct workshops to quantify and interrelate the selected JTIs (from the final list -per pilot-).
- **CARTIF & VTT**: train local facilitators for them to conduct these workshops.

Timing	Allocation
M13-M15	WP5 (CS1,2,3)

- **Pilots (all)**: hold the workshops involving stakeholders suitable to each regional context.
  - Conducted in the local language.
  - Facilitated by regional experts.
  - Results translated into English and published in the R4C portal.

Timing	Allocation
M15-M18	T2.3

- **VTT & CARTIF**: define the levels, flows, variables/constants and feedback loops to build-up the SD models (**D2.3: M24**).

Timing	Allocation
M19-M24	T2.3

Figure 1. *Agreed pathway to SD modelling.*

3. Just transition indicators

Getting data at European level that enable comparisons between countries and regions is always a complex and intensive task. EUROSTAT is the statistical office of the EU, but although it is a reputable source for data, there are drawbacks and limitations for its databases to be fully used for SD modelling of the just transition:

1. Time lag: there is a big delay in the availability of up-to-date data from collecting. This limits the usefulness of statistics for real-time or current analysis.
2. Data quality variations: EUROSTAT relies on data provided by member countries, and there are clear differences in methodologies, definitions, and data collection practices, leading to inconsistencies or biases, affecting comparability and accuracy.
3. Aggregation level: EUROSTAT data is developed at the EU or Eurozone level. Specific data for particular countries or smaller geographic areas (NUTS[1]) are needed and the required granularity is not always provided.
4. Scope: just transition related topics are limited or not included in their datasets.
5. Methodological changes: methodologies and classifications are periodically updated, which can affect the comparability of data over time.
6. Interpretation and context: EUROSTAT statistics alone do not provide a complete understanding of the underlying socio-economic dynamics or factors influencing trends.

Therefore, additional data and contextual information at 'pilot level' are required for a comprehensive understanding. Eight reasons justify setting up pilot meaningful indicators as crucial issue to modeling the Just Transition (so called JTIs):

i. Tailored approach: different pilot-regions and communities have unique economic, social, and environmental characteristics. What constitutes a "just transition" in one area may not be applicable to another. By defining meaningful indicators, transition plans can be tailored to the specific needs and challenges.
ii. Inclusivity: Just Transition aims to ensure that no one is left behind in the shift to a more sustainable and equitable economy. Pilot meaningful indicators allow for the inclusion of diverse voices and perspectives from the affected community. This inclusivity helps create a transition plan that addresses the concerns and priorities of all stakeholders.
iii. Measuring progress: pilot meaningful indicators provide a way to measure progress toward a just transition at the community level. They offer a concrete way to assess whether the transition is achieving its intended goals and benefiting the local population. Without meaningful indicators, it is challenging to evaluate the effectiveness of transition efforts.
iv. Resource allocation: defining pilot-region meaningful indicators helps allocate resources effectively. It allows policymakers and stakeholders to identify where investments and resources are most needed. This targeted approach maximizes the impact of limited resources.
v. Accountability: pilot-region meaningful indicators make clear what outcomes are expected from the transition process, which can help hold governments, businesses, and organizations accountable for their commitments to the just transition.
vi. Adaptability: different pilot-regions may face changing circumstances or unexpected challenges during a transition (even throughout R4C). Pilots' meaningful indicators allow for adaptability in the transition plan. If certain indicators are not met or new issues arise, adjustments can be made to the plan to address these changes effectively.
vii. Community ownership: involving local communities in the process of defining indicators gives them a sense of ownership over the transition. When people have a say in setting the goals and metrics for their community's future, they are more likely to actively participate in and support the transition efforts.
viii. Long-term success: The ultimate goal of a just transition is to create sustainable, resilient, and prosperous communities. Pilots' meaningful indicators help ensure that the transition is not just a short-term fix at all, but a long-term strategy for building a better future for the community.

[1] EU nomenclature of territorial units for statistics: https://ec.europa.eu/eurostat/web/nuts/overview

In this way 9 JTIs are proposed. They are all equally structured and also are specific, measurable, achievable, relevant and time-bound (SMART).

JTI1	**Employment transition rate**
Description: This JTI measures the rate at which workers are transitioning from industries or sectors heavily reliant on fossil fuels to new industries that support renewable energy and sustainable practices[2].	
Purpose: It reflects the success of the just transition in creating new job opportunities.	
Source[3]: Indicate (if available)	
Calculation[4]: $\frac{\text{Workers from industries or sectors supported on renewable energy and sustainable practices}}{\text{Workers from industries or sectors reliant on fossil fuels}}\ x\ 100$	
Units: %	Delay (cause-effect)[5] [months]: TBP[6]
Impact on: ☐ Maximizing the social opportunities of climate action. ☑ Maximizing the economic opportunities of climate action. ☐ Minimizing the risks of climate change.	

JTI2	**Training and re-skilling effectiveness**
Description: This JTI evaluates the effectiveness of training and re-skilling programs provided to workers affected by the transition.	
Purpose: It measures the percentage of workers who successfully acquire the necessary skills to participate in new industries or sectors.	
Source: Indicate (if available)	
Calculation: $\frac{\text{Number of workers who successfully acquire the necessary skills to participate in new industries or sectors per year}}{\text{Number of workers undergoing to acquire those skills}}\ x\ 100$	
Units: %	Delay (cause-effect) [months]: TBP
Impact on: ☑ Maximizing the social opportunities of climate action. ☐ Maximizing the economic opportunities of climate action. ☐ Minimizing the risks of climate change.	

JTI3	**Income and wage equality**

[2] It is related to 'green jobs'. The United Nations Environment Program (UNEP) define green jobs as "*positions in agriculture, manufacturing, R&D, administrative, and service activities aimed at substantially preserving or restoring environmental quality*".
[3] VERY IMPORTANT: If existing, please indicate a reliable database/s (or eq) to directly provide this JTI. It can be taken at the geographical scale/s considered to be meaningful and representative to the pilot for the just transition can be fully understood. Otherwise, it is recommended to follow the description given in 'calculation'.
[4] Obtaining the exact values for the intervening factors may be time-consuming or resource-intensive. Using acceptable approximations is allowed for practical and efficient reasons.
[5] Delay refers to the time it takes for the effects of the topic faced by the JTI to be felt. If it is not known exactly, an approximation should be given (based on experience, forecast or other). Delays can play a crucial role in achieving goals, such as providing time for decision-making, coordination, or adaptation.
[6] To Be Provided.

<u>Description:</u> This JTI assesses the level of income and wage equality[7] within the transitioning industries.	
<u>Purpose:</u> It measures the distribution of income and wages among workers to ensure that the just transition promotes fairness and reduces inequalities.	
<u>Source:</u> Indicate (if available)	
<u>Calculation:</u> ○ Step 1: define the monthly average earnings for [men / women / race / ethnicity / other][8] in the same job or occupation. ○ Step 2: compute the average of the earnings defined in Step 1. ○ Step 3: calculate the deviations of the wages for [men / women / race / ethnicity / other] defined in Step 1 regarding the average resulting of Step 2. ○ Step 4: compute the mean of the deviations resulting from Step 3.	
<u>Units:</u> €/month	<u>Delay</u> (cause-effect) [months]: TBP
<u>Impact on:</u> ☑ Maximizing the social opportunities of climate action. ☐ Maximizing the economic opportunities of climate action. ☐ Minimizing the risks of climate change.	

JTI4	**Environmental impact reduction**
<u>Description:</u> This JTI measures the reduction in environmental impact resulting from the transition.	
<u>Purpose:</u> The aim is to track the positive environmental outcomes of the transition, measuring these facts: • Reduction in greenhouse gas (GHG) emissions. • Reduction in energy consumption. • Reduction in water usage. • Reduction in waste generation.	
<u>Source/s:</u> Indicate (if available for all the points faced in 'purpose')	
<u>Calculation:</u> Average percentage of the following factors (those that apply): • Reduction in greenhouse gas (GHG) emissions: percentage decrease in GHG emissions[9]. • Reduction in energy consumption: percentage decrease in energy consumption[10]. • Reduction in water usage: percentage decrease in water usage[11]. • Reduction in waste generation: percentage decrease in waste generation[12].	
<u>Units:</u> % (all facts)	<u>Delay</u> (cause-effect) [months][13]: TBP
<u>Impact on:</u> ☐ Maximizing the social opportunities of climate action. ☐ Maximizing the economic opportunities of climate action. ☑ Minimizing the risks of climate change.	

JTI5	**Community well-being**

[7] Wage equality involves assessing the extent to which individuals receive equitable compensation for their work, regardless of their gender, race, ethnicity, or other relevant factors on the basis of similar qualifications and job responsibilities.
[8] As appropriate for each pilot.
[9] It is related to 'emissions intensity'.
[10] It is related to 'energy intensity'.
[11] It is related to 'water intensity'.
[12] It is related to 'waste intensity'.
[13] Taken as the longest of the delays of the applying factors described.

<table>
<tr><td colspan="2">Description:
This JTI evaluates the overall well-being and quality of life within the communities affected by the transition.</td></tr>
<tr><td colspan="2">Purpose:
The goal is to ensure that the just transition improves the overall living conditions of the communities involved, measuring these facts:
• Access to healthcare (physical and mental).
• Access to education.
• Access to social services.
• Affordable housing.</td></tr>
<tr><td colspan="2">Source/s: Indicate (if available for all the points faced in ‘purpose’)</td></tr>
<tr><td colspan="2">Calculation:
Average percentage of the following factors (those that apply):
• Access to healthcare: percentage of population with doctors, right to use to healthcare facilities, geographic approachability, affordability, and care quality.
• Access to education[14]: percentage of the population in a specific age group (typically the official school-age population) that is enrolled in a particular level of education (such as primary, secondary, or tertiary).
• Access to social services[15]: percentage of individuals or households that receive or have access to housing, social welfare programs, or employment support.
• Affordable housing[16]: percentage of income dedicated to housing costs (rent or mortgage payments)[17].</td></tr>
<tr><td>Units: % (all facts)</td><td>Delay (cause-effect) [months][18]: TBP</td></tr>
<tr><td colspan="2">Impact on:
☑ Maximizing the social opportunities of climate action.
☐ Maximizing the economic opportunities of climate action.
☐ Minimizing the risks of climate change.</td></tr>
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<table>
<tr><th>JTI6</th><th>Economic diversification</th></tr>
<tr><td colspan="2">Description:
This JTI evaluates the diversification of the local economy as a result of the transition.</td></tr>
<tr><td colspan="2">Purpose:
It measures the extent to which new industries or sectors are emerging and contributing to the overall economic growth and stability of the region.</td></tr>
<tr><td colspan="2">Source: Indicate (if available)</td></tr>
<tr><td colspan="2">Calculation:
$$\frac{\text{Economic amount generated by the companies or sectors that create 'green jobs' or make 'green investments}^{19}\text{'}}{\text{Global economic amount generated in the territorial area and activity of the pilot}} \; x \; 100$$</td></tr>
<tr><td>Units: %</td><td>Delay (cause-effect) [months]: TBP</td></tr>
<tr><td colspan="2">Impact on:
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☑ Maximizing the economic opportunities of climate action.
☐ Minimizing the risks of climate change.</td></tr>
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<table>
<tr><th>JTI7</th><th>Social cohesion and inclusivity</th></tr>
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[14] It is referred to the ‘Gross Enrollment Ratio (GER)’.
[15] It is related to the ‘Service Coverage Rate’.
[16] It is referred to the ‘Housing Cost Burden’.
[17] Generally accepted threshold for affordability: spending no more than 30% of household income on housing.
[18] Taken as the longest of the delays of the applying factors described.
[19] Towards low-carbon and sustainable undertakings, including renewable energy, energy efficiency, and sustainable infrastructure.

<table>
<tr><td colspan="2"><u>Description:</u>
This JTI assesses the level of social cohesion and inclusivity within the transitioning communities.</td></tr>
<tr><td colspan="2"><u>Purpose:</u>
It measures 3 factors to ensure that the just transition fosters a cohesive and inclusive society:
Social integration.
Cultural diversity.
Reduction of social disparities.</td></tr>
<tr><td colspan="2"><u>Source/s</u>: Indicate (if available for all the points faced in ‘purpose’)</td></tr>
<tr><td colspan="2"><u>Calculation:</u>
Average percentage of the following factors (those that apply):
Social integration[20]: percentage of population that participate in shared social activities and relationships[21].
Cultural diversity[22]: percentage of population belonging to diverse ethnic or racial groups.
Reduction of social disparities[23]: percentage of the reduction of JTI3 (income and wage equality) in a year.</td></tr>
<tr><td><u>Units:</u> % (all facts)</td><td><u>Delay</u> (cause-effect) [months][24]: TBP</td></tr>
<tr><td colspan="2"><u>Impact on:</u>
☑ Maximizing the social opportunities of climate action.
☐ Maximizing the economic opportunities of climate action.
☐ Minimizing the risks of climate change.</td></tr>
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<table>
<tr><td>JTI8</td><td>Stakeholder[25] engagement and participation in decision making</td></tr>
<tr><td colspan="2"><u>Description:</u>
This JTI assesses the level of stakeholder engagement and participation in the decision-making processes related to the transition[26].</td></tr>
<tr><td colspan="2"><u>Purpose:</u>
It measures the involvement of various stakeholders, including workers, communities, industry representatives, and environmental organizations, to ensure that their voices are heard and considered.</td></tr>
<tr><td colspan="2"><u>Source:</u> Indicate (if available)</td></tr>
<tr><td colspan="2"><u>Calculation:</u>
Number of comprehensive pilot-related just transition plans, regulations and legal reforms yearly shaped involving co-participative processes[27].</td></tr>
<tr><td><u>Units:</u> # (integer)</td><td><u>Delay</u> (cause-effect) [months]: TBD</td></tr>
<tr><td colspan="2"><u>Impact on</u>:
☑ Maximizing the social opportunities of climate action.
☐ Maximizing the economic opportunities of climate action.
☐ Minimizing the risks of climate change.</td></tr>
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<table>
<tr><td>JTI9</td><td>Stakeholder satisfaction and perception</td></tr>
<tr><td colspan="2"><u>Description:</u></td></tr>
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[20] It is a simplification of the ‘Social Cohesion Index’.
[21] This means trust in institutions, community engagement, civic participation, sense of belonging, and perceptions of fairness and equality.
[22] It is a simplification of the ‘Ethnic or Racial Diversity Index’.
[23] It is a simplification of the ‘Gini coefficient’.
[24] Taken as the longest of the delays of the applying factors described.
[25] Depending of the pilot region: see examples in ‘Purpose’.
[26] It is related to ‘social dialogue’.
[27] Taking into consideration the youths and vulnerable groups is important.

This JTI measures the satisfaction levels and perception of various stakeholders regarding the just transition.
Purpose: Gather feedback and insights on the effectiveness, fairness, and overall impact of the transition.
Source: Indicate (if available)
Calculation: Conduct a survey (or interview) to measure pilot's stakeholder satisfaction and perception by means of the following single closed-ended question upon Likert scale 5[28] rating: *How much do you agree with the effectiveness, equity and overall impact of the just transition?* 1. *Strongly disagree* 2. *Disagree.* 3. *Neither agree nor disagree.* 4. *Agree.* 5. *Strongly agree.* Next, the average of all the Likert scale-5 ratings resulting from the single-question survey will be calculated.
Units: # (Likert scale 5) — Delay (cause-effect) [months]: TBP
Impact on: ☑ Maximizing the social opportunities of climate action. ☐ Maximizing the economic opportunities of climate action. ☐ Minimizing the risks of climate change.

When combining the effects of multiple factors (JTI4, JTI5 and JTI7), using the mean value is a more appropriate and intuitive approach compared to multiplying them. The reasoning on this regard is summarized in five points:

a) Normalization of scales: when multiplying factors together, a factor with a larger value can dominate the overall result, even if its impact should be relatively smaller. Taking the mean value helps to normalize the scales, giving each factor an equal weight in the combined effect.
b) Insensitivity to extreme values: multiplying factors together can lead to significant changes in the result when even one factor has an extreme value (for instance zero). This misleads interpretations of the overall effect. Using the mean value provides a more stable and balanced representation of the combined effect.
c) Easier Interpretation: the mean value represents a typical value of the factors being considered. It's easier to interpret and explain to pilot-regions, especially when discussing the overall impact of multiple factors within a JTI. This can be particularly important for them in decision-making and communication.
d) Mitigation of overestimation/underestimation: multiplying factors together could sometimes lead to overestimation or underestimation of the combined effect. The mean value tends to provide a more accurate representation of the collective impact of the factors.
e) Avoiding double counting: If the factors for combining are not truly independent and have some overlapping effects, multiplying them together lead to double counting of those effects. Using the mean value ensures that each factor contributes only its fair share.

Moreover, it is necessary to know the time interval for which each JTI will be projected, which is a fact directly related to the delays provided by the pilot regions.

[28] A Likert scale is a commonly used rating scale in survey research to measure attitudes, opinions, or perceptions of respondents. It provides a way to quantify subjective data by capturing the degree of agreement or disagreement with a statement or the intensity of a particular feeling.

4. What is required from Pilots?

According to the defined pathway to SD modelling (see chapter 2), R4C regions must follow a four-step process, which is described below through the detailed instructions provided to the pilot regions so that they can complete it successfully.

4.1 Step 1: JTIs assessment and fine-tuning

The JTIs presented during the WP5 – Challenge Suite (CS) meetings (CS1, CS2, and CS3) should be initially assessed by the pilot regions in R4C in terms of adequacy and feasibility.

In this first stage, what is required to know is:

1. **If pilots are able to select those JTIs appropriate for their context[29].**
2. **If it is possible for them to collect the information embedded into the selected JTIs[30].**
3. **If any other pilot-specific JTI should be added (but quantifiable and fitting to the same structure) [31].**

Key issues:

→ **It is not necessary to involve regional stakeholders at this point** (unless you want to and it is possible for you). That's for later stages.
→ Deadline to accomplish this first stage:
  - CS1 Pilots: October 10, 2023 (one week after the October 2, 2023 CS1 Meeting)
  - CS2 Pilots: November 10, 2023 (one week after the November 2, 2023 CS2 Meeting)
  - CS3 Pilots: October 31, 2023 (one week after the October 23, 2023 CS3 Meeting)
  - Clarifications with concrete Pilots (depending on feedback): To be done by CARTIF & VTT throughout November (once compiled the responses from CS1, CS2, CS3).

4.1.1 Step 1 submission

Let's take an example: you are a pilot region that considers JTI1, JT4, JTI5, JTI6 and JTI9 to be adequate, but you can probably only quantify JT1, JT4 and JTI9 (even if only approximately). That will be your selection.

If you also want to propose a new JTI (say JTI10, faithfully following the same structure as those already presented and as long as you are able to quantify it), it is the right time to let us know.

Please send an email to: CARTIF (pedler@cartif.es) and VTT (carmen.antuna@vtt.fi) with your selection of JTIs written in the body of the email (just name them: JTI1, JT4, ...) and, only if true added value is provided, your proposal for new JTIs.

The subject of the email should be: R4C: JTIs - Feasibility Testing: CS[x] - [Pilot Name], where [x] is the Challenge Suite (CS) number where you fit in (1, 2 or 3) and [Pilot Name] is the name of your region (as shown in the CS). Example: *R4C: JTIs – Feasibility Testing CS1 – Basque Country (ES)*

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[29] It means both the regional context and the context of the innovation packages (IP) developed as part of the regional demonstration. Therefore, the indicators chosen must be suitable for both.
[30] Data collection for the proposed JTIs during the development of the R4C project will be done by yourself and/or any regional entity / Research and Technology Organizations (RTOs) / other you deem necessary. Data recordings will be validated by CARTIF and VTT. In the future (i.e. after the project ends), if regions decide to adopt these JTIs, they can take charge of data collection themselves or the entity they designate for that purpose.
[31] In case of suggestion of new JTIs you will be requested to a meeting with CARTIF and VTT.

The results obtained and their corresponding analysis are shown in **Annex 1**.

4.2 Step 2: Preparing JTIs quantification and interrelation

All pilot regions are requested to nominate local facilitators[32] and identify relevant stakeholders[33], as well as to plan the workshops for quantification and interrelation of the selected JTIs. To make all this viable, CARTIF & VTT propose the three-phase procedure described below.

Define local facilitators	Local facilitators are assumed to be the representatives of each pilot region who best understand the local context, culture, and concerns of the pilot's community. They also play a crucial role in bridging the gap between different participants. However, considering the fact that each pilot region is different, and with due justification, the local facilitator may be someone other than the representative of the region in the R4C project (**Annex 2: List of local facilitators**).
Define key stakeholders	Local facilitators from each pilot region have to identify all relevant stakeholders who should participate in the workshops. Depending on the case, this could include local communities, industry representatives, labor unions, environmental groups, government officials, and other affected parties deemed necessary (even if they do not speak English).
Develop a workshop agenda	Local facilitators from each pilot region must create an agenda adapted to their own context that outlines the structure of the workshop, expected to be held in a single session (exceptionally could be several); whether these sessions will be in-person (preferably), online or hybrid upon a collaborative schema. They must make sure to dedicate enough time but not too much in order not to tire the participants and maintain their interest and motivation (no more than 3 hours per session is highly recommended). The agenda will be sent to everyone involved (2 weeks in advance is suggested). To facilitate this work, VTT & CARTIF experts prepared a 'reference agenda' that can then be customized by the pilot regions according to their specific needs and conditions (**Annex 3**: **Annotated reference agenda for SD workshops**).

4.2.1 Step 2 submission

On one hand, the definition of local facilitators and stakeholders are explained to the pilot regions in the respective CS according to the following schedule:

→ CS1 Pilots: February 13, 2024 (11:00h – 12:30h CET)
→ CS2 Pilots: February 13, 2024 (14:00h – 15:30h CET)
→ CS3 Pilots: February 15, 2024 (10:00h – 11:00h CET)

Pilots are requested to send by an email to: CARTIF (pedler@cartif.es) and VTT (carmen.antuna@vtt.fi) naming the local facilitators by February 23, 2024.

On the other hand, the pilot regions are invited to upload the agenda (naming convention: JTIs_Workshop_Agenda-[Pilot Name]) detailing the date, items and timing for the workshop on quantification and interrelation of JTIs to the *R4C Sharepoint*: *WP2 Just Transition and Social Equity > T2.3 System dynamic modelling > Regional SD Workshops (within that folder there is another folder per CS, and within each CS folder, another one per pilot region).*

[32] Local facilitator refers to someone who is familiar with the pilot region as specific context in which the SD modeling is taking place. This individual plays a crucial role in guiding the process of quantification and interrelation of the selected JTIs within the local context, ensuring these reflect the dynamics and relationships relevant to the pilot as system being studied, also helping to ensure that the SD modeling process is both rigorous and relevant to the stakeholders involved.
[33] The stakeholder mapping is defined in T7.1. Each pilot's stakeholders have been already involved in T2.1.

CARTIF and VTT will monitor these agendas weekly to verify that the workshops will be held in a timely manner.

4.3 Step 3: Conducting workshops for the quantification and interrelation of the selected JTIs

Holding workshops is a valuable approach to ensure a smooth and collaborative process to quantify and interrelate the JTIs selected by the pilot regions in Step 1 with the support of local facilitators and the participation of relevant stakeholders as indicated in Step2.

Workshops are required to be carried out into the M15-M18 period (29 March, 2024 to 31 May, 2024).

4.3.1. How to conduct the pilot regions workshops

Below are the phases that the pilot regions must follow to organize these workshops, as well as practical suggestions for their successful achievement:

Collect data	Gather relevant data for the selected JTIs to be quantified. If recognized data sources are used, please provide the latest available record. If not, use the proposed calculation method. Remind that a reliable estimate is acceptable[34]. It is also acceptable to answer that ultimately it is not possible to quantify one or more of the selected JTIs, but an appropriate justification must be provided.
Interrelate JTIs[35]	Discuss how the selected JTIs are interconnected and how changes in one of them might affect others (when possible). Consider using visualization tools like flowcharts or CLD[36]. Provide these relationships as clearly as possible in the most comfortable way for you (whiteboard, sheet of paper, PowerPoint, ...).
Foster collaboration	Take advantage of being able to **work in your native language**. Encourage open dialogue among stakeholders to ensure that a diversity of perspectives, experiences, and interests are considered, but specially to find common ground when providing estimates. Transparency is crucial to building trust.
Document workshop results	Ensure that the results of the workshop are thoroughly documented in English (including attendance), i.e. in writing, graphically and photographically. The material obtained will be processed and shared on the R4C project website[37]. Workshops can be promoted, and their results disseminated through R4C social media channels.
Long lasting commitment	Make sure you continue to work closely and maintain connections with the pilot region community beyond R4C and therefore plan accordingly. JTIs and SD modelling are useful in providing regular updates on the progress of the regional just transition.

Keep in mind that the success of the workshops (and the just transition itself) will depend on active engagement, meaningful participation, building trust, and continued collaboration with all stakeholders involved going forward.

Additionally, pilots are encouraged to adapt and refine the suggested approaches as required by their regional conditions to address the unique challenges and opportunities posed by each specific pilot region context.

[34] Estimations could come out from expert judgment, interpolation and extrapolation of historical data, surveys and sampling, simulation or machine-generated (among others). These estimations are accepted in situations where obtaining precise or real data is challenging or impractical. However, it's crucial to be transparent about the nature of the estimates and reveal any uncertainties.
[35] See 'Example of interrelation of selected JTIs'.
[36] It is a 'snapshot' of all 'relationships that matter'. See 'Example of interrelation of selected JTIs'.
[37] For example: The Regional Climate Resilience Dashboards (RCRDs) developed within T3.5 are suggested on how to further communicate the results in a summary manner.

4.3.2. Examples of quantification of selected JTIs

Let's assume that JTI1, JTI2 (simple indicators) and JTI4 (composite indicator) have been selected. Although there are plenty of possibilities, some useful examples on the descriptions necessary for quantification are given in blue.

JTI1 example: No source available. Calculation method or estimated guess provided.

JTI1	Employment transition rate
Description: This JTI measures the rate at which workers are transitioning from industries or sectors heavily reliant on fossil fuels to new industries that support renewable energy and sustainable practices.	
Purpose: It reflects the success of the just transition in creating new job opportunities.	
Source: Example 1: Not official statistics available Example 2: The source of this data is unknown Example 3: Data only accessible upon a fee Example 4: An external entity is needed to support this ….	
Calculation: $\frac{\text{Workers from industries or sectors supported on renewable energy and sustainable practices}}{\text{Workers from industries or sectors reliant on fossil fuels}} \; x\ 100$ Example A: 20% (Calculation used: Numerator and denominator provided in national, regional, or local statistics) Example B: 17% (Calculation not used; As an alternative, this estimated guess is provided based on green investments)	
Units: %	Delay (cause-effect) [months]: 24 (estimation based on green investments execution)
Impact on: ☐ Maximizing the social opportunities of climate action. ☑ Maximizing the economic opportunities of climate action. ☐ Minimizing the risks of climate change.	

JTI2 example: Source available. No calculation method used.

JTI2	Training and re-skilling effectiveness
Description: This JTI evaluates the effectiveness of training and re-skilling programs provided to workers affected by the transition.	
Purpose: It measures the percentage of workers who successfully acquire the necessary skills to participate in new industries or sectors.	
Source: Example 1: 73% [www.regionaldata.org] Example 2: 73% (data directly requested to the training companies) ….	
Calculation: $\frac{\text{Number of workers who successfully acquire the necessary skills to participate in new industries or sectors per year}}{\text{Number of workers undergoing to acquire those skills}} \; x\ 100$	

Units: %	Delay (cause-effect) [months]: 14 (time comprising the 9 months that the courses to acquire the necessary skills are typically lasting plus another 5 months for the acquired skills are actually put into practice).
Impact on: ☑ Maximizing the social opportunities of climate action. ☐ Maximizing the economic opportunities of climate action. ☐ Minimizing the risks of climate change.	

JTI4 example: Mix of sources, calculations and estimates based on selection of facts.

JTI4	**Environmental impact reduction**
Description: This JTI measures the reduction in environmental impact resulting from the transition.	
Purpose: The aim is to track the positive environmental outcomes of the transition, measuring these facts: • Reduction in greenhouse gas (GHG) emissions: Important • Reduction in energy consumption: Important • Reduction in water usage: Important • Reduction in waste generation: N/A	
Source/s: See calculation	
Calculation: Average percentage of the following factors (those that apply): **7.3 %** $\left(\frac{10\%+7\%+5\%}{3}\right)$ • Reduction in greenhouse gas (GHG) emissions: 10% decrease in GHG emissions [www.nationalstatistics.com]: representative for the country and applicable for the pilot region. • Reduction in energy consumption: 7% decrease in energy consumption (deduced from the data purchased to the electricity and gas companies operating in the pilot). • Reduction in water usage: 5% decrease in water usage (data provided by the local administration since it is a KPI for the deployment of policies in this regard). • Reduction in waste generation: N/A.	
Units: %	Delay (cause-effect) [months][38]: 36 (expert opinion based on observation of trend changes in data from the last five years)
Impact on: ☐ Maximizing the social opportunities of climate action. ☐ Maximizing the economic opportunities of climate action. ☑ Minimizing the risks of climate change.	

4.3.3. Example of interrelation of selected JTIs

It is convenient to draw a diagram with the relationships among the selected JTIs (supposed JTI1, JTI4 and JTI7), pointing out **goals, trends and/or expectations the pilot region wants to achieve in the mid-term (one to five years)**. This will help understanding the correlations or identifying new unforeseen relations.

Pilots are free to use any means to represent these interrelationships. A suitable tool to do this is a CLD, which is a visual representation of JTIs as key factors and how they are interconnected.

The interrelations could be positive or negative. If an increase in one JTI could cause an increase in other JTI then it is a positive loop, or negative loop otherwise. This approach helps to understand the pilot regions' dynamic behavior: negative cycles lead to a stable situation and positive cycles make it unstable, regardless of the starting situation.

For instance, an increase in the employment transition rate (JTI1) could lead to a positive effect on the environmental impact reduction (JTI4), but to a negative effect on inclusivity (JTI7) due to the high professionals' skills required for

[38] Taken as the longest of the delays of the applying factors described.

the green-jobs that are being created (Figure 2). Every percent point of employment transition rate (JT1) is thought to cause 3%[39] of environmental impact reduction (JTI4), while the effect in social cohesion and inclusivity (JTI7) cannot be quantified (unknown).

Delays among interrelated JTIs, which are very helpful, will be addressed by VTT and CARTIF[40].

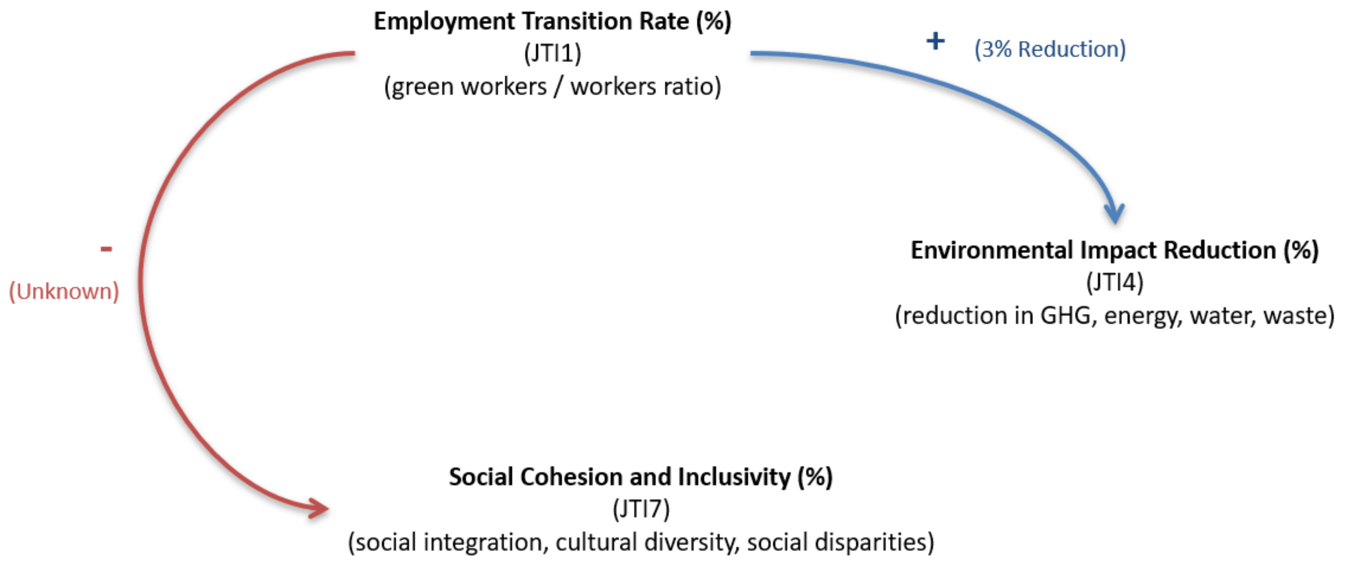

Figure 2. *Example of CLD: Causal Loop Diagram.*

4.3.4 Step 3 submission

A specific template for each pilot region (naming convention: JTIs_Quantificate_Interrelate-[Pilot Name]) pointing out the selected JTIs and also providing a space for their interrelation is available in the *R4C Sharepoint*: *WP2 Just Transition and Social Equity > T2.3 System dynamic modelling > Regional SD Workshops (within that folder there is another folder per CS, and within each CS folder, another one per pilot region).*

The results of the quantification and interrelation of JTIs must be submitted by May 31, 2024.

All these results will be carefully examined and interpreted during the month of June, with SD modelling beginning from that moment on, so the pilot regions may be requested at any time by VTT and CARTIF in a concerted and bilateral manner for any clarifications and particularizations that may be necessary.

[39] It can be an estimate or a well-known trend-based data.
[40] They could be taken as the average, maximum or minimum (as appropriate) of the individually specified delays for the intervening JTIs.

5. SD Modelling

SD is an approach to understanding and modelling the behavior of complex systems over time. A system is defined as a set of independent elements interacting each other, so that a change in one element affects all of them.

A SD model is based on the straightforward definition of four factors:

- → Levels: elements to consider (for example: people).
- → Flows: elements evolution (for example: people/h).
- → Variables and constants: parameters that condition the behavior of the flows.
- → Feedback loops: relationships among levels, flows and variables (negative loops take the model towards a stable situation and positive loops make it unstable).

Combining top-down and bottom-up approaches is sometimes essential for capturing the full spectrum of system behaviours. The top-down approach provides a broad overview supported on JTIs, identifying key trends and strategic interactions at the macro level. Conversely, the bottom-up approach focuses on particular, micro-level processes and interactions, highlighting operational specifics. Offer one or another possibility (even both) enhance the SD approach by enabling cross-validation, incorporating diverse perspectives, and ensuring pilot regions' adaptability and scalability.

5.1 Top-down approach

Top-down approach is covered by the JTIs and the modelling of the just transition under the four steps schema proposed to the pilots (see Section 2).

Pärnumaa (EE)

This is the simplest case. It is a very particular case that only considers JTI8 (Stakeholder engagement and participation in decision making). 'Pending tasks' in the naming of the **just transition plans, regulations and legal reforms yearly shaped involving co-participatory processes**.

Assuming that 5 of these tasks are developed per year[41] (all equally important) and that 'Achievement' implies a number of 'Total planned tasks' per month of 0.42 (5/12), the model obtained is indicated in **Figure 3**.

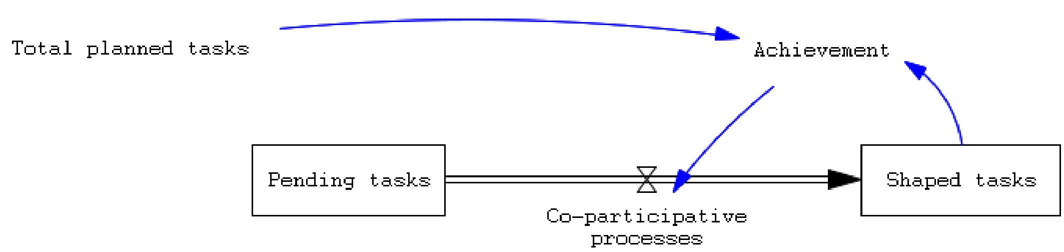

Figure 3. *SD model for Pärnumaa (EE).*

The behaviour of the co-participative processes, the pending tasks, and the shaped tasks (which means achieved tasks) is given in Figure 4. It is clearly observed that this behaviour is linear, regardless of the number of just transition plans, regulations and so on annually launched.

[41] Medium-term estimate. At this time one standard is developed per year.

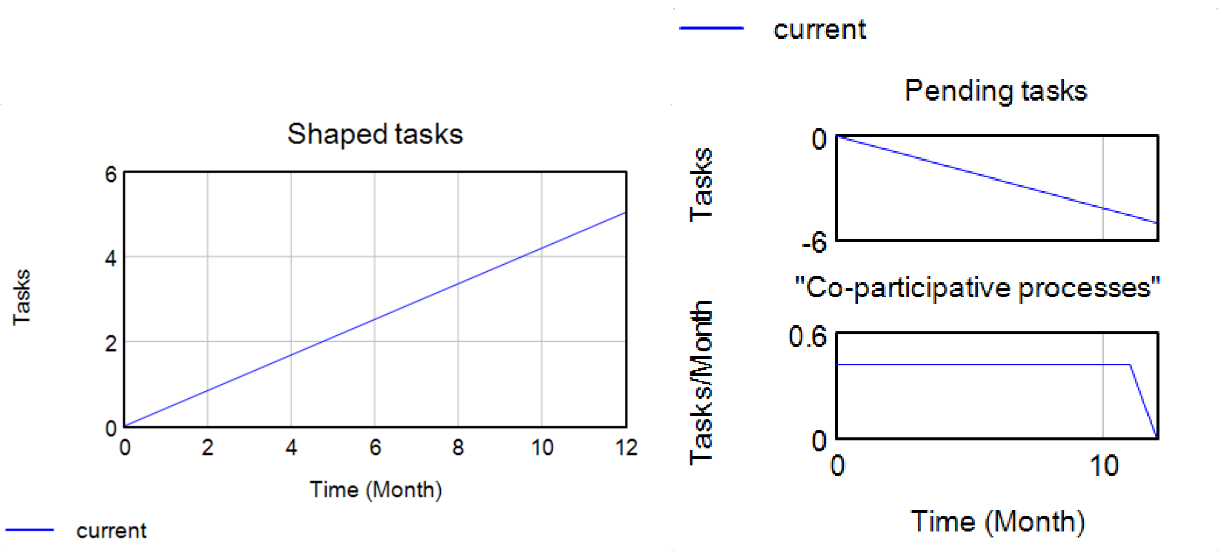

Figure 4. *Scenario for JTI8- Pärnumaa (EE).*

Castilla y León (ES)

Creating a system dynamics model requires not only the quantification of JTI2 (Training and Re-skilling Effectiveness) and JTI4 (Environmental impact reduction) since JTI9 (Stakeholder satisfaction and perception) was finally discarded[42], but also the quantification of the interrelation between JTI2 and JTI4.

JTI2 is realistically estimated taking the agricultural sector as the region's primary sector (economically and socially). JTI4 is calculated with data supported by the statistical reports periodically published by the Regional Ministry of the Environment[43]. Delays are set accordingly. A positive feedback loop supports ongoing improvements in both workforce development and environmental impact reduction, but this loop cannot be quantified due to the complex interdependencies and varying time lags in observing measurable outcomes from enhanced skills to specific environmental improvements.

Thus, a **long-term monitoring**[44] of both indicators **upon a yearly basis**[45] is proposed to know the interdependencies and time lags between training programs and their effects on environmental outcomes, that often span several years

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[42] It is assumed that only can be quantified upon a long-term approach, once just transition policies in Castilla y León develop and evolve.
[43] Through the 'Natural Heritage Foundation of Castilla y León' (Fundación del Patrimonio Natural de Castilla y León).
[44] For strategic goals such as organizational change or sustainability initiatives, long-term might span a decade, allowing sufficient time to assess the impact of these significant changes.
This period is considered to align well with the phased implementation of policies and the time it often takes to see tangible results from initiatives aimed at transitioning from fossil fuels to more sustainable energy sources, adjusting workforce skills, and other related socio-economic changes.
This is why 10-year timeframe is a sound approach for monitoring JTIs (in general).
[45] Monitoring on a yearly basis is primarily driven by the alignment with annual fiscal, statistical and planning cycles of organizations. This frequency allows for meaningful data collection and analysis, accommodating the time needed to observe significant environmental, social, and economic changes. Additionally, it aligns with common reporting standards and compliance requirements, facilitating structured stakeholder communication and enabling organizations to assess and adjust their strategies efficiently over a manageable timeframe.

or even decades. Only under this consideration (which in fact demonstrates the **alignment of tasks *T2.3: SD modelling* and *T3.2: Integrated monitoring & evaluation***) the feedback loop mechanism inherent in system dynamics models could make possible revealing trends and dependencies that are not immediately apparent (Figure 5). This depth of analysis is crucial for accurately assessing the effectiveness of interventions and for quantifying the positive feedback loop where improved training programs lead to better environmental outcomes, which then justify further investments in human capital development.

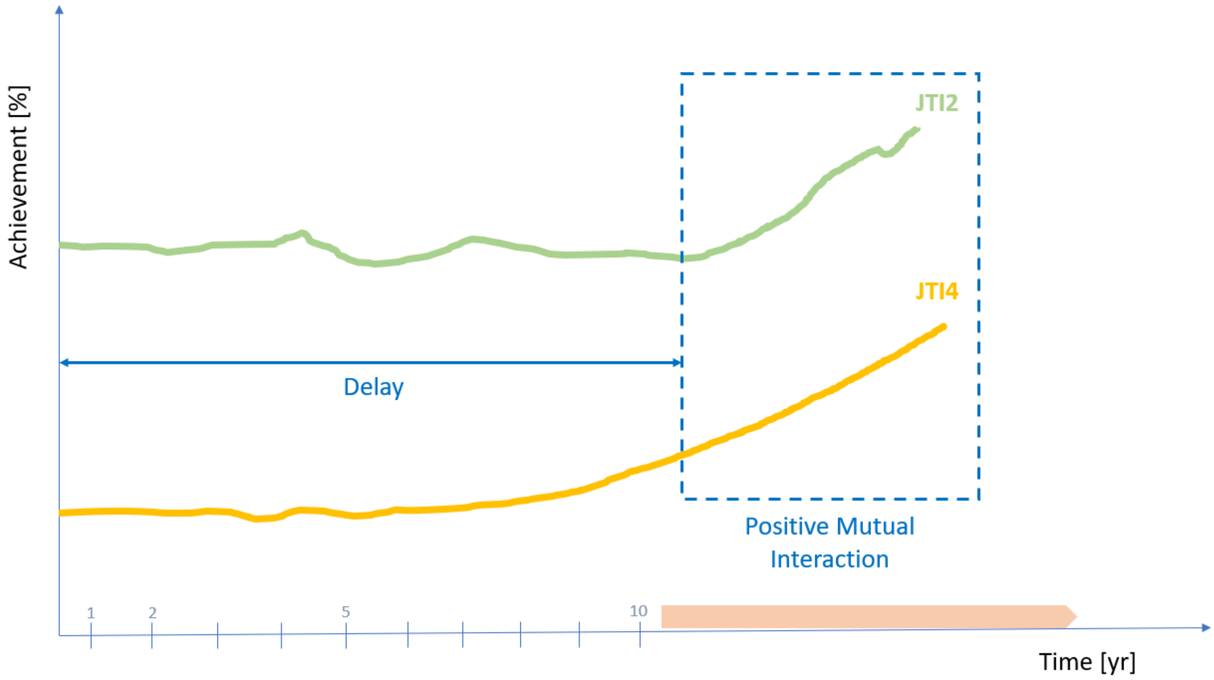


Figure 5. *Long-term monitoring approach to deduce the interrelationship between JTI2 and JTI4.*

Although longer than the duration of the R4C project, this approach is presented as the **viable option** for understanding the system behavior, so will be considered **for all those pilot-regions that are able to quantify the corresponding JTIs but not their interrelationships**. By committing to long-term monitoring, stakeholders can ensure that the data collected is robust enough to support significant policy decisions and strategic planning, essential for a just and sustainable transition.

This monitoring approach to deduce relationships between indicators was successfully proven in the RURITAGE project, where SD modeling played a crucial role by helping to understand and simulate the complex interactions among various elements of rural areas, such as economic, social, environmental, and cultural factors. A robust framework for exploring how different strategies for rural regeneration lead to sustainable growth and revitalization was provided, considering the unique characteristics and needs of each pilot (rural area) involved in the project. Due to the importance of this monitoring approach to support SD modelling, it was required to be presented at the UNESCO headquarters in Paris during the RURITAGE Final Conference (June 2021).

Several mathematical methods could be employed to effectively interrelate, analyze, and understand JTIs in the context of R4C. Regression analysis and differential equations are considered particularly relevant as they allow for the analysis of time series data of JTIs, providing insights into trends and potential inflection points so that various future scenarios can be simulated and thus plan accordingly.

- Regression analysis: it is a powerful arithmetical tool used to examine the relationship between two or more factors. This can help in understanding how various JTIs influence each other and predict future trends based on historical data. For instance:

→ Linear regression: if a direct, proportional relationship between two JTIs is assumed, linear regression can quantify this relationship. For example, if it is assumed that improvements in environmental impact reduction (JTI4) directly correlate with training and re-skilling effectiveness (JTI2), linear regression helps to model and predict re-skilling based on environmental impact metrics.

→ Multiple regression: it extends the analysis to include multiple independent factors. For instance, if it were supposed that the employment transition rate and training effectiveness both impact economic diversification, multiple regression allows to understand each factor's unique contribution and their combined effect.

- Differential equations: are used to model the rates of change over time, integrating the dynamic feedback loops that are characteristic of the system faced. This approach is particularly useful when modeling complex interdependencies among JTIs, where the rate of change of one indicator affects others. Constructing the model could begin by defining each JTI as a stock. The flow into and out of these stocks (changes in the JTIs) can be modeled with differential equations based on the causal relationships identified through theoretical understanding or empirical data. Differential equations would then quantify how rapidly changes propagate through the system, allowing for the simulation of dynamics under different scenarios.

Implementing these methods in a SD model requires robust data collection and careful consideration of the underlying assumptions about the relationships between different JTIs.

These should be the elements of the SD model for the case of Castilla y León (**Figure 6**; equations to be derived from long-term monitoring):

Levels (Stocks)	• Workforce capability level (JTI2): reflects the current capability of the workforce, which is affected by the flow of training and skills acquisition. • Environmental quality level (JTI4): represents the state of environmental impacts (GHG emissions, energy, water, waste), which is influenced by the flow of improvements driven by the skilled workforce.
Flows	• Training to skill acquisition (JTI2 flow): represents the process where training programs lead to new skills, affecting employability. • Environmental improvements (JTI4 flow): encompasses the reductions in GHG emissions, energy, water, and waste as a result of better practices taught in re-skilling programs.
Variables	• Employability rate (JTI2): the percentage of workers who acquire the necessary skills for new industries, based on training programs. • Skills acquisition rate (JTI2): the actual rate at which skills are being learned or certified. • Reduction in GHG Emissions (JTI4): measured as a percentage decrease. • Energy consumption reduction (JTI4): measured as a percentage decrease. • Water usage reduction (JTI4): measured as a percentage decrease. • Waste generation reduction (JTI4): measured as a percentage decrease.
Feedback loops (between JTI2 and JTI4)	• Positive feedback loop (training effectiveness to environmental improvement): ○ As training programs become more effective, the skills relevant to environmental sustainability improve. ○ This leads to better environmental practices, which contribute to reductions in GHG emissions, energy usage, water consumption, and waste generation. ○ Improved environmental outcomes validate and support the continuation and expansion of specialized training programs, enhancing the feedback loop. • Negative feedback loop (potential – to be studied: resource limitation impacting training): ○ Limited environmental resources or increased regulatory pressure might restrict certain industrial practices.

This model (**Figure 6**) could help to understand the **interdependencies between workforce development and environmental sustainability**, allowing for more strategic planning and resource allocation in the context of a just transition in Castilla y León. External influences such as economic shifts, technological advancements, and policy changes that might affect both the employability and environmental outcomes need to be considered.

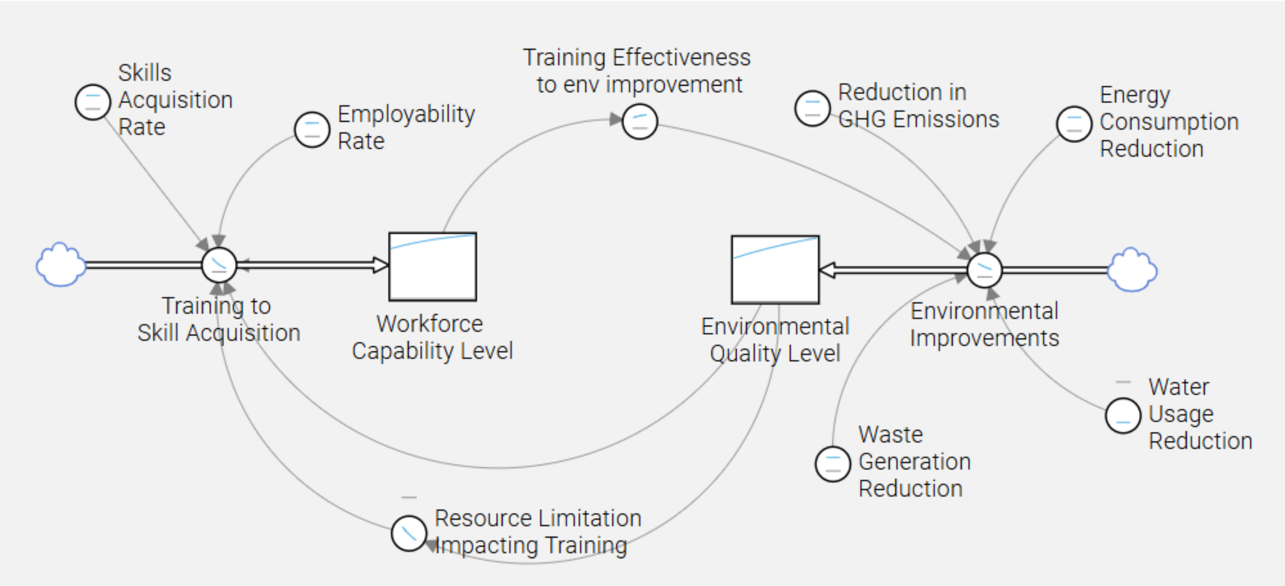


Figure 6. *SD model approach for Castilla y León (ES).*

The information provided by the stakeholders at the local workshop has been used to define the values of the variables and set the parameters for levels and flows. In particular, the reduction in GHG from 2000 to 2021 has been estimated in 62 %; the reduction in energy consumption for the 2012-2021 time period is estimated in 38 %; and a 10 % reduction in waste generation has been achieved between 2012-2022. In the opposite side, an increase of 30 % water usage has been noted between 2012-2022 (**Figure 7** - ISACYL[46] 2022).

The value 72.5 % for *Employability Rate* was provided by the stakeholders in the Castilla y León local workshop, while the value 11.5 % for *Skills Acquisition Rate* has been estimated according to the average value for Castilla y León region of *SDG 4.3: Ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university - 4.3.1: Proportion of persons between 25 and 64 years old attending any training in the last 4 weeks*[47], from 2010 to 2022 (**Figure 8**).

[46] ISACYL: *Informe de Sostenibilidad Ambiental de Castilla y León* (Environmental sustainability report of Castilla y León): https://medioambiente.jcyl.es/web/es/planificacion-indicadores-cartografia/informe-sostenibilidad-ambiental.html
[47] Source: https://servicios4.jcyl.es/ods2030/

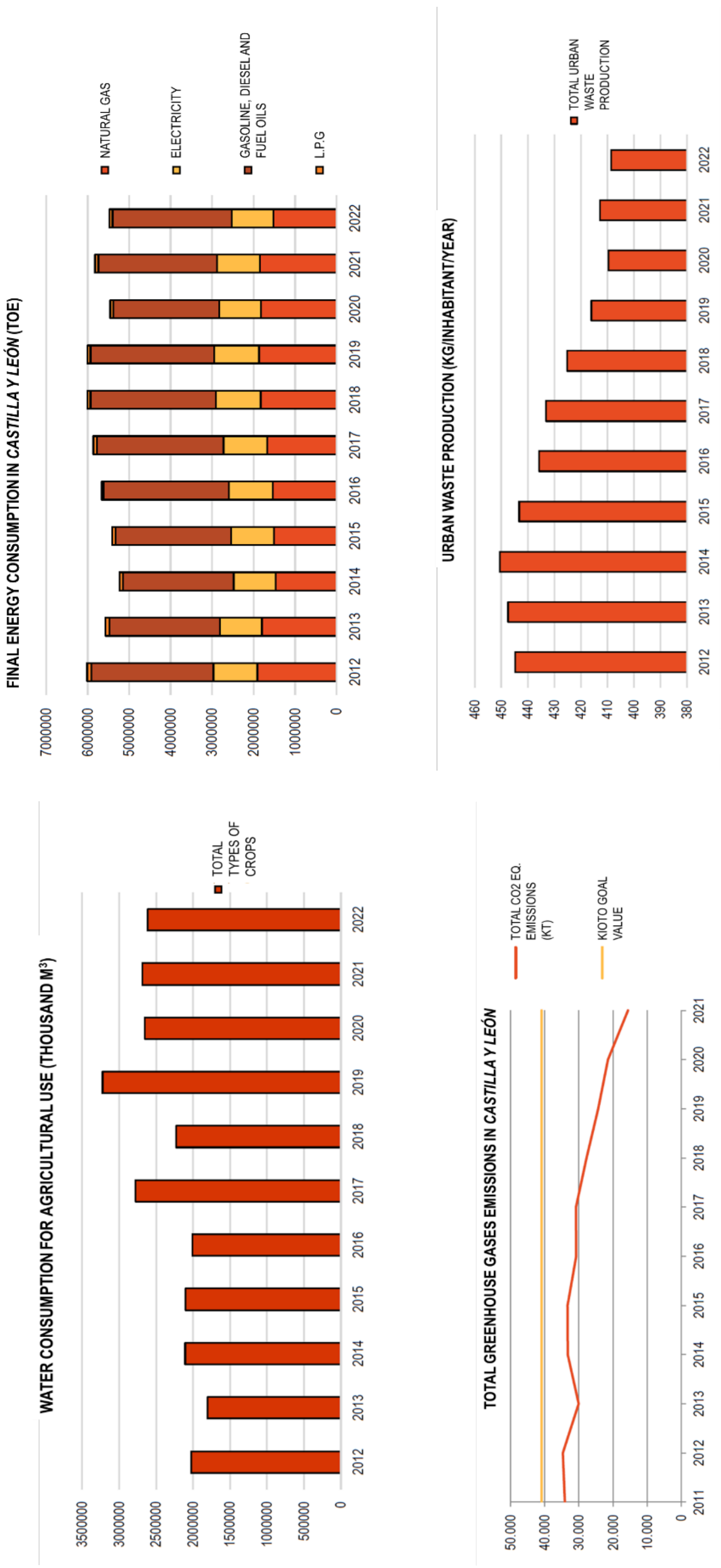


Figure 7. *Data contributed by local stakeholders (Castilla y León).*

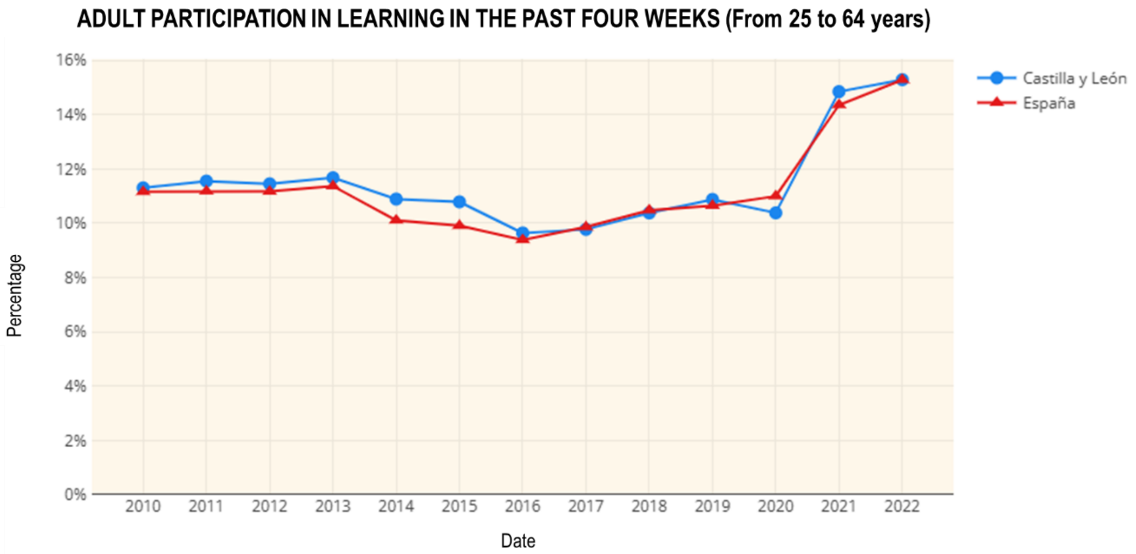
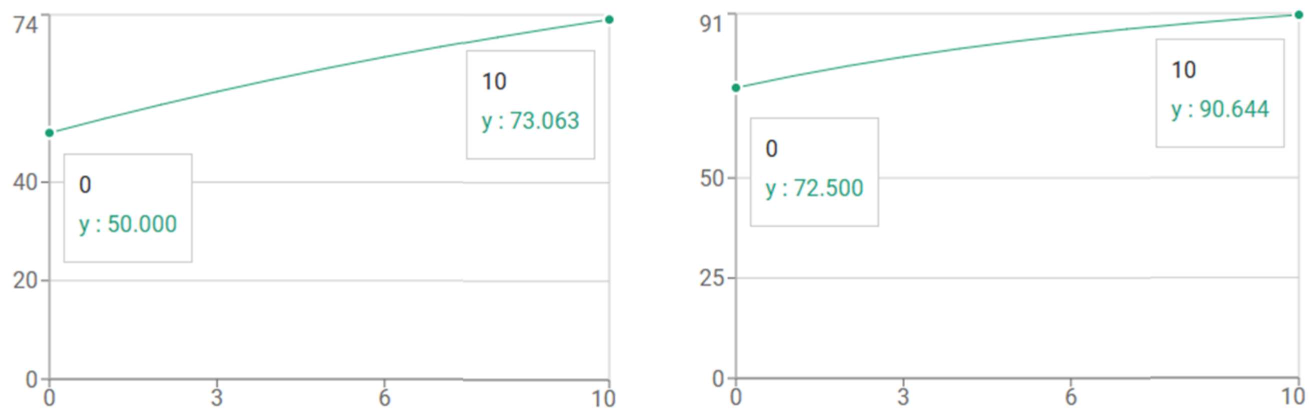


Figure 8. *Adult participation in learning in the past 4 weeks (Castilla y León).*

A [0, 100] range has been set for *Environmental Quality Level*. Within this range, let 50 be the initial value at initial time (t_0). Once initial conditions are set, it is possible to run the model to simulate what would be the evolution over time. For instance, with a time unit of 1 year ($d(t)$ = 1), the value after 10 years will be 73 (t_{10} = 73.06). That means a positive evolution of the environmental quality level with a slope of 2.31 % of average yearly increase. Similarly, the initial value for *Workforce Capability Level* has been set to 72.50 by the local stakeholders (t_0 = 72.50). After 10 years simulation, the stock reaches the value of 90.64 (t_{10} = 90.64), i.e. 1.81 % slope (see **Figure 9** (a) and (b)). That could be interpreted as the positive feedback loop among workforce capability level and environmental quality level overpasses the negative feedback loop and creates a virtuous circle where increasing the workforce skills affects positively to the overall environmental quality.



(a) Environmental Quality Level *(b) Workforce Capability Level*

Figure 9. *SD stocks evolution over time (Castilla y León).*

In any case, a bottom-up SD model (Section 5.2) is additionally proposed for dynamic stock management for sustainable horticultural and agricultural production for the companies NAVALFRESA (Partner 45) and HORTAFERCAR (Partner 46).

Tuscany (IT)

JTI2 (Training and Re-skilling Effectiveness) is realistically estimated considering responsible behaviours and preventing practices that could increase the risk of coastal erosion. JTI4 (Environmental impact reduction) is adequately quantified using regional statistical and cadastral databases, together with deliverable D1 of the REWAT project[48]. JTI8 (Stakeholder engagement and participation in decision making) is quantified also taking REWAT into account, in addition to the first 'Contratti di Fiume'[49] and the ReS_EAU Project[50]. Delays for JTI2, JTI4 and JTI8 are set accordingly. But JTI9 (Stakeholder satisfaction and perception) cannot be currently quantified because just transition policies are still in their early stages in the region. However, JTI9 is considered of interest given the increasing number of initiatives and projects related[51].

Therefore, creating a system dynamics model requires the quantification of the interrelation between JTI2, JTI4, JTI8 and JTI9. Stakeholders expressed concerns regarding the possibility of quantifying these interconnections numerically, arguing that providing a scientifically accurate number was not feasible. Consequently, they preferred to conduct the qualitative approach shown in Figure 10.

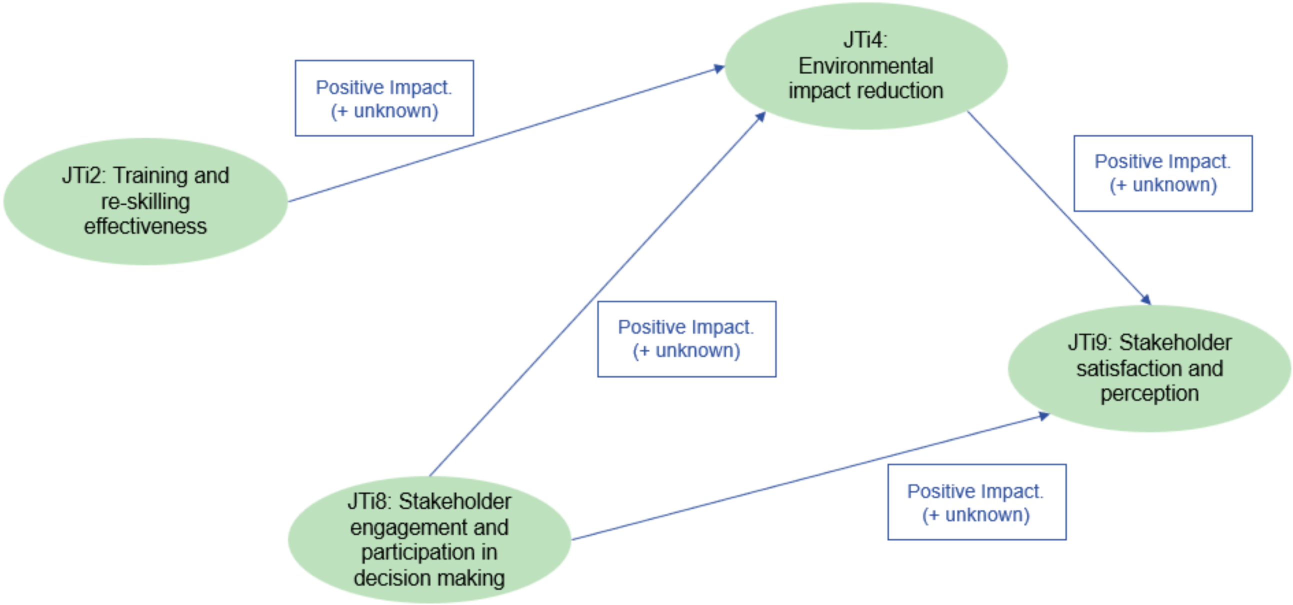


Figure 10. *Feedback loops among the JTIs selected by the Tuscany pilot region.*

[48] REWAT LIFE Project: LifeRewat_18_EN_06 (regione.toscana.it)
[49] Already in 2015, the Italian national strategy for adaptation to climate change drawn up by the Ministry of the Environment and Protection of Land and Sea (adopted with decree 16 June 2015, n. 86) included among the proposals for non-structural action participatory forms for resource management, such as 'Contratti di Fiume' (River Contracts).
[50] ReS_EAU INTERREG Project: https://interreg-maritime.eu/web/reseau/progetto
[51] The stakeholders involved in the Workshop for the quantification and interrelation of the selected JTIs expressed their willingness to provide a comprehensive list of relevant contacts to face this JTI9 in the future.

Thus, taking as reference the case of Castilla y León, a long-term monitoring approach for JTI2, JTI4, JTI8 and JTI9 (when possible) upon a yearly basis is proposed to know the interdependencies and time lags among them in order to establish the relational equations that allow SD modeling.

These should be the elements of the SD model (**Figure 11**; equations to be derived from long-term monitoring):

Levels (Stocks)	• Skilled workforce (JTI2): represents the total number of workers who have successfully acquired new skills relevant to new industries or sectors. It's a cumulative measure influenced by training programs. • Environmental quality (JTI4): a composite measure reflecting reductions in GHG emissions, energy consumption, water usage, and waste generation. • Stakeholder engagement (JTI8): quantifies the degree of stakeholder involvement in decision-making processes related to the transition. • Stakeholder satisfaction (JTI9): represents the overall satisfaction and perception of stakeholders regarding the just transition processes.
Flows	• Training completion rate (JTI2 flow): the rate at which workers complete training programs and acquire necessary skills. • Environmental improvement rate (JTI4 flow): rate of improvement in environmental measures. • Engagement rate (JTI8 flow): rate at which stakeholders are engaged and participate in transition-related decision-making. • Satisfaction change rate (JTI9 flow): rate of change in stakeholder satisfaction based on their perceptions of the transition's fairness and effectiveness.
Variables	• Training effectiveness: influences the training completion rate. • Policy strength: affects the environmental improvement rate. • Communication effectiveness: impacts both the engagement rate and the satisfaction change rate.

Feedback loops	• Positive feedback loops:
	  ○ Between JTI2 and JTI4: as the skilled workforce level increases, it can lead to better implementation of environmental practices, improving the environmental quality, which in turn may facilitate more effective training or the development of new training programs focusing on environmental skills.
	  ○ Between JTI8 and JTI4: as stakeholders see tangible environmental improvements, their increased support leads to even more effective implementation of sustainable practices, creating a self-reinforcing loop that benefits both the community and the environment.
	  ○ Between JTI8 and JTI9: higher engagement levels lead to increased satisfaction, as stakeholders feel their voices are heard, which can further motivate them to engage more deeply.
	  ○ Cross-linkage: high environmental quality could increase stakeholder satisfaction if they value environmental outcomes, thereby connecting JTI4 directly to JTI9.
	  ○ From JTI9 to JTI8: if the stakeholder satisfaction decreases, it might reflect issues in how engagement processes are being handled, prompting a review and potential decrease in engagement effectiveness.

This structure will allow for a detailed simulation of **how training programs, environmental policies, and stakeholder engagement strategies dynamically interact and affect the transition process over time**.

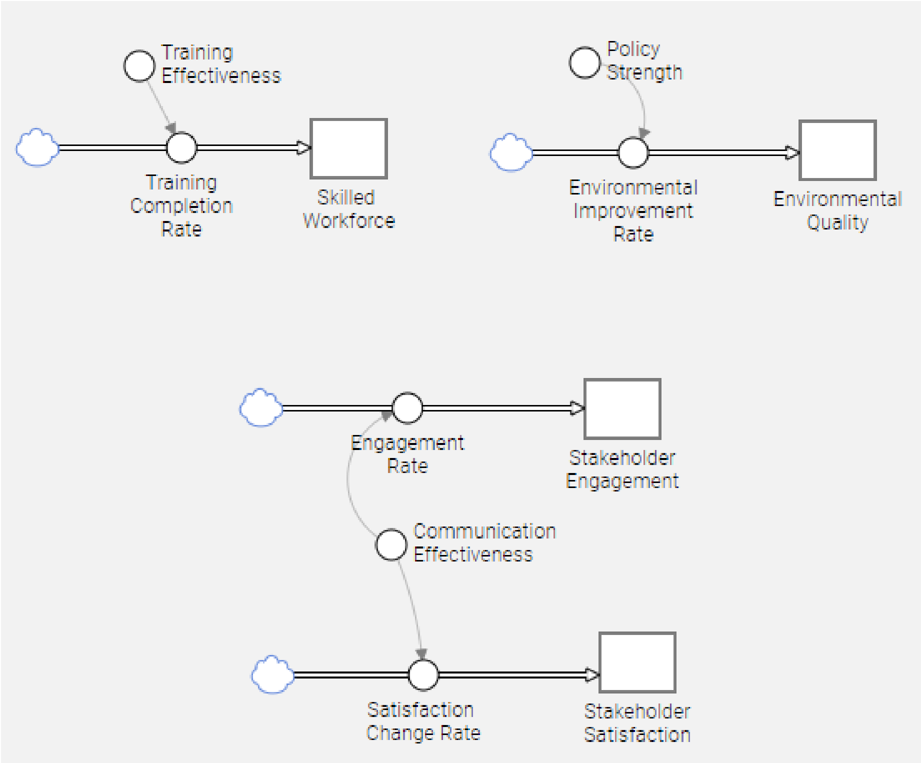


Figure 11. *SD model approach for Tuscany (IT).*

Basque Country (ES)

Last March 2024, the Law on Energy Transition and Climate Change of the Basque Country (the "LTECC") was published in the Official State Gazette, with the aim of establishing a stable legal framework to achieve climate neutrality and a fair energy transition by 2050. With this regulation, the Basque Autonomous Community accelerates the decarbonization process and facilitates the alignment of the Basque Country with the rest of Spain and European regulations and plans focused on achieving climate neutrality.

The JTIs are considered useful for monitoring the objectives and the planning instruments of the recent LTECC due to the following reasons:

1. Comprehensive coverage of transition elements: the JTIs cover key dimensions critical to the energy transition, including employment, training, income equality, environmental impact, community well-being, economic diversification, social cohesion, stakeholder engagement, and satisfaction. This broad range ensures that all aspects of the transition are monitored and aligned with the goals of the LTECC.
2. Regional relevance and specificity: the JTIs are tried to be quantified to the specific economic, social, and environmental contexts of the Basque Country, making them directly relevant to the region's transition needs. For instance, JTI1 (Employment transition rate -particularly important-) measures the shift from fossil fuel-dependent jobs to those in renewable sectors, directly addressing LTECC's aim to support sustainable economic development.
3. Stakeholder engagement: extensive consultations with stakeholders in the Basque Country are needed to ensure that the JTIs reflect the needs and expectations of the local communities and industries. This aligns with the LTECC's emphasis on participatory approaches in policymaking and transition planning.
4. Quantitative and qualitative approaches: the JTIs provide both quantitative metrics (e.g., percentage reductions in greenhouse gas emissions, training effectiveness) and qualitative-related assessments (e.g., stakeholder satisfaction), allowing for a comprehensive evaluation of progress.

5. Focus on just transition principles: each JTI is designed to ensure that the transition to a low-carbon economy is just and inclusive, minimizing risks while maximizing social and economic opportunities. This directly supports the LTECC's objectives of promoting equity and sustainability in the transition process.
6. Policy feedback and adjustment: the indicators offer measurable feedback on the implementation of the LTECC, allowing policymakers to track effectiveness and make necessary adjustments. This feedback loop is critical for refining strategies and achieving the law's long-term goals.

These reasons have led the Basque pilot region to try to address the quantification of each and every JTI, beyond the 6 initially chosen (see **Annex 1**). This important effort has led to quantifying JTI1 (Employment transition rate); JTI3 (Income and wage equality); JTI4 (Environmental impact reduction); JTI5 (Community well-being); JTI7 (Social cohesion and inclusivity) and JTI8 (Stakeholder engagement and participation in decision making) through clear statistical markers taken from official and recognized regional databases (mainly EUSTAT[52] and IKUSPEGI[53], which are highly beneficial due to their regional specificity, comprehensive data coverage, and reliability).

On one hand EUSTAT provides a broad spectrum of socio-economic and environmental data tailored to the Basque context, ensuring that these JTIs are relevant and accurate for monitoring LTECC. On the other hand, IKUSPEGI offers specialized insights into social integration, crucial for evaluating the inclusiveness of the transition process. Regular updates from both sources ensure timely monitoring, while their alignment with regional policies enhances the credibility and effectiveness of the JTIs in achieving sustainable and equitable transition goals.

On the contrary, no information is available at regional level for JTI2 (Training and re-skilling effectiveness). There are no existing recordings either for JTI6 (Economic diversification) and JTI9 (Stakeholder satisfaction and perception).

From the point of view of the interrelationships between JTIs, it has only been possible to establish a positive feedback loop between JTI1 (Employment transition rate) and JTI3 (Income and wage equality). Also, between JTI1 (Employment transition rate) and JTI4 (Environmental impact reduction). Another negative loop between JTI1 (Employment transition rate) and JTI7 (Social cohesion and inclusivity) was established (**Figure 12**).

An increase of 1% in JTI1 has been assumed in all cases, supposing that green jobs entail wage equality (JTI3), while attempting to determine the level of influence of each constituent factor of JTI4 and JTI7 (yellow underlines in **Figure 12**). The only way to quantify these attempts is long-term monitoring, as defined for the case of Castilla y León. This is further reinforced by the fact that no delay could be established for any of the quantified JTIs. Thus, long-term monitoring is crucial in the Basque pilot region because it allows policymakers to track progress against goals upon the LETCC, understanding the effectiveness of interventions over time, so that the just transition is managed effectively, with ongoing adjustments to strategies as new challenges and opportunities arise.

[52] EUSTAT: Basque Statistics Office.
[53] IKUSPEGI: Basque Observatory for Immigration.

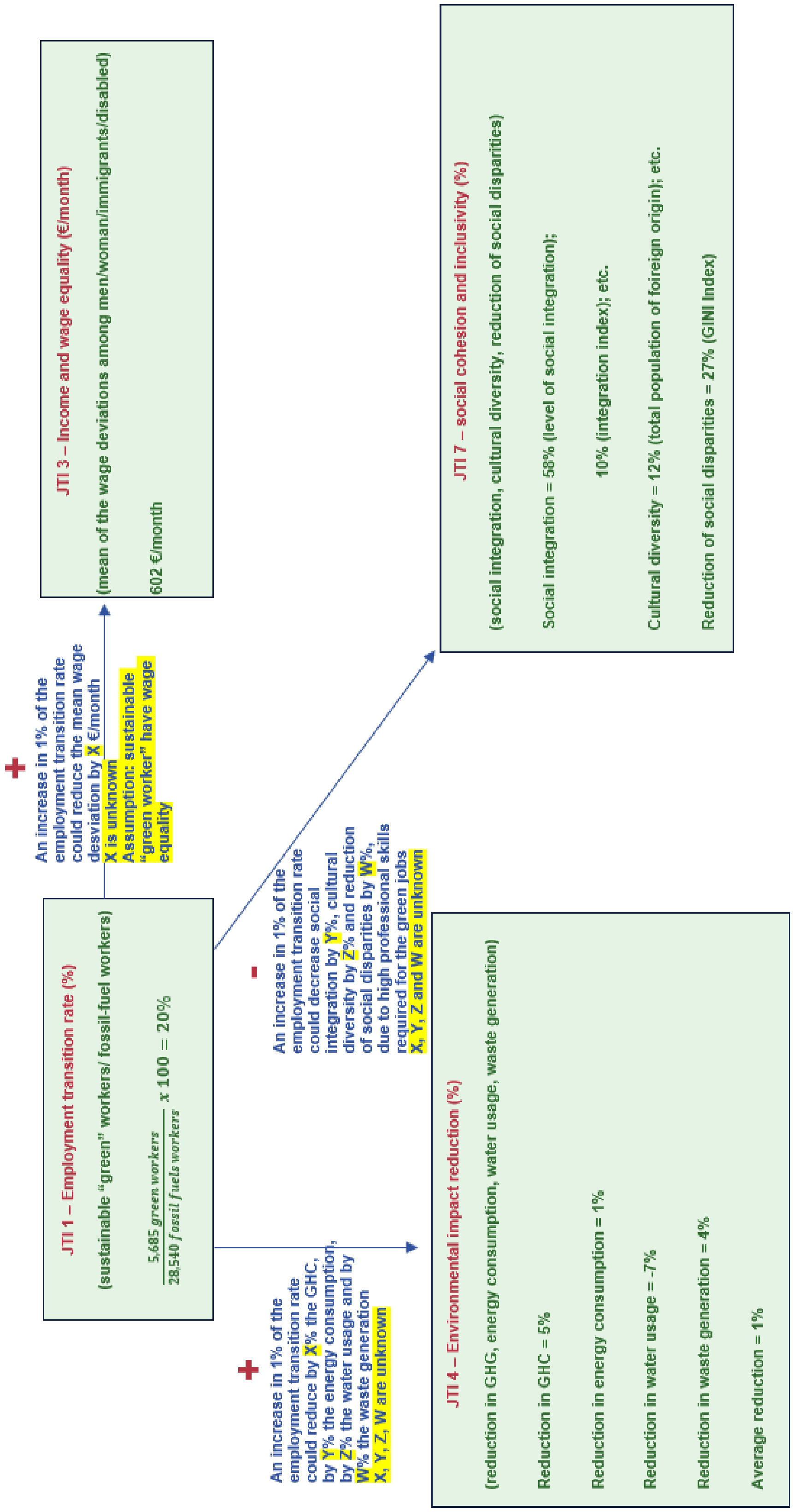


Figure 12. *Interrelation among the JTIs interesting for the Basque Country pilot region.*

Next are indications about how the levels, flows, variables and feedback loops could be to further define the SD model for the JTIs in the Basque Country to allow for more effective policy adjustments and planning (equations to be derived from long-term monitoring) upon a comprehensive approach (**Figure 13**):

<table>
<tr><td>Levels (Stocks)</td><td>Workforce in sustainable sectors: total number of workers in industries supporting renewable energy and sustainable practices (JTI1).
Workforce in non-sustainable sectors: total number of workers in industries reliant on fossil fuels (JTI1).
Skilled workforce: workers who have undergone training and successfully acquired new skills (defining information at the regional level for JTI2).
Community well-being (JTI5): an aggregate measure of health, education, housing, and social services quality.
Environmental impact reduction (JTI4): composite of metrics on GHG emissions, energy consumption, water usage, and waste generation.</td></tr>
<tr><td>Flows</td><td>Transition rate: rate at which workers move from non-sustainable to sustainable sectors (JTI1).
Employment rate in new sectors: rate of employment in new, sustainable industries (JTI1).
Training rate: rate at which workers are being trained and re-skilled (JTI2).
Change in environmental quality: rate of improvement or degradation in environmental conditions (JTI4).</td></tr>
<tr><td>Variables</td><td>Policy support (related to JTI7): level of governmental and regulatory support for just transition initiatives.
Economic conditions (related to JTI3 and JTI6): general state of the regional economy, affecting investment and jobs.
Stakeholder engagement level (JTI8): degree of involvement by workers, communities, and industries in the transition planning.
Stakeholder satisfaction level (JTI9): overall satisfaction with the transition's effectiveness and equity.</td></tr>
<tr><td>Feedback loops</td><td>Positive feedback loops:
Workforce development loop: increased policy support leads to higher training rate, increasing the skilled workforce, which boosts the employment rate in new sectors, further encouraging policy support.
Community engagement loop: improvements in community well-being enhance stakeholder satisfaction, leading to more effective stakeholder engagement, which then influences policy support positively.
Negative feedback loops:
Environmental stress loop: if the environmental impact reduction declines, stakeholder satisfaction decreases, potentially reducing stakeholder engagement and affecting policy support negatively.
Economic dependency loop: high reliance on non-sustainable sectors reduces the transition rate, negatively impacting the workforce in sustainable sectors and the overall environmental quality.</td></tr>
</table>

This structured approach is intended to allow policymakers to identify leverage points where interventions could have the most significant impact and to foresee potential unintended consequences of policies on the just transition process.

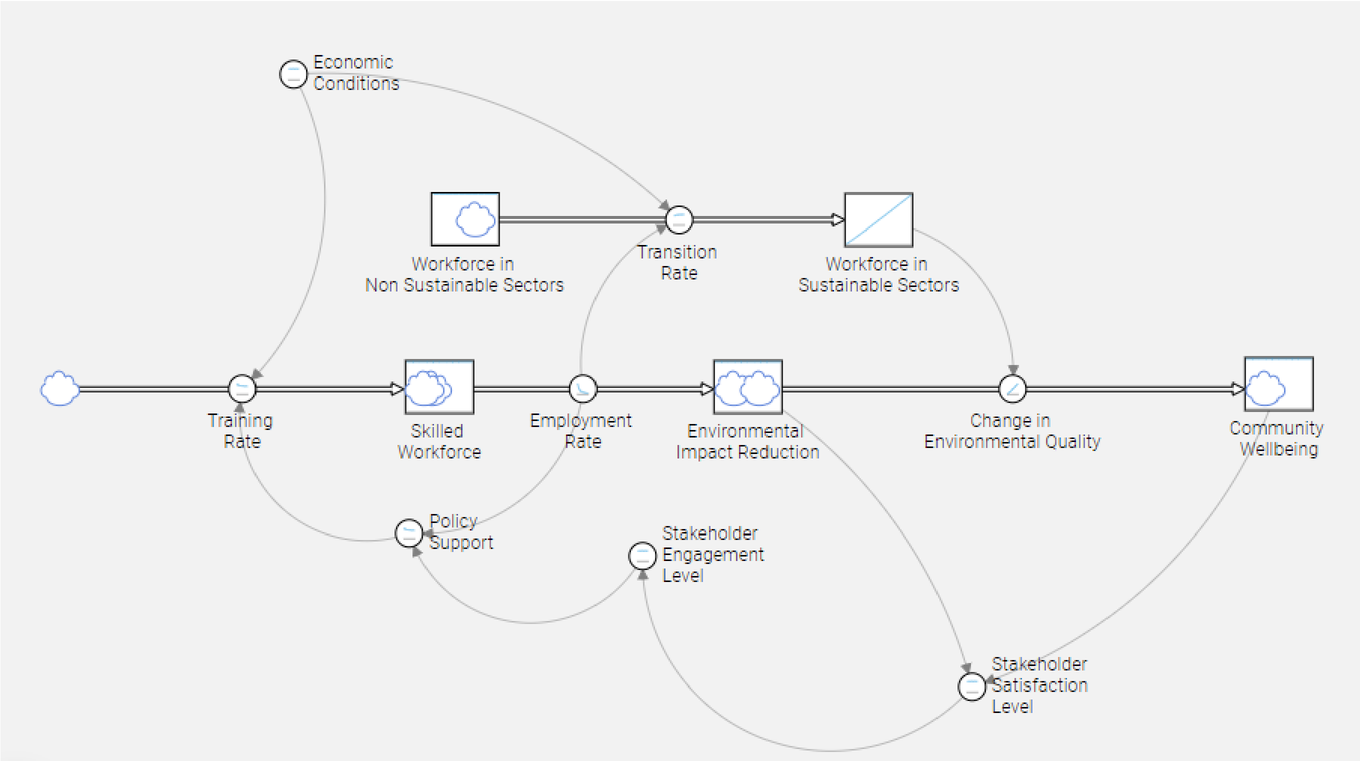


Figure 13. *SD model approach for Basque (ES).*

Azores (PT)

Azores has made an important effort in bringing together the stakeholders who act as a lever for the development of the territory, and also in understanding and making these stakeholders understand the meaning and importance of having just transition evaluation indicators such as the proposed JTIs. In this pilot region JTI5 (Community well-being) and JTI8 (Stakeholder engagement and participation in decision making) are brought into play.

JTI5 is quantified using data from: the Regional Health Service by 2024; the report on the State of Education in Portugal (2022); regional statistical data on those factors related to the access to social services offered by the Portuguese government; and the Household Expenditure Survey (2022/2023) by the Portuguese Institute of Statistics. For its part, JTI8 identifies the 3 pilot-related just transition plans already shaped involving co-participatory processes. However, a delay is not established for either of these two JTIs.

Positive feedback between JTI5 and JTI8 is considered, but in a complementary and absolutely qualitative manner, additional factors supposed to be of interest in the interrelation between JTI5 and JTI8 are included (Figure 14).

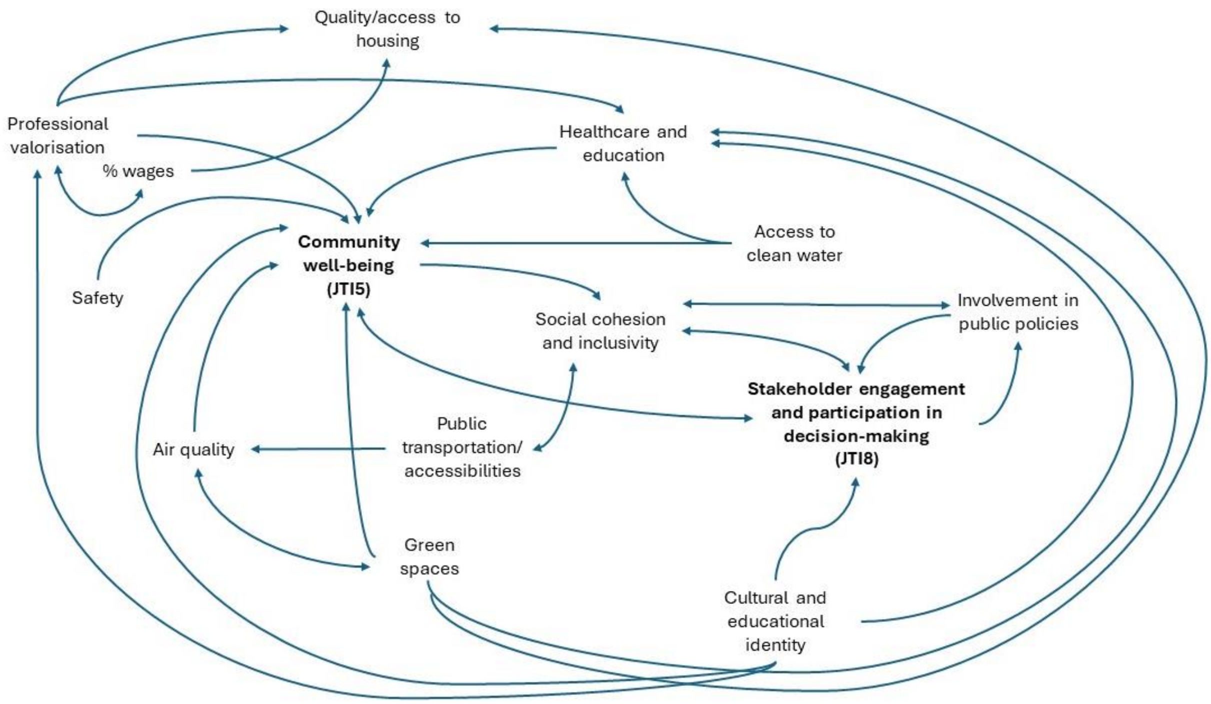


Figure 14. *Diagram illustrating the interconnections between JTI5, JTI8 and other factors considered relevant.*

Overall, Figure 14 effectively illustrates how various factors contribute to the positive cycle of improvement in community well-being (JTI5) and stakeholder engagement (JTI8). By highlighting these interconnections, the importance of holistic and inclusive approaches in fostering a just transition is reinforced.

Despite all these interrelationships, the positive feedback loop between JTI5 and JTI8 could not be quantified. This would lead us to consider long-term monitoring (equivalent to the previous cases) of both JTIs upon a yearly basis to know their interdependencies and time lags. But let assume that JTI5 and JTI8 could be analyzed separately. JTI8 would lead to establish an SD model equivalent to that of Pärnumaa, simply modifying the number of annual co-participatory tasks from 5 to 3.

The interest is focused on JTI5: **community well-being is pivotal for Azores in terms of just transition**, primarily due to the unique socio-economic and environmental context of the region. As a remote archipelago, Azores face distinct challenges that are intensified by the effects of climate change, making the transition to sustainable practices both necessary and urgent. Ensuring the well-being of the community involves maintaining a robust and inclusive socio-economic framework that can adapt to these changes without leaving any group behind. This approach is essential to support a balanced transition that aligns with the islands' ecological vulnerabilities and economic needs. By focusing on community well-being, the just transition in the Azores aims to enhance access to healthcare, education, social services, and affordable housing, which are vital for sustaining the region's social fabric and resilience against environmental adversities.

Moreover, a community that sees tangible improvements in living conditions and inclusivity is more likely to support and engage with sustainable initiatives and policies. This is particularly relevant for the Azores, where local engagement and stakeholder participation are crucial in shaping policies that reflect the specific needs and values of the community. The emphasis on community well-being ensures that the transition not only mitigates environmental impact but also maximizes social opportunities, making the process a holistic development towards sustainability. This holistic approach is necessary for Azores to manage its dependency on natural resources and transition towards a diversified and resilient economy, ensuring long-term sustainability and quality of life for its residents. Therefore, making a very basic systemic modeling only for JTI5 is interesting.

The following criteria are considered.

- Community well-being ranges from 0 (baseline value) to 100 (maximum value).
- Inputs are a function of the level of well-being not achieved yet, so that when well-being is minimal it will be achieved quickly, and when it is close to the maximum inputs will be very small. The parameter k1 is specific to this design for the system.
- k1 = 6, being a constant that accounts for the lowest number of years it takes to have perceptible progress. This value results from the percentage rounding of the consideration of a period of 1.5 years to obtain data on access to healthcare, education, social services and affordable housing, over a total of 24 years of development of policies favoring well-being[54].
- Outputs are a function of the level of achievement of Community well-being, so that when it reaches high values the outputs will be fast, and when it is very low the outputs will be much smaller. The parameter k2 is specific to this design.
- k2=20, which is the number of years considered appropriate for community well-being to permeate socially (taken as the 24 years indicated for k1, subtracting the 4 years of deep crisis in Portugal from 2008 to 2012).

The resulting systemic model is given in **Figure 15**. A Community well-being percentage of 75% could be achieved in 16 years (approx.) while applying effective policies to support it (Figure 16).

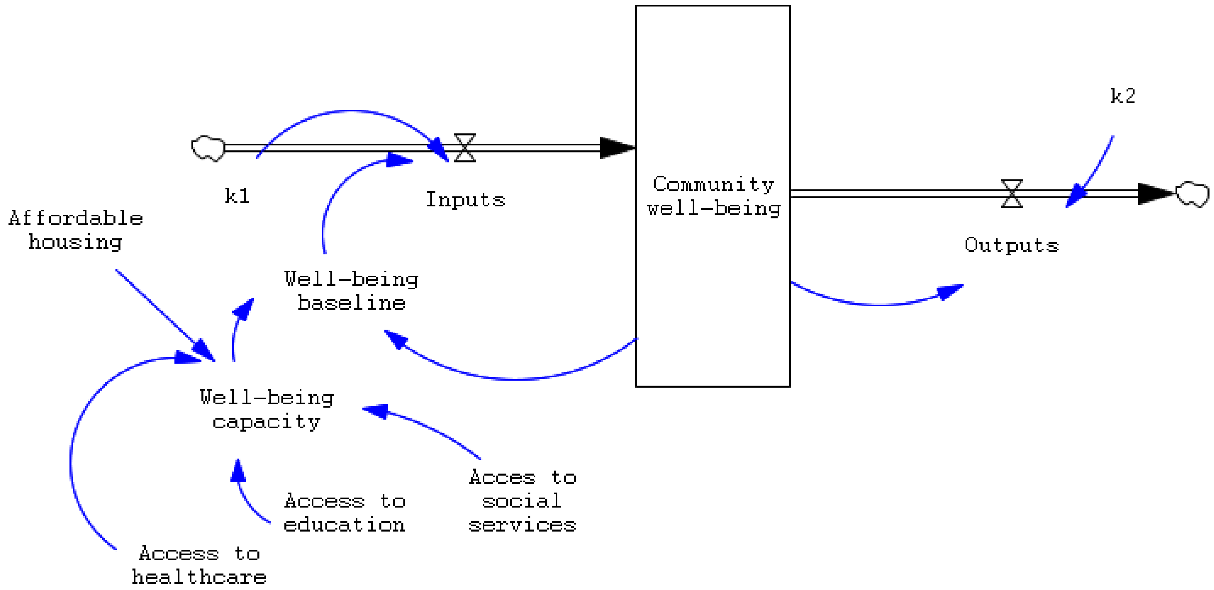


Figure 15. *SD model showing the achievement of Community well-being in the Azores Islands (PT) over a 20-year scenario.*

[54] Portugal has progressively oriented its policies toward community well-being, particularly since the early 2000s, with a significant push following the 2008 financial crisis. Recent years have seen an increased focus on renewable energy and sustainability, alongside continued support for essential social services like education and healthcare, which collectively enhance community well-being. Then the government have been implementing measures for 24 years aimed at economic stability, social equity, and health improvements.

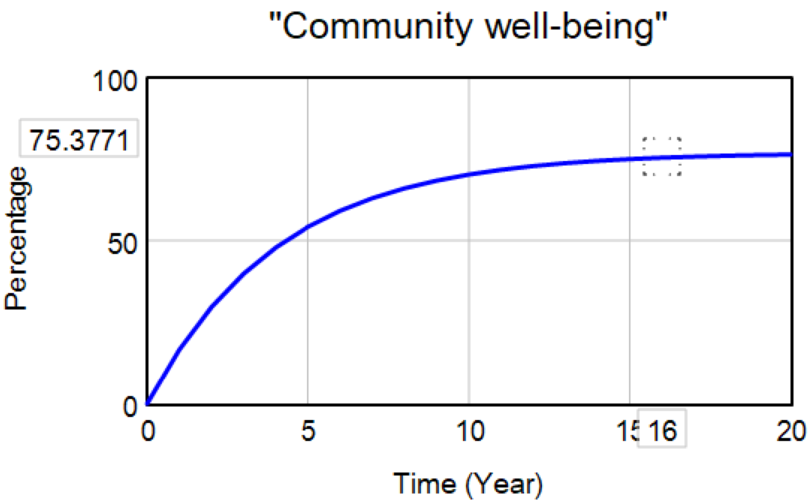


Figure 16. *Projected evolution of Community well-being for Azores (PT).*

Køge Bay (DK)

This case JTI7 (Social cohesion and inclusivity); JTI8 (Stakeholder engagement and participation in decision making) and JTI9 (Stakeholder satisfaction and perception) are tried to be quantified and interrelated. It presents the interesting addition of connecting these JTIs (societal level) with the IPs level (**Figure 17**).

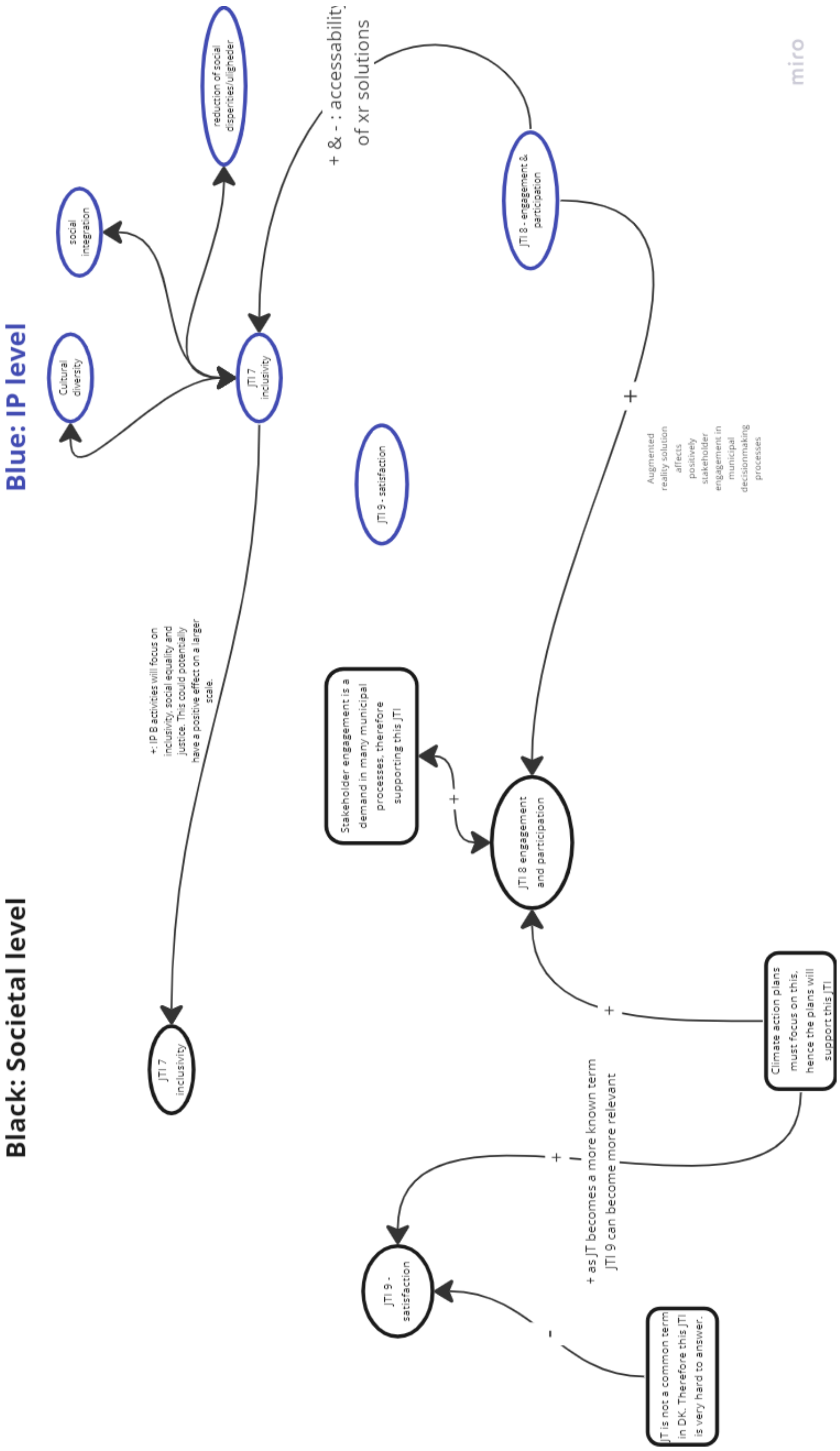


Figure 17. *Interrelation among the JTIs (dark) selected by Køge Bay and their IP actions (blue).*

However, it is worthy of remark that the relationships established at the JTIs and IPs level are qualitative and not quantifiable, as is also the case with the selected JTIs themselves. Only JTI7 presents a biased approximation based on publicly available national data from Statistics Denmark: Social integration (voting rate at local government elections in flood prone municipalities compared with national average. Source: KVRES[55]); Cultural diversity (proportion of population with non-western cultural background. Source: FOLK2[56]); Reduction of social disparities (proportion of population in flood prone areas with a household income below the national relative poverty line, i.e. less than 50 % of median household income. Source: IFOR12P[57]).

Yet, JTI8 and JTI9 are considered more complicated. The explanatory statement is given below:

- Particularly for JTI8, data are not readily available. However, an inventory of the number of responses during public hearings (relevant to climate change adaptation in municipalities) could be made, but it will require resources beyond the R4C mandate. Another measure could be to count the number of policy documents and/or public engagement activities conducted in other languages than Danish (e.g. English, Polish, Ukranian, Arabic, Turkish, Urdu, Mandarin), or targeting fellow citizens who are underrepresented in public engagement (e.g. children), or people with disabilities (e.g. dyslexia, blindness). This would also require a substantial data collection effort which goes beyond the capacity of R4C partners in Denmark.

- Regarding JTI9, a survey among key regional stakeholders (i.e. the 11 municipalities along Køge Bay) in year 2024 and year 2026 to gauge their perception of just transition for climate resilience is thought that could be made. The survey could be scaled up to the national level in Denmark, covering all 98 municipalities, as well as national government agencies and other key Danish stakeholders such as Danske Regioner, KL, Concito. This would require additional resources and fundraising beyond the R4C project.

The inability to quantify JTI7, JTI8, and JTI9 for Køge Bay relies on the initiatives brought into play, which in its opinion are directly linked to three key facts:

1. Complexity of objectives: these JTIs engage multifaceted goals, making them hard to measure directly.
2. Long-term outcomes: these JTIs involve long-term goals that may take years to materialize. Short-term assessments may not capture the full impact, making immediate quantification misleading or incomplete.
3. Resource constraints: measurement itself requires resources, including time, expertise and tools. Additional external experts are vital for measuring JTI7, JTI8, and JTI9 as they bring specialized knowledge and an objective view that enhance evaluation quality. Their expertise will help dealing with related politics, benchmarks against industry best practices and add credibility with already involved stakeholders. Furthermore, they should assist in resource augmentation and provide training to build internal evaluation capabilities.

These arguments lead to considering Køge Bay region as an **exception for SD modelling**.

South Aquitaine (FR)

This pilot region focused its efforts on putting the selected JTIs into context to assess the impacts and effectiveness of environmental and social initiatives quantitatively and qualitatively in close relation to the innovation actions linked to the IPs.

JTI4 focuses on reducing environmental impact through mitigating measures like beach profiling and sandbag use, optimizing these efforts with new monitoring and forecasting systems developed within the R4C project to minimize CO_2, energy, water, and waste outputs.

[55] Elections to municipality councils: https://m.statbank.dk/TableInfo/KVRES
[56] Population by sex, age, ancestry, country of origin and citizenship (1 January, 2024): https://sdg.statistikbank.dk/statbank5a/SelectVarVal/Define.asp?Maintable=FOLK2&PLanguage=1
[57] Persons in Risk of Poverty: https://m.statbank.dk/TableInfo/IFOR12A

JTI5 aims to improve community well-being, assessing risks such as submersion and erosion that could lead to displacement and affect living conditions and standards. It also considers the economic impacts of increased insurance premiums and public costs from storm damage.

JTI8 measures stakeholder engagement and decision-making participation, particularly among residents, to ensure they are integral to developing local management strategies and crisis management measures.

JTI9 evaluates stakeholder satisfaction and perceptions of the equitable transition's effectiveness and fairness, using tools and methods developed in R4C to better manage risks and disseminate timely information to the public.

Quantifying JTI4, JTI5, JTI8 and JTI9, as well as their interrelationships (Figure 18), presents significant challenges for this pilot region:

- The indicators are considered that dynamically interact over time. This complexity makes it difficult to isolate specific impacts or attribute changes directly to project interventions without extensive data.

- These JTIs often rely on indirect measures or proxies to infer impacts. For instance, environmental improvements (JTI4) are inferred from reduced resource usage, while community well-being (JTI5) might be gauged from access to services or housing stability. The indirect nature of these measures complicates both quantification and the assessment of causal relationships.

- In many cases, consistent and reliable data that can be longitudinally tracked are not available, particularly for newly implemented measures or in less monitored municipalities.

- Both JTI8 and JTI9 focus on subjective perceptions and engagement levels, which are thought inherently qualitative and could vary widely among individuals and groups. This variability makes customary quantification challenging.

- The interdependencies among these indicators are influenced by numerous external and internal factors, making it difficult to predict or quantify how changes in one subject (like environmental management) directly affect others (such as community well-being or stakeholder satisfaction).

A case-by-case approach is deemed necessary to evaluating these indicators and their interrelationships, focusing on trends and estimative assessments rather than precise quantification due to the current lack of consistent data for long-term analysis.

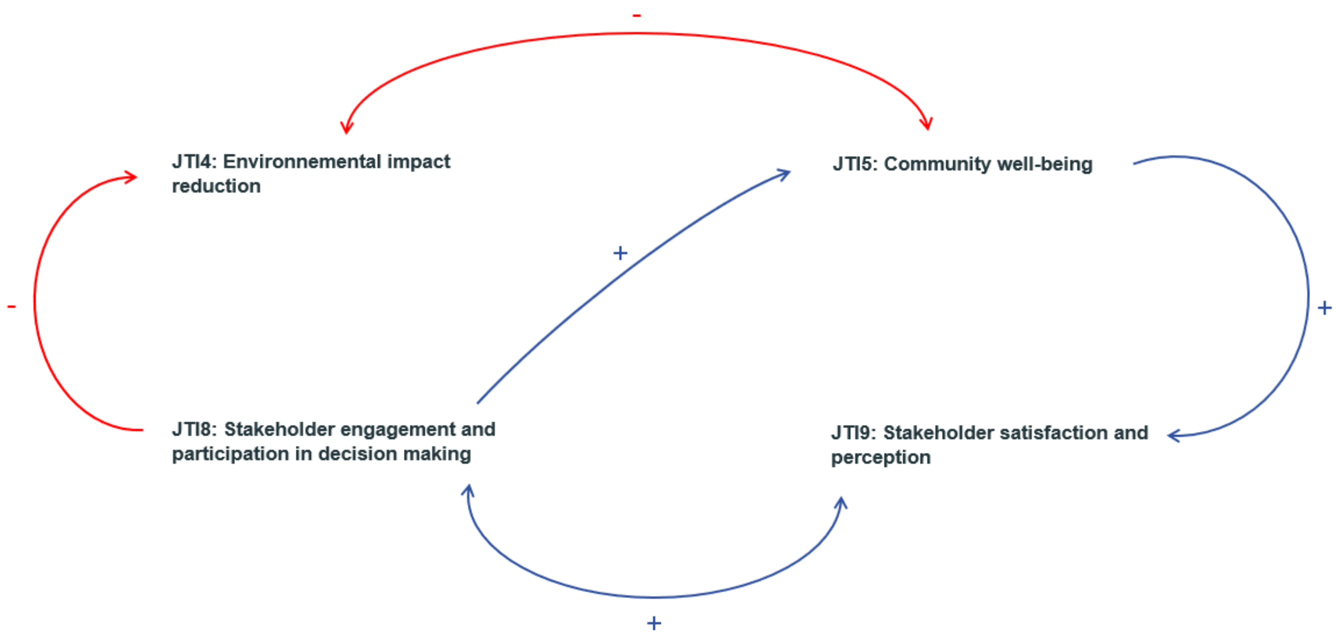


Figure 18. *Qualitative interrelationship among the selected JTIs in South Aquitaine.*

SD modeling for the case of South Aquitaine involving JTI4, JTI5, JTI8, JTI9 without long-term analysis poses challenges because they all heavily rely on historical data to predict future trends and evaluate policy impacts. Without long-term data, it is very difficult to capture the variability and feedback loops accurately, making predictions less reliable and potentially leading to suboptimal decision-making. Thus, robust long-term data is considered crucial, making South Aquitaine a **temporary exception for SD modelling**.

Burgas (BG)

The following JTIs were chosen by this pilot region: JTI3 (Income and wage equality); JTI5 (Community well-being); JTI6 (Economic diversification); JTI8 (Stakeholder engagement and participation in decision making) and JTI9 (Stakeholder satisfaction and perception). JTI3 and JTI6 are finally discarded because related data are measured at country level (National Bulgarian Statistical Institute), not at district level (as deem necessary for this pilot region).

Burgas has the capability to define the most appropriate methods of assessment (either 'Source' or 'Calculation') for JTI5, JTI8, and JTI9, yet no specific figures are provided for these indicators for several reasons:

- The choice between using 'Source' and 'Calculation' often depends on the complexity of the indicator. For instance, JTI9 might rely on surveys or polls (as mentioned, polls on social networks), which require fresh data collection cycles that are periodic and not instantaneous. The method of calculating averages from survey data introduces a delay (difficult to quantify without involving social media experts) and depends on the availability of fresh data, leading to a situation where figures are not provided immediately.

- For JTI5 and JTI8 the actual figures might not be readily available due to the need for new data collection and for new surveys or efforts that are specific to the transition-related activities within the pilot region. The existing data sources may require significant processing to extract useful figures.
  Specifically, the calculation method for JTI5 primarily relies on surveys and existing infrastructural data. Surveys collect direct feedback on residents' well-being, covering healthcare, education, and social services access. Concurrently, existing data is used to assess infrastructural impacts on well-being, with findings represented as percentages of the total population of 210,284 in Burgas. This dual approach ensures a

comprehensive assessment, blending qualitative insights from surveys with quantitative data on available community services.

It is highlighted that the workshop discussions and stakeholder decisions reflect the **practical challenges in measuring the selected JTIs**. The stakeholders might have decided to focus on qualitative assessments (Figure 19) or may have deferred quantitative assessments to a later stage when more accurate or relevant data becomes available, even raising the possibility of creating specific ad-hoc measurement methods. This strategic decision-making ensures that the indicators remain relevant and are measured correctly, even if it means delaying the provision of specific numerical values.

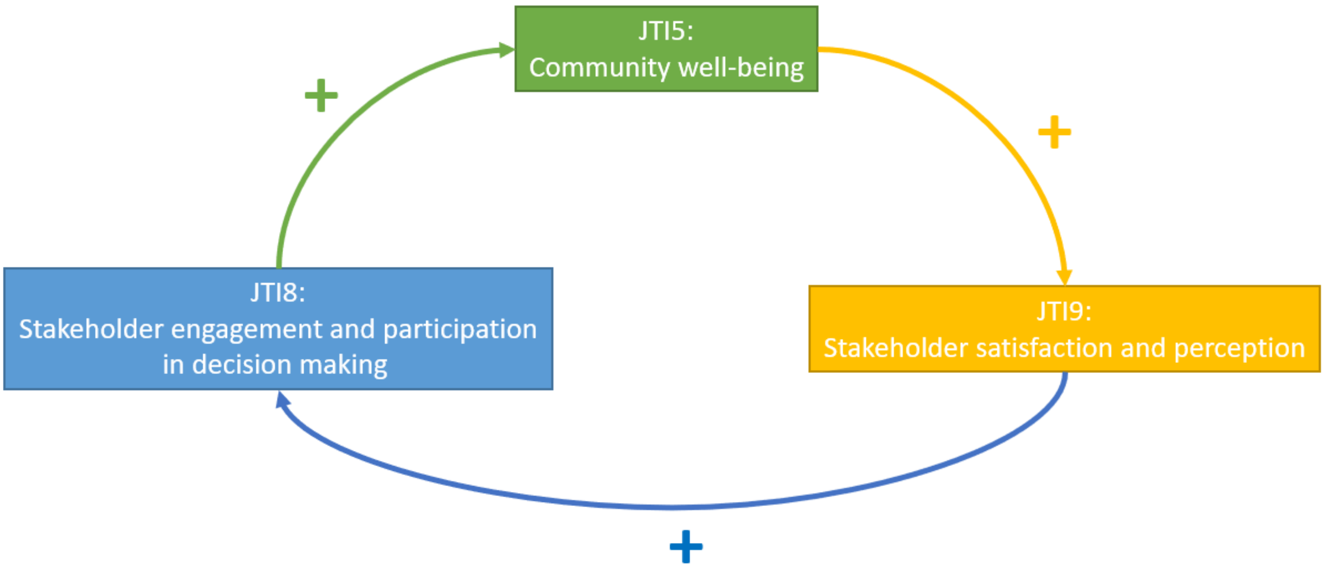


Figure 19. *Positive feedback interrelationship for the selected JTIs in Burgas.*

5.2 Bottom-up approach

Bottom-up approach for SD model developments are addressed when cases of interest either arise after the attempt to quantify and interrelate the JTIs, or upon request with sufficient availability of information.

Nordic Archipelago (FI/SE/AX)

The two workshops of Nordic Archipelago included participants from Åland public sector and the regional 'development council'. Most of the time in both workshops was used to define the JTIs and their relevance for this pilot region. It was Nordic Archipelago's wish that transitions are analysed broadly. Indicators are not quantified because the workshop efforts focused on specifying the meaning of indicators in Nordic Archipelago's context, and their interconnections.

The priority issue in the Nordic Archipelago, according to workshop participants, is maintaining a stable population in the archipelago through a sustainability transition. The ability to maintain a sustainable population is under multiple stressors. First, the availability of services and the connectivity of the transportation networks are not always ideal, which are an important reason for people to move out. Second, young people who move away from Nordic Archipelago might not return after graduating. Third, there is significant variation in Nordic Archipelago's population due to seasonal residents who have only their summer homes there. In peak summer months, when seasonal residents, tourists and permanent residents are all in the Nordic Archipelago, there are legitimate concerns for resource sufficiency (e.g. of potable water sufficiency). Fourth, there is some amount of social schism between permanent residents and seasonal residents, and it is notable that seasonal residents are often somewhat wealthier than permanent residents. Nordic Archipelago faces typical sustainability transitions issues, such as green energy and environmentally regenerative employment, and needs to tackle the political issues regarding which technologies, business sectors, and lifestyles should change and how. But these are specifically contextualized in Nordic Archipelago's priority to maintain a stable and cohesive population.

Figure 20 shows a causal loop diagram that is a cleaned-up summary of views from both workshops. Multiple feedback loops were postulated. Employment in green sectors can promote itself through an **industrial renewal dynamic**, where the more industries transition, the more there is demand for relevant skills, and thus incentive to supply of those skills, leading to further industrial renewal. Simultaneously, actors in 'sundown' industries or actors using outdated technologies and methods may directly lose out in competition. If economic activity increases in the process of such industrial renewal, this itself can create economic resources for relevant training of new skills. This can happen either through a public sector channel, where increasing tax incomes are spent on public training institutions, of through a private sector channel, where businesses recognize a future-oriented incentive to spend some of their resources on re-skilling. These are all accelerating effects. The main potential balancing effect in the industrial renewal dynamic is that if employment declines in 'non-green sectors' as it increases in 'green' ones, it is not clear that the net effect is an increase in economic activity. Thus, transition driver of increased economic resources and incentives could possibly not work. These contrasting narratives open up an interesting modelling question to explore further. SD simulation is particularly strong with evaluating which dynamic logic dominates -the acceleration or the balancing effect- or under what assumptions would one dominate the other. Furthermore, question left open in the workshop discussions was whether the Nordic Archipelago population itself demands re-skilling and education. This is represented with the question mark in Figure 20. SD simulation can be used also to test the significance of whether this link exists or not. Its existence could represent, for instance, pro-transition cultural and attitudinal change during a transition period. Its non-existence could represent a top-down scenario of transition, where local Nordic Archipelago residents are not invested, but only authorities and certain businesses are trying to push for change. The two scenarios would likely have different outcomes.

Figure 20 illustrates that economic activity, wellbeing, environmental quality, democratic participation and inclusion support one another, particularly in if economic productivity is sufficient and inequality does not grow excessively. The only feedback loop in this part of the model is between wellbeing, democratic participation, and inclusion. We may term this the **wellbeing dynamic**. As the industrial renewal aspect of the model, also the wellbeing dynamic represents an ideal outcome. Its exogenous aspects such as environmental quality (which could improve with 'green sector' work) should be seen as a target or a vision rather than the status quo. Likely, various steering policies and societal conditions need to be in place for the model overall to work in a way where employment stays high, sectors renew toward green activities, and wellbeing improves. Conditions that lead to these occurring can be tested with simulation.

Ultimately, the model can be tied back to the policy priorities of Nordic Archipelago: sustainable population and sustainable resource use. The variables representing employment can be interpreted in terms of 'permanent' and 'seasonal' workers, and the balance between the two can be fed into the wellbeing dynamic (highly divergent populations may cause social strain, as mentioned earlier). Economic activity can possibly be tied also to touristic attractiveness, which as discussed above, feeds to economic activity but can contribute to resource and social strain. Resource use can be interpreted as a linear function of permanent and seasonal population at any one time. These additions to the model will be co-created with Nordic Archipelago going forward. Once this **population dynamic** is added, it can be used similarly to the wellbeing dynamic and industrial renewal dynamic to test for the conditions of desirable and undesirable outcomes.

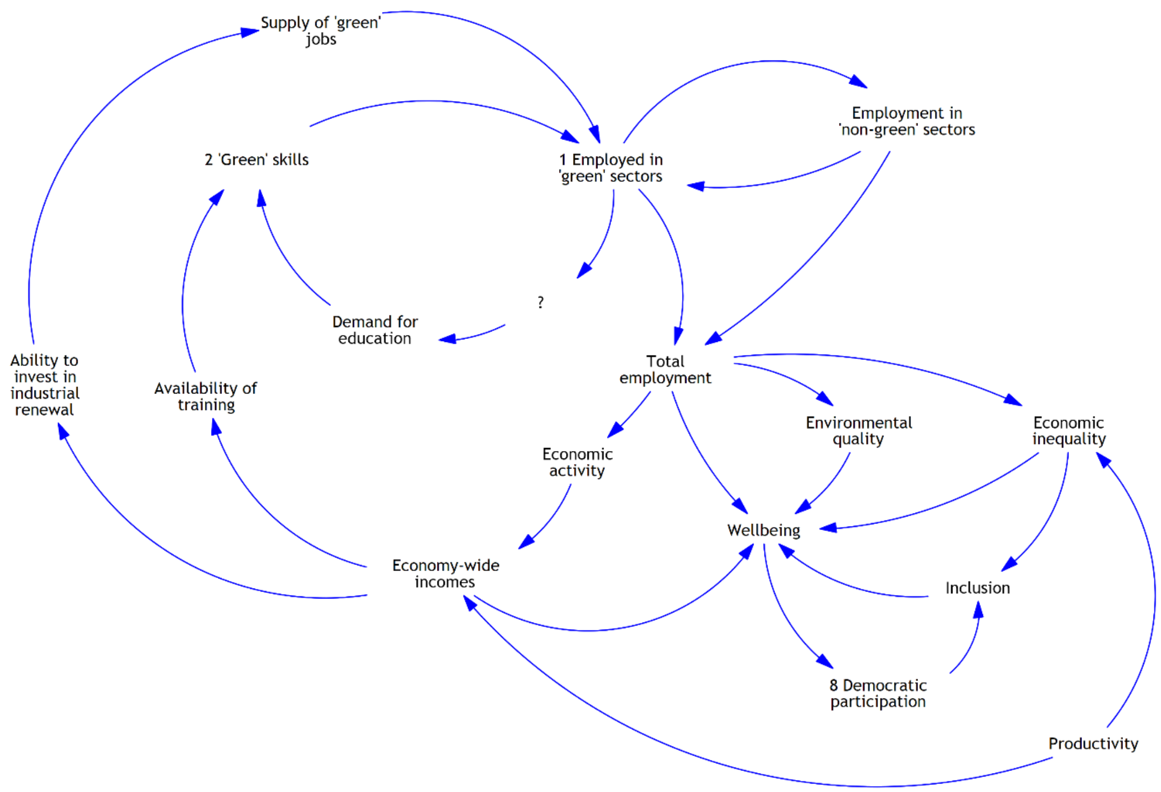


Figure 20. *Summary of the two Nordic Archipelago workshops.*

Figure 21 shows a screen capture of the first simulation model iteration, which applies the qualitative learnings from the workshops in quantitative form. We illustrate the dynamics of the model with six tests, outlined in the table after that figure. The following illustrates the basic nonlinearities of the model, rather than results. The final results will be iterated based on data and stakeholder opinion, but these initial results demonstrate that the model can be used for making decisions between policy actions and evaluating the significance of different uncertainties. The units of the results are for the time being arbitrary (the important aspect is that certain parameter changes can lead to unintuitive dynamics, which justifies a simulation method).

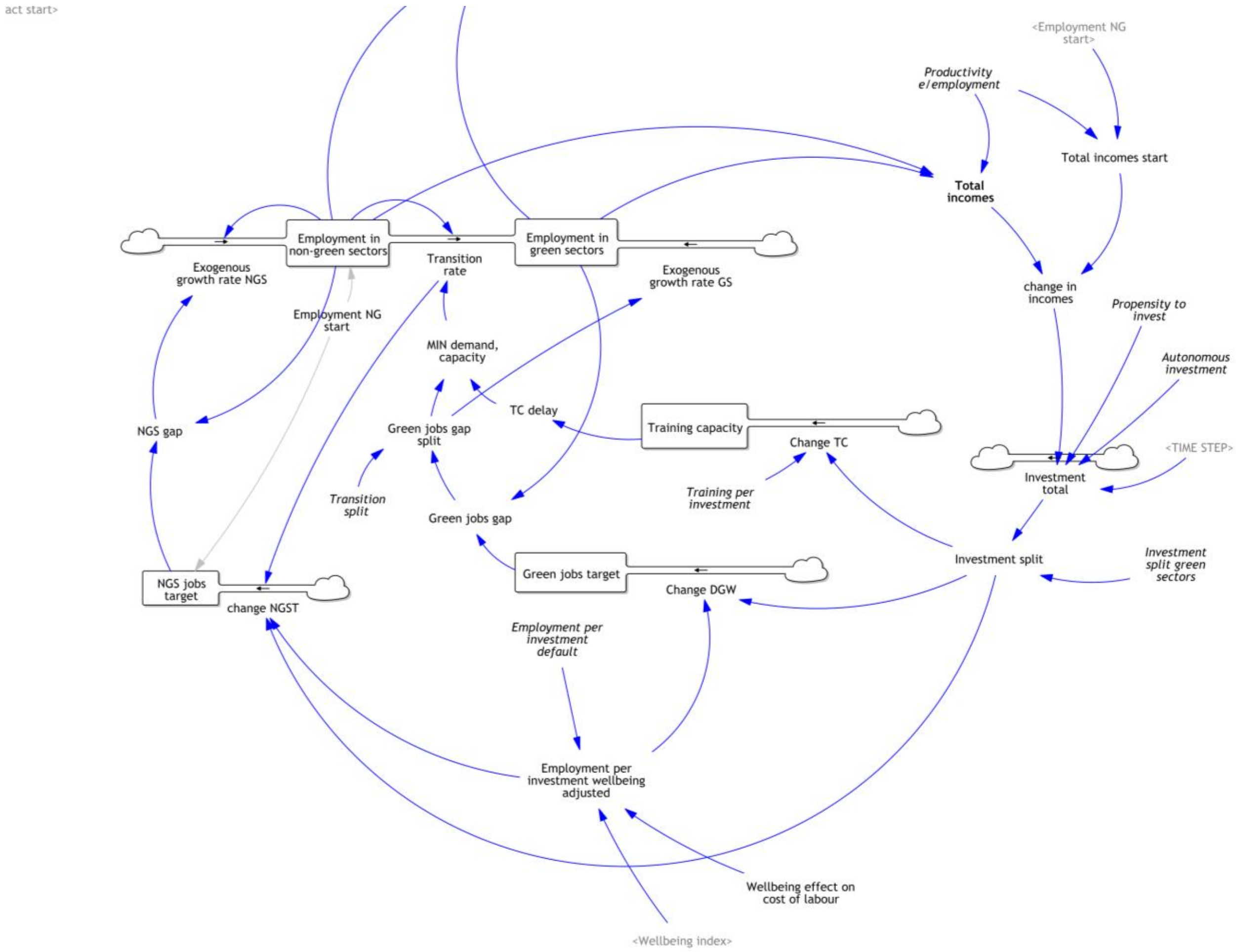


Figure 21. *Simulation model for Åland archipelago.*

Test	Description
BL	Baseline scenario where investment is targeted evenly to non-green employment, green employment, and green skills development.
No NonGreen	No investment goes to jobs creation in the non-green sector.
GreenJobsEmphasis	Same as above, but most of green investment goes to jobs creation directly and only a smaller part goes to skills development.
GreenJobsEmphasis HighEnvImp	Same as above, but the environmental impact of the green sector is only 10% lower than that of the non-green sector – instead of 50% as in other tests.
GreenJobsEmphasis WellbEff	Same as *GreenJobsEmphasis*, but improved wellbeing makes Nordic Archipelago a more attractive place to work, leading to higher employment per amount of money invested.
GreenJobsEmphasis SENS	Same as *GreenJobsEmphasis*, but the wellbeing effect and environmental impact parameters are uncertain. 200 simulations with random sampling of values within a range.

Figure 22 and Figure 23 show the development of green employment and environmental impact respectively for the first five tests. The *Baseline test* (blue) leads to the highest growth of green employment, because also non-green employment is growing, and some portion of non-green workers continuously transition to green sectors. Though green employment is high, and its environmental impact is only 50% of non-green sectors, total environmental impact grows because the total amount of work grows. The situation is amended if no new investment is targeted at non-greens employment at all (red). Total jobs do not change much, green jobs grow somewhat and mostly displace non-green jobs, and environmental impact declines. This potential for improvement can be accelerated if green investment is targeted in a more effective balance between direct employment and skills development (green). However, this result rests strongly on assumptions of environmental impact: if we assume that the environmental impact of the green sector is only slightly lower than that of the non-green sector (grey), even the more effective green investment strategy from the green test leads to environmental impact *rising* instead of falling. Finally, if we consider environmental improvements to improve wellbeing (and reputation) in the Nordic archipelago, therefore making it easier to attract labor the green growth effect is amplified further (black).

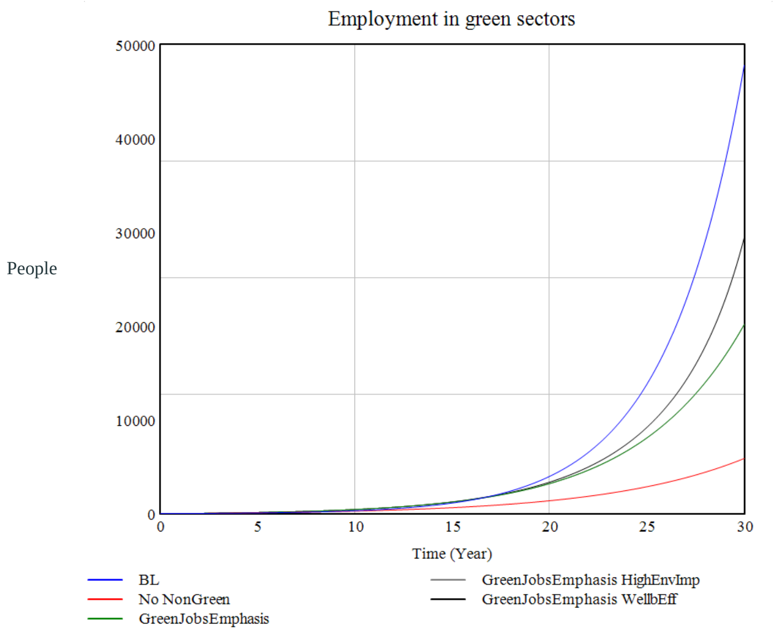


Figure 22. *Development of green employment for the Nordic Archipelago.*

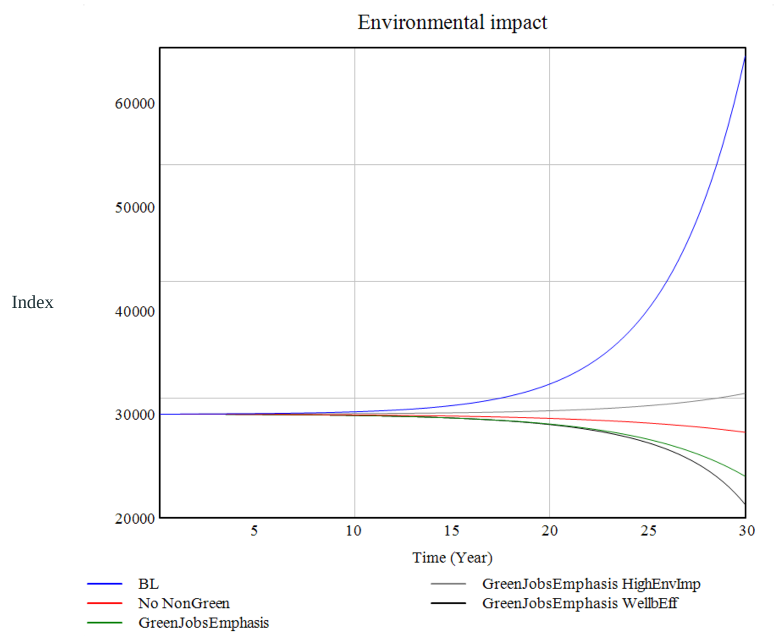


Figure 23. *Development of environmental impact for the Nordic Archipelago*.

Finally, Figure 24 shows an example of a random sampling test, where the exact amount of environmental impact and economy-amplifying wellbeing effect are not known exactly but can be given a min-max range. The range of environmental impact is broad, though in most cases declining. Yet, if these are the uncertainties, the policymaker should know that also very minimal improvement, or even worsening, of environmental impact is possibly under this scenario unless the uncertainties are controlled more carefully. Such a result could for example justify a more careful selection of which sectors are considered 'green' and thus strategically targeted, or it could justify better communication of the improving environmental impact of the region's economy (stronger wellbeing-economy link).

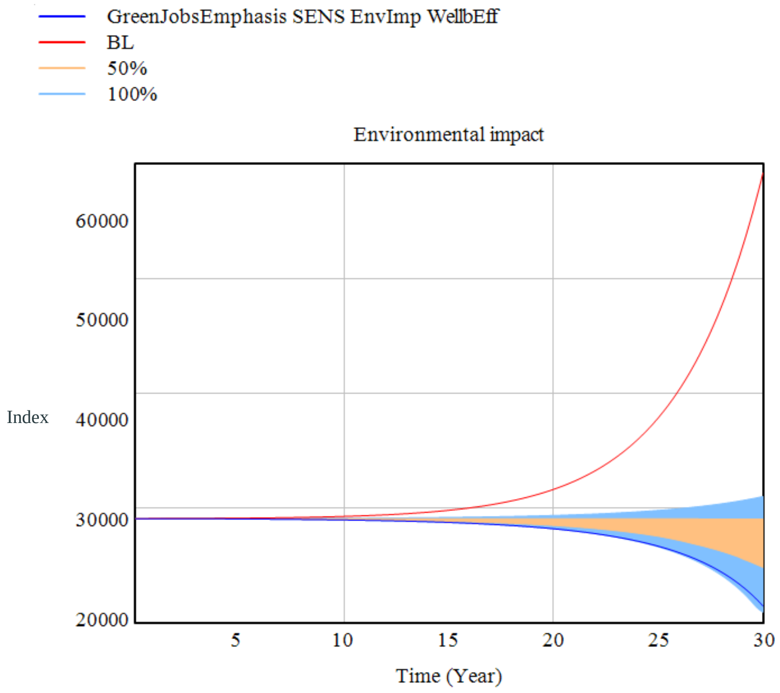


Figure 24. *Mix-max range for environmental impact in the Nordic Archipelago.*

The following table reports the JTIs that were most interesting to workshop participants, though in both workshops all JTIs were included in discussion.

JTI	Description
JTI1: Employment transition rate	Measures number of employed in businesses with a primary energy supply from electrical grid or own renewables such as heat pumps.
JTI4: Environmental impact reduction	The aim is to track the positive environmental outcomes of the transition, measuring these facts: • Reduction in greenhouse gas (GHG) emissions. • Reduction in energy consumption. • Reduction in water usage.
JTI5: Community wellbeing	The goal is to ensure that the just transition improves the overall living conditions of the communities involved, measuring these facts: • Access to healthcare. • Access to education. • Access to social services. • Living costs.

JTI7: Social cohesion and inclusivity	Measures qualities of the local population • Seasonal employees. • Permanent employees. • Seasonal residents. • Permanent residents. • People belonging to clubs and organizations.
JTI6: Economic diversification	Measures the extent to which new industries or sectors are emerging and contributing to the overall economic growth and stability of the region. • Regenerative agriculture. • Green electricity sector. • Circular economy businesses.

Helsinki-Uusimaa (FI)

One workshop was held with Uusimaa, including participants from different divisions of the Uusimaa-Helsinki Regional Council and the University of Helsinki. The Uusimaa partners did not prefer to try to model effects of their pilot (heat map digital twin) on JTIs at this stage. This is because the pilot is in very early stages, so there is little expert opinion on its effects, and because the scale of effect of the pilot is expected to be very different to the framing of just transition or the original JTIs. The workshop modelled just transition in Uusimaa region from the perspective of Uusimaa Regional Council adaptation strategy. Though it, for now, set aside what the impact of the pilot may be, it will likely be possible to interpret the pilot impacts through the framework of the general just transition model. It was not possible to quantify indicators/variables, since most of the indicator portion of the workshop was spent discussing the meaning of JTIs, their connection to Uusimaa and the pilot, and regional just transition priorities. Quantification should be possible in principle for all, and participants felt hopeful and optimistic about model development. The main concerns had to do with the applicability of JTIs, the best scope of the model, and the connection between workshopping and R4C deliverables.

A summary model of the interconnections discussed at the workshop is shown in **Error! Reference source not found.**. It focuses particularly on the effects of exogenous **new construction** in the Uusimaa region. The amount, density and location of construction steers indicators representing health (cardiovascular hospitalization rate was deemed a good indicator that entails relatively good baseline measurements), wellbeing (social connections, access to services, access to greenspace), economic activity (particularly in the agriculture and forestry sectors), and biodiversity. The intermediate variables to these effects include heat risk and land use change.

The strength of the model draft is that is captures both desirable and undesirable effects of new construction, the multiple and sometimes shared causes of key indicators (e.g. biodiversity is affected by new construction through multiple channels), and the multitude of key causes from particular construction effects (e.g. density of construction improves social connections, but could also lead to heat risk). However, the weakness of this view so far is that it is an entirely exogenous explanation of the key indicators. Effects will be possible to simulate, but given that there are no feedback loops that steer outcomes in one direction or another, the accuracy of simulation parameters becomes more important, and thus the necessary data quality level for building a useful model rises.

There are two options for analysis that open from the Uusimaa workshop which are not mutually exclusive. The first is to do quantitative linear assessment. The possibility of this route will be investigated next, and determining its limits (e.g. due to data availability) will be relatively quick. The second option, which we can begin soon after first experiences of option one, is to further develop **Figure 25** toward a dynamic hypothesis that includes feedback loops.

Possible sources of feedback loops in this model are through the **economic dynamics of urban planning**. After an initial construction investment, the qualities (e.g. heat risk) of the area will be altered, which leads to a re-evaluation of real estate based on user experience and attractiveness. The value of real estate has broader macroeconomic effects (so-called wealth effect) locally in Uusimaa, factors into contractors' decision-making concerning new construction, and informs the city about its zoning and urban planning decisions. The acceleration or deceleration of construction in itself has impacts of local incomes through contractor employment. The macroeconomic conditions, mainly aggregate income levels, can be connected back to the demand and supply of construction. Thus, overall, the Uusimaa model can be developed to a dynamic simulation model that creates different scenarios of **sustainable urban renewal toward climate resilience**, or failure to achieve it. Thus, the Uusimaa dynamic simulation model would promote both Uusimaa local policy priorities and the overall aims of R4C. Figure 26 shows a screen capture of the initial simulation model.

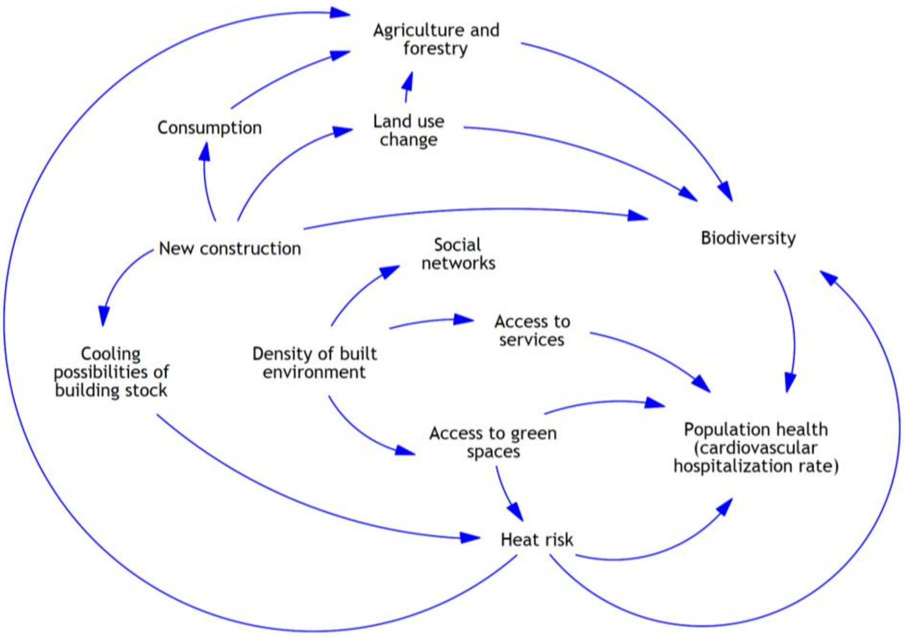


Figure 25. *Summary of the Uusimaa workshop on variable interrelations.*

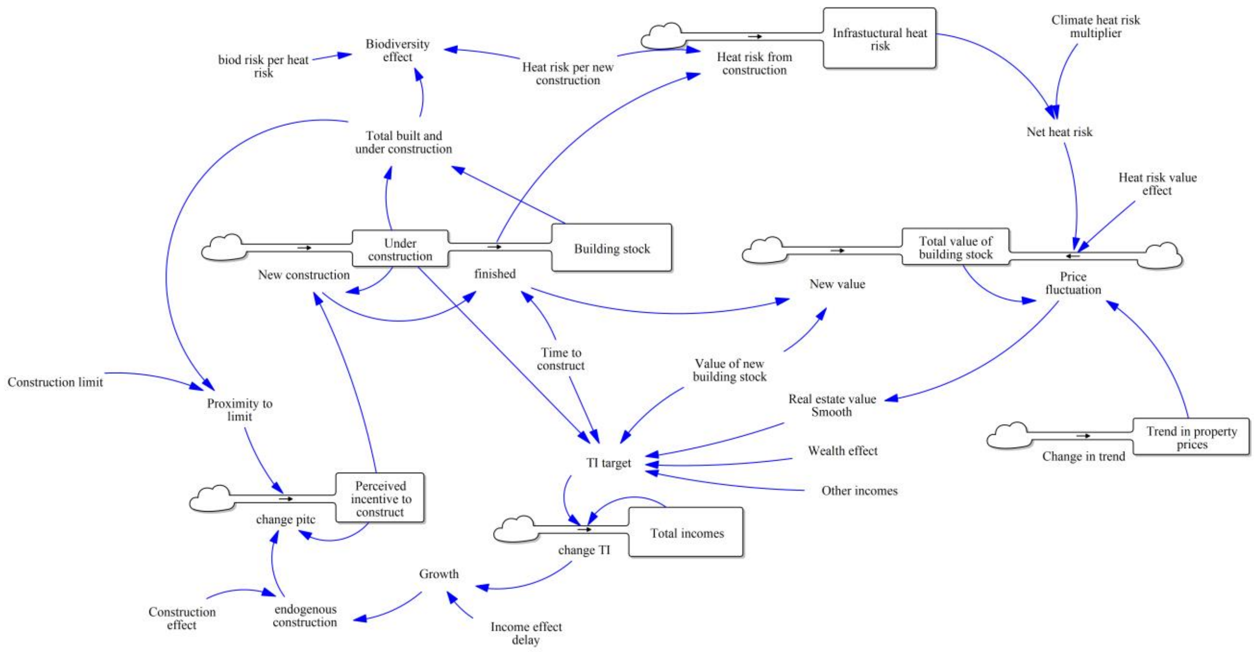


Figure 26. *Simulation model of sustainable urban renewal toward climate resilience for Uusimaa.*

Figure 27 and Figure 28 demonstrate simulations for total construction and biodiversity effect respectively. Even though there is feedback from the property value declines from heat risk back into construction, improving new construction in terms of its heat risk does not hinder construction very much (compare blue and red curves in Figure 27). This is because the incentive to construct is dominated by other regional incomes apart from just property values, under current parametrization, so the negative feedback is dampened. Another aspect that explains the low effect of heat risk mitigation is that construction drives economic growth and thus incentivizes itself. The negative feedback did not strengthen much even if it is assumed that the negative economic effects of heat risk are twice as large (green curve, Figure 27). However, assuming that heat risk effects and biodiversity effects correlate (e.g. through land use change that reduces greenery and forests), the environmental effects of constructions can be mitigated even if construction itself is high (Figure 28). In fact, even if we increase the willingness to construct (grey curve), leading to more new buildings, a lower environmental impact per building can counteract the environmental impact of a larger scale of construction (compare blue and grey curves).

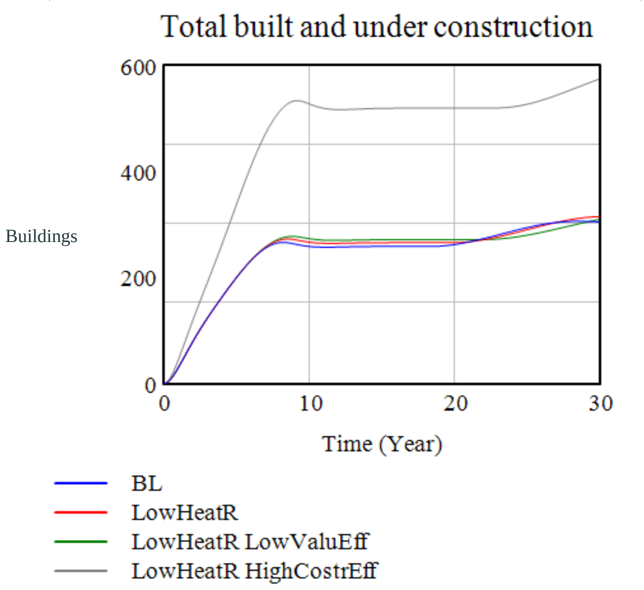


Figure 27. *Simulations for total construction in Uusimaa.*

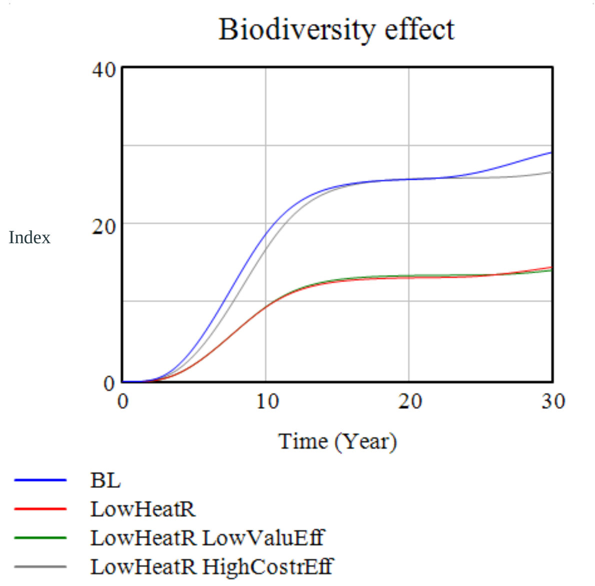


Figure 28. *Simulations for biodiversity effect in Uusimaa.*

The following table shows the indicators highlighted by Uusimaa workshop participants. The workshop group based the indicator selection on the regional adaptation strategy. Most of these correspond with the original JTIs, though they do not cover every proposed aspect of them. A couple did not fit intuitively to the original JTIs, so these are included as potential 'additional indicators'. Uusimaa Regional Council listed other indicators/variables of interest based on their adaptation strategy. Most of these seem to have correspondence with the original JTIs (e.g. potable water services and energy production).

Indicator	Description	Data source
JTI4: Environmental Impact Reduction	The aim is to track the positive environmental outcomes of the transition, measuring these facts: • Biodiversity. • Land use change. • Access to green space.	Helsinki-Uusimaa Regional Council
JTI5: Community wellbeing	Measures risk and realization of heat-related health issues: • Cardiovascular hospitalization rate. • Access to services.	The relevant expert with access to this knowledge was identified.
JTI7: Social cohesion and inclusivity	Measures to size of people's social networks as affected by the density of the built environment.	To be determined
Built environment	Measures change in amount and quality of old and new construction, which goes on to affect agriculture and forestry, health (JTI5) and biodiversity (JTI4). This indicator may also be left as a scenario assumption rather than an indicator by itself, if nothing in the model affects it.	Helsinki-Uusimaa Regional Council
Agriculture and forestry	Measures agricultural and forestry activity that is impacted by construction of new infrastructure and which itself goes on to affect biodiversity (JTI4).	Helsinki-Uusimaa Regional Council

Sitia (EL)

According to local stakeholders, the priority sustainability transition issue in Sitia (Crete island), is stability of the local population and sustainability of water resource use. From a local perspective, just transition and the economic renewal it entails concerns primarily the agricultural sector. In a modelling workshop, Sitia identified the most relevant indicators to be JTI1 (Employment transition rate); JTI3 (Income and wage equality); JTI4 (Environmental impact reduction -in particular water scarcity-); JTI8 (Stakeholder engagement) and JTI9 (Stakeholder satisfaction). Sitia found that employment transition rates could possibly quantified to an extent-based employment statistic from Hellenic Statistics, but for other indicators data availability is low. In terms of interrelations, Sitia considers employment transitions and water scarcity to influence income levels and equality, but in an uncertain and thus unquantified way. Local stakeholders did not connect stakeholder engagement and satisfaction to other indicators. Overall, it is notable that Crete does not have an already existing just transition plan to draw on.

The primary problem areas of population stability and water scarcity resemble those of Nordic Archipelago. Particularly, the two regions have similar concerns with young people moving away for education (and staying away), and seasonal employment fluctuations and tourism. The most productive way forward is likely to be the careful transfer of modelling approaches from Nordic Archipelago to the context of Sitia.

Nordic Archipelago and Sitia are ultimately different regions with different local particularities. The transferral of a model from one context to other needs to therefore be done critically and with inclusion of stakeholder validation. At the very least, the two models will be parametrized differently. Furthermore, since Sitia did not create a causal loop diagram of interconnections, a separate discussion needs to be held where the plausibility of the feedback loops in the Nordic Archipelago model for Sitia context is verified. It is possible that some connectivities are excluded after such discussions. However, it is intuitive that many of the interconnections in the Nordic Archipelago model are relatively general-purpose as possible future scenarios. Even though Sitia struggled to connect their key JTIs, connectivity will likely be validated after the initiative to propose useful and interesting dynamic hypotheses is articulated by the modelers of the project.

One open question for transferring Nordic Archipelago insights to Sitia is whether the meaning of ‘industrial renewal’ is transferrable. For instance, if Nordic Archipelago emphasizes an energy source transition and renewal of business practices, does this vision correspond with Sitia’s transition vision. Here care needs to be taken. However, even if for Sitia another form of industrial renewal is most relevant, for instance the climate resilience of agriculture, it is likely that the ‘industrial renewal’ logic developed for Nordic Archipelago remains largely the same.

The promise of system dynamics modelling for Sitia will, by this plan, be essentially the same as for Nordic Archipelago. The model will allow testing, under different parametric assumptions, how a desirable and self-reinforcing **industrial renewal logic** (reduction of environmental impact of farming / improvement of climate resilience of farming), **population sustainability**, and **water resource sustainability** is possible, taking also into account the possibility of wellbeing dynamics akin to Nordic Archipelago where industrial renewal can either improve or place strain of social cohesion (Figure 29). Figure 30 shows a simulation model iteration of the causal loop diagram.

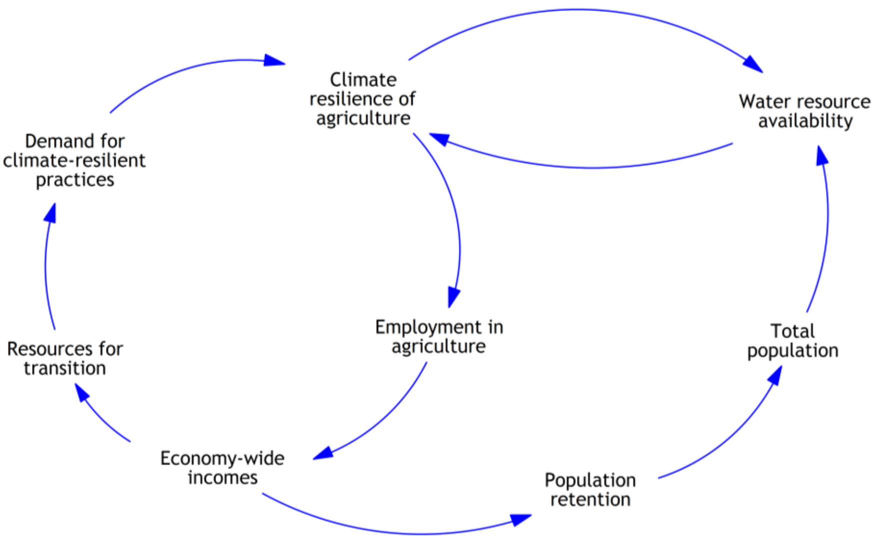


Figure 29. *Summary of the dynamics for Sitia.*

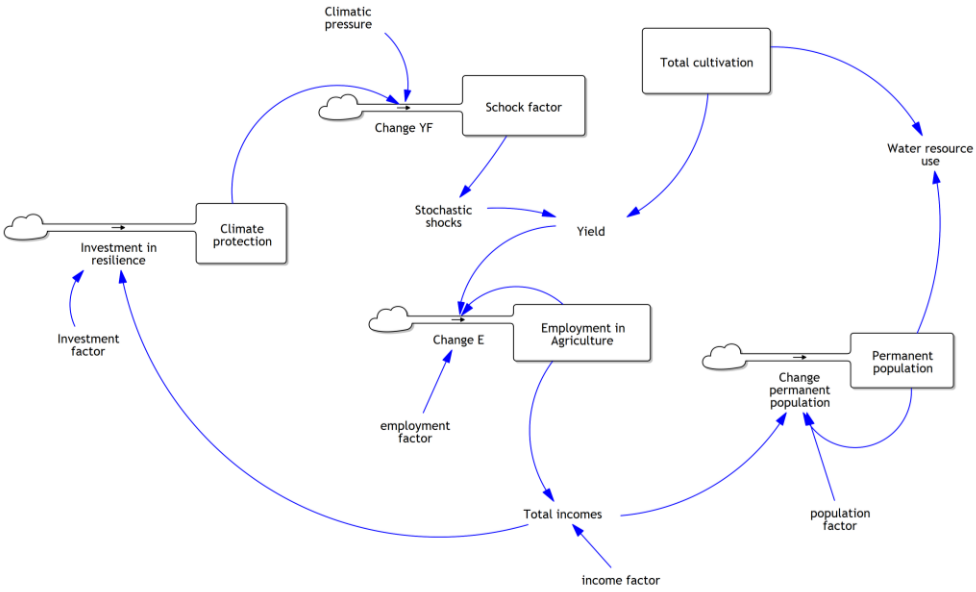


Figure 30. *SD model for Sitia.*

Figure 31 shows three simulation results that illustrate the functionality of the model. In the blue Baseline scenario, employment in Sitia agriculture declines over time due to increasing exogenous climatic pressure. The constant 'jiggle' of the curves is due to the stochastic formulation of climate-related shocks. The baseline shows a long-term decline in agricultural yield, leading to long-term decline in sector employment, but the model is equally well suited for representing sharp short-term stochastic declines in agricultural yield. In the red curve, long-term decline is avoidable if some amount of agriculture sector incomes is invested in climate resilience. Despite an initial decline, employment rebounds given that there are still enough resources for investment in resilience. The model allows testing for the limits of such actions: the green curve assumes a steeper increase of adverse climate risks over time, with the same resilience impact of investment. Due to greater climatic stress, agricultural yields decline more, the immediate employment effect is worse, and fewer resources are available for investment in climate resilience overall. The employment decline is expectedly worse than in the red curve, but after some time the climate resilience improvements of agriculture outpace additional climate pressure, and the agricultural sector moves to an upswing. These kinds of sensitivity tests allow policymakers to evaluate the robustness of actions. If the green curve is deemed unacceptable due to the short-term decline, yet the climate risk assumption is deemed realistic, then something else needs to be done to course-correct. Actors could for instance search for more cost-effective resilience investment options.

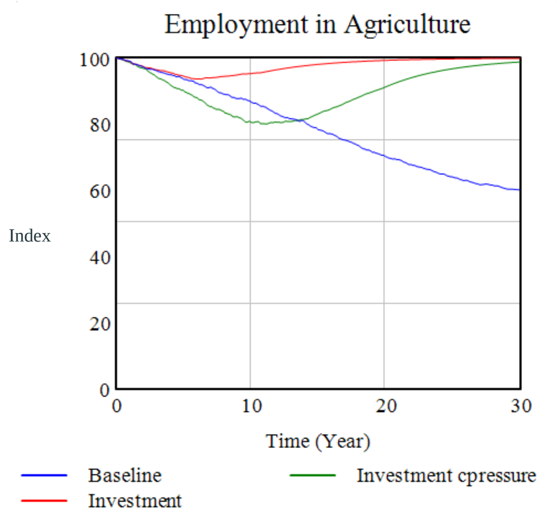


Figure 31. *Evolution for employment in Agriculture for Sitia.*

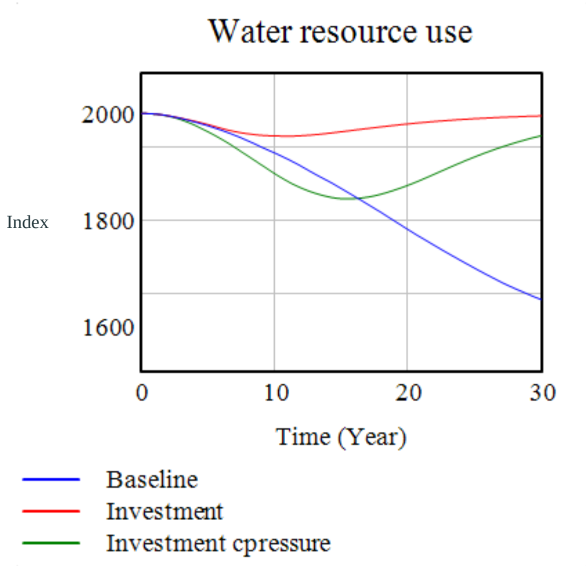


Figure 32. *Evolution of water resource use for Sitia.*

Figure 32 shows the same scenarios for the key environmental impact variable water resource use. Results mirror the employment effect of the scenarios, since employment factors into the permanent population in Sitia. In additional simulations, water resource use can be connected to agricultural economics so that lower water availability, or more expensive water resource use, undermines the availability of the sector to invest in resilience. A negative tourism (Sitia population) effect of low water resources can also be implemented. These alternatives make the system yet more complex, motivating a simulation method.

Castilla y León (ES)

Dynamic stock management is crucial for sustainable horticultural and agricultural production, processing, and distribution because it minimizes food waste by optimizing inventory levels, ensures efficient resource utilization, improves supply chain logistics, supports local and seasonal production, and enhances profitability through cost reduction. This ensures that the transition towards sustainability benefits all stakeholders, including workers, communities, and the environment.

Both NAVALFRESA and HORTAFERCAR request facing this as they are companies subject to instability in their production and stocks. The following criteria are agreed with them:

- The desired production is determined in advance based on the expected demand. It is also modified to maintain stocks at a required level. The actual production coincides with the desired one since those companies have adequate production teams.
- Both companies deliver to their customers from a warehouse which is generally capable of serving the orders received.
- Companies calculate the expected demand by averaging the orders received in the last eight weeks. This way the effect of atypical orders is eliminated.
- The desired stocks of finished products must be those necessary to cover four weeks of orders.
- Companies tend to correct discrepancies between present and desired stocks in eight weeks. However, they must be prepared to do it in four weeks.

The starting point is the hypothesis of an initial situation in balance between the desired and actual stocks, as well as the forecast and orders. As a result, the model is based on a balance between production and orders. Although depending on the season, it is taken as an acceptable hypothesis that orders are equal to 1000 units/week ('units' being a generic nomenclature, which is mainly transcribed into pallets) until week 10 in which they increase by 10% and remain constant at that new value.

The model is then specified with the behavior of the stocks and the desired stocks (**Figure 33**, **Figure 34**, **Figure 35**). This way NAVALFRESA and HORTAFERCAR can gain insights into the behavior of stocks, assess their alignment with desired levels, and identify strategies for improving stock management practices to achieve sustainability and efficiency goals.

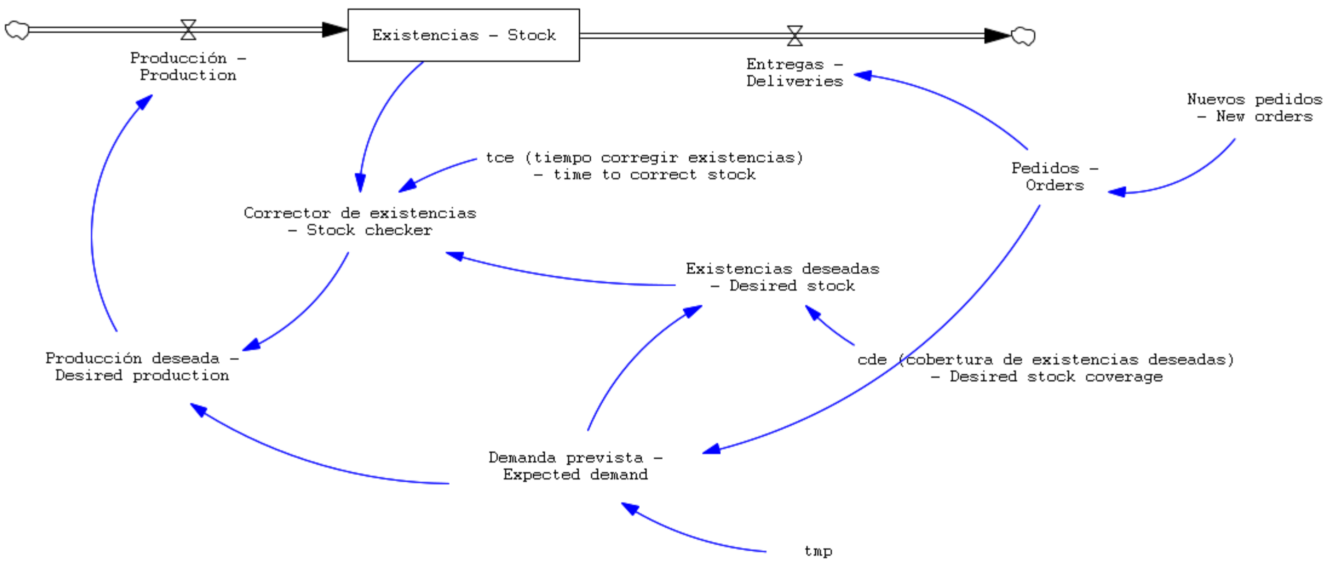


Figure 33. *SD model for dynamic stock management in NAVALFRESA and HORTAFERCAR.*

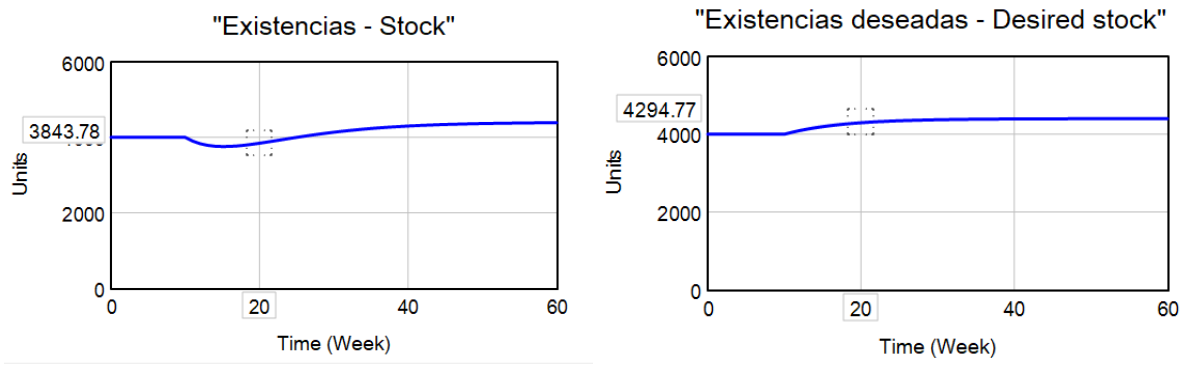


Figure 34. *Scenario to correct discrepancies between present and desired stocks in 8 weeks.*

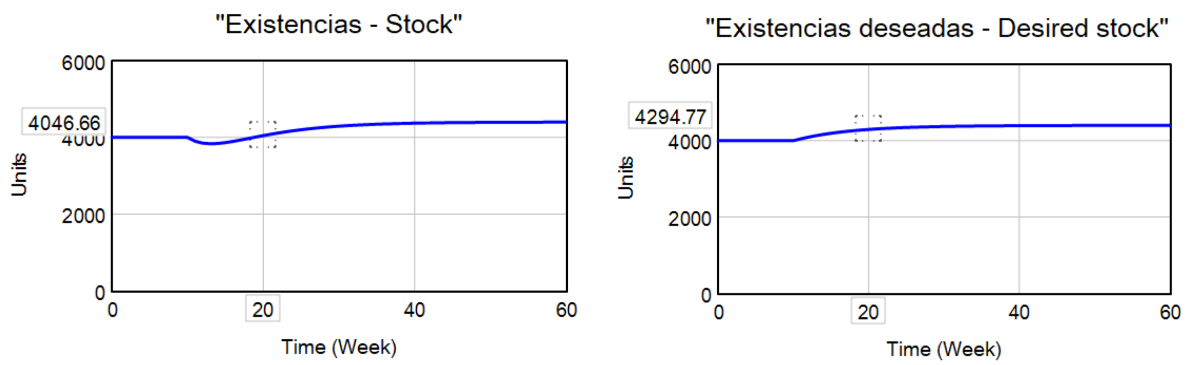


Figure 35. *Scenario to correct discrepancies between present and desired stocks in 4 weeks.*

Troodos (CY)

This pilot region presented an elaborate calculation method to quantify JTI4 (Environmental impact reduction) and offered an appropriate response to JTI8 (Stakeholder engagement and participation in decision making). However, it is not able to quantify the positive feedback loop that exists between these two factors. This is mainly due to the deployment of the Joint Sustainable Energy and Climate Action Plan (SECAP) in Cyprus, which particularly apply to JTI4 in the long-term. Troodos would then be framed in the top-down long-term monitoring approach proposed for Castilla y León, but an important case study emerges here in a bottom-up context.

It presents a scenario where sustainable tourism, particularly hotel operations, deeply interacts with conservation goals. The application of SD modelling helps elucidate the **complex relationships between the hotel industry's environmental impact** (energy consumption, waste generation and GHG) **and the region's ecological and historical preservation**. By a simulation on how hotels take a proactive approach in the Troodos region to integrate sustainability into their operations, focusing on energy efficiency and the adoption of renewable energy, helps not only highlight the hotels' commitment to lowering their energy footprint and time required, but also contribute to the broader sustainability goals of the region, promoting its reputation as a sustainable tourism destination.

The following criteria have been considered for the SD model given in **Figure 36Error! Reference source not found.**:

- The proposed delay scenario is 60 months.

- 1000 tasks are assumed to be planned for the group of 78 hotels in the pilot region to start being aligned with sustainable tourism objectives. The tasks will all be considered equivalent since unpredictable aspects such as deviations are faced. This rounded figure come of considering 12 key tasks for each of the 78 hotels in the Troodos pilot region for the reductions established in JTI4 to be achieved:
    1. Innovation and technology integration: this task directly encompass the adoption of innovative solutions like renewable energy systems for improved environmental management in hotels.
    2. Energy consumption analysis: assess hotel energy use to target reduction opportunities.
    3. GHG emission audits: to establish a baseline for GHG emissions and track reductions.
    4. Waste management workshops: conduct instructions on reducing waste through innovative strategies.
    5. Historical preservation assessments: evaluate and mitigate hotel impacts on local historical sites.
    6. Ecosystem impact studies: analyze and mitigate the ecological impacts of hotel activities.
    7. Sustainable procurement plans: implement sustainable and local sourcing policies.
    8. Water usage reduction initiatives: identify conservation areas and install water-saving technologies.
    9. Stakeholder engagement programs: involve community and groups in sustainable hotel practices.
    10. Educational campaigns for hotel staff and guests: educate about sustainability efforts and encourage participation.
    11. Legislation advocacy: inspire supportive sustainable tourism policies.
    12. Impact measurement and reporting: develop metrics for environmental performance and report regularly.
- 'Implementation Quality' reflects the quality of the work completed.
- The 'Deviations' are linked to the amount of work done by the percentage of work that does not comply with the implementation.
- A constant fraction of the ‘Undetected Deviations’ is taken.
- The 'Delay in detecting deviations' is 3 months.
- At most, it is considered that the group of hotels treated carry out 100 tasks per month to perform the proposed environmental impact reduction. The ‘minimum’ function (MIN) is used so that when there are less than 100 pending tasks in a period, all the remaining tasks are done.

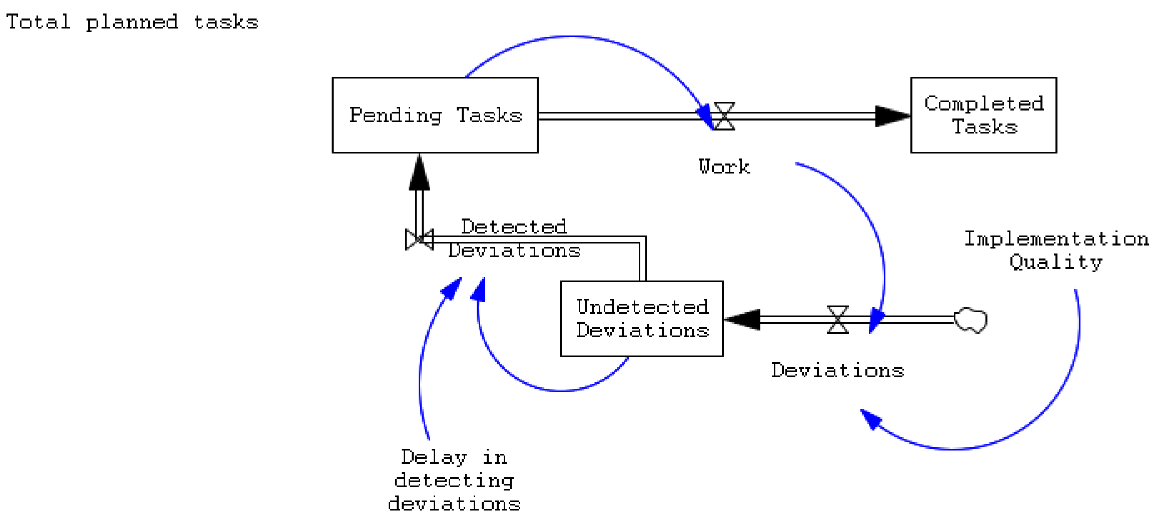


Figure 36. *SD model facing the adaptation to the reduction of environmental impact for the group of hotels in the Troodos mountains (CY).*

It is observed that the minimum time to begin reducing the energy footprint in the target group of hotels is approximately 2.5 years (**Figure 37**).

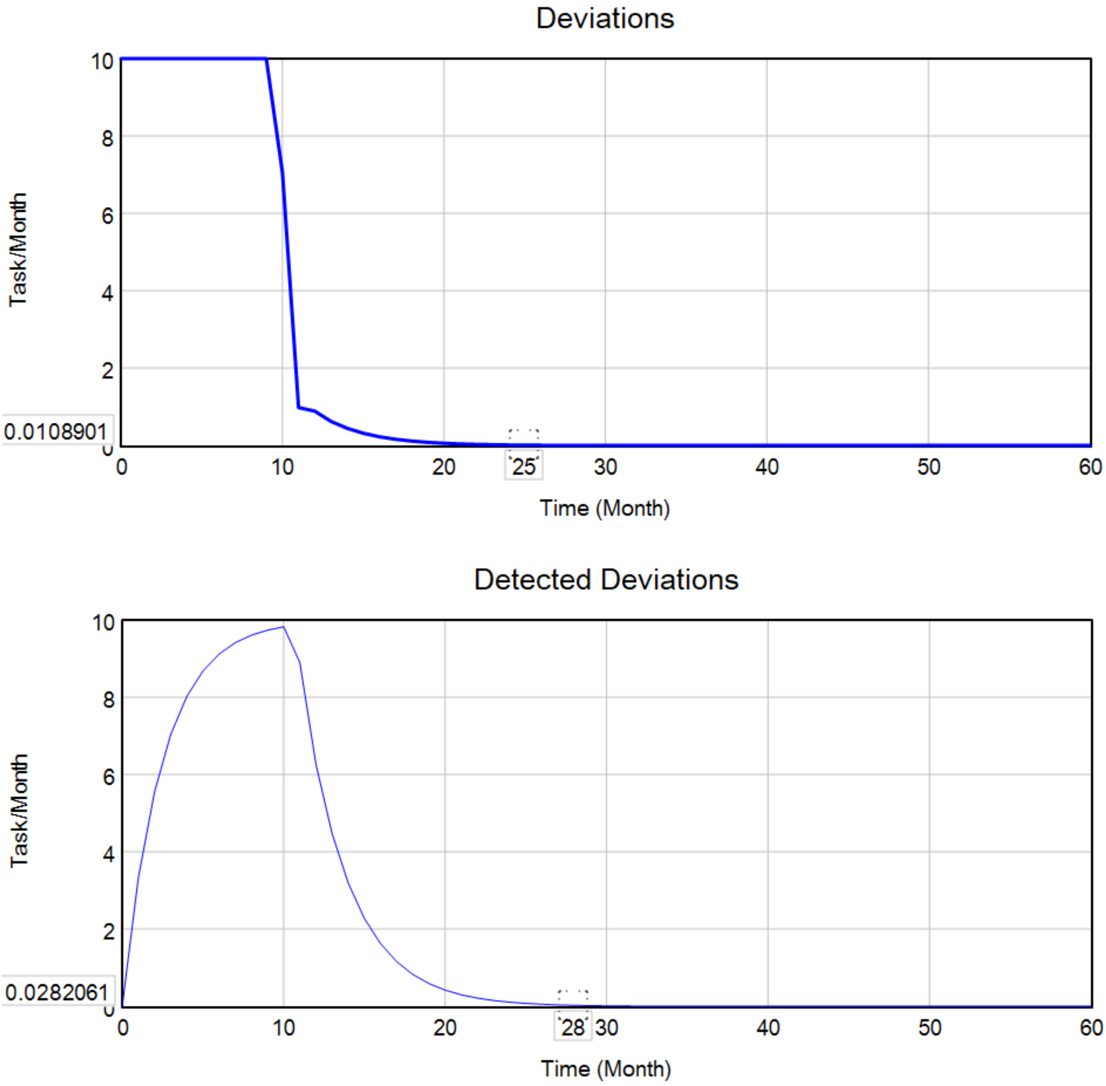


Figure 37. *Adaptation scenario to reduce the environmental impact of the group of hotels in the Troodos mountains (CY).*

6. Conclusions

The proposed JTIs demonstrate significant novelty and usability within the EU, primarily by integrating comprehensive and measurable criteria tailored to the diverse conditions of different regions. These JTIs are validated upon co-participative consensus and structured to be SMART, making them practical tools for assessing the multidimensional aspects of the just transition, thinking of Europe's broader strategy to sustainability. Moreover, the JTIs are designed to foster significant regional customization and stakeholder engagement, enhancing their applicability across European regions. Each pilot region can select and revise the JTIs to reflect economic, social, and environmental conditions, thereby maximizing relevance and effectiveness. This customization is supported through workshops that encourage stakeholder participation, ensuring that the JTIs not only consider the needs and conditions of the communities, but also promote inclusive decision-making.

Supported on the proper pilot regions' selection of JTIs, top-down and bottom-up approaches are used in SD modelling (as usually required), providing complementary insights and advantages that can lead to a more robust and comprehensive understanding of pilot regions while offering added value for them to be understood as complex systems in terms of just transition.

The top-down approach leads to the consideration of three scenarios based on the quantification and interrelation of JTIs:

- JTIs quantified & interrelations quantified (Pärnumaa and Azores)
  - Description: JTIs have been quantified, and the relationships between them are clearly defined and measurable.
  - Outcome: this scenario allows for robust SD modelling, as the data is sufficient to create detailed models with clear feedback loops and dependencies.
  - Feasibility: high. The SD modelling can be implemented effectively with the existing data.

- JTIs quantified, interrelations not quantified (Castilla y León, Tuscany and Basque Country. Burgas is just approaching)
  - Description: while the JTIs themselves are quantified, the interrelations between them are not yet measured or understood.
  - Outcome: long-term monitoring and analysis will be needed to discover and quantify the interrelations. SD modelling is possible but will only be viable beyond R4C, once interrelations have been established.
  - Feasibility: medium. Requires additional data collection and analysis. There is a direct link to Task 3.2, which may involve setting up mechanisms to monitor and analyse interrelations over time.

- *No JTIs quantification & no interrelations quantified (Køge Bay. South Aquitaine tends towards the second scenario previously proposed).*
  - Description: neither the JTIs nor their interrelations are quantified.
  - Outcome: SD modelling is not feasible due to the lack of necessary data. This scenario may require foundational work to start quantifying JTIs and understanding their relationships before any modelling can be considered.
  - Feasibility: low. Extensive groundwork is needed to enable any kind of meaningful modelling in the future.

Bottom-up approach is employed when cases of interest either arise after the attempt to quantify and interrelate the JTIs, or upon request with sufficient availability of information (Nordic Archipelago, Helsinki-Uusimaa, Sitia, Castilla y León and Troodos).

The inability of certain pilot regions to quantify the interrelationships among the chosen JTIs is fundamentally and truly rooted in the difficulty they face in thinking systemically, that is, trying to project these relationships into the future based on goals, trends and/or expectations wanted to achieve in the mid-term, far beyond the typical thinking based on solely searching for statistical data that do not exist, it is not known where to find them, or they result from combining other indirect data that are difficult for the pilot region to interpret (even if they are very useful).

The process of quantifying the interrelationships among the JTIs presents significant complexities, primarily due to parametric uncertainty. This uncertainty can be managed through exploratory modelling techniques like sensitivity testing, which examines how changes in parameters within a reasonable range affect the outcomes. SD models, which are often used in such assessments, benefit from the fact that results are typically influenced more by feedback loops than by precise parameter values. This characteristic allows for the prediction of general trends, such as exponential growth or stagnation, even amid uncertainty, provided the underlying feedback mechanisms are accurately represented.

Exploratory modelling proves invaluable, particularly when initial parameter values or interconnections are challenging to quantify. It serves as a robustness check against potential data inaccuracies. However, a limitation arises when models lack strong feedback structures, leading to a wide range of possible outcomes without a clear trend. In such scenarios, exploratory modelling helps delineate the possible outcome spectrum but cannot necessarily narrow-down parametric uncertainty. If these indeterminate results are problematic, further efforts in parameter specification or model restructuring may be required to derive meaningful insights.

Køge Bay (DK) and South Aquitaine (FR) as current exceptions for SD modelling can be understood through their unique regional characteristics. Both pilot regions face specific challenges in quantifying and interrelating JTIs due to the multifaceted nature of their goals, which involve intricate environmental, social, and economic dynamics. Addressing societal issues and IPs simultaneously show conflicts due to their differing objectives and requirements. The societal level involves long-term, broad-based planning aimed at enhancing social, economic, and environmental interests, requiring widespread consensus and extensive resource allocation (not currently available), counting on qualified external services, as pointed by Køge Bay (DK). In contrast, the IP focuses on promoting rapid technological advancement and market competitiveness, necessitating a dynamic and flexible approach to policymaking. Thus, addressing JTIs and IP independently, but complementary, should lead to better management of resources, reducing implementation complexity and clarifying success metrics, thereby avoiding potential conflicts and inefficiencies that arise from a dual focus.

Burgas (BG) is a singular sideway case. It is strategically managing the assessment of the finally selected JTIs by choosing the most appropriate methods that ensure relevance, accuracy, and practicality, even though this might mean that specific figures are not immediately available. This approach allows for a more flexible and responsive adaptation to the local context and needs.

The next two tables demonstrate the functionality of each pilot region from a systemic modeling perspective. These tables effectively map out the regional applications and the associated JTIs, showcasing the varied strategies employed. This diversity in approaches, facilitated by the dual bottom-up and top-down modeling perspective, not only enriches the adaptability and scalability of the models across the EU, but also ensures that SD modelling is capable of addressing specific regional nuances and priorities, fostering a broader implementation of sustainable practices.

TOP-DOWN APPROACH

Pärnumaa (EE)	Creating just transition plans, regulations and legal reforms yearly shaped involving co-participatory processes.
Castilla y León (ES)	Need of long-term monitoring of JTIs upon a yearly basis to know the interdependencies and time lags among them to set-up realistic modelling. Understanding the interdependencies between workforce development and environmental sustainability.
Tuscany (IT)	How training programs, environmental policies, and stakeholder engagement strategies dynamically interact and affect the transition process over time.
Basque Country (ES)	Usability of the JTIs for monitoring the objectives and the planning instruments of the recent Law on Energy Transition and Climate Change of the Basque Country (LTECC) as example of stable legal framework to achieve climate neutrality and a fair energy transition by 2050.
Azores (PT)	Community well-being as pivotal factor in terms of just transition.
Køge Bay (DK)	Exception for SD modelling. Qualified external services required.
South Aquitaine (FR)	Robust long-term data for JTIs compelled to predict future trends and evaluate policy impacts.
Burgas (BG)	Reflecting the practical challenges in measuring the selected JTIs.

BOTTOM-UP APPROACH

Nordic Archipelago (FI/SE/AX)	Simulating the co-influence of green industrial renewal, population stability, and community wellbeing.
Helsinki-Uusimaa (FI)	Simulating the co-influence of new construction, climate-resilience, and economic dynamics, and the effect of these dynamics on health and land use.
Sitia (EL)	Simulating the co-influence of climate-resilient agricultural transition, population stability and water resource sustainability.
Castilla y León (ES)	Dynamic stock management as key aspect for sustainable horticultural and agricultural production, processing, and distribution.
Troodos (CY)	Elucidating the complex relationships between the hotel industry’s environmental impact and the region's ecological and historical preservation.

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Annex 1: JTI selection by pilot regions

- Dispersal: spreading of JTIs over their total number.
- Relevant: JTIs selected by at least 3 of the 4 pilots that make up each CS.
- Not relevant: JTIs not selected by any of the pilots that make up each CS.

	CS1: Coastal ecosystem Integrity										
	JT1	JTI2	JTI3	JTI4	JTI5	JTI6	JTI7	JTI8	JTI9	JTI adds	Remarks
Basque (ES)	•	•	•	•	•				•	No	Lack of references (conceptual and data) to work on the just transition. JTI1 is the only one that could be calculated in the short term.
South Aquitaine (FR)				•	•			•	•	No	
Azores (PT)					•			•		No	Azores is a less developed demo region, so it is unable to quantify many of the JTIs.
Toscana (IT)		•		•				•	•	No	
	Dispersal [7/9]										Relevant [≥3/4]: • Environmental impact reduction (JTI4) • Community well-being (JTI5) • Stakeholder engagement and participation in decision making (JTI8) • Stakeholder satisfaction and perception (JTI9) Not Relevant [0]: • Economic diversification (JTI6) • Social cohesion and inclusivity (JTI7)

	CS2: Gathering more and better data on climate-related risks and losses while enhancing Climate-ADAPT Platform										
	JTI1	JTI2	JTI3	JTI4	JTI5	JTI6	JTI7	JTI8	JTI9	JTI adds	Remarks
KØge Bay (DK)							•	•	•	No	
Burgas (BG)			•		•	•		•	•	No	
Uusimaa (FI)			•		•				•	No	Regional data is likely to be found for JTI5. Identification of adequate stakeholders is needed for JTI9, but possible to survey.
Pärnumaa (EE)								•		No	
	Dispersal [6/9]										Relevant [≥3/4]: • Stakeholder engagement and participation in decision making (JTI8) • Stakeholder satisfaction and perception (JTI9) Not Relevant [0]: • Employment transition rate (JTI1) • Training and re-skilling effectiveness (JTI2) • Environmental impact reduction (JTI4)

	CS3: Enhancing the climate change resilience of primary industries										
	JT1	JTI2	JTI3	JTI4	JTI5	JTI6	JTI7	JTI8	JTI9	JTI adds	Remarks
Crete (EL)				•	•	•				No	JTI1 interesting but difficult to measure. JTI6 pending to see if it is linked to farmers.
Castilla y León (ES)		•		•					•	No	JTI3 and JTI8 could be added depending on the Regional Government's response capacity.
Nordic Archipelago (SE/AX/FI)	•			•		•				No	**The transition won't happen during the project lifetime.** JTI6 requires to understand the renewable & sustainable investments for JTI1. Thus, a particularly tailored coupled energy-transport SD model could help to quantify e.g. the total revenue related to these investments.
Cyprus (CY)				•				•		No	
	Dispersal [7/9]										Relevant [≥3/4]: • Environmental impact reduction (JTI4) Not Relevant [0]: • Income and wage equality (JTI3) • Social cohesion and inclusivity (JTI7)

Regions 4Climate

Annex 2: List of local facilitators

CS1: Coastal ecosystem Integrity	
Basque Country (ES)	Andrea Del campo (adelcampo@azti.es) Roland Garnier (rgarnier@azti.es)
South Aquitaine (FR)	Denis Morichon (dmoricho@univ-pau.fr) Matthias Delpey (matthias.delpey@suez.com)
Azores (PT)	Catarina B. Gonçalves (Catarina.B.Goncalves@azores.gov.pt)
Toscana (IT)	Pasquale Pinto (pasquale.pinto@rina.org) Michele Valery (michele.valery@rina.org)
CS2: Gathering more and better data on climate-related risks and losses while enhancing Climate-ADAPT Platform	
KØge Bay (DK)	Amalie Laursen (amalie.laursen@regionh.dk): Capital Region of Denmark Helene Strøbech (helene.lykke.stroebech@regionh.dk): Capital Region of Denmark Alexander Hauer (ahaue@regionsjaelland.dk): Region Zealand
Burgas (BG)	Georgi Sakaliev (g.sakaliev@burgas.bg) Kira Danabasheva (k.danabasheva@burgas.bg)
Helsinki-Uusimaa (FI)	Heikki Kallasvaara (heikki.kallasvaara@uudenmaanliitto.fi) Laua Wiman (Laua.Wiman@vtt.fi)
Pärnumaa (EE)	Toomas Toodu (toomas@parnumaa.ee)
CS3: Enhancing the climate change resilience of primary industries	
Sitia (EL)	Thanasis Sfetsos (ts@ipta.demokritos.gr) Pavlos-Alexandros Kapetanakis (papagduke007@gmail.com)
Castilla y León (ES)	Carlos Albano Martín Puentes (carlosalbano.martin@jcyl.es) Esther San José Carreras (estsan@cartif.es)
Nordic Archipelago (SE/AX/FI)	Laua Wiman (laua.wiman@vtt.fi) Arto Laikari (arto.laikari@vtt.fi)
Troodos (CY)	Louisa Shakou (Louisa.shakou@cea.org.cy)

Annex 3: Annotated reference agenda for SD workshops

Date: *(Please specify)*

Facilitator: *(Please adapt to your region)*

Participants[58]**:** Provide the complete list (*Please adapt to your region)*

Equipment: Suggested (but not limited to): post-it notes and felt tip pens; whiteboard and whiteboard pens AND/OR laptop and projector (including HDMI cable)

STEPS	DURATION	NOTES
Round of introductions	10 min	Short introductions: ~1 min per person, including area of specialization in relation to the Workshop topics
Introduction of Workshop	10 min	Facilitators explain the aims and content. Possibility for participants to ask questions.
Understanding and quantifying each JTI individually	50 min	About 5 min per JTI selected. Facilitators introduce the meaning and purpose of each JTI selected. Participants give tentative values for the selected JTIs. Facilitators take note of all opinions even if they diverge. A group consensus can be sought, if possible, by scrutinizing where disagreement stems from. The calculation/definition of selected JTIs should be explained verbally in a way that everyone (who contributes to quantification) understands them. If a participant thinks they can provide a known or more accurate value after the Workshop by consulting a source (e.g., public statistics), this can be noted, and we can move to the next JTI. Facilitators take note of how certain participants are in the values they provide (e.g., the value is known with certainty, the value is an educated guess, the value is highly uncertain).
Break	5-10 min	
Connecting JTIs	50 min	Facilitators go through each selected JTI, asking if other JTIs affect it, and if it affects other JTIs. The nature of the relationship can be discussed if time permits, and the facilitators take note. For example: Is the relationship certain or uncertain? Is it direct or delayed? (If possible, indicate how long); Is the effect strong or weak? (If possible, quantify the effect)
Open discussion	≤20 min	Concluding thoughts from the Workshop. For example: Do participants want to clarify something? Are there follow-up questions to be answered later (e.g., missing values)? Have participants' perspectives on just transition changed during the Workshop?

[58] Selected stakeholders, but may also include some useful complementary organization, such as RTDs.