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Creating local storylines for climate mitigation and adaptation with policymakers across Europe: a new participatory and bottom-up method

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ABSTRACT

While climate change is a global problem, solutions are often rooted at the local level. Consequently, the capacity to mitigate or adapt to climate change in local contexts is increasingly recognized as a crucial element in coping with it. Climate policies must be highly context-dependent, as they need to account for local needs and priorities. This article contributes to the ongoing research on participatory climate change socioeconomic scenarios and climate-resilient development pathways by presenting a participatory methodology for creating bottom-up, locally tailored climate adaptation and mitigation storylines. The methodology combines a visioning technique with an analytical framework that categorizes the visioning outcomes, facilitating scenario development while addressing real challenges to promote the co-creation of viable, site-specific solutions. We applied this methodology with policymakers from four case studies across Europe, revealing significant differences in how mitigation and adaptation are prioritized, policy actions chosen, key actors involved, and economic sectors impacted in each case. These findings underscore the value of the method in bridging local and scientific knowledge and generating context-sensitive narratives which can be compared between them. Finally, we present a set of qualitative climate mitigation and adaptation scenarios, outlining possible and desirable developments for each case study by 2050.

1. Introduction

Despite sustained global efforts to address climate change under frameworks such as the UNFCCC, greenhouse gas emissions continue to rise, threatening to disrupt the Earth's stable Holocene climate regime (Richardson et al., 2023). While climate change is a global issue, its impacts are deeply local, manifesting in specific vulnerabilities shaped by environmental, social, and economic factors at the regional and municipal levels (IPCC, 2023; Trivedi & Jolly, 2023). These local vulnerabilities not only influence the severity of climate risks but also shape the adaptive capacity and the feasibility of mitigation strategies (Khan & Munira, 2021; Kumar, 2021; Nash et al., 2019). In this context, there is growing recognition that climate solutions must be tailored to local needs and developed with local actors, who are central to designing place-based interventions (Hoppe et al., 2014).

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To address the uncertainty and complexity inherent in climate change, scenario development at the local level has become a key method for assessing risks and exploring diverse solution pathways. Scenarios can take multiple forms: while quantitative scenarios provide rigor, they can be challenging to develop in complex contexts involving multiple actors. In contrast, qualitative scenarios of preferred futures (also called 'storylines', 'narratives' or 'visions' (Wiek & Iwaniec, 2014) can offer a more flexible structure and help to elucidate pathways while capturing intangible elements such as culture, values, and institutions (cf. (Alcamo, 2008; Swart et al., 2004; Van Vuuren et al., 2012). Recent literature on climate-resilient development pathways focuses on developing trajectories of plausible futures that combine adaptation and mitigation actions to realize the goal of sustainable development (Werners et al., 2021). The concepts of preferred futures/visions (Jørgensen & Grosu, 2007) are close to mitigation and adaptation pathways since both serve to make decisions that might influence the future as desired by the scenario creators (Abbass et al., 2022; Fawzy et al., 2020; Filho et al., 2022). The development of desirable or normative future scenarios might broaden the possibility space and empower different actors to understand their role in building sustainable societies, thereby encouraging stakeholders to discover new opportunities for mitigation and adaptation actions and policies (Neuvonen et al., 2014).

The spread of climate assemblies across Europe has raised questions of greater citizen involvement regarding the development of desirable climate futures (Boswell et al., 2023; Elstub et al., 2021). At the same time, there has been growing recognition of the importance of participatory and inclusive scenario creation—particularly in locally specific contexts—and its role in producing feasible and actionable policy recommendations (Pereira et al., 2021; Venturini et al., 2019). Participatory methods have also been used to design climate-resilient adaptation pathways (Pulido-Velazquez et al., 2023). By adopting a participatory approach, both stakeholders and researchers engage in a learning process aimed at action that leverages the implicit and explicit knowledge of stakeholders to create standardized and shared representation(s) of reality (Voinov et al., 2018). It has been widely recognized that stakeholder engagement is a powerful feature of scenario co-design, as it allows professional and personal knowledge (e.g., sectoral, geographical, knowledge of different local contexts) to be captured within regional scenarios (Harmáčková et al., 2022). In addition, by including participatory elements, regional scenarios gain credibility, legitimacy, and salience when diverse stakeholder groups are included in the scenario development, and this also increases the usefulness of the final scenario products (Kok et al., 2019; Rounsevell & Metzger, 2010). Participatory methods include workshops, semi-structured interviews, surveys, structured brainstorming, and voting mechanisms (Gallagher et al., 1993).

Participatory local scenarios can be categorized into top-down and bottom-up approaches (Absar & Preston, 2015). In top-down approaches, participatory elements have been used to adapt global socioeconomic scenarios to regional and local contexts (Harmáčková et al., 2022; Kebede et al., 2018; Mitter et al., 2019; Reimann et al., 2018; Suchá et al., 2022; Vafeidis et al., 2024). This approach has the advantage of relying on already validated scenarios and being, to a certain degree, consistent across scales since creating new scenarios from scratch can be very resource-intensive (Frame et al., 2018). At the same time, some complexities of top-down methods include local stakeholders finding it challenging to relate to global climate scenarios frameworks. Additionally, top-down methods require global scenarios aligned with the issues investigated at local levels. The need for better coordination between scales has also emerged (Kok et al., 2019). In contrast to top-down methods, bottom-up approaches, while less common, allow creating scenarios tailored to the needs of specific regions and not necessarily linked to upper-scale trends (Holman et al., 2005). This approach allows scenario creators more flexibility because they are not limited by prior elements and boundary conditions and gives participants more freedom in their visioning process, thus increasing their sense of 'ownership' of and commitment to the developed scenarios (cf. Elstub et al., 2021). A greater variety of storyline development techniques can be used, leading to highly diversified scenarios. Nevertheless, the level of comparability of the storylines and scenarios generated is generally lower than in regional scenarios produced through the top-down approach (Absar & Preston, 2015; Zurek & Henrichs, 2007). Previous work within this approach includes participative local scenario development linking visions of sustainable futures to climate policies and economic structural change (Raudsepp-Hearne et al., 2020; Svenfelt et al., 2019).

Current literature on local climate mitigation and adaptation scenarios reveals several gaps. First, climate action scenarios tend to focus on either mitigation or adaptation, with few addressing both dimensions simultaneously (Werners et al., 2021). Second, while participatory methods are increasingly used, their high demands on time and resources can lead to fragmented engagement and stakeholder fatigue (Mitter et al., 2019). This intensity also poses challenges for replicating these methods across diverse contexts, thereby limiting comparability and cross-regional learning (Lang et al., 2012). Third, essential elements such as normative future visioning (NFV), which enable the articulation of creative, desirable futures, remain underutilized. As a result, stakeholders are often constrained in their ability to proactively engage in co-creating futures with a strong sense of ownership and agency (Pelling et al., 2024).

This paper responds to these gaps by introducing a novel bottom-up participatory methodology for developing local qualitative climate adaptation and mitigation scenarios,[1] contributing to the literature on participatory socio-environmental scenario development and climate-resilient development pathways. Our approach integrates visioning techniques (using "what-if" questions) with a structured analytical framework that organizes local knowledge into coherent and policy-relevant storylines. The methodology is designed to be both replicable and resource-efficient, allowing its application in contexts with limited capacity, while also ensuring transparency and comparability across regions.

Importantly, the methodology enables stakeholders to consider mitigation and adaptation either simultaneously or independently, depending on local priorities, and to articulate how place-specific conditions shape those priorities and policy pathways. We applied

[1] From now on, unless specifically mentioned otherwise, we will use the term 'scenario' to refer to qualitative scenarios, which are also called storyline, narrative or vision, depending on the literature.

this method with policymakers in four diverse case studies in Northern, Eastern, Southern, and Western Europe, resulting in a rich set of normative, context-specific scenarios. To our knowledge, these regions had not previously engaged in structured scenario planning. The resulting storylines are grounded in real-world challenges and actor roles, making them directly applicable for informing policy decisions, modeling efforts, and roadmap development.

The remaining part of the paper is structured as follows: in 2, we outline the key background features of the NEVERMORE Project within which this study is situated; in 3, we explain the participatory process generated and the main outcomes arising from its application, including the resulting scenarios; and finally, in 4 and 5, we offer discussion and conclusions, respectively.

2. Research context: the NEVERMORE project and the case studies

The Horizon Europe Project NEVERMORE (New Enabling Visions and Tools for End-useRs and stakeholders thanks to a common MOdeling appRoach towards a ClimatE neutral and resilient society) aims to work together with policymakers to understand better the local impacts of climate change and support them in making decisions on the mitigation and adaptation futures of their communities. While recently it has become common to involve stakeholders in research projects through co-design methodologies, in NEVERMORE they are given a central role in the knowledge generation process by being partners in the project consortium and collaborating in many of the project's tasks via participatory processes. By doing so, the project aims to produce research outputs grounded in their local knowledge and experience of climate change, and valuable to them.

NEVERMORE's stakeholders are policymakers and citizens from the different case studies of the project. Four case studies[2] took part in this study: three sub-national regions (Norrbotten (Sweden), Trentino (Italy), Tulcea (Romania)) and a city (Sitia, Greece). As illustrated by Fig. 1, the four case studies that participated cover the margins of Europe (Norrbotten, Tulcea, Sitia) and its center (Trentino), and represent different geographic, climatic, and socioeconomic backgrounds, thus allowing the consideration and comparison of different climate-related challenges and policy options. Table 1 shows their main characteristics, including a general description, the main climate change-related challenges, and the key economic sectors of each region. This information was co-produced with policymakers throughout the course of the project (for more details, refer to Ramos et al. 2023). The table shows that policymakers across the case studies do not view climate change challenges in isolation. Instead, they consider a broad spectrum of environmental, social, and economic factors specific to their regions that interact with climate vulnerability. For example, climate change-related challenges extend beyond climatic hazards to include other environmental issues, such as water stress indirectly exacerbated by climate change, as well as socioeconomic barriers that hinder effective adaptation.

3. Participatory scenario-building process

The participatory scenario-building methodology we created to produce local mitigation and adaptation scenarios together with the NEVERMORE policymakers was developed starting from previous participatory scenario development methodologies (Absar & Preston, 2015; Mitter et al., 2019), which we refined to meet the needs of the project and the mindsets of the policymakers we worked with. Our methodology aims, on the one hand, to incentivize stakeholders to use their knowledge to think of specific solutions to their local challenges and, on the other hand, to produce mid-term (until 2050) qualitative policy-action scenarios at local scales that are consistent, rich, creative, salient, and legitimate - in one word, meaningful - for local policymaking (Mitter et al., 2019) and modeling.

We followed a 3-step process, and we hypothesized a fourth one to complete it. The first step was for us, researchers, to create a new methodology by adapting and merging existing ones; the second was for the policymakers taking part in this activity to do the tasks; and the third step consisted of us, researchers, analyzing the outcomes of the participatory exercise and use them to create coherent, meaningful, and locally tailored stories. Finally, a potential fourth step would be quantifying the elements elicited from the exercise and modeling them to create quantitative scenarios. This last step will be explored during the rest of the NEVERMORE project. Fig. 2 summarizes all these steps. The following sub-sections contain a detailed description of each of them.

3.1. Step 1: methodology development

The participatory methodology we developed has three elements at its core: the climate change-related challenges, the what-if questions, and the Scope-Actions-Actors-Sectors (SAAS) framework.

- Climate change challenges form the foundation for scenario building, ensuring the process begins with a clear understanding of the specific issues each region faces. By focusing on concrete problems, the method is grounded in the region's real concerns, ensuring that the resulting scenarios are more practical and actionable. We instructed participants to base their work on the main challenges previously identified in the project (see Table 1), but they also had the possibility to re-characterize them if necessary.
- The use of 'what-if' questions aims to boost imagination and encourage participants to explore alternative futures by thinking beyond current constraints, thereby fostering innovation and creativity. This approach is commonly used in both model-based scenarios and climate fiction (Van Beek & Versteeg, 2023), so we selected it as a means to integrate visioning practices into scenario development.

[2] There is another case study in the NEVERMORE Project (Murcia, Spain) that did not take part in this research since it follows an alternative co-creation process in the project, and its work follows different steps and timelines.

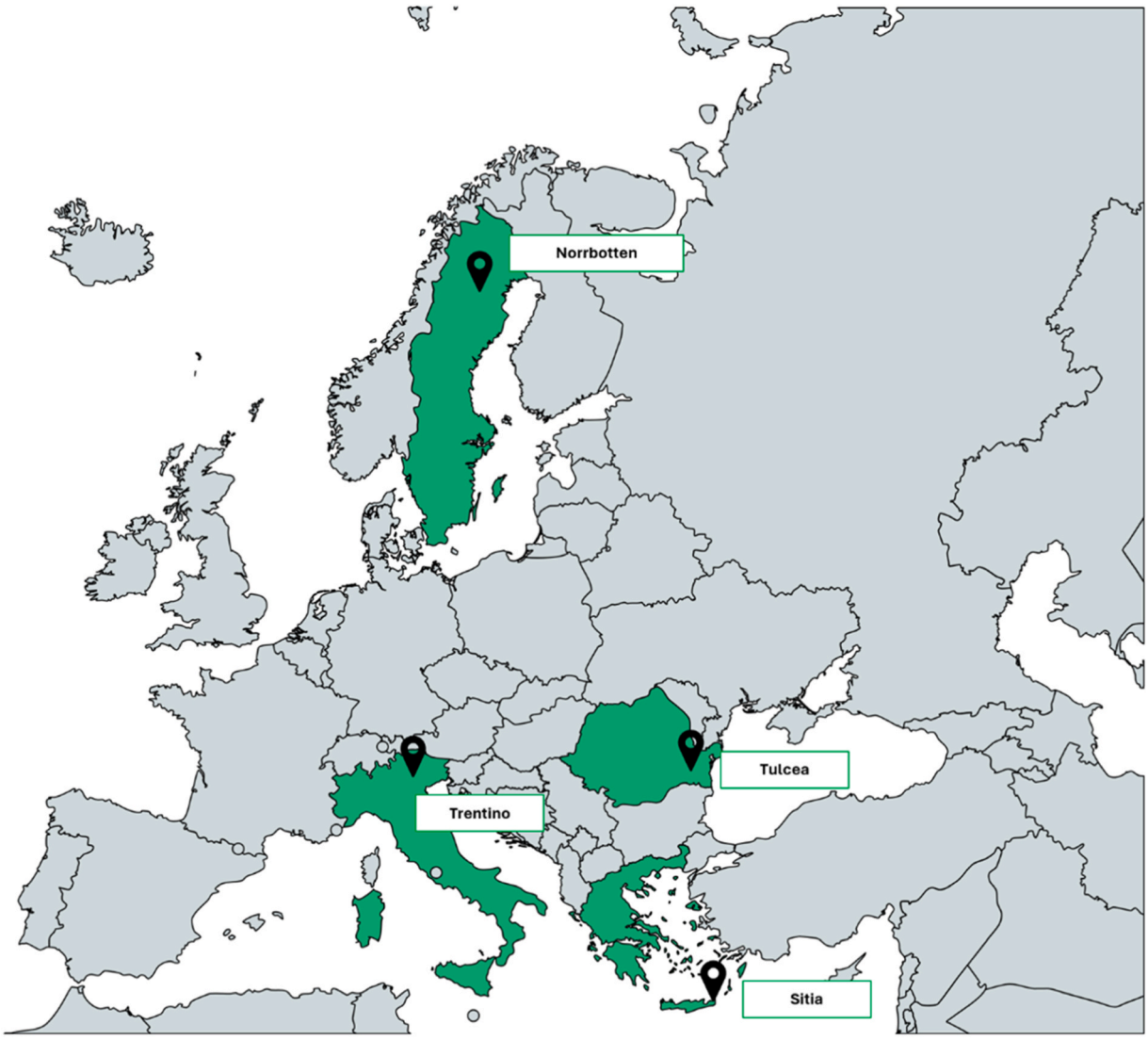

Fig. 1. A map showing the location of the 4 case studies taking part in the study across Europe.

- The Scope-Actions-Actors-Sectors (SAAS) framework is employed to systematize the scenario-building process by organizing diverse participant inputs into coherent categories, chosen for its capability to address the complexity of socioeconomic systems in a structured manner and to define relevant aspects of socioeconomic futures. The framework is an adaptation and extension of the Factors-Actors-Sectors (FAS) framework used in previous exercises of participatory local scenario development (Absar & Preston, 2015; Kok et al., 2006; Rotmans et al., 2000). The original version consisted of three elements: 'Factors' that represent themes, instruments, or aspects of the system on which policy issues are of particular interest; 'Actors' that represent individuals or organizations with the capacity to provoke changes; and 'Sectors' that represent an area, dimension, or group of the system, such as industries or types of activities. We adjusted the framework's structure based on previous experiences in co-production processes with the policymakers. Specifically, we replaced the 'Factor' element with 'Action' to facilitate the consideration of concrete measures and introduced 'Scope' to categorize these actions into climate mitigation, adaptation, or both. This adjustment addresses the potential ambiguity of the 'factor' term and aligns with policymakers' familiarity with the concepts of scope and actions.

By following our methodology, stakeholders are encouraged to think of 'what-if' questions that explore hypothetical actions (policies, measures, grassroots activities, etc.) that are desirable for them, and that they would like to explore. Each of the what-if questions must be related to one or more climate change-related challenges specific to the local context and broken into the SAAS framework components. To ensure a clear understanding of the process, we provided them with Table 2, which outlines the structure they had to use to formulate their what-if questions, linked to challenges and broken down into SAAS components. Table 2 also included a few what-if questions that we, the researchers, generated through brainstorming based on the project's knowledge to

Table 1
Main characteristics of the case study regions.

	Description	Climate-related challenges	Affected sectors
Norrbotten (SE), a Boreal Region	Norrbotten County is a case study located in northern Sweden, with 98,911 km^2, 64 % of which is boreal forest land. The population is about 250,000 inhabitants. The local economy highly relies on industrial production, natural resources, particularly forest resources, energy infrastructure and mineral deposits.	**Pressures**: Warming climate, more ice in winter, vegetation changes, heavier rains. **Barriers:** Low investment in the transport sector, lack of investments in fossil free energy matching projected growth of use, reduced local influence on sustainability transitions	**Main sectors**: forestry, mining, hydroelectric power, and Sami reindeer herding. **Secondary sectors**: tourism and innovation.
Trentino (IT), a Mountain Region	The Autonomous Province of Trento is situated in the North-East of Italy. It covers 6200 km^2 with a population of more than 540,000 inhabitants. The territory is characterized by diverse geographies and climatic conditions, ranging from an alpine climate in mountain valleys to a sub-Mediterranean climate close to Lake Garda.	**Pressures:** Rising average temperatures, melting and retreat of glaciers, decrease in snow precipitation and permanence on ground, hydrogeological disruptions, floodings, windstorms. **Barriers:** Dependence on a tourism model very intensive on energy consumption, lack of coordination and integrated actions to tackle climate change.	**Main sector:** summer and winter tourism. **Secondary sectors**: energy and water (hydropower production).
Tulcea (RO), a Wetland Region	Tulcea County is situated in the southeastern part of Romania, within the Danube Delta, representing the most significant wetland in Europe. It is a nature reserve with a high diversity of flora and fauna.	**Pressures:** Land-use-related challenges such as desertification, deforestation, water scarcity, unsustainable farming. **Barriers:** Socioeconomic context characterized by depopulation and unemployment; high energy consumption in the transport sector.	**Main sector**: agriculture. **Secondary sectors**: tourism, environmental protection, services, renewable energy, and heavy industry.
Sitia (GR), a Mediterranean Island Region	Sitia is a town in the eastern part of the island of Crete in Greece. It is considered Europe's most extreme climate hotspot, mainly due to thermal drought conditions.	**Pressures:** Temperature increase, longer dry periods (droughts), water scarcity, extreme weather events, sea level rise. **Barriers:** Weak water supply network, high vulnerability of the key economic sectors.	**Main sector**: agriculture. **Secondary sectors**: tourism.

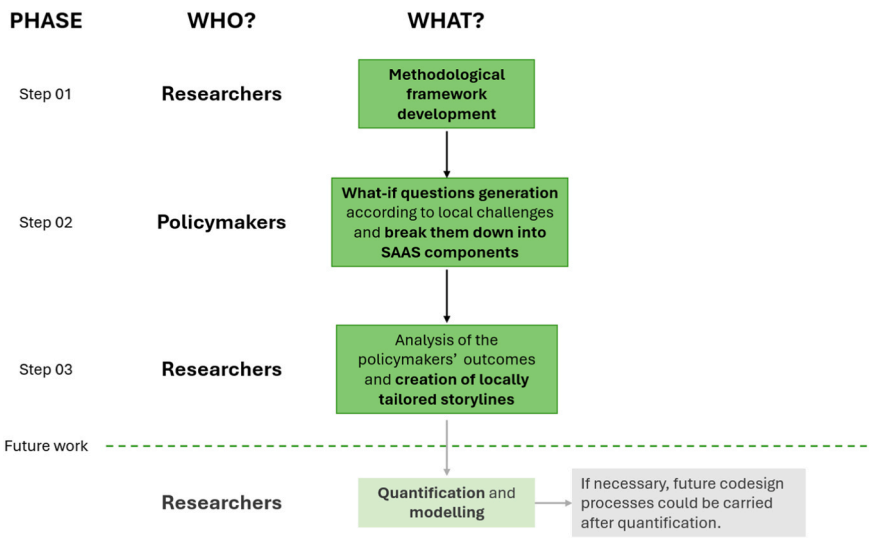

Fig. 2. The participatory process followed to derive local qualitative scenarios.

provide them with examples of the expected outcome. In addition to the three full examples given, we also provided an initial set of categories for possible sectors and action components they should consider, while clarifying that this list could be expanded if necessary. While the scope essentially comprised climate mitigation and adaptation, a range of different exemplary actions was proposed, considering actors from the public and private spheres as well as civil society. The sectors outlined included primary, secondary, and tertiary sectors, and could be complemented by site-specific economic sectors. The examples were meant to provide guidance to the policymakers about what kind of information we aimed to collect through this exercise. This participatory

Table 2
Table scheme to be filled out by the participants with the what-if questions, specifying which challenge, scope, type of action, actor, and sector each question addresses. The first lines are filled with examples by the researchers to provide guidance of the expected outcome of the exercise.

Climate change-related challenge	What-if question	Scope	Action	Actor	Sector
Water scarcity	*What if the public authorities invest in better infrastructure for wastewater treatment and recycling?*	*Adaptation*	*Investment*	*Public authorities / Local government*	*Water and waste (incl. Water treatment and distribution-infrastructures)*
Too high greenhouse emissions	*What if citizens create local associations to foster agroecological practices?*	*Mitigation*	*Consumption*	*Citizenship*	*Agriculture, Forestry and Fishing*
Lack of energy resources	*What if private companies produce energy through renewable energy sources?*	*Mitigation & Adaptation*	*Production*	*Private companies*	*Energy (incl. Energy production and distribution-infrastructures)*
…	…	…	*Regulation*	*NGOs*	*Industry and commerce (incl. refinery, chemicals, metals, other manufacturers)*
			Protection	…	*Transport (incl. transport infrastructure)*
			Prevention		*Mining and Quarrying*
			Prices		*Cities, urban planning and construction*
			Taxes		*Tourism/Leisure /cultural heritage*
			Subsidies		*Technology, Information and Communication*
			Sharing Economy		*Finance*
			Collective Action		*Society (incl. Human health, wellbeing, migration and Education)*
			…		*Biodiversity and natural heritage*
			…		…

methodology allows participants to understand better what elements to focus on and researchers to group the information received in a systematic and structured manner that helps handle the complexity of a local socioeconomic system and decide on all the relevant aspects of the scenarios.

3.2. Step 2: policymakers' engagement with the method

After creating the methodology, we invited the policymakers and their supporters (techno-scientific partners of the NEVERMORE project) to a plenary online meeting where we explained the purpose, the activity, and the deadline of the exercise we were going to propose them. We explained that the ultimate goal of this activity was for us to produce locally coherent storylines, as storylines are policy actions coherently grouped to form a consistent narrative, which could be used in the future as a starting point for modeling, scenario planning, and decision-making. The guiding questions to start thinking of the what-if questions were, *"How do you wish your city/region to be in 2050? What are the possible future pathways we can take to achieve it?"*. We explained to them that the what-if questions they were going to formulate should be motivated by local climate change-related challenges but also by desirability, curiosity, feasibility, and local knowledge, meaning that a what-if question could make sense for a case study but not another one, depending on local features or interests. In this way, policymakers were prompted to imagine and identify desirable and locally grounded solutions to climate change challenges. We presented them with the scheme in and discussed the examples to ensure they understood the meaning and guidelines of the activity.

Policymakers were asked to fill out the scheme illustrated in Table 2 with the help of their supporting partners. They were asked to brainstorm between a minimum of 15 and a maximum of 30 what-if questions informed by the identified challenges but also by desirability and feasibility aspects based on the participants' local knowledge. We gave the participants two weeks to complete the tasks, offering them the option to work remotely or to organize in-person or online meetings with their team and supporting partners. 21 people took part in this activity in total. The teams from each case study varied in the number of participants from the policymaker and supporter groups. The number of people involved in the activity was determined by the policymakers and supporting partner institutions for each case study. A detailed representation of the participants is shown in Table 3.

The policymakers involved have different specializations and applied their professional lens when looking at the challenges posed by climate change. Norbotten's policymakers[3] are the County Administrative board and the municipalities. Energikontor Norr is a non-profit company, owned by the municipals and the County Council of Norrbotten, and whose role is to support the municipalities in reducing their carbon footprint; Trentino's policymakers are public officials working for the Tourism and Sport Service of the Autonomous Province of Trento; Tulcea's policymakers are public officials working in the European Affairs Office of Tulcea County Prefect's Office, and Sitia's policymakers are responsible for the Civil Protection department of the Municipality and the head of the

[3] The representatives of Norbotten, Energikontor Norr, clarify that they could be better defined as 'representatives for policymaking'. They are funded by local and regional governmental entities and represent the public sector, providing direct support to policymaking.

Table 3
List of participants.

Case Study	Role	Institution name	Number of participants
Norrbotten (SE), a Boreal Region	Policymaker	Energikontor Norr (EKNorr)	2
	Supporting partner	Swedish Environmental Research Institute (IVL)	4
Trentino (IT), a Mountain Region	Policymaker	Autonomous Province of Trento	4
	Supporting partner	Centre for Sustainable Energy at Bruno Kessler Foundation (FBK-SE)	1
Tulcea (RO), a Wetland Region	Policymaker	Tulcea County Council	4
	Supporting partner	Software Imagination & Vision (SIMAVI)	2
Sitia (GR), a Mediterranean Island Region	Policymaker	Sitia Municipality	2
	Supporting partner	National Centre for Scientific Research Demokritos (NCRSD)	2
Total			**21**

local Fire Brigade. This variety of roles increases the likelihood of significant differences in stakeholders' desired futures.

3.3. Step 3.1: analysis of the policymakers' outcomes

The Norrbotten, Trentino, Tulcea, and Sitia case study participants created a list of 25, 20, 16, and 20 what-if questions, respectively. In Table 4, we collected a few examples of the what-if questions for each case study, while the complete list of the what-if questions linked to the SAAS framework and the challenges can be found in the Appendix (Tables from A.1 to D.1). These questions are not presented as anecdotal data but as the foundation of the entire visioning process. They reflect how local actors conceptualize desirable futures in response to local climate-related challenges and help to understand stakeholder reasoning and priorities in a comparable way.

Since the objective was to use the what-if questions to build storylines, we processed the outputs from Tables A1 to D1 to compare the interests of the four case studies and identify what they found most relevant to their desired future development. For each case study, we counted the different sub-categories assigned to each of the SaaS elements and calculated the relative proportions (percentages) to better understand their interests. For example, we found that Norrbotten developed 18 (60 %) what-if questions focused on mitigation and 12 (40 %) on adaptation.[4] We applied the same method to the other categories (actions, actors, and sectors) too. Continuing with the same example, we noted that citizens took the lead in 2 (6 %) of the what-if questions, the reindeer herding sector appeared 4 times (13 %), and investment actions were mentioned 11 times (37 %). By processing the outcomes from Tables A1 to D1 in this way, we generated Table 5 to systematically compare how each case study distributed emphasis across the SAAS framework components. While this table presents outputs from the participatory exercise, its purpose goes beyond descriptive reporting, forming the analytical foundation of our scenario-building process. Through the SAAS coding of the what-if questions, we are able to extract patterns in stakeholder preferences—for instance, regarding the type of climate action favored (adaptation vs mitigation), the dominant actors, or the key sectors involved. This comparative analysis allows us to interpret the visions not merely as isolated ideas, but as reflections of broader governance, investment, and institutional priorities. Table 5 thus serves as an essential intermediate analytical step that informs the qualitative construction of the storylines, enhancing their coherence, legitimacy, and relevance.In Appendix E (Table E.1), we also provide an overview of the specific challenges emerged from the what-if question gathered by thematic area.

The case studies differ significantly in the number of what-if questions dedicated to the mitigation of, or adaptation to, climate change. While 60 % and 67 % of the what-if questions devised by participants from Norrbotten and Tulcea aimed at improving climate mitigation of their regions, Trentino participants focused more on successful climate adaptation (addressed in 64 % of the what-if questions), and Sitia's focus exclusively was on adaptation to adverse climate change impacts. This is closely related to the main challenges that each case study faces, which the what-if questions are intended to address.

Regarding the actors, public authorities are the main protagonists across all scenarios, playing a role in half or almost half of the what-if questions in Sitia, Norrbotten, and Trentino, whereas in Tulcea, they appear in a third of the questions. Private companies also play a significant role as they appear in about a third of the solution-oriented what-if questions of Tulcea and Sitia, surpassed only by Trentino (40 %). Apart from public and private actors, in Tulcea, NGOs are perceived as decisive actors in 25 % of the questions, whereas they barely appear in Norrbotten's imagined future (3 %). Conversely, landowners are considered major players in Norrbotten (19 %), while they are practically absent in Trentino and Sitia. These two regions also consider the capacities of citizens to positively influence future socio-ecological developments in 11 % of the what-if questions, in contrast to Norrbotten and Tulcea, which expect less agency by citizenry.

There are also considerable differences between the regions regarding the actions implicitly expressed through the what-if questions that the participants selected. In Norrbotten, about 45 % of the what-if questions are about investments and technological

[4] The sum exceeds the total because five of the what-if questions apply to both mitigation and adaptation areas.

Table 4
An extract of the What-if questions from the four case studies.

	Norrbotten	Trentino	Tulcea	Sitia
1	*What if reindeer husbandry always could be protected when areas and land are selected for wind power?*	*What if the local government applies a maximum number for access to specific hotspots or services?*	*What if Danube Delta water levels were stable?*	*What if a rainwater harvesting system was built?*
2	*What if we could use recycled metals only (no new mines allowed)?*	*What if the local government promotes the development of tourism services also in the off-peak seasons?*	*What if energy efficiency was increased by 20 % in the Tulcea region?*	*What if there was a system to recycle/ reuse wastewater?*
3	*What if important areas of forest always could be protected?*	*What if the local government redefines the calendar of school vacations and holidays?*	*What if renewable energy plants increased in the Tulcea region by 30 %?*	*What if the local and regional authorities take action to install and use biological wastewater treatment systems?*
4	*What if energy efficiency was increased by 50 % in Norrbotten?*	*What if the local government promotes investment in technology infrastructure to encourage forms of workation?*[a]	*What if 50 % of cars in the Tulcea region were electric cars?*	*What if the waters of rivers and creeks running through Sitia were restored to help with irrigation?*
5	*What if there were renewable fuels or electric airplanes for domestic flights in Sweden?*	*What if the local government limits the allocation of new land use change for the tourism industry?*	*What if the government provided free public transport for everyone in the Tulcea region?*	*What if an agri-economic analysis was performed and resource allocation was done according to resource demand?*

[a] A type of vacation where people work remotely from a different location than their usual office

development, almost a third are legislative actions, and the last are collective actions. While Tulcea also shares this pattern and even puts more emphasis on the role of technological development (13 % of the what-if questions vs. 7 % in the case of Norrbotten), in the Trentino case study, the most predominant actions are subsidies and regulations (present in almost 40 % of the questions). Sitia, on the other hand, pursues another strategy by prioritizing preventive or protective actions in nearly 70 % of the what-if questions and investments in the remaining third of the questions.

The imagined policy actions also address different sectors according to the respective local context and topics explored in the NEVERMORE project: in Norrbotten, the focus is on the primary vulnerable sectors and sectors of their economy (reindeer herding, natural heritage, energy, forestry, agriculture) and the transport sector. Trentino's policy actions are mainly oriented to the tourism (33 % of the what-if questions) and water management (13 %) sectors. In contrast to the other study cases, Tulcea focuses more on fishing, waste, cities, construction, and traditional occupations in the Danube Delta, a specific sector of this case study. Finally, Sitia emphasizes policy actions oriented toward the adaptation to biodiversity loss, climate change-stressed agriculture, water problems, urban planning issues (13 %), and the information and communication sector (3 %). The last sector is only addressed by this case study.

3.4. Step 3.2: a range of local storylines about possible and desirable climate action future developments

Based on the analysis of the outcomes provided by the local participants, we developed storylines narrating desirable local developments until 2050. These are not the only conceivable storylines, nor do they function as predictions of local futures. Rather, they present possible futures featuring policy action elements highlighted by the local stakeholders involved in the participatory process. Our scenarios are qualitative since they are presented as narratives and are not currently integrated into a numeric model. Moreover, as previously stated, our scenarios are normative instead of explorative, as they prioritize desirable mitigation and adaptation policy actions instead of describing other possible happenings (van Notten et al., 2003).

3.4.1. A possible desirable future for Norrbotten

Given the information gathered from the what-if questions, we consider that a storyline adapted to the local context and needs, which could be of interest to Norrbotten, would be focused on nature-based solutions and natural resources protection and could be formulated in the following way:

Aiming at conserving the extraordinary natural heritage of the region, including traditional activities such as reindeer herding, agriculture, and forestry, while using the opportunities opened up by modern technological development, Norrbotten embarks on a development path embracing nature-based solutions and natural resource protection. While public authorities implement advanced environmental legislation, business actors focus on greener investment strategies and adopt advanced, cleaner technologies. These combined strategies lead to an increase in the region's renewable energy installations and bio-gas production, a halt in forest deforestation, and an increase in metal recycling. Non-human species finally have air to breathe as, over the years, increasing forest and sea areas are protected from human resource exploitation, and measures are undertaken to guarantee the free movement of migratory species, such as, for example, an adaptation of hydropower constructions to allow fish to pass and a less fragmented landscape. The proactive role of politicians and business actors is influenced by, and in turn, further incentivizes, the proactive behavior of environmentally conscious citizens and landowners. While the former claim more participation in decisions affecting their region's ecological, economic, and social future and begin to consider more sustainable dietary options, the latter start to apply innovative forest management practices. In 2050, thanks to these consistent and ambitious collective efforts of the whole region's citizens, the area has made substantial contributions to climate mitigation and improved its adaptive capacities.

Table 5
The SAAS framework applied to the what-if questions. Percentage (%) values indicate the percentage of what-if questions in the respective SAAS category. The case study with the highest % value is marked in yellow, while the case study with the lowest value is marked in green.

	Norrbotten	Trentino	Tulcea	Sitia
SCOPE				
Adaptation	40%	64%	33%	100%
Mitigation	60%	36%	67%	0%
ACTIONS				
Collective action	30%	0%	33%	3%
Investment	37%	36%	25%	28%
Legislation and regulation	27%	14%	29%	0%
Prevention	0%	14%	0%	41%
Protection	0%	12%	0%	28%
Subsidies	0%	24%	0%	0%
Technological development	7%	0%	13%	0%
ACTORS				
Citizens	6%	11%	2%	11%
Landowners	19%	0%	9%	3%
NGOs	3%	5%	25%	6%
Private companies	23%	39%	27%	31%
Public authorities	48%	45%	36%	50%
SECTORS				
Reindeer herding	13%	0%	0%	0%
Biodiversity	13%	3%	6%	17%
Natural heritage	13%	3%	6%	0%
Energy	13%	10%	9%	0%
Transport	13%	5%	6%	0%
Agriculture	10%	8%	14%	33%
Forestry	13%	3%	11%	0%
Fishing	3%	0%	9%	0%
Tourism	3%	33%	3%	7%
Leisure	3%	0%	0%	0%
Cultural heritage	3%	0%	0%	3%
Education	0%	5%	0%	0%
Commerce	0%	3%	0%	0%
Industry	0%	3%	0%	0%
Technology	0%	5%	0%	7%
Water	0%	13%	9%	13%
Waste	0%	5%	9%	0%
Society	0%	3%	0%	0%
Traditional occupations in the Danube Delta	0%	0%	3%	0%
Cities	0%	0%	6%	3%
Urban planning	0%	0%	6%	13%
Construction	0%	0%	6%	0%
Information and Communication	0%	0%	0%	3%

3.4.2. A possible desirable future for Trentino

A possible desirable future for Trentino will likely feature public-private cooperation with the objective of transforming the region's tourism sector to its core.

Public authorities in Trentino, faced with increasing adverse climate impacts such as reduced snow cover and extreme weather events, worry about the future of the tourism sector, which has proven to be crucial for the region's economic prosperity in the past. Although they are aware of their responsibility and the economic opportunities of climate mitigation, increasing the adaptive capacity of the tourism sector is one goal for local politicians and is appreciated by citizens who suffer the negative consequences of over-tourism. Seeking cooperation with the private sector, public authorities mainly push efficiency improvements and technological solutions to prevent adverse impacts caused by global environmental changes and repair damages already inevitable. Thus, political and business actors aim to promote diversification and innovation within the tourism sector but also rely on technological measures to shield vulnerable parts of the tourism sector from harmful abrupt collapses. Also, water storage and management systems are improved, and win-win policies that both boost the local economy as well as the region's carbon footprint are implemented, such as incentivizing the consumption of local products, respecting biodiversity regulations, and strengthening local food chains. As time goes by, it turns out that making tourism more sustainable not only produces a positive knock-on effect on other sectors but also increases citizens' quality of life. By 2050, the tourism sector will have greatly evolved in a direction favored by business and political actors and Trentino's inhabitants. However, critical voices claim that considerably more could have been done to increase climate mitigation efforts.

3.4.3. A possible desirable future for Tulcea

A possible storyline for a desirable future of Tulcea will probably include the characteristic ecological feature of the region (the Danube Delta) as well as a green growth paradigm based on the stakeholder's emphasis on technological development:

Tulcea faces a range of environmental, social, and economic challenges threatening to undermine the prospects of prosperous future development. Thus, the population quickly begins to recognize that both climate mitigation and adaptation are crucial to solving the region's problems and embarks on a green growth development pathway that stresses mitigation and adaptation measures based on efficiency, innovation, and technological-related policy actions. Although the government takes a strong role in realizing the new paradigm, it is limited to supporting favorable developments by creating smart incentives for private companies to behave in a more socio-ecological way. Green growth, especially investment in technological development, is seen by political and business actors and society as crucial in fighting climate change and revitalizing the region's economy, which is badly affected by depopulation and unemployment. NGOs, after a period spent with strategic considerations, decide to join this public-private coalition to push the new development paradigm further and try to influence the public discourse toward the importance of adapting to water scarcity and desertification processes while mitigating further biodiversity losses and protecting the Danube Delta. In 2050, the region will have restored its vulnerable tourism sector and made its economy more energy efficient. Local authorities are content with the economic revitalization while they consider their responsibility to mitigate fulfilled, especially because of the measures undertaken to conserve the region's Delta.

3.4.4. A possible desirable future for Sitia

Sitia is focused strongly on adaptation; thus, public-led efforts to increase the city's adaptive capacity are at the center of the suggested storyline.

Given the severe negative impacts experienced by Sitia's inhabitants due to wildfires, extreme events threatening human lives, and various water scarcity issues, public authorities finally decide to take ambitious actions to adapt to changed environmental circumstances and to address economic mismanagement aggravating existing problems through an interventionist approach. The municipal government, therefore, assumes a strong regulating role, hoping to achieve faster progress by adopting strong and binding rules. However, the local government also acts as an investor, carrying out specific infrastructure construction actions. In the following years and decades, ambitious policy actions are undertaken to protect citizens from adverse damages, with a focus on vulnerable groups, but also to prevent further damages. The actions comprise several sectors, including agriculture, water, urban planning, and information and communication. While public authorities take the lead, the role of private companies is limited to the tourism sector, where they implement measures aiming at increasing the sector's capacity to cope better with extreme weather events, usually incentivized by public policies. The private sector also builds adaptive infrastructure according to public-private cooperation and planning. Conversely, the role of citizenship is limited in policymaking. Rather, citizens are encouraged to change their mentality, such as opening up to new farming techniques and technologies. In 2050, the region's adaptive capacity to climate change has considerably increased, although continued increases in temperature pose consistent challenges and require a constant renewal of adaptation methods. Meanwhile, public authorities have to deal with critiques from other regions due to the lack of mitigation that characterized Sitia's policy agenda during the last 25 years.

4. Discussion

In this work, we presented and applied a methodology for local scenario development that has proven insightful in various ways, both in its process-oriented and product-oriented nature (Hulme & Dessai, 2008). Hulme and Dessai (2008) state that scenario exercises might not be evaluated only according to the product they generate (such as robust decision-making or predictions); rather, they stress the benefits of the process dimension of scenario exercise.

As a process-oriented tool, our methodology has proven to be accessible to stakeholders without prior training in scenario thinking, making it a user-friendly tool for scenario visioning and training, even for those unfamiliar with such methodologies. The framework strengthens the capacity of local actors to be agents of transformative change by allowing them to consider a diverse array of climate action solutions, in contrast to top-down methods, which tend to be more generic by focusing on socio-economic structural developments (e.g., (Kok et al., 2019)). For example, under the same framework, the participants from Norrbotten could focus on actions

targeting their concerns about reindeer husbandry, while the participants from Tulcea had the possibility to brainstorm about how to support the conservation of the Danube Delta.

As a product-oriented method, our framework facilitates the development of policy-relevant, context-specific storylines. These narratives are co-produced through participatory processes that integrate visioning with structured scenario building, enhancing the plausibility, legitimacy, and salience of the outputs (Harmáčková et al., 2022). The approach used promotes creative storylines, therefore fostering hope, a key objective of scenario development (van Vliet et al., 2012). The balance between creativity and structure promotes stakeholder engagement while yielding coherent outputs that are suitable for modeling and policy design. Although co-creation and transdisciplinary processes like this can face challenges, such as issues of salience or validation, the storylines were reviewed and validated by both policymakers and researchers, ensuring they are robust, well-structured, and adaptable storytelling tools that can be further used for scenario modeling and roadmap design (Moezzi et al., 2017; Wiek & Iwaniec, 2014).

Scenarios like these are needed to help communities navigate uncertainty and make informed, locally grounded decisions about the future. They empower stakeholders to move from passive recipients of top-down solutions to active co-creators of policy-relevant pathways (Raudsepp-Hearne et al., 2020). By encouraging speculative thinking grounded in real-world constraints, the method fosters agency, hope, and long-term vision among policymakers (van Vliet et al., 2012).

Within the NEVERMORE project, these storylines are intended for use in downstream modeling and policy analysis. They provide qualitative inputs that will inform integrated assessment models and scenario-based policy roadmaps. This was an original goal of the project, and the methodological design—particularly the SAAS framework—was crafted to ensure compatibility with such analytical tools (Mallampalli et al., 2016).

Our contributions to literature are several. First, unlike many climate scenario tools, our methodology bridges mitigation and adaptation, allowing both to be considered simultaneously or separately based on local priorities. Second, it connects climate issues with broader sustainability concerns and identifies policy trade-offs and synergies (Filho et al., 2022). Third, it offers a combination of flexibility and structure, balancing open-ended visioning with an analytical framework that enables replication, comparison, and integration into broader policy processes (Lang et al., 2012; Reed et al., 2013). Fourth, it creates bridges between the visioning and scenario planning literature (Nikoleris et al., 2017; Van Beek & Versteeg, 2023). The methodology addresses key gaps in the literature, such as the lack of integration between mitigation and adaptation (Werners et al., 2021); the resource intensity and limited replicability of participatory methods (Biggs et al., 2007; Mitter et al., 2019); and the underuse of normative future visioning in local scenario development (Pelling et al., 2024; Wiek & Iwaniec, 2014).

In summary, the proposed methodology: i) bridges mitigation and adaptation challenges; ii) connects climate issues with broader sustainability topics; iii) allows for the flexible development of locally grounded storylines; iv) balances imaginative thinking with structured outputs suitable for modeling and policy; v) fosters dialogue between policymakers and modelers by translating visioning outputs into structured scenarios.

The outcomes of the process are normative, backcasting, issue-based local and qualitative scenarios (cf. van Notten et al. (2003). In this paper, our work has been focused on creating normative scenarios focused on desirable futures, but the methodology could be used for exploratory scenarios not necessarily desirable for the stakeholders. The scenarios generated here should be understood as summaries of the visioning process of the participating stakeholders (policymakers) rather than as political prescriptions.

Applying this methodology has also allowed researchers to better understand the case studies and the participants' political priorities and/or backgrounds.[5] This diversity reflects the differing climatic, economic, and socio-political contexts of each site and supports the idea that local conditions strongly shape the feasibility and desirability of climate action (Bachtrögler et al., 2020). Additionally, many proposed actions extended beyond direct climate responses, addressing indirect effects and emerging risks, such as over-tourism in Trentino. This highlights a broader systems-thinking perspective among participants and reinforces the value of integrating diverse, context-aware insights into policy design (Adger et al., 2022; Andrews et al., 2023).

5. Limitations and further work

Our methodology and the resulting storylines also present limitations that are worth discussing. Firstly, the outcomes of the participatory processes, and therefore the storylines, are constrained by the selection of the stakeholders. The storylines produced here reflect the policymakers' imaginative processes, rather than incorporating input from all relevant stakeholders in a specific region. Due to time and resource constraints, as well as the organizational complexity of applying the method at four different study sites, the number of participants per site was rather small and cannot be considered representative of what the general population could imagine as a desirable climate adaptation and/or mitigation future (see footnote 8). Biases in storyline design are inevitable and well-acknowledged in the literature (Richter et al., 2023; Schirrmeister et al., 2020) and generalizability is not the goal of our participatory design.

Although the final visions were authored by the research team and fully grounded in participant input, including a validation loop in which participants reviewed and commented on the storylines, they were not fully co-produced with stakeholders in terms of their final narrative construction. Nevertheless, the collaborative effort between policymakers and researchers, their privileged understanding of their territories, the high number of questions they generated, and the proper application of the methodology—particularly

[5] In the Trentino case study, the participants clarified that they approached the exercise as thought experiment considering criteria of curiosity and project goals, and stressed that the selected what-if questions must not be regarded as representative for the Province's dynamically changing political priorities.

the SAAS framework, which tracks variability—ensured rigor, plausibility, and salience of the results.

Additionally, while following a strictly bottom-up method offers advantages in terms of flexibility, creativity, and situatedness, it also has drawbacks. One is the lack of consideration for feasibility analysis. Feasibility analysis can help reveal complex interactions that remain hidden in the storyline creation process (Biggs et al., 2007). This can be understood as the lack of consideration for national, continental, and global dynamics, as well as the absence of analysis regarding whether some measures could reach certain ecological limits (e.g., some of the policies outlined belong to the green growth paradigm, which has faced criticism due to its perceived unfeasibility in achieving sustainability goals (Nieto et al., 2020).

Future work will focus on addressing these limitations. For example, the methodology could be tested in different contexts with various types of stakeholders and enhanced with additional participatory elements to engage diverse groups and facilitate discussion and collaboration in the co-creation process. Direct co-writing of the narratives with stakeholders would also be a valuable enhancement to increase ownership and agency. Additionally, the feasibility and usefulness of the storylines will be explored in the remaining phases of the NEVERMORE Project. This will likely involve quantifying the storylines using local participatory models (Moallemi & Malekpour, 2018) (see the last step outlined in Fig. 2), informed by outputs from global models, thereby evaluating both internal feasibility and constraints from broader scales.

6. Conclusion

In this article, we presented a novel participatory methodology for developing bottom-up climate mitigation and adaptation storylines. We applied the methodology with policymakers in four case studies situated in Northern (Norrbotten, Sweden), Eastern (Tulcea, Romania), Southern (Sitia, Greece), and Western (Trentino, Italy) Europe, and we generated qualitative climate mitigation and adaptation scenarios, outlining possible and desirable developments for each case study by 2050. This approach combines normative visioning (using "what-if" questions) with a structured analytical framework—the SAAS framework—anchored in region-specific climate challenges. The method enables the efficient creation of context-specific and policy-relevant narratives, demonstrating its value as a practical tool for generating storylines. Methodologically, it contributes to the literature by offering a replicable and time-efficient framework that bridges participatory visioning with structured scenario development, enhancing both comparability and usability of local storylines. The results reveal substantial variation in regional priorities, actor roles, and sectoral focus, reflecting how diverse socio-economic and climatic conditions influence locally grounded climate pathways. Practically, the method strengthens stakeholder agency and supports anticipatory governance by generating creative yet actionable storylines that can inform downstream modeling and policy design. Future research should aim to broaden stakeholder diversity, assess feasibility constraints, and explore integration with quantitative modeling frameworks to further enhance its robustness and applicability.

CRediT authorship contribution statement

López-Muñoz Paola: Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Llases Luis:** Writing – review & editing, Writing – original draft, Visualization, Validation, Formal analysis, Data curation. **Lauer Arthur:** Writing – original draft, Visualization, Validation, Methodology, Formal analysis, Conceptualization. **Mencarini Eleonora:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization.

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Declaration of Generative AI and AI-assisted technologies in the writing process

During the phreparation of this work, the authors used DeepL Translate in order to make English expressions natural and ChatGPT in order to extract the essence of a description and efficiently create Abstract with consistent content. After using these services, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Table A.1
Challenges, what-if questions, and SAAS elements for Trentino

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Overtourism	What if the local government applies a maximum number for access to specific hotspots or services?	Adaptation	Regulation, Prevention, Protection	Public authorities	Tourism
Overtourism	What if the local government promotes the development of tourism services also in the off-peak seasons?	Adaptation	Regulation, Prevention, Protection, Subsidies, Investment	Public authorities, private companies	Tourism
Overtourism	What if the local government redefines the calendar of school vacations and holidays?	Adaptation	Regulation	Public authorities	Tourism, Education
Overtourism	What if the local government promotes investment in technology infrastructure to encourage forms of workcation?	Adaptation	Investment, Subsidies	Public authorities, private companies	Tourism, Job
Land use	What if the local government limits the allocation of new land use change for the tourism industry?	Mitigation	Regulation, Prevention, Protection	Public authorities	Tourism, Agriculture, Forestry
Agri-food chain and tourism	What if tourism businesses promote the consumption of local products that foster biodiversity and give more value to the local food chains?	Mitigation & Adaptation	Investment, Subsidies, Protection	Public authorities, private companies, NGOs	Tourism, Agriculture, Commerce, Biodiversity and natural heritage
Reduced snow cover on the ground	What if enterprises optimize and develop technologies to produce artificial snow at higher temperatures?	Adaptation	Investment	Private companies	Tourism, Industry, Technology, Water&Waste
Reduced snow cover on the ground	What if the local government promotes the implementation of multifunctional storage basins?	Adaptation	Investment, Subsidies	Public authorities, private companies	Tourism, Agriculture, Energy, Water&Waste
Reduced snow cover on the ground	What if the local government promotes a diversification of tourism offer?	Mitigation & Adaptation	Regulation, Prevention, Protection, Subsidies, Investment	Public authorities, private companies	Tourism
Extreme events (e.g. VAIA)	What if the local government, together with other local actors, invests in a real time information system on the possibility of territorial fruition?	Adaptation	Prevention, Investment	Public authorities, private companies	Tourism, Technology
Predominantly car-based tourist transport model	What if the local government incentivizes alternative mobility (e-bikes, public transportation, cable cars, etc.)?	Mitigation & Adaptation	Subsidies, Investment,	Public authorities, private companies, citizenship	Transport (incl. transport infrastructure),
Predominantly car-based tourist transport model	What if the local government invests in public transportation infrastructure?	Mitigation & Adaptation	Subsidies, Investment,	Public authorities, private companies, citizenship	Transport (incl. transport infrastructure)
Decreasing water resources	What if the local government promotes more and more installations and use of water storage systems (especially better spread of rainwater storage)?	Mitigation & Adaptation	Subsidies, Investment,	Public authorities, private companies, citizenship	Water
Decreasing water resources	What if the local government promotes the mapping and digitalization of water management systems for its better monitoring and use?	Adaptation	Investment	Public authorities, private companies	Water
Decreasing water resources	What if local governments create/update water management plans for water storages in order to promote the coordination and optimization according to needs during different seasons?	Adaptation	Investment	Public authorities, private companies	Water, energy, Tourism
Energy consumption linked to tourism activities	What if businesses promote the implementation of new technologies in energy-consuming tourism activities (especially hydrogen supply for snow grooming, building energy requalification etc.)?	Mitigation & Adaptation	Subsidies, Investment, Regulation	Public authorities, private companies	Tourism, energy
Energy consumption linked to tourism activities	What if the local government, together with businesses, promotes the use of only	Mitigation	Subsidies, Investment	Public authorities, private companies	Tourism, energy

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Table A.1 (*continued*)

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
	renewable energy in some tourist locations?				
Behavioral change	What if all businesses and operators involved in tourism took part in accredited training on sustainable development of the sector and on climate change?	Mitigation & Adaptation	Investment, Prevention	Public authorities Citizenship Private companies NGOs	Society, Education

Appendix B

Table B.1
Challenges, what-if questions and SAAS elements for Sitia

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Rain/River water ends up in the sea	What if a rainwater harvesting system was built?	Adaptation	Protection, Prevention	Public authorities	Water resources, Agriculture
Water resources	What if there was a system to recycle/reuse wastewater?	Adaptation	Investment	Public authorities	Agriculture
Water resources	What if the local and regional authorities take action to install and use biological wastewater treatment systems?	Adaptation	Investment	Public authorities	Water resources, Agriculture
Drinking water is used for irrigation	What if the waters of rivers and creeks running through Sitia were restored to help with irrigation?	Adaptation	Prevention	Public authorities, private companies	Agriculture
Water resources being mis-managed	What if an agri-economic analysis was performed, and resource allocation was done according to resource demand?	Adaptation	Investment	Public authorities, private companies	Agriculture
Droughts affecting water resources	What if water reservoirs were built to collect rainwater?	Adaptation	Prevention	Public authorities, private companies	Water resources
Droughts affecting water resources and agriculture	What if water dams were built to save water resources and supply the irrigation system?	Adaptation	Prevention	Public authorities, private companies	Water resources, Agriculture
Landslides affect agriculture	What if existing "farming steps" were restored and new ones were built?	Adaptation	Prevention, Investment	Citizenships, Landowners	Agriculture
Wildfires	What if more wildfire buffer zones were created?	Adaptation	Protection, Prevention	Public authorities, Citizenships	Agriculture, Biodiversity, Economy
Wildfires	What if the local authorities provided support to raise awareness on reducing the risk of starting wildfires among the general population e.g. from burning debris or dead vegetation?	Adaptation	Prevention	Public authorities, NGOs	Agriculture, Biodiversity, Economy
Coastal erosion affects coastal areas, infrastructures, and safety	What if breakwaters were placed to reduce the wave momentum on the coasts?	Adaptation	Prevention, Protection, Investment	Public authorities, private companies	Urban planning, Biodiversity, Economy
Floods affect urban areas	What if stricter rules were put in place to prevent uncontrollable construction?	Adaptation	Protection, Prevention	Public authorities, private companies	Urban planning
Floods affect urban areas	What if a rainwater drainage system was constructed in the city of Sitia?	Adaptation	Prevention, Protection, Investment	Public authorities, private companies	Urban planning
Extreme events threaten human lives	What if economic support and funding was provided to acquire new equipment and reinforce civil protection?	Adaptation	Protection	Public authorities	Economy, Agriculture, Biodiversity
Extreme events threaten human lives	What if a real-time warning system was developed to warn citizens and visitors of extreme events e.g., heatwave, wildfire, floods?	Adaptation	Prevention, Protection	Public authorities, private companies	Technology, Information and Communication
Extreme events threaten human lives	What if the municipality organized awareness activities, civil protection exercises for vulnerable groups?	Adaptation	Prevention, Protection	Public authorities, NGOs	
Biodiversity/Endangered species	What if the local authorities increased the margins of protected areas so that they remain mostly inaccessible to tourists?	Adaptation	Collective action	Public authorities, Citizenships	Biodiversity and cultural heritage
Tourism affecting energy and water demands	What if the local authorities invested in the digitalization of a management system to better meet increased energy and water	Adaptation	Investment	Public authorities, private companies	Technology, Cities

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Table B.1 (*continued*)

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
	demands due to tourism in specific months of the year?				
Extreme events threaten human lives	What if funding was allocated to build new hotel units using the most modern materials and complying with the latest safety standards regarding natural disasters?	Adaptation	Investment, Protection	Private companies	Tourism, Urban planning, Economy
Green tourism	What if local authorities provided incentives to promote "greener tourism" e.g., sustainable hotel units, agro-tourism, endangered species, and reforestation volunteering activities, etc.?	Adaptation	Investment, Prevention	Public authorities, Private companies, Citizenships	Tourism, Economy

Appendix C

Table C.1
Challenges, what-if questions and SAAS elements for Tulcea

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Biodiversity risk	What if Danube Delta water levels were stable?	Mitigation	Collective action	Public authorities, private companies, NGOs	Biodiversity and natural heritage
Inefficient and expensive energy use	What if energy efficiency was increased by 20 % in the Tulcea region?	Mitigation	Collective action	Public authorities, private companies, NGOs	Energy (incl. Energy production and distribution-infrastructures)
Unsustainable energy production	What if renewable energy plants increased in the Tulcea region by 30 %?	Mitigation	Investment, legislation & technological development	Public authorities, private companies, NGOs	Energy (incl. Energy production and distribution-infrastructures)
Inefficient energy use (transport)	What if 50 % of cars in the Tulcea region were electric cars?	Mitigation	Investment, legislation & technological development	Public authorities, private companies, citizens	Transport (incl. transport infrastructure)
Energy use (transport)	What if the government provided free public transport for everyone in the Tulcea region?	Mitigation	Investment, legislation & technological development	Public authorities	Transport (incl. transport infrastructure)
Deforestation by pests (more aggressive in the area caused by climate change)	What if the state increased incentives in sustainable solution research?	Mitigation & Adaptation	Legislation, Investment	Public authorities	Forestry, Biodiversity and natural heritage and agriculture
Illegal fishing and overfishing	What if fish poaching was reduced by 70 %?	Mitigation & Adaptation	Legislation	Public authorities	Agriculture, Forestry and Fishing
Lack of investment in sustainable irrigation systems in agriculture	What if sustainable energy was involved in irrigation system development?	Mitigation	Investment	Public authorities, private companies, NGOs, other landowners	Energy (incl. Energy production and distribution-infrastructures) and Agriculture
Unsustainable farming, carbon storage	What if farmers transitioned into regenerative agriculture?	Mitigation & Adaptation	Collective action	Public authorities, private companies, NGOs	Agriculture, Forestry and Fishing
Depopulation caused by unemployment in the Danube Delta	What if the local government promoted the development of a tourist offer also in the off-peak seasons?	Mitigation & Adaptation	Collective action	Public authorities, private companies, NGOs, other landowners	Tourism; traditional occupations in the Danube Delta
Decreasing water resources	What if the local government promoted more and more installations and use of water storage systems (especially a better spread of rainwater storage)?	Mitigation & Adaptation	Regulation	Public authorities	Water and waste (incl. Water treatment and distribution-infrastructures)
Decreasing water resources	What if the local government promoted the mapping and digitalization of water management systems for its better monitoring and use?	Mitigation & Adaptation	Collective action	Public authorities, private companies, NGOs, other landowners	Water and waste (incl. Water treatment and distribution-infrastructures)

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Table C.1 (*continued*)

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Decreasing water resources	What if local governments supported the construction of green infrastructure (particularly based on nature-based solutions) for water harvesting?	Mitigation & Adaptation	Collective action	Public authorities, private companies, NGOs	Water and waste (incl. Water treatment and distribution-infrastructures)
Heat waves	What if green areas in urban settlements were particularly designed to foster biodiversity and to protect from heat waves?	Mitigation & Adaptation	Collective action	Public authorities, private companies, NGOs	Cities, urban planning and construction
Carbon print	What if the local government applied incentives for using buildings with low-carbon materials?	Mitigation	Legislation, Investment	Public authorities, private companies, NGOs	Cities, urban planning and construction
Desertification	What if local governments sanctioned owners of abandoned/ uncultivated lands?	Mitigation	Collective action	Public authorities, private companies, NGOs, other landowners	Agriculture, Forestry and Fishing

Appendix D

Table D.1
Challenges, what-if questions, and SAAS elements for Norrbotten

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Reindeer husbandry land use	What if reindeer husbandry always could be protected when areas and land are selected for wind power?	Adaptation	Legislation	Public authorities	Reindeer herding
Reindeer husbandry/ biodiversity and land use	What if we could use recycled metals only (no new mines allowed)?	Mitigation	Collective action, legislation, investments & technological development	Public authorities, private companies	Reindeer herding
Biodiversity	What if important areas of forest always could be protected?	Adaptation	Collective action	Public authorities, private companies, NGOs, other landowners	Biodiversity and natural heritage
Energy use	What if energy efficiency was increased by 50 % in Norrbotten?	Mitigation	Collective action	Private companies	Energy (incl. Energy production and distribution-infrastructures)
Energy use (transport)	What if there were renewable fuels or electric airplanes for domestic flights in Sweden?	Mitigation	Investment, legislation & technological development	Private companies	Transport (incl. Transport infrastructure)
Energy use (transport)	What if all cars in Norrbotten were electric?	Mitigation	Investment	Public authorities, private companies, citizens	Transport (incl. Transport infrastructure)
Energy use (transport)	What if the government provided free public transport for everyone in Norrbotten?	Mitigation	Investment	Public authorities	Transport (incl. Transport infrastructure)
Lack of public transport	What if the norrbottniabanan was built?	Mitigation	Investment	Public authorities	Transport (incl. Transport infrastructure)
Lack of fossil free fuels	What if there were more incentives for bio-gas production?	Mitigation	Investment	Public authorities	Agriculture
Deforestation	What if all state-owned forests in Norrbotten were protected from deforestation?	Mitigation & adaptation	Legislation	Public authorities	Forestry
Overfishing	What if more areas of the sea were protected from fishing?	Mitigation & adaptation	Legislation	Public authorities	Fishing
Lack of local influence over transition	What if local citizens/organizations/ landowners/companies had much more influence over large exploitation projects like mines, wind power, roads etc.?	Mitigation	Legislation	Public authorities	Reindeer herding

(*continued on next page*)

Table D.1 (*continued*)

CHALLENGE	WHAT-IF QUESTIONS	SCOPE	ACTIONS	ACTOR	SECTOR
Loss of good enough grazing land for reindeer	What if authorities subsidized feed for reindeer if grazing lands were lost due to climate change or climate mitigation (mines, wind power, unsustainable forestry)?	Adaptation	Investment	Public authorities	Reindeer herding
Lack of fossil free energy	What if there was more sea-based wind power?	Mitigation	Investment	Public authorities	Energy (incl. Energy production and distribution-infrastructures)
Lack of migration routes for species	What if all hydropower dams had to be adapted so that fish can pass?	Adaptation	Legislation	Public authorities	Energy (incl. Energy production and distribution-infrastructures)
Lack of undisturbed areas for species	What if there were more species management areas, where wildlife is left alone for parts of the year?	Adaptation	Legislation	Public authorities	Tourism/leisure /cultural heritage
Lack of migration routes for species	What if there were more incentives for increasing the connectedness of the landscape, so that species could migrate?	Adaptation	Investment	Public authorities	Biodiversity and natural heritage
Unsustainable farming, carbon storage	What if farmers transitioned into regenerative agriculture?	Mitigation & adaptation	Collective action	Private companies	Agriculture
Lack of fossil free energy	What if forest fertilization was increased, to increase tree growth for biofuel and increased carbon capture?	Mitigation	Investment	Landowners	Forestry
The landscapes wetlands and water (and carbon) holding capacities have been decreased due to draining activities	What if draining ditches were removed from forest land and wetlands restored or recreated?	Mitigation & adaptation	Collective action	Landowners	Forestry
Carbon storage, biodiversity	What if planted forest stands were made up of several tree species, not mostly spruce or pine, leading to higher diversity, lessening risks of tree die-offs because of pests?	Mitigation & adaptation	Collective action	Landowners	Forestry
Lack of fossil free energy	What if more hydropower was constructed?	Mitigation	Investment	Private companies	Energy (incl. Energy production and distribution-infrastructures)
Biodiversity, carbon storage	What if there were larger, grazing animals, enhancing biodiversity on open land and carbon storage in soils?	Mitigation	Collective action	Landowners	Biodiversity and natural heritage, Agriculture
Biodiversity	What if rewilding strategies were followed?	Adaptation	Collective action	Landowners	Biodiversity and natural heritage
Unsustainable farming	What if people changed diets to more sustainable diets?	Mitigation	Collective action	Citizens	

Appendix E

Table E.1
Overview of the challenges derived from the what-if questions. If there is more than one what-if question pertaining to one challenge, the number of what-if questions is given in brackets

Thematic area	Norrbotten	Trentino	Tulcea	Sitia
Climate change / extreme weather events & warming		Extreme events (e.g., Vaia)	Heat waves	Wildfires (2)
		Reduced snow cover on the ground (2)		Extreme events threaten human lives (4)
Climate change / energy	Energy use (especially transport) (5)	Energy consumption linked to tourism activities (2 questions)	Inefficient and expensive energy use (3)	
	Lack of fossil free energy (3)		Unsustainable energy production	
Climate change / Biodiversity	Biodiversity & carbon storage (4)		Biodiversity	Biodiversity/Endangered species
	Lack of migration routes for species (2)			
	Lack of undisturbed areas for species			
Climate change / land use change	Reindeer husbandry land use (3)	Land use (2)	Desertification	Land & coastal erosion (2)
	Deforestation		Deforestation by pests (more aggressive in the area caused by climate change)	
	Unsustainable farming (2)		Unsustainable farming, carbon storage	
Climate change / water	The landscapes wetlands and water (and carbon) holding capacities have been decreased due to draining activities	Decreasing water resources (3)	Decreasing water resources (3)	Droughts affecting water resources (2)
				Mismanaged water resources (4) (e.g., Drinking water used for irrigation)
				Rain/River water ends up in the sea
				Floods affect urban areas (2)
Climate change / resources	Overfishing		Illegal fishing and overfishing	
Climate change / economy	Lack of public transport	Overtourism (4)	Lack of investment in sustainable irrigation systems in agriculture	Unsustainable tourism (2)
		Agri-food chain and tourism	Depopulation caused by unemployment in the Danube Delta	
		Predominantly car-based tourist transport model (2)		
Other	Lack of local influence over transition	Required behavioral change	Carbon footprint	

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