



FARCLIMATE

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Environment v1

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List of acronyms

EEA: European Environment Agency

ENoLL: European Network of Living Labs

EU: European Union

IPCC: Intergovernmental Panel on Climate Change

IUCN: International Union for the Conservation of the Nature

NbS: Nature-based Solutions

NUTS: Nomenclature Of Territorial Units For Statistics

RAST: Regional Adaptation Support Tool

VUCA: Volatility, Uncertainty, Complexity and Ambiguity

WP: Work Package

Project information

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7	GREEN GROWTH GENERATION GGG
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Abstract:	This document outlines initial findings on climate risk scenarios for the agriculture, forestry, and fisheries sectors. It details how these scenarios, derived from a comprehensive information review, represent current and ongoing challenges rather than distant future possibilities. The report also presents preliminary managerial and strategic implications for the project, based on an assessment of the FARCLIMATE case study strategy. The document offers recommendations to improve the living lab's organisation, risk assessment activities, the development of adaptation solutions, monitoring and evaluation.

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Executive Summary

This deliverable D2.5 presents the initial findings on climate risk scenarios identified across the FARCLIMATE case studies. It also outlines preliminary managerial and strategic implications for the project's overall case study strategy.

Section 1 provides insights into the scenarios expected within the sectors under scrutiny: agriculture, forestry, and fisheries. In the context of climate change, these are essentially risk scenarios. These scenarios are the result of a comprehensive review of information collected from both current and potential case studies. The review resulted in 42 risk scenarios: 9 in the fishery sector, 13 in the forestry sector, 14 in agriculture and 6 cross-sectoral. The risk scenarios reveal that the vast majority of climate risks identified by the case studies' stakeholders are not future possibilities but are, in fact, current, ongoing challenges.

For example:

- A significant risk in fisheries is the collapse of traditional stocks due to major ecosystem shifts driven by rising sea temperatures and altered currents.
- A key risk in forestry is catastrophic wildfires and large-scale forest degradation, fuelled by a loop of prolonged drought and rising temperatures.
- In agriculture, the sector faces a dual water-related threat: prolonged droughts and heat stress on one hand, and destructive floods and hailstorms on the other.

These scenarios highlight the risk of systemic collapse, where ecological degradation and economic decline are inextricably linked. Analysis of the scenarios shows that within the communities participating in FARCLIMATE, the stakeholders primarily impacted are businesses (implied in 20 scenarios), followed by citizens (13) and the public sector (9). In reality, climate risks affect all segments of society; however, the identified scenarios suggest that as a climate problem escalates, its primary impact can broaden from the local business sector to the broader community.

Section 2 sets out preliminary managerial and strategic implications. Based on the Regional Adaptation Support Tool (RAST) framework, we assess gaps in the FARCLIMATE case study strategy and offer managerial recommendations to enhance such a strategy.

- To prepare for Adaptation (Section 2.3), the recommendation is a shift from a heavily data-driven start to an action-oriented, informed decision-making approach. For newly formed living labs, prioritising stakeholder engagement, developing a shared understanding, and building learning capacity is more effective than attempting to build a comprehensive evidence base from the outset. Political support and awareness-raising campaigns are identified as potential solutions to be cocreated within these labs.
- Regarding risk assessment (Section 2.4), efforts should focus on the most significant and actionable risks. A key recommendation is to help stakeholders learn to address and embrace uncertainty, treating future scenarios as plausible alternatives rather than seeking definitive forecasts. This approach should foster a mindset that prioritises developing flexible, adaptive strategies that are resilient across various potential outcomes.

- To support the development of adaptation options (Section 2.5), it is strongly recommended to develop robust strategies and solutions designed to perform effectively across a range of uncertain futures. This involves designing for flexibility, fostering multi-stakeholder collaboration, and ensuring solutions address immediate, existing risks while simultaneously building capacity for future, unforeseen challenges. Furthermore, a crucial goal for the success of the living labs is to build their own adaptive capacity. This involves developing the agility needed to sense changes, seize opportunities and transform in response to the volatile and uncertain environment we all face.
- Finally, regarding monitoring and evaluation (Section 2.6), it is recommended that the evaluation of adaptation solutions be guided by criteria such as their effectiveness in risk reduction, efficiency, avoidance of maladaptation, coherence with broader strategies, and the promotion of just resilience. These criteria are also important for the selection of adaptation solutions (Section 2.5).

1 Initial scenarios for the case studies

Climate adaptation requires understanding future climate scenarios, but also the current scenarios, since the climate in the different regions of our world is already changing due to climate change. Future scenarios are not predictions but justified views of how the future could develop. These scenarios can help us understand the factors that will shape the future, helping us to react effectively as events unfold. They function as the basis on which we can define our strategies and actions for the future—and therefore drive us into desired directions.

In the context of climate change, future scenarios are essentially risk scenarios because they describe what might happen if certain risks materialise or what is currently starting to happen, as many climatic risks have already materialised. Adaptation measures and policies are essential in reducing the overall risk of those scenarios, aiming to cope with climate impacts and improve the resilience of the communities affected. In FARCLIMATE, we employ the terminology from the risk assessment approach of the Intergovernmental Panel on Climate Change (IPCC). The IPCC framework (Simpson et al., 2022) was initially used in our project during the selection process, and further details are provided in deliverables D2.2 and D2.7.

We present in this section a collection of expected risk scenarios in the fields under scrutiny (agriculture, forestry and fishery). These scenarios are derived from information gathered from case study candidates during their selection process, as well as from information collected from stakeholders of the case studies during the initial activities of the first wave of living labs. Additionally, we present these scenarios using a synthesised representation based on the terminology of IPCC but structured in a way that also highlights relevant factors from the managerial perspective of FARCLIMATE, namely the distinction between actual (materialised) and potential climate change hazards or the use of the quadruple helix for stakeholder representation. This analysis also feeds the managerial implications of FARCLIMATE's approach to risk assessment (Section 2.4).

A risk is a potential adverse consequence to something we value. For instance, people, organisations, nature or the resources we depend on.

Risk arises from the interplay of three factors:

1. Hazards, which are events or trends caused by nature or human activity that can lead to damage. *For example, flooding, heatwaves, droughts, temperature rises, extreme weather, and anomalous seasonal weather.* Climate change can create the possibility of these hazards or alter the frequency, magnitude or duration.

It is important from the strategic point of view to distinguish between those that we believe are more or less likely to happen in the future (potential hazards) and those that are already happening (materialised hazards).

2. Exposure, which is the presence of people, organisations, activities, infrastructure, resources, ecosystems or other assets in places and settings that could be affected by a hazard. *For example, coastal communities are exposed to rising sea levels and stronger storms, and farmers in dry regions are exposed to the risk of prolonged droughts.*

3. Vulnerability, which is how likely something is to be harmed from a hazard and how hard it is to recover. It depends on many environmental, social or technical factors and reflects our capacity to prepare, prevent, respond, cope or adapt to hazards. *For example, a town with poorly maintained flood defences; a farming region without irrigation systems being more vulnerable to droughts; communities with limited healthcare or emergency services being more vulnerable to extreme weather events; or the economic dependency on crops more vulnerable to climate change.*

It is important from the strategic point of view to consider vulnerable economic sectors, vulnerable social groups and vulnerable ecosystems or resources. That is, those groups and resources are likely to be more sensitive or have less capacity to adapt to climate change risks. This vulnerability dimension allows us to identify the societal implications of climate change. In the context of FARCLIMATE living labs, we employ the quadruple helix (i.e., classifying stakeholders as business, academia, public administration and citizens). The information provided by the case study stakeholders indicates that most risks usually affect several of these four groups of stakeholders. As such, in this assessment, we focused on identifying the group of stakeholders that the case studies consider the primary, either in the sense of being the most affected or the one with the most power to manage the risk.



Figure 1. Risk and its components, based on the IPCC approach to risk (Simpson et al., 2022).

A crucial step of any risk assessment is defining its scope. This includes both the geographical scope of the assessment and its time horizon.

Territorial scope: Our case studies range from the municipality scale to ecosystems present across sub-national regions. In NUTS terms, most case studies are framed within NUTS3 regions, although some cover various NUTS3 regions, several NUTS3 regions, a NUTS2 region and, the broadest, areas of two NUTS2 regions.

Time horizon: As a reference, the latest IPCC report refers to 2021–2040 as the near term, 2041–2060 as the mid-term, and 2081–2100 as the long term (IPCC, 2022). These time horizons are adequate for public institutions that have to build strategies to deal with the long-term effects of climate change. However, in the case of FARCLIMATE, most stakeholders of our living lab are businesses, workers who are starting to deal with climate change challenges. Their adaptation needs to focus on viability, and thus, for them, the present scenario and the next five to ten years are crucial. As such, most of the case studies adopt a time horizon focused on the period from 2025 to 2035, with some case studies hosted by public administrations further extending the end of the time period. This way, we can represent the already materialised problems of climate change, as well as the future escalations of those existing problems or potential new problems they envision that can affect their territories and activities.

There could be conflicting or contradictory risks, even in the same territory. This may come from different predictions of how climate change can impact a region. Different models, scenarios or uncertainties may suggest opposing outcomes for the same region. These conflicting hazards highlight the complexity of climate change impacts and the need for flexible, adaptive

management strategies that can address multiple, sometimes opposing, risks. For example, in a given coastal region, there is a risk that water temperatures will rise (due to an increase in ocean temperature), but there is also a risk that they will fall (due to changes in marine currents). So far, the risk we derived from the information of the stakeholders does not indicate any relevant contradiction. However, the idea that there could be conflicting or contradictory risks is something that FARCLIMATE and its case studies should keep in mind during the rest of the project.

Based on that, the risk scenarios presented below are the result of a comprehensive review of the information collected from the case studies and potential case studies. While the texts and information gathered from sessions with stakeholders mention a wide array of climate-related challenges, hazards, exposures or vulnerabilities, this section deliberately focuses on a synthesised selection of the most significant risks to provide a clear and strategic overview. This overview is structured in accordance with the risk considerations we described in the preceding paragraphs. The risks presented were chosen based on their prominence within the information and the completeness of their description. Priority was given to those that were emphasised by stakeholders and for which the interplay of a specific hazard, a clearly identified exposed system, and an apparent vulnerability could be robustly established. This selective methodology ensures the analysis remains centred on the most critical, well-documented, and actionable challenges facing the case studies, avoiding a dilution of focus across less developed issues.

Where possible, the risks associated with each scenario are categorised under fisheries, silviculture, or agriculture. In case studies that span multiple sectors, risks are attributed to specific sectors whenever they can be clearly defined. However, specific agricultural and forestry systems are so closely interrelated that presenting them in an integrated manner enhances understanding. For this reason, we have included a dedicated subsection titled 'Cross-Sectoral Risk Scenarios'. A subsection that also includes other critical risks at the territorial level.

1.1 Fishery risk scenarios

Case study 1 – Ría de Pontevedra (1st wave)

NUTS3: Pontevedra (Spain).

Risk	M1. Collapse of shellfish harvesting activity
Hazard	Extreme weather events, particularly torrential rains and intensified river floods, which increase sediment and fresh water runoff into the ría. Algal blooms and rising temperatures are contributing factors.
Type of hazard	Materialised.
Exposure	Shellfish stocks (clams, cockles, etc.) living in the intertidal zones and local communities and businesses that heavily rely on shellfish harvesting.
Vulnerability	The high economic dependency of the shellfish sector, which is described as fragmented and having low diversification. This limited capacity to absorb shocks makes them highly susceptible to stock mortality events.
Primary stakeholder	The vulnerable group falls under the business category of the quadruple helix, including shellfish harvesters' guilds (cofradías) and related enterprises.

Risk	M2. Disruption of traditional fishing due to ecosystem shifts
Hazard	A combination of rising sea temperatures and strengthening marine currents that alter marine ecosystems. This leads to a redistribution of traditional fish species and the introduction of new ones.
Type of hazard	This is a materialised hazard, with observations of species like hake migrating away and new species, such as monkfish and lobster, appearing.
Exposure	The local fishing fleet and the entire fishing sector, which are configured to target specific, traditionally abundant species. Their fishing grounds, equipment, and knowledge are all tied to the historical composition of the marine ecosystem.
Vulnerability	The sector's reliance on traditional species and a general lack of knowledge of the impact of climate change. This is compounded by institutional rigidity and slow legislative adaptation, which hinders the sector's ability to adjust its practices, gear, or target species quickly.
Primary stakeholder	This vulnerability primarily affects the business group (shipowners, fishermen, fish markets).

Risk	M3. Environmental and social degradation from over-tourism
Hazard	Overcrowding and mass tourism, intensified by climate change, are becoming a significant issue as the region becomes a "climate refuge." This leads to secondary hazards like increased pollution (wastewater, plastics, chemical runoff from sunscreens) and physical pressure on coastal ecosystems.
Type of hazard	Materialised.
Exposure	The natural coastal environment (including protected areas like the Atlantic Islands National Park), local infrastructure (especially sanitation systems like those in tourist towns), and the local population.
Vulnerability	The low social commitment to the preservation of the coastal environment, combined with inadequate waste and pollution management systems that easily overwhelm during peak season. This saturation degrades the very environment on which the economy depends and diminishes the quality of life for residents.
Primary stakeholder	The most affected vulnerable group is citizens, who experience the negative impacts on their environment and daily lives.

Risk 4	M4. Reduced operational viability for marine professionals
Hazard	Increased instability and unpredictability of weather patterns, specifically the weakening and erratic nature of the prevailing Northeast winds. This makes sea conditions variable and difficult to forecast.
Type of hazard	Materialised.
Exposure	Fishermen and shellfish harvesters who depend on safe and predictable weather conditions to plan and carry out their daily work at sea or on the coastline.

Vulnerability	The lack of economic diversification in the sector means that lost workdays due to unsafe conditions directly translate to lost income. This structural weakness reduces the capacity of the sector to cope with increasing weather uncertainty.
Primary stakeholder	Business group (fishermen and shellfish harvesters).

Sources: Deliverable 2.7; Ria de Pontevedra Living Lab Mapping Canvas; Ria de Pontevedra SWOT analysis; Ria de Pontevedra risk identification session.

Case study 2 – Ría de Arousa (1st wave)

NUTS3: Pontevedra, A Coruña (Spain).

Risk	M5. Collapse of shellfish harvesting
Hazard	A combination of rising water temperatures, changes in salinity, and the proliferation of both new predator species (e.g., eagle ray) and harmful algae. These environmental stressors are degrading the habitat for shellfish.
Type of hazard	This is a materialised hazard, as stakeholders actively report it.
Exposure	The shellfish stocks themselves, particularly the dominant japonica clam, and the thousands of shellfish gatherers and their families whose livelihoods depend directly on these resources. The broader local economy, which relies on the processing and sale of shellfish, is also exposed.
Vulnerability	The sector's high dependence on a monoculture of japonica clams, which increases susceptibility to species-specific diseases or stressors. This is compounded by insufficient infrastructure for cultivation, a lack of innovation, and a general lack of coordinated climate adaptation projects.
Primary stakeholder	The vulnerable group falls under the Business category of the quadruple helix, encompassing the shellfish gatherers' guilds and related enterprises.

Risk	M6. Disruption of artisanal fishing due to ecosystem shifts
Hazard	Rising sea temperatures and changing marine currents are causing a significant ecosystem shift. This manifests in two ways: traditional commercial species are migrating to colder waters, and new, often predatory, species (like tuna) are arriving in the ría.
Type of hazard	This is a materialised hazard.
Exposure	The artisanal fishing fleet, its traditional target species, and the entire value chain (ports, markets, processors) are exposed to this shift. Small-scale fishers are particularly exposed as their target species become prey for new arrivals.
Vulnerability	The fishing sector is characterised by individualism, a lack of coordination, and resistance to change. This social dynamic is a significant barrier to collective adaptation. Furthermore, there is an insufficient transfer of scientific knowledge to the sector, hindering their ability to understand and respond to the changes.

Primary stakeholder	This primarily affects the Business group (shipowners, fishers, and their guilds).
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Risk	M7. Decreased marine productivity from environmental degradation
Hazard	A weakening of the nutrient-rich cold-water upwelling system due to changing currents, combined with ongoing pollution and industrial discharges. This dual pressure reduces the overall food availability in the marine trophic chain, threatening the fundamental productivity of the ría.
Type of hazard	This is a materialised hazard.
Exposure	The entire marine ecosystem of the Ría de Arousa is exposed. Consequently, all dependent economic sectors, including fishing, aquaculture, and shell-fishing, are exposed to a potential decline in the resources they can harvest.
Vulnerability	A critical vulnerability is the general lack of awareness about the environmental status of the ría, stemming from insufficient water sampling and monitoring. This information gap prevents effective management. The problem is exacerbated by coastal infrastructure projects that lack proper environmental impact assessments, further stressing the ecosystem.
Primary stakeholder	This lack of oversight and data points to a vulnerability within Public Administration.

Risk	M8. Generational crisis and loss of cultural heritage
Hazard	Increasing socio-economic precarity and future uncertainty, which is accelerated by the unpredictable impacts of climate change on marine resources.
Type of hazard	This is a materialised trend.
Exposure	The long-term continuity of the fishing and shell-fishing communities. The region's unique maritime cultural heritage, traditional knowledge, and social fabric are also directly exposed to being lost as the sector shrinks.
Vulnerability	A low social valuation of sea-related professions, coupled with the perception among young people of poor pay and difficult working conditions. This systemic failure to attract a new generation creates a crisis of continuity, threatening the entire social structure that has been built around the sea.
Primary stakeholder	The vulnerable group is Citizens, representing the local communities and their cultural identity.

Sources: Deliverable 2.7; Ria de Arousa Living Lab Mapping Canvas; Ria de Arousa SWOT analysis; Ria de Arousa risk identification session.

Case study 21 – Emilia-Romagna Region (selected for 2nd wave)

NUTS2: Emilia-Romagna (Italy).

Risk	M9. Disruption of traditional fisheries by invasive alien species
Hazard	The rapid expansion of invasive alien species, particularly the Blue Crab, which is facilitated by rising sea temperatures and altered salinity.

Type of hazard	This is a materialised hazard.
Exposure	The traditional fisheries and aquaculture sectors, their equipment, and the native biodiversity of the coastal and lagoon ecosystems. The disruption also affects downstream seafood value chains, including local gastronomy.
Vulnerability	The ecological and economic systems were unprepared for the sudden explosion of the blue crab, exposing a lack of proactive management strategies for invasive species. While reactive measures are now being developed (e.g., valorisation of the crab), the initial shock severely impacted the livelihoods of fishers.
Primary stakeholder	Business group (fisheries, aquaculture operators), especially.

Sources: Deliverable 2.7.

1.2 Forestry risk scenarios

Case study 4 – Fundão (1st wave)

NUTS3: Beiras e Serra da Estrela (Portugal).

Risk	F1. Ecosystem collapse and increased wildfire catastrophe
Hazard	An intensifying cycle of large forest fires, driven by rising temperatures and prolonged drought. These conditions make the landscape more flammable and degrade the forest's natural resilience.
Type of hazard	This is a materialised hazard.
Exposure	The Serra da Gardunha Forest ecosystem, a designated Site of Community Importance with exceptional biodiversity. Also exposed are commercial plantations, rural infrastructure, and the communities living near the forest boundary.
Vulnerability	Fragmented land ownership is a critical structural vulnerability, as it hinders the implementation of coordinated, landscape-scale fire prevention and sustainable forest management. This makes it challenging to create firebreaks or manage fuel loads effectively across a mosaic of small properties. The challenge of coordinating numerous private actors highlights a governance vulnerability, primarily affecting Public Administration in its role as strategic coordinator.
Primary stakeholder	Public administration.

Sources: Deliverable 2.7; Fundão Living Lab Mapping Canvas.

Case study 7 – Málaga (1st wave)

NUTS3: Málaga (Spain).

Risk	F2. Forest degradation and the collapse of bioeconomy initiatives
Hazard	The combined and intensifying effects of prolonged droughts, extreme temperatures, and increased fire frequency. This creates a feedback loop that degrades forest health and resilience.
Type of hazard	Materialised hazard.
Exposure	The forest environments of Málaga province, their biodiversity, and their capacity to capture CO ₂ . Also exposed are the province's bioeconomy and circular economy initiatives, which depend on a sustainable supply of forest biomass for energy.
Vulnerability	The small municipalities (<20,000 inhabitants) that host these forests often lack the specialised resources, budget, and technical capacity for advanced, province-wide sustainable forest management and large-scale fire prevention. Their vulnerability lies in their limited scale to tackle landscape-level problems.
Primary stakeholder	This represents a vulnerability of Public Administration at the local municipal level.

Sources: Deliverable 2.7; Málaga Living Lab Mapping Canvas.

Case study 8 – Rebollo in Castilla y León (1st wave)

NUTS2: Castilla y León (Spain).

Risk	F3. Ecological decline of Pyrenean oak forests
Hazard	The increase in the frequency and intensity of summer droughts and rising temperatures leads to heightened water stress, which in turn increases the risk of catastrophic wildfires.
Type of hazard	This is a materialised trend.
Exposure	The Pyrenean oak forest ecosystems, particularly the vast areas of overly dense, ageing stands resulting from past management. The long-term sustainability and biodiversity of these 716,000 hectares in Castile and León are directly exposed.
Vulnerability	The forests' current structure is a legacy of historical management practices (coppicing for firewood), which created homogenous stands with low ecological maturity. This makes them highly susceptible to drought-induced decline and disease. The low economic return of the species means many of these vulnerable stands receive no silvicultural treatment, perpetuating the risk.
Primary stakeholder	This vulnerability ultimately affects Citizens, who depend on the forests for vital ecosystem services, such as water regulation, soil stability, and recreation.

Risk	F4. Economic stagnation and failure to adapt to forest management
Hazard	The ongoing pressure of climate change demands a shift away from traditional, low-value management towards more resilient and profitable models. The hazard is the persistence of the status quo in a rapidly changing environment.

Type of hazard	This is a materialised hazard.
Exposure	The local rural economy is linked to the Rebollo species forests. The potential for developing new, high-value industries (e.g., wine barrels, quality timber) and the livelihoods of forest owners and workers are exposed to this stagnation.
Vulnerability	A complex web of social and market barriers, including a lack of coordination, resistance to change from traditional uses, and limited access to markets for innovative wood products. This inertia prevents the adoption of climate-adaptive silviculture, trapping the sector in a low-value, low-resilience cycle.
Primary stakeholder	This vulnerability primarily hinders Business (forest owners, firewood producers, potential new industries) from unlocking the forests' economic potential and securing their future viability.

Risk	F5. Failure of adaptation efforts due to governance gaps
Hazard	The complexity of climate adaptation requires robust, integrated, and long-term governance structures to translate plans into effective, on-the-ground action.
Type of hazard	Materialised.
Exposure	The long-term success of strategic adaptation initiatives, including the Living Lab itself and related projects like LIFE Rebollo. The collective ambition to create a resilient and profitable future for the region's forests is exposed to failure.
Vulnerability	A fragmented knowledge system combined with a governance structure that is still under development. While stakeholders are engaged, formal mechanisms for decision-making, resource allocation, and ensuring long-term commitment have yet to be established. This creates a significant risk that initial momentum will fade and pilot projects will fail to scale into lasting, landscape-level change.
Primary stakeholder	This is a vulnerability primarily within Public Administration and its partners in steering the multi-stakeholder process.

Sources: Deliverable 2.7; Rebollo Living Lab Mapping Canvas.

Case study 9 – Gorenjska Region (selected for 2nd wave)

NUTS3: Upper Carniola, Central Slovenia (Slovenia).

Risk	F6. Forest degradation and economic disruption to the forestry sector
Hazard	Droughts, bark beetle outbreaks, windthrow, and ice damage. Rising temperatures and extreme weather events drive these hazards.
Type of hazard	Increasing risks, indicating they are both materialised and potential (expected to worsen).
Exposure	The extensive forest cover of the Gorenjska region constitutes a primary natural and economic resource covering most of the landscape. This includes vital riparian and mountain forests.

Vulnerability	The forestry sector is highly vulnerable due to its economic dependence on the health and stability of forests. The degradation of forests directly threatens the viability of this sector, which plays a crucial role in the regional economy.
Primary stakeholder	Businesses.

Risk	F7. Increased flood and landslide damage to communities
Hazard	Floods and soil erosion/degradation, which can lead to landslides. These are listed as the main climate change impacts to be addressed.
Type of hazard	The hazard is considered materialised and potential (expected to worsen).
Exposure	Local communities and critical infrastructure are situated in valleys and other vulnerable areas throughout the mountainous region.
Vulnerability	The increased vulnerability of local communities stems from their reliance on the protective services of riparian and mountain forests. As droughts, pests, and storms weaken these forests, their ability to regulate water flow and stabilise soil diminishes, making the exposed communities and infrastructure much more susceptible to damage from floods and landslides.
Primary stakeholder	Citizens.

Risk	F8. Loss of biodiversity and ecosystem services
Hazard	Loss of biodiversity and habitats, listed as a direct impact of climate change. This results from compounding pressures such as heat stress, fires, and the spread of invasive species.
Type of hazard	The hazard is considered materialised and potential (expected to worsen).
Exposure	The region boasts a unique and diverse natural landscape, featuring the Julian Alps and Karavanke mountain ranges. It is one of the most environmentally sensitive regions in the country.
Vulnerability	The region's ecosystems are inherently sensitive to rapid climatic shifts. This vulnerability lies in their limited capacity to adapt, leading to the degradation of essential ecosystem services like carbon sequestration and water regulation.
Primary stakeholder	The responsibility for managing these falls to civil society organisations, but ultimately to public bodies. As such, the Public Administration is a primary stakeholder.

Sources: Deliverable 2.7.

Case study 13 – Radiata pine in the Basque Country (selected for 2nd wave)

NUTS2: Basque Country (Spain).

Risk	F9. Forest productivity decline from climate-exacerbated diseases
Hazard	Outbreaks of forest diseases are exacerbated by climate change impacts such as heat stress and changes in precipitation patterns.

Type of hazard	Materialised.
Exposure	The forestry sector and its related activities have led to a decrease in overall production. This also exposes the natural capital of the forest, including its biodiversity and habitat value.
Vulnerability	A general vulnerability of local communities to these impacts, but specifically, the affected Private actors and Administration lack the immediate capacity to curb the large-scale spread of diseases affecting the productive forest.
Primary stakeholder	Business (Private actors involved in forestry).

Sources: Deliverable 2.7.

Case study 17 – Alcornocales Natural Park (selected for 2nd wave)

NUTS3: Cádiz, Málaga (Spain).

Risk	F10. Ecosystem degradation and economic loss from oak decline
Hazard	An increase in temperatures, changes in rainfall, and an extension of the summer are contributing to a higher incidence of 'la seca' (oak decline) in cork oak stands.
Type of hazard	This is a materialised hazard.
Exposure	The large formations of <i>Quercus suber</i> (cork oak) and <i>Quercus canariensis</i> forests within the protected natural area. As such, forestry, specifically valuable cork production, and the associated extensive livestock activity are exposed.
Vulnerability	The decline has a direct impact on the economic viability of the cork industry. Dependence of forest owners on profitability for appropriate forest management.
Primary stakeholder	The ongoing mortality rate indicates a systemic vulnerability that affects businesses (forest owners, cork industry) and, by extension, the Public Administration responsible for managing the protected area.

Sources: Deliverable 2.7.

Case study 20 – Vaia Strom (selected for 2nd wave)

NUTS2: Trentino-Alto Adige/Südtirol (Italy).

Risk	F11. Forest ecosystems collapse from extreme weather and pest outbreaks
Hazard	Increased frequency of extreme weather events, such as severe windstorms, and secondary hazards like bark beetle outbreaks that thrive in weakened forests.
Type of hazard	Materialised.

Exposure	The vast forest areas of the region, the entire timber value chain (from harvesting to processing), and critical ecosystem services like water regulation and tourism.
Vulnerability	The prevalence of monoculture forests, inherently less resilient to windthrow and pest infestations compared to mixed, diverse stands. Engagement with public institutions is still in process, suggesting a potential fragmentation in a fully coordinated, multi-actor response.
Primary stakeholder	This vulnerability affects Business (private landowners) and, by extension, Public Administration responsible for the management of the area.

Sources: Deliverable 2.7.

Case study 24 – Abruzzo (selected for 2nd wave)

NUTS3: L'Aquila (Italia).

Risk	F12. Catastrophic wildfires in abandoned pine plantations
Hazard	An increasing risk of summer wildfires.
Type of hazard	This is a materialised trend.
Exposure	The mismanaged pine plantations, which are described as easy fire baits, surround valuable assets like truffle oak orchards and native forests.
Vulnerability	A legacy of mismanaged and semi-abandoned artificial pine plantations has created a highly flammable landscape. This is compounded by the area being heavily depopulated, which reduces the local capacity for forest management, fire prevention, and rapid response.
Primary stakeholder	This vulnerability directly impacts Citizens and their safety.

Sources: Deliverable 2.7.

Case study 25 – Focșani (selected for 2nd wave)

NUTS3: Vrancea (Romania).

Risk	F13. Decline of protective forests due to climate stress and lack of adaptation
Hazard	Climate challenges, including drought and heat stress, are causing severe tree drying phenomena and affecting the stability of the forest stands.
Type of hazard	Materialised.
Exposure	The pine plantations occupy previously degraded land. Critically, the protective ecosystem services these forests provide (soil stability, water regulation) are also exposed, which in turn affects the local environment and inhabitants.
Vulnerability	These stands were planted 50-70 years ago on already degraded lands, making them inherently unstable as they age under increasing climate pressure. The key vulnerability is that no adaptation measures are currently in place, leaving these at-risk forests without active management to improve their resilience.

Primary stakeholder	This points to a vulnerability within the responsible Public Administration.
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Sources: Deliverable 2.7.

1.3 Agriculture risk scenarios

Case study 4 – Fundão (1st wave)

NUTS3: Beiras e Serra da Estrela (Portugal).

Risk	A1. Crop failure and economic loss in high-value agriculture
Hazard	A combination of rising average temperatures, reduced water availability, fewer frost hours, and altered plant life cycles. These changes disrupt the specific climatic conditions required by high-value crops.
Type of hazard	This is a materialised hazard.
Exposure	The region's flagship agricultural products, particularly the Fundão cherry, which constitutes 60% of national production and is a cornerstone of the local economy. Other key products like olives, grapes, and almonds are also exposed.
Vulnerability	The high economic dependence on a few specialised, climate-sensitive crops creates a major concentration of risk. Despite significant investment in innovation (e.g., AgroTech Centre), crop losses are still projected, and there is a lack of concrete solutions in situ to protect against these impacts, suggesting a gap between technological development and on-farm implementation.
Primary stakeholder	The vulnerable group is Business (farmers, cooperatives, and the wider agribusiness sector).

Sources: Deliverable 2.7; Fundão Living Lab Mapping Canvas.

Case study 5 – Growing Cities Lab, Torino (1st wave)

NUTS3: Torino (Italy).

Risk	A2. Physical collapse of urban garden production
Hazard	More intense extreme weather events, particularly prolonged, heavy rainfall causing waterlogging and flooding, followed by high summer temperatures and drought, leading to soil desiccation. The urban heat island effect exacerbates the heat stress.
Type of hazard	This is a materialised hazard.
Exposure	The urban garden plots, their soil health, the crops themselves, and the basic irrigation infrastructure. The entire short-supply food chain and the social activities centred around the gardens are also exposed to these failures.
Vulnerability	A critical lack of resilient infrastructure, specifically inadequate drainage systems to cope with excess water and the absence of adequate covers and plant protection systems to mitigate heat stress or hail. This makes the

	gardens highly susceptible to being damaged or destroyed by predictable seasonal extremes.
Primary stakeholder	The primary vulnerable group is Citizens (the community gardeners and residents) who invest their time and effort in these spaces.

Risk	A3. Increasing difficulties in the fulfilment of the social mission of urban gardens
Hazard	The increasing frequency and severity of climate disruptions place a strain on resources and energy, requiring constant crisis management in urban gardens.
Type of hazard	Materialised.
Exposure	The network of volunteers, staff, and partner associations is exposed to burnout and disillusionment.
Vulnerability	This is further threatened by external factors like high competition for funding and the risk of disengagement if community expectations are not met. This undermines the ability to achieve its long-term social goals.
Primary stakeholder	This vulnerability lies within the civil society network, which is best represented by the Citizens category in the quadruple helix.

Sources: Deliverable 2.7; Growing Cities Lab Living Lab Mapping Canvas.

Case study 6 – Tarcyżn (1st wave)

NUTS3: Warszawski zachodni (Poland).

Risk	A4. Crop failure due to pollination and weather disruption
Hazard	Unpredictable spring weather, characterised by late frosts and conditions that are unfavourable for pollinating insects
Type of hazard	This is a materialised hazard.
Exposure	The apple blossoms during its critical and narrow flowering period. The economic viability of the individual apple farms is directly exposed, as a failed pollination event leads to a catastrophic loss of yield for the entire year.
Vulnerability	The orchards' high dependence on a successful pollination window, which is made precarious by the declining population of natural pollinators. The fact that farmers are exploring measures like reintroducing bumblebees indicates that the current natural system is no longer resilient enough to guarantee pollination.
Primary stakeholder	The primary vulnerable group is Business (the individual and corporate apple farmers).

Risk	A5. Production loss and environmental damage from extreme water events
Hazard	An alternating pattern of prolonged droughts and dry spells, followed by hyper-intensive, unpredictable downpours and storms. This creates a dual stress of both water scarcity and sudden, damaging excess.

Type of hazard	This is a materialised hazard.
Exposure	Apple orchards are exposed to water stress during droughts. Simultaneously, the surrounding landscape, including inter-field ponds and watercourses, is exposed to heavy soil erosion and runoff contaminated with pesticides during intense storms.
Vulnerability	A low capacity for soil-based water retention, meaning the land cannot effectively absorb and store water during downpours, making it susceptible to both drought and erosion. Furthermore, the reliance on pest management practices that require costly re-spraying after heavy rain makes the farms economically vulnerable to this weather pattern.
Primary stakeholder	This directly affects Business (the farmers) through increased operational costs and potential yield loss.

Risk	A6. Landscape-scale biodiversity collapse
Hazard	The combined and interacting pressures of intensive horticulture practices and the impacts of climate change (droughts, extreme weather).
Type of hazard	This is a materialised hazard.
Exposure	The entire landscape ecosystem, including the habitats of birds, amphibians, and reptiles. Crucial ecological infrastructure, such as inter-field ponds, bushes, and ecological corridors, is also directly exposed to degradation and loss.
Vulnerability	Widespread agricultural practices such as extreme edge ploughing, fencing, and the removal of idle land and bushes. This systematic fragmentation destroys habitats and breaks ecological corridors, severely weakening the ecosystem's ability to support biodiversity and adapt to climate change.
Primary stakeholder	The lack of coordinated stewardship to protect these shared natural assets points to a vulnerability that affects Citizens, who value and benefit from a healthy and biodiverse rural environment.

Sources: Deliverable 2.7.

Case study 7 – Málaga (1st wave)

NUTS3: Málaga (Spain).

Risk	A7. Agricultural sector decline due to water scarcity
Hazard	Severe and prolonged droughts, leading to a critical lack of water for irrigation and cultivation.
Type of hazard	Materialised hazard.
Exposure	Agriculture in the rural environments of Málaga, including all crops and livestock that depend on a stable water supply for their survival and productivity.
Vulnerability	The high dependency of the region's agricultural model on water in a climate that is becoming progressively hotter and drier. This is compounded by the social vulnerability of depopulation due to climate

	issues, where farming becomes economically unviable, forcing people to abandon rural areas and further weakening the local economy.
Primary stakeholder	This primarily affects Business (farmers and agricultural enterprises).

Sources: Deliverable 2.7; Málaga Living Lab Mapping Canvas.

Case study 10 – Vlore (selected for 2nd wave)

NUTS3: Vlore (Albania).

Risk	A8. Economic viability collapse in the viticultural sector
Hazard	There have been cases of drought.
Type of hazard	A materialised hazard that is already affecting the region.
Exposure	The vineyards, which cover a significant portion (30%) of the municipality's agricultural territory, and the farmers who depend on them for their livelihood.
Vulnerability	Several factors make viticulture highly vulnerable. First, the low profitability of vineyards, leading to their abandonment. Second, maladaptation: The practice of planting foreign varieties not suited to the local soil and climate increases their susceptibility to drought-related damage. Third, lack of capacity: No measures have been taken to support climate change adaptation, signifying a very low capacity to prepare for or respond to drought events.
Primary stakeholder	Business (farmers, agricultural producers).

Risk	A9. Crop destruction and production loss from extreme weather
Hazard	Untimely hailstorms.
Type of hazard	These have already caused vineyard damage and decreased production, making this a materialised hazard.
Exposure	All agricultural activities in the municipality are exposed, particularly the vineyards, olive groves, and vegetables.
Vulnerability	The local agricultural sector is extremely vulnerable due to a complete lack of protective strategies. There are no early warning systems, physical protections (like anti-hail nets) to help farmers prevent or recover from the significant production and financial losses caused by these events.
Primary stakeholder	Business (farmers, agricultural producers).

Sources: Deliverable 2.7.

Case study 11 – Sicily (selected for 2nd wave)

NUTS3: Agrigento, Trapani (Italy).

Risk	A10. Economic collapse of small-scale viticulture
Hazard	Water scarcity, prolonged droughts, and heat stress. These issues are already causing major problems.

Type of hazard	Materialised.
Exposure	The entire viticulture and winemaking value chain is exposed. This includes the physical vineyards, grape cultivation, wine production, and related services like wine tourism.
Vulnerability	Small and medium-sized winemakers are particularly vulnerable. Their vulnerability is primarily economic, stemming from decreased grape yields and quality, which destabilise harvest cycles and threaten their income. This can lead to job losses and the abandonment of their activity.
Primary stakeholder	Businesses.

Risk	A11. Increased production instability from pests and extreme weather
Hazard	An increase in pests and diseases, favoured by milder winters, and more frequent extreme weather events like storms.
Type of hazard	Materialised.
Exposure	The vineyards and their annual grape production cycles.
Vulnerability	The stability of the local agrifood supply chains. This vulnerability arises from the unpredictability of these hazards, which can cause sudden physical damage to vineyards and widespread crop loss. This disrupts the entire production and commercialisation cycle, affecting connected services like processing, packaging, and export.
Primary stakeholder	Businesses.

Risk	A12. Long-term degradation of agricultural land
Hazard	Soil erosion and degradation. This hazard is intensified by the hardening of climatic conditions and is described as an ongoing issue.
Type of hazard	Materialised.
Exposure	The agricultural land and soil of the region, which form the fundamental resource base for the local economy.
Vulnerability	The long-term viability of the rural economy and communities. The gradual yet persistent decline of soil fertility undermines agricultural productivity. This threatens not only the economy but also traditional farming practices and the region's cultural heritage, potentially leading to the abandonment of rural areas.
Primary stakeholder	Citizens (as rural communities).

Sources: Deliverable 2.7.

Case study 14 – Kaem (selected for 2nd wave)

NUTS3: Laconia-Messenia (Greece).

Risk	A13. Olive production failure from water scarcity and heat stress
Hazard	Prolonged water scarcity and drought, coupled with intense heat stress. These conditions directly harm olive trees and their reproductive cycle.
Type of hazard	This is a materialised hazard, with observed effects on flowering and quality.
Exposure	The olive trees (the main crop in Messenia and Greece) and the entire olive oil value chain. The welfare of the rural population in Messenia, which directly depends on the sustainability of this sector, is also critically exposed.
Vulnerability	The sector currently lacks concrete adaptation initiatives or measures, making it highly susceptible to these climate impacts.
Primary stakeholder	This lack of implemented solutions reflects a vulnerability across Businesses (local farmers, farmer groups, cooperatives).

Sources: Deliverable 2.7.

Case study 15 – EXO (selected for 2nd wave)

NUTS3: Potenza (Italy).

Risk	A14. Socio-economic collapse from compound climate disasters
Hazard	A combination of prolonged drought and water crisis, extreme weather events (including frequent heatwaves and intense storms), and increased hydrogeological fragility (leading to landslides and floods). These hazards are interconnected and exacerbate each other.
Type of hazard	This is an ongoing hazard, materialised but with potential to worsen.
Exposure	The rural population and local communities of Basilicata, their livelihoods, and the region's cultural resources. The entire rural economy across the livestock, agriculture, and forestry sectors is directly exposed.
Vulnerability	The region's existing structural weaknesses (e.g., inadequate water infrastructure maintenance, brain drain, and depopulation) amplify the impact of climatic events. The ongoing depopulation and brain drain further erode the human and cultural capital needed to recover and adapt, increasing the region's sensitivity and reducing its adaptive capacity.
Primary stakeholder	This primarily affects Citizens (as rural communities).

Sources: Deliverable 2.7.

Case study 18 – SUSGRASS (selected for 2nd wave)

NUTS3: Pohjois-Savo (Finland)

Risk	A15. Instability in forage production and supply chain disruption
Hazard	More variable weather patterns, including frequent heavy rains that cause soil saturation and occasional droughts. These unpredictable conditions lead to significant fluctuations in grass yields and increased nutrient leaching.

Type of hazard	This is a materialised hazard.
Exposure	The grasslands and forage production systems, which are critical for the region's dairy and meat production. The entire supply chain for these products, from farms to markets, is also exposed to instabilities.
Vulnerability	Farmers face challenges in forage planning due to unpredictability and increased economic uncertainty. While some adaptation measures are underway (e.g., enhanced drainage, diversified crops), the inherent variability of the climate still strains the resilience of local food systems and advisory services.
Primary stakeholder	This primarily affects Business (private farmers, milk, and fodder producers).

Sources: Deliverable 2.7.

1.4 Cross-sectoral risk scenarios

Case study 3 – Mediterranean rural Spain (1st wave)

NUTS2: Andalucia, Extremadura (Spain).

Risk	C1. Economic collapse of the Dehesa production model
Hazard	A combination of climate-driven pressures, including rising average temperatures and reduced water availability, decreases farm productivity. These are amplified by market forces that favour industrial farming.
Type of hazard	Materialised hazard.
Exposure	The extensive livestock farming operations that form the economic backbone of the Dehesa system. This also exposes the rural families and communities whose livelihoods and presence on the land depend on this activity.
Vulnerability	The economic model of extensive livestock farming is inherently uncompetitive against intensive, industrial alternatives. A critical vulnerability is the failure of the market and policy to assign a price to the vital ecosystem services the Dehesa provides (e.g., fire prevention, biodiversity maintenance, carbon sequestration). This leaves farmers economically fragile and unable to absorb the additional costs imposed by climate change.
Primary stakeholder	The vulnerable group is Business (the Dehesa owners and farmers).

Risk	C2. Ecological degradation of the agrosilvopastoral system
Hazard	Intensifying drought, water stress, and temperature extremes driven by climate change. These factors directly weaken the oak trees, making them susceptible to diseases like "la seca" (oak decline), and degrade the quality of pastureland.
Type of hazard	This is a materialised hazard.
Exposure	The entire Dehesa ecosystem, which is a tightly integrated system of trees (the forestry component) and pasture (the agricultural component). The keystone holm and cork oaks are directly exposed to mortality, while the pastureland is exposed to degradation, affecting livestock.
Vulnerability	The symbiotic relationship between the system's components. The loss of trees (forestry) reduces shade, acorns, and soil moisture, which harms the livestock (agriculture). Conversely, the abandonment of extensive grazing (agriculture)

	leads to scrub encroachment, increased fire risk, and reduced biodiversity, which degrades the forest ecosystem (forestry).
Primary stakeholder	The lack of adequate, integrated sustainable management policies to protect this interdependence points to a vulnerability within Public Administration.

Sources: Deliverable 2.7; Mediterranean rural Spain Living Lab Mapping Canvas.

Case study 4 – Fundão (1st wave)

NUTS3: Beiras e Serra da Estrela (Portugal).

Risk	C3. Degradation of inland aquatic ecosystems
Hazard	Increasingly unpredictable rainfall patterns, leading to both intense storms (causing flooding and erosion) and periods of low flow, combined with fluctuations in water temperature. This disrupts the physical and thermal stability of riverine habitats.
Type of hazard	This is a materialised hazard.
Exposure	The health of inland aquatic ecosystems, and the viability of the aquatic organisms that depend on them.
Vulnerability	These ecosystems are highly sensitive to the interconnected impacts of climate change on the surrounding landscape. Their health is vulnerable to agricultural runoff, soil erosion from fire-damaged forests, and altered water flows. A general lack of concrete, real-time solutions to mitigate these widespread environmental transformations, leaving aquatic systems with little protection.
Primary stakeholder	This impacts especially citizens, who value and depend on these ecosystems for water quality, biodiversity, and recreation.

Sources: Deliverable 2.7; Fundão Living Lab Mapping Canvas.

Case study 7 – Málaga (1st wave)

NUTS3: Malaga (Spain).

Risk	C4. Public health crisis and tourism disruption from extreme heat
Hazard	An increase in the frequency, duration, and intensity of extreme temperature episodes (heatwaves).
Type of hazard	Materialised hazard.
Exposure	The health and well-being of the population, particularly vulnerable groups like the elderly and children in small municipalities. The province's vital tourism sector is also exposed, as extreme heat can negatively affect visitor comfort and alter seasonal tourism demand.
Vulnerability	A lack of sufficient infrastructure and preparedness to protect the population during heatwaves. This is evidenced by the fact that the provincial council is currently conducting studies for the future creation of a "provincial network of climate shelters," implying this protective network is not yet entirely in place.
Primary stakeholder	This vulnerability directly impacts Citizens.

Sources: Deliverable 2.7; Málaga Living Lab Mapping Canvas.

Case study 19 – Portosanto (selected 2nd wave)

NUTS3: Madeira (Portugal).

Risk	C5. Infrastructure damage and water insecurity
Hazard	The dual climate impact of lower average rainfall (leading to water scarcity and drought) and more frequent episodes of heavy, erosive rainfall.
Type of hazard	This is a materialised hazard.
Exposure	The island's populations and infrastructure, particularly those located near waterlines that are at risk from flash floods and land erosion, are of concern. The island's limited freshwater resources are also exposed.
Vulnerability	The degraded soils make the landscape highly susceptible to erosion during intense rain, increasing the risk to nearby infrastructure. This is compounded by the island's inherent sensitivity to water scarcity, creating a significant vulnerability for both the resident and large tourist populations.
Primary stakeholder	This directly impacts the safety and well-being of Citizens.

Risk	C6. Collapse of the tourism-based economy
Hazard	An increase in the frequency and intensity of heavy rainfall episodes, which accentuates erosion phenomena.
Type of hazard	Materialised.
Exposure	The island's primary economic asset is Porto Santo beach, which underpins its entire tourism industry. The wider tourism sector, including hotel groups and tourist agents, is also directly exposed.
Vulnerability	The island's extreme economic dependence on a single sector (tourism) is directly threatened by the erosion of its main natural attraction. The degradation or loss of the beach would have a catastrophic effect on the local economy.
Primary stakeholder	A critical vulnerability for the island's business community.

Sources: Deliverable 2.7.

1.5 Evaluation of the risk scenarios

First of all, the generalisation of these findings should be approached with caution due to the nature of the case study selection. The participating organisations were not chosen through a random sampling process but based on the regional sector's vulnerability to climate change and the interest of the candidates in FARCLIMATE. This selection introduces a bias towards regions already experiencing significant climate change impacts and possessing a higher awareness of the associated risks, which motivated their interest in the project. Additionally, the geographical distribution of the case studies is not uniform, with certain vulnerable European regions having greater representation than others. Nevertheless, despite these limitations, this collection of insights into risk scenarios provides a valuable and indicative snapshot of the diverse and pressing risk scenarios that communities and territories, reliant on fisheries, agriculture, and forestry, are confronting due to climate change across Europe.

General implications

Adapting to the present: A clear conclusion from the analysis is that the overwhelming majority of risks identified across the case studies are not distant threats but current realities. The hazards driving these risks—from extreme weather events to ecosystem shifts—are consistently classified as 'materialised', meaning they are already occurring. A few scenarios explicitly note that the hazards are both materialised and potential, indicating that while the risks have already started, they are expected to worsen in the coming years. For many of the

risks classified as materialised, stakeholders also shared the impression that their impacts would intensify over time. This has a significant implication for strategy-making. Rather than primarily anticipating and preparing for future, abstract risks, most case studies face a scenario where climate challenges are already impacting their activities and livelihoods. This present-day urgency means that adaptation must focus on managing ongoing problems, not just planning for potential ones. Consequently, the situation reinforces the suitability of the selected time horizon for the FARCLIMATE project, 2025-2035. This timeframe is well-aligned with the stakeholders' needs as it addresses the already materialised problems while also accounting for the near-term future or potential challenges they envision affecting their sectors.

Based on the 42 risk scenarios identified in the case studies, the primary stakeholder groups are business (20), citizens (13) and public administration (9). It is also noteworthy that Academia, the fourth group in the quadruple helix model, is not identified as a primary stakeholder in any scenario. This is mainly because the ultimate consequences and management responsibilities for these identified risks fall directly upon businesses facing economic loss, citizens experiencing impacts on their safety and environment, or public administrations tasked with governance and ecosystem management.

The analysis reveals that business is the primary stakeholder most frequently identified as being at risk from climate-related issues. This may reflect the specific nature of the selected case studies, which often emphasise collaboration with farms, fisheries, and forestry organisations working directly in economic activities with climate-sensitive resources. However, this focus on a single primary stakeholder is a simplification for analytical clarity; in reality, climate risks affect all segments of society. The provided scenarios suggest that as a climate problem escalates, its primary impact can also escalate from the local sector to the broader community of the territory. A risk that begins as an economic threat to local businesses can grow into a major concern for public bodies or the general population. For instance, while initial concerns of economic viability of primary sectors are framed as a risk to the business group, the resulting degradation of the entire system becomes a primary concern for public administrations, which could lead to widespread socioeconomic collapse in rural areas, ultimately affecting all citizens in the territory.

Fishery risk scenarios

A dominant theme across the fishery case studies is the risk of major ecosystem shifts driven by changing marine conditions. In both the Ría de Pontevedra and Ría de Arousa, the core hazard is a combination of rising sea temperatures and altered marine currents. This manifests in the redistribution of traditional fish species, the arrival of new predators, the proliferation of harmful algae, and an increase in invasive species like the Blue Crab in the Emilia-Romagna region. The exposure is consistently placed on the local fishing fleets, valuable shellfish stocks, and the entire coastal communities whose economies are built around these resources.

The underlying vulnerabilities that amplify these hazards are remarkably similar across the cases. A critical vulnerability is the high economic dependency on a few specific species, such as the reliance on traditional fish stocks or the monoculture of japonica clams, which concentrates risk and reduces resilience. This is compounded by significant social and governance barriers that hinder adaptation. These include institutional rigidity and slow legislative

adaptation, a lack of coordination and resistance to change within the sector, and an insufficient transfer of scientific knowledge to fishers, which prevents them from effectively understanding and responding to the rapid changes in their marine environment.

Forestry risk scenarios

The interconnected risks of catastrophic wildfires and broad-scale forest degradation overwhelmingly dominate the forestry scenarios. Across diverse European landscapes, especially in southern Europe, a recurring combination of hazards is identified: prolonged droughts, rising temperatures, and extreme weather events, such as windstorms. This creates a dangerous feedback loop where drier, hotter conditions increase forest flammability while simultaneously weakening trees, making them highly susceptible to secondary impacts like disease (e.g., oak decline) and massive pest outbreaks (e.g., bark beetles).

A crucial insight from the analysis is that the vulnerability of these forests is often deeply rooted in their structural composition, which is a direct legacy of past management practices. Many of the exposed forest ecosystems are susceptible not just because of climate change, but because they were already in a fragile state. Common vulnerabilities include the prevalence of homogenous, low-resilience monocultures that are vulnerable to pests and windthrow; fragmented land ownership that prevents coordinated, landscape-scale fire prevention; and a legacy of mismanaged or abandoned artificial plantations that have become highly flammable "fire baits". These structural weaknesses severely compromise the forests' natural capacity to adapt to intensifying climate hazards.

Agriculture risk scenarios

Across the agricultural case studies, the sector is consistently caught between two extremes of a dual water-related threat: prolonged water scarcity from drought and heat stress on one hand, and sudden, damaging deluges from intense downpours, hailstorms, and floods on the other. This pattern of both "too little" and "too much" water is a recurring hazard that threatens a wide range of farming systems, including high-value products like viticulture in Italy, olive groves in Greece, cherry production in Portugal, and apple orchards in Poland. The exposure consistently falls on these specialised crops and, by extension, the entire regional agrifood value chains and rural economies that depend on their viability.

The vulnerabilities that make these agricultural systems so susceptible are also markedly consistent. A primary structural vulnerability is the high economic dependence on a few specialised, climate-sensitive crops, which concentrates risk and leaves little room for failure. An apparent gap in on-farm adaptive capacity frequently exacerbates this. This manifests as a lack of resilient infrastructure (such as adequate drainage, irrigation systems, or anti-hail nets), maladaptive practices like planting crop varieties ill-suited to the changing climate, and a general absence of concrete, implemented adaptation measures, signalling a gap between recognising the risk and taking action.

Cross-sectoral risk scenarios

The cross-sectoral scenarios demonstrate how climate impacts cascade beyond a single industry to threaten entire socio-ecological systems. A key theme is the risk of systemic collapse, where ecological degradation and economic decline are inextricably linked. This is exemplified by the Dehesa in Spain, where climate-driven pressures and market forces

threaten both the ecosystem's health and the economic viability of its production model. The hazards in these cases are often compound and interconnected, such as the dual threat of reduced average rainfall combined with more frequent, erosive downpours that cause infrastructure damage and heighten water insecurity.

Consequently, the vulnerabilities identified are systemic and complex. A critical, recurring vulnerability is the failure of existing governance and market structures to properly value the ecosystem services (e.g., fire prevention, water regulation) that underpin regional stability, leaving these systems economically fragile. Another shared vulnerability is an extreme economic dependence on a single natural asset or sector, such as Porto Santo's tourism-based economy that relies on a major beach threatened by erosion. These scenarios also expose vulnerabilities at a community-wide level, including a lack of protective public infrastructure to shield citizens from extreme heat or to manage flood risks in landscapes with degraded soils.

2 Initial managerial implications of the FARCLIMATE case studies

2.1 Introduction to the managerial implications

The second purpose of this deliverable is to evaluate the initial managerial implications of the FARCLIMATE case studies. The managerial approach for the FARCLIMATE case studies has taken form during the first 24 months of the project. This approach is founded upon the original project proposal and has been further detailed in various deliverables produced during this period. Specifically, the core management processes for the case studies are defined within WP2 and WP3, which together provide a framework for integrating the activities of other WPs into the management of the case studies.

In a nutshell, the managerial approach of the FARCLIMATE case studies centres on the launch of living labs, which serve to form community-based working groups for climate change adaptation based on the living lab methodology. The core activities of these living labs focus on identifying the challenges that climate change poses to their sectors and territories and subsequently devising potential solutions to support their adaptation efforts.

The project's various tasks and deliverables provide a comprehensive set of strategies and supporting tools to facilitate the launch and establishment of the FARCLIMATE case studies. To understand the role of the strategies defined in those tasks, it is helpful to consider three basic managerial dimensions they address: the organisation, the problem and the solution.

Establishment of the living lab in the case study (organisation dimension): *Task T2.1 "Methodological approach to identify cases and their extent"* provides the guidelines and strategy for setting up FARCLIMATE living labs. This has been documented in *D2.1 "Methodological approach for FARCLIMATE"*. *Task T2.3, "Stakeholder management strategy,"* further extends the FARCLIMATE strategy in the domain of stakeholder engagement and with further details to complement the living lab strategy initially defined in *Task T2.1*. This has been documented in *D2.3 "Stakeholder management strategy"*. *Task T2.4 "Set up of the case studies through living lab methodology"* implements the strategies defined in the previous tasks, including the evaluation of the living labs. Finally, some considerations concerning key indicators to support the project or case studies are addressed in *T3.1, "Integrated assessment framework"* and documented in its corresponding deliverable, *D3.1 "Characterisation of Case Studies: Guidelines and Indicators"*.

Analysis of climate change challenges of the specific sectors and territories (problem dimension): The living lab strategy of *T2.1/D2.1* defines the integration of problem identification activities within the overall living lab methodology. In addition, *T2.3/D2.3* further extends this aspect. *Task T2.2 "Selection of case studies"* bases its selection, among other criteria, on a risk assessment of the different regions, as well as on a first characterisation of the problems the candidate's sectors and territories face. This has been documented in the first and second compilation of FARCLIMATE case studies (deliverables *D2.2* and *D2.7*). As such, besides helping in the selection, *T2.2* has provided an initial panorama of the climate challenges in the different case study candidates. Regarding WP3, most of its tasks focus on analysis, as they seek to characterise key economic (*T3.2*), social (*T3.3*), consumer (*T3.4*) and environmental (*T3.5*) aspects of the case studies. In addition, some considerations on key indicators relative to this topic are addressed in *T3.1*.

Cocreation of climate change adaptation ideas, strategies and projects (solution dimension): The living lab strategy of T2.1/D2.1 defines the integration of problem identification activities within the overall living lab methodology. In addition, T2.3/D2.3 further extends this aspect. T3.1 addresses some considerations regarding key indicators that the project or the case studies would use for the solutions they devise. Specially important is *T3.6 "System climate innovation"*, which has established the strategies for designing climate change adaptation solutions, bridging the solution-development approach of living labs defined in WP2 with the solution-development approach of other FARCLIMATE tasks, especially for the sectoral solutions of WP5. This is documented in *D3.9 "Analysis of the Agriculture, Forestry and Fisheries Sectors"*.

This deliverable (D2.5) is part of task *T2.5 "Fostering a transformative change to resilience environments"*, which is also framed within this third dimension of cocreation of solutions. Since the generation of solutions occurs in the living labs as a result of cocreation by participants, T2.5 assumes the role of strategic assistance. Namely, T2.5 aims to (1) integrate and align the solutions developed by the living labs to the overall framework of FARCLIMATE and (2) provide strategic support to the living labs to help them mature, from a managerial and strategic aspect, the solutions they devise. As such, the current deliverable D2.5 acts as an initial document to help guide such strategic support.

The depth of progress across the three dimensions of organisation, problem and solution currently diverges among the case studies. While the initiation of the first eight living labs and the identification of several initial challenges associated with climate scenarios are well underway, the development of solutions and the initiation of the other 12 living labs are scheduled for later project stages. This sequencing is necessary, as the development of solutions is contingent upon the living lab process within each case study.

In the context of this progress, our managerial approach is also evolving from the lessons we learn from working with the case studies. Over the past 24 months, we have gained valuable insights from our engagement with both candidates and the final selected participants who started the 1st wave of case studies. The lessons, detailed in D2.4, are the following:

1. Engagement is a key principle to steer the project.
2. The importance of properly handling the learning curve and the evolution of case studies.
3. Fostering flexible, bottom-up living labs.
4. Carefully plan interactions with the case study communities in an integrated way.
5. Respecting the independence of case study communities to define their climate change adaptation actions.
6. The need for participatory approaches to innovation that emphasise the role of those who experience the problem as much as those who are experts on the problem.
7. Case studies may have to progress at different rhythms.

These lessons have helped refine our process for recruiting and kicking off the case studies, with the long-term aim of ensuring they have a lasting impact. We also believe these lessons will be valuable for other social innovation initiatives that aim to engage local communities in developing social and environmental projects. In the context of this document, the important lessons from the case studies are also critical for identifying gaps between the theoretical

groundings and plans of FARCLIMATE and the actual results and practices, subsequently providing managerial and strategic recommendations.

2.2 Methodology: managerial and strategic gap analysis and recommendations

Our approach to evaluate the initial managerial implications of the FARCLIMATE case studies is to employ the Regional Adaptation Support Tool (RAST) as a framework to identify gaps (European Environmental Agency, 2024). RAST is a comprehensive framework developed by the European Environment Agency (EEA) in partnership with the European Commission to assist local and regional authorities with climate change adaptation strategies and plans. Since the early 2020s, RAST has gained significant traction across Europe, particularly through the EU Mission on Adaptation to Climate Change's Mission Implementation Platform (MIP4Adapt), which launched the tool as a core component of its support to regional and local authorities. The tool has been actively implemented by Charter Signatories of the EU Mission, with documented success stories showcasing its application in numerous regions across Europe, demonstrating RAST's value in helping authorities transform strategic planning into concrete climate adaptation actions. The widespread application of RAST across multiple European regions and its use in various EU-funded climate adaptation projects have provided substantial validation and testing of the framework's comprehensibility in practice.

The tool is designed to help authorities navigate the complex journey of their adaptation initiatives. It offers practical guidance through six structured steps to support climate adaptation policy processes:

1. Preparing the ground for adaptation.
2. Assessing climate change risks and vulnerabilities.
3. Identifying adaptation options.
4. Assessing and selecting adaptation options.
5. Implementing adaptation policies and actions.
6. Monitoring, evaluation, and learning.

RAST is flexible and iterative, adapting to local or regional authorities' policy-making processes and unique local context, whether they are starting from scratch or are further along in the adaptation process. Each step includes a comprehensive overview and detailed support sections, supplemented by resources from the EU Mission on Adaptation, Climate-ADAPT, and other partners, providing access to data providers, examples, and tools specifically developed to help local and regional authorities across the European Union.

Although RAST was explicitly designed as a tool for helping to build climate change adaptation strategies for local and regional authorities, its broad coverage of topics provides a tested framework that can effectively evaluate local and regional climate change initiatives such as ours, the FARCLIMATE living labs for climate change adaptation. The comprehensive nature of RAST offers a robust structure for comparing whether the strategic approach of FARCLIMATE for the climate adaptation case studies is sufficiently comprehensive and well-structured.

As such, RAST serves as a comparative reference, helping to check whether all essential strategic components involved in climate adaptation are adequately addressed. The tool's

emphasis on stakeholder engagement, participatory decision-making, and iterative learning processes aligns particularly well with the living lab approach of FARCLIMATE, which relies heavily on multi-stakeholder collaboration, cocreation processes, and real-world experimentation. For a project like ours, RAST can therefore be repurposed as an analytical lens to assess whether our living lab's strategic approach is sufficiently thorough. By mapping FARCLIMATE's approach for the implementation of living labs and the development of adaptation solutions, we can identify potential gaps in our strategic approach. This enables us to critically evaluate our approach and ensure comprehensive coverage of strategic and managerial elements, thereby enhancing the overall effectiveness of our climate resilience initiatives and strengthening their potential to generate sustainable outcomes.

In addition to RAST, as mentioned, the lessons learned from working with the case studies also play a crucial role in identifying managerial and strategic gaps in the FARCLIMATE case study approach.

Based on the aforementioned gap analysis, this document provides recommendations to enhance the FARCLIMATE case study approach. These recommendations are intended to complement the guidelines already established within other project tasks and deliverables. The aim is to offer insights that are both practical for implementation and theoretically sound, being grounded in established strategic management and scientific literature.

2.3 Preparing the ground for adaptation: Analysis of the living lab strategy and management

RAST step 1 focuses on "preparing the ground for adaptation." Applied to the FARCLIMATE case studies, it mainly involves the strategy for setting up the living labs.

Building the evidence base (RAST step 1.1)

This step recommends building a robust evidence base to inform policymaking and guide adaptation planning. In the context of RAST, this applies to local or regional authorities, but evidence-based management is actively promoted for many types of organisations, projects and initiatives.

Analysis: FARCLIMATE, as a Horizon Europe framework in the EU Mission on Adaptation, has been designed with a similar approach. In that sense, the WP2 and WP3 approaches we mentioned in Section 2.1 are designed in a manner that is amenable to the benefits that the evidence base could bring. However, most of the evidence base that FARCLIMATE will create focus on the execution of the different analyses that the consortium will carry out to support case studies. A different topic is the own evidence base that FARCLIMATE studies may build on their own.

Critical analysis of evidence-based policymaking reveals significant limitations when applied to complex, uncertain domains like climate adaptation. The complexity of climate adaptation requires pragmatic approaches that combine scientific evidence with governance principles and stakeholder engagement (Saltelli & Giampietro, 2017). In participatory climate adaptation, higher levels of stakeholder involvement, particularly through partnerships, led to more robust and contextually appropriate outcomes than consultation-heavy approaches that rely primarily on expert data. While consultation is often perceived as a method to engage experts for technical matters, meaningful partnership approaches integrate "the technical approach of

professionals with that of citizens who might have a non-scientific knowledge of the territory" (Rudge, 2021). Rigid adherence to comprehensive evidence bases can create barriers to adaptation implementation (CASCADE Consortium, 2020).

As such, newly formed working groups for climate change adaptation can be more effective when they prioritise participant understanding and learning capacity over establishing a comprehensive evidence base from the outset. This approach, while seemingly counter to the principles of many climate adaptation frameworks, is supported by both literature and lessons learned from our practice. This is also supported by several of the lessons we learned from the case studies; namely, engagement (lesson 1), learning curves (lesson 2), flexible and bottom-up living labs (lesson 3) and emphasising experiential problem solving (lesson 4). This former aspect of the relevance of experiential learning is further analysed in D2.3. Furthermore, climate adaptation is a wicked problem (D2.3) and involves competing values and interests, which cannot be easily reconciled through technical analysis alone (Sørensen & Ansell, 2023). As such, we consider that a data-initiated approach to the case studies may hinder the bottom-up approach of the FARCLIMATE case studies.

Recommendations:

- Building evidence bases as a ground for the FARCLIMATE living labs is problematic. On the contrary, we find that prioritising understanding and action over comprehensive evidence is necessary for the successful launch of the FARCLIMATE case studies. We suggest an informed decision-making approach instead of a data-driven approach.
- Building a local, sectoral evidence base may be a potential solution or future project within the living lab that the different case studies may consider. In that sense, we find that evidence generation can be more effective when developed through partnerships between communities, local authorities and research institutions.

Securing political support and ownership (RAST step 1.2)

Step 1.2 focuses on engaging politicians and ensuring long-term political support for planning and implementing climate adaptation. Since RAST is targeted at regional and local authorities, political support is a key dimension; however, it is also a fundamental goal and resource for the FARCLIMATE case studies, some of which involve local administrations.

Analysis: FARCLIMATE living lab strategy (D2.1) already covers this as a core element. Specifically, the quadruple helix approach to stakeholders has public administrations as one of the four major groups of stakeholders to engage in living labs. This works at two levels. First, in case studies, local and other relevant administrations are engaged to participate in the living labs to discuss climate change and its impact in the sectors, as well as in the cocreation of adaptation solutions. Second, the stakeholder management activities of the living lab strategy and the stakeholder management strategy (D2.3) guide the analysis, engagement and participation of diverse external stakeholders, including public administrations, in the living lab activities. In addition, WP6 will generalise a set of policy recommendations based on our learnings on this topic from the FARCLIMATE case studies.

Indeed, public administration support may be a critical element in promoting ideas, strategies, or solutions proposed by the living lab. This may involve engagement of local authorities for specific projects, the formation of coalitions to promote specific actions or even the recruitment of local administrations to help bring concerns and the pressure to resolve them to higher-level

authorities. However, these types of action are dependent on a well-defined problem and proposal, and the corresponding commitment of resources and effort.

Recommendations:

- Securing political support is of strategic importance: This is the process from which the policy implications of FARCLIMATE will arise and be further refined.
- Initiatives for gaining political support may be a potential solution to be cocreated in the living labs. In the context of FARCLIMATE living labs, these types of political initiatives are candidates for potential solutions to be discussed or codesigned within the living labs by the stakeholders.

Setting up governance structures to support adaptation (RAST step 1.3)

This step highlights the importance of establishing structures to streamline coordination and collaboration, both within the organisation and externally. It is also important to determine the members, define objectives, clarify tasks and work programmes, agree on collaboration structures, establish schedules and milestones, and maintain transparent documentation.

Analysis: FARCLIMATE living lab strategy (D2.1) already covers this. Specifically, this is covered by the following Living Lab Mapping Canvas quadrants: Governance (for structures), Purpose (for objectives), People and Internal Roles (for members and internal coordination and collaboration), Stakeholders and External Roles (for external coordination and collaboration), Strategy (for work programmes, schedules, milestones). The living lab documentation recommended by D2.1 is also oriented to be maintained as living documents and transparent to the stakeholders involved.

No managerial or strategic gap has been identified.

Identifying resources (RAST step 1.4)

This step highlights the importance of the identification and availability of resources for supporting adaptation planning. Specifically, RAST highlights human resources, technical resources and financial resources. Regarding financials, it is also important to consider financial viability.

Analysis: FARCLIMATE living lab strategy (D2.1) already covers this. Specifically, this is covered by the following quadrants: People and Internal Roles (human resources), Resources and Sustainability (human, technical and financial resources; financial viability).

No managerial or strategic gap has been identified.

Communicating adaptation and raising awareness (RAST step 1.5)

This step involves two aspects. First, establishing consultative and participatory mechanisms. Second, develop a communication strategy to raise awareness of climate adaptation and encourage active citizen engagement.

Analysis: Regarding participation, the FARCLIMATE living lab strategy (D2.1) and stakeholder engagement strategy already cover this. Indeed, stakeholder participation is the core principle these two strategies are devoted to, shaping all the other activities in a participatory manner. As demonstrated by the paradigmatic example of the co-creation of solutions.

Regarding the communication strategy, the FARCLIMATE living lab strategy (D2.1) already covers this. Specifically, this is covered by the following quadrant: Communication Strategy and Channels.

Recommendations:

- Designing and implementing local, sectoral awareness-raising activities in the living lab are solutions that the case studies are interested in. On the one hand, WP4 is developing a series of cross-case study trainings. On the other hand, specific ideas of awareness-raising campaigns or activities are something that case studies consider as a supporting activity. For instance, we are starting to introduce dissemination activities to high school students, focusing on topics such as climate change action and social entrepreneurship.

2.4 Assessing climate risks: local climate risks to the communities of the case studies

RAST step 2 focuses on assessing climate risk. From a strategic and managerial perspective, this corresponds to environmental scanning. In the context of climate change adaptation, this environmental scanning focuses on the present and future scenarios of climate change and thus, risk analysis is a dominant aspect of it. This also applies to the FARCLIMATE project and case studies. Specifically, the problem analysis activities of the FARCLIMATE living labs focus on identifying local climate risks to the sectors and communities involved in the case studies.

Defining the core elements of the climate risk assessment (RAST step 2.1)

This step focuses on defining the essential elements of the risk assessment methodology.

Analysis: In FARCLIMATE, we employ the terminology from the risk assessment approach of the Intergovernmental Panel on Climate Change (IPCC). This IPCC framework (Simpson et al., 2022) was initially used in our project during the selection process, and further details are provided in deliverables 2.2 and 2.7. Our central differing principle is the time frame. As described in Section 1, common time frames in climate adaptation have a time frame focusing on 2040 onwards. However, we decided to adopt a time horizon focused on the period 2025-2035 to (1) provide a time frame relevant for the viability of the activities of most case study stakeholders and (2) to represent the already materialised problems of climate change. The horizon of 2035 helps to cover the potential future problems that could affect their territories and activities. When it comes to the risk assessments we perform together with the stakeholders of the case studies, we conduct a simplified version aimed at promoting risk identification, discussion, structuration, understanding and goal setting.

The case studies' risk assessment is integrated into the FARCLIMATE living lab approach. Specifically, the living lab strategy of T2.1/D2.1 defines the integration of problem identification activities within the overall living lab methodology. Risk assessment is one of these problem identification activities. In addition, T2.3/D2.3 provides complementary material that may help engage stakeholders in such activity. Task T2.2 bases its selection of case studies, among other criteria, on a risk assessment of the different regions. This has been documented in the first and second compilation of FARCLIMATE case studies (D2.2 and D2.7). Finally, in task T3.6, which established the strategies for designing climate change adaptation solutions, it integrates risk assessment elements in the first stages of its solution-development approach.

No managerial or strategic gap has been identified.

Identifying (RAST step 2.2) and assessing climate risks (RAST step 2.3)

Step 2.2 focuses on identifying the specific risks, emphasising the significance of vulnerabilities. Step 2.3 focuses on analysing data on climate-related risks.

Analysis: The identification of climate risks primarily relies on the information provided and discussed by stakeholders during the living lab. Following the rationale, we argued for in relation to the role of an evidence base for our project, we consider that the starting point for risk assessment is an open discussion about climate risks among different stakeholders of the case studies. This way, they identify relevant potential hazards, exposures and vulnerabilities. They discuss their importance, ramifications and contradictions. It is also an opportunity for them to learn how to structure these uncertainties through risk-related concepts.

Recommendation:

- Here also applies the issue of building evidence bases as a ground for the FARCLIMATE living labs, as discussed for RAST step 1.1 in Section 2.3. As such, we find that a methodology that prioritises understanding of risks and action to address them over comprehensive evidence is necessary for the successful launch of the risk assessment for the FARCLIMATE case studies.
- The future is not a single, predictable point; yet many stakeholders still think and demand certainty. Moreover, this is further complicated by misinformation and partisanship, which can affect people's beliefs and understanding of complex topics involving significant uncertainties, such as climate change and its social impacts. Instead of betting on one forecast or relying on [unrealistic] certainties, FARCLIMATE should help stakeholders learn to address uncertainty, to treat future (even present) scenarios as plausible alternative settings. This would enable us to establish a mindset for building flexible and adaptive strategies that are robust across various potential scenarios, including potentially contradictory ones. The goal is to be prepared to act effectively and fairly, regardless of how it unfolds.

Defining key risks and adaptation objectives (RAST step 2.4)

This step focuses on selecting the key risks and building adaptation objectives based on them that will provide a clear direction for the adaptation efforts.

Analysis: As mentioned in the RAST step 2.1, the risk assessment is integrated in the FARCLIMATE living lab approach. In practical terms, we aim for the risk assessment exercises with the case studies to conclude not only with a list of priority risks, but also with a set of ideas or goals that help the case study consider potential adaptation solutions.

Recommendation:

- The goals derived from the risk assessments should help ground strategies of case studies and potential solutions in the present while preparing for the future. It is crucial to address materialised challenges that are already impacting the sectors in the territories while simultaneously using scenarios to prepare for a future with more substantial impacts of the materialised risk and potential new risks.

- We cannot address every potential issue. Strategic focus is key. As such, we recommended concentrating efforts on the most significant risks—those that are most prominent, whose components (hazard, exposure, vulnerability) are well understood. A risk that is relevant for several types of stakeholders is also significant, because it may help engage and mobilise the different stakeholders involved in the living lab.
- Centre the strategy on stakeholders and actionability. A strategy is only effective if it is relevant to those it affects. It is essential to understand the needs, perspectives, and vulnerabilities of all key groups (e.g., business, public bodies, citizens). It is also important to ensure that efforts are directed toward the most critical and actionable challenges. A robust strategy should have levers to address all three risk components: reducing exposure and decreasing vulnerability of the different groups. Sound adaptation responses must also contribute to or at least align with the mitigation of climate hazards; i.e., there is no proper adaptation without climate change mitigation and sustainability. Finally, this includes aligning strategic time horizons with stakeholder priorities; a 30-year plan has little value to a business concerned with surviving the next five years.

2.5 Adaptation options: Cocreation of climate change adaptation solutions

RAST steps 3–5 focus on the identification, assessment, selection and implementation of adaptation solutions. Since RAST focuses on supporting public authorities, its primary focus is on policy development.

Derived from this and previous managerial implications, we discuss two additional recommendations to help design the strategy of climate adaptation options cocreated by the living labs:

- Building robust strategies and solutions for local climate change adaptation.
- Building adaptive capacity in FARCLIMATE Living Labs.

Identifying adaptation options (RAST step 3.1)

Step 3.1 emphasises the consideration of a diverse range of adaptation options, ensuring the alignment with other initiatives and the compilation of fact sheets for each option.

Analysis: This relates to the process of cocreation of climate change adaptation solutions. The living lab strategy of T2.1/D2.1 defines the integration of problem identification activities within the overall living lab methodology. In addition, T2.3/D2.3 further extends this aspect regarding the engagement of stakeholders for cocreation. In addition, T3.6 has established strategies for designing climate change adaptation solutions, bridging the solution-development approach of living labs defined in WP2 with the solution-development approach of other FARCLIMATE tasks, particularly for the sectoral solutions outlined in WP5. This is documented in D3.9.

The participatory approach of FARCLIMATE living labs ensures a collaborative environment where stakeholders propose, discuss, and refine adaptation options. In addition, one of the outcomes of the previous step of risk assessment (Section 2.4) is the generation of adaptation goals that help guide the identification of adaptation options. Finally, the living lab methodology of WP2 and the solution-development approach of T3.6 will generate basic information,

equivalent to factsheets, on the proposed solutions, especially on sustainability, risk, participatory and stakeholder aspects.

Alignment with other activities is treated below in the point addressing RAST steps 5.1 and 5.2

No managerial or strategic gap has been identified.

Taking inspiration from good adaptation practices (RAST step 3.1)

Step 3.2 emphasises the importance of drawing inspiration from and learning from other cases.

Analysis: FARCLIMATE has dedicated a WP for this. WP7 is building a knowledge platform to share these types of stories. In addition, the FARCLIMATE case studies, but also external parties, can contribute to it. Task T6.6 is devoted to the creation of the European Climate-Resilient Communities Network, involving FARCLIMATE case studies or similar initiatives from other projects. One of the main purposes of such a network is the exchange of experiences on climate change adaptation.

No managerial or strategic gap has been identified.

Assessing (RAST step 4.1) and selecting adaptation options (RAST step 4.2)

Steps 4.1 and 4.2 emphasise the need for assessment and selection criteria agreed with relevant stakeholders. These criteria shall reflect the adaptation principles, including factors like contribution to broader sustainability objectives, just resilience, impact on local or regional development, and costs. The goal is to have suitable adaptation options criteria. These steps also emphasise that stakeholder engagement is key to setting the criteria and selecting the solutions.

Analysis: Both the living lab and stakeholder engagement strategies (WP2) and adaptation-solution development strategy (T3.6) provide a basis for generating participative and sustainable criteria. However, we consider that the guidance on assessment criteria established by RAST step 4.1 could benefit this specific aspect in FARCLIMATE. Regarding the establishment of a participatory selection of options, this is part of the living lab methodology.

Recommendation: Follow the principles of solution assessment criteria specified in RAST step 4.1, namely:

- Effectiveness in reducing climate risks.
- Efficiency in addressing the various potential futures and bringing about significant benefits (i.e., robust strategies).
- Determination of whether the option leads to incremental improvements or transformative changes to existing systems.
- Avoidance of maladaptation.
- Coherence with broader strategies.
- Interactions with other social objectives.
- Just resilience.
- Political and cultural acceptability.
- Urgency for action.

Development (RAST step 5.1) and integration of climate adaptation plans (RAST step 5.2)

Step 5.1 focuses on setting up a dedicated climate adaptation plan, while Step 5.2 explores integrating these plans into broader strategies to mainstream adaptation, thereby reinforcing it.

Analysis: As the living lab equivalent of the business model canvas, the Living Lab Mapping Canvas (D2.1) fulfils the role of the adaptation plan for FARCLIMATE case studies. This canvas has also been used in living labs in other projects by ENoLL. Furthermore, although a business model is not the same as a strategy or a plan, it can fulfil its role in many types of organisations. Specially, initiatives that are starting up that require strategic flexibility. A business model reflects the key capabilities or characteristics of an organisation to carry out its purpose and being viable. This picture allows a situational awareness of the organisation and where it should be headed. As such, it allows a positional strategy that provides more flexibility and clarity than rules-based or procedural plans. The same rationale applies to the Living Lab Mapping Canvas.

Recommendation: Regarding the integration of the adaptation plans of the FARCLIMATE living lab in broader climate adaptation plans, we find that such activity could be an opportunity for engagement with other living labs, other types of local initiatives working in climate change adaptation or local/regional authorities. In the sense of working together on potential projects for aligning local initiatives with broader-level coordination efforts.

Securing funding (RAST step 5.3) and maintaining supporting governance (RAST step 5.4)

Step 5.3 deals with securing funding or finance for implementing the adaptation options. Set 5.4 highlights that successful implementation relies on supporting governance, including multi-level coordination and continuous stakeholder engagement.

Analysis: FARCLIMATE living lab strategy (D2.1) already covers this. Specifically, this is covered by the following Living Lab Mapping Canvas quadrants: Governance (for governance structures) and Resources & Sustainability (for securing funding).

No managerial or strategic gap has been identified.

2.5.1 Building robust strategies and solutions for local climate change adaptation

Derived from the managerial implications of risk assessment (Section 2.4) and the identification and assessment of adaptation options (RAST steps 3 and 4 in Section 2.5), we highlight the importance of developing adaptation solutions that can perform effectively across uncertain future scenarios. Drawing on literature from political science, business management, and climate policy, this recommendation outlines practical principles for developing robust solutions to local climate change adaptation that can withstand uncertainty while maintaining actionability and stakeholder relevance.

Strategic management literature under uncertainty emphasises four key levels of decision-making contexts (Courtney et al., 1997), from "clear enough futures" to "true ambiguity". Robust business strategies share several characteristics: they avoid betting on single forecasts, maintain strategic flexibility across different potential outcomes, and focus on building adaptive capacity rather than optimising for predicted scenarios. Indeed, decision-making under deep uncertainty (DMDU) frameworks emphasises exploratory modelling across multiple scenarios, adaptive planning that evolves over time, and collaborative sense-making among diverse stakeholders (Marchau et al., 2019)

Robust strategies emphasise the capacity of systems to absorb and manage disruptions while maintaining core functions. From an institutional point of view, relevant for the living lab as a community or organisation and its governance, robustness involves three interconnected dimensions (Sørensen & Ansell, 2023): polity robustness (institutional flexibility), robust politics (adaptive strategic processes), and robust policy (modular designs that mobilise diverse stakeholder agency). Key principles include preserving flexibility while accomplishing short-term objectives, enabling repositioning and experimentation, and creating "multi-vocal policies" that can be interpreted differently by various stakeholders while maintaining coherence. Furthermore, in the case of conflicting goals and needs of stakeholders, particularly relevant for climate adaptation, it is essential to promote political processes that transform conflict into constructive engagement rather than attempting to eliminate disagreement. In the context of climate change, robust climate policies share several characteristics: they perform well across multiple plausible futures, incorporate adaptive management principles, and maintain legitimacy across diverse stakeholder groups (Workman et al., 2024; Suprayitno et al., 2024).

Organisational ambidexterity—the ability to simultaneously pursue exploitation of existing capabilities and exploration of new opportunities (Nieto-Rodriguez, 2014; Du & Chen, 2018)—emerges as a critical capability for robust climate adaptation solutions. In the climate adaptation context, this translates to the capacity to address immediate, materialised climate risks (exploitation) while simultaneously developing innovative approaches for uncertain future scenarios (exploration). Furthermore, ambitious climate adaptation organisations may even embrace what recent literature terms "multidexterity"—the ability to simultaneously carry out multiple strategic activities based on diverse logics and operational levels (Robbins et al., 2021). This involves three key dimensions: structural multidexterity (creating separate units for immediate response and long-term planning), contextual multidexterity (enabling teams to shift between operational and innovative activities seamlessly), and temporal multidexterity (sequentially adjusting focus between different strategic priorities as conditions evolve). However, developing such a sophisticated capability is a notable challenge.

The significance of ambidexterity for robust strategies lies in its capacity to resolve tensions inherent in climate adaptation under uncertainty. Organisations face the challenge of optimising current adaptation measures while simultaneously experimenting with novel approaches for unknown future conditions—a classic trade-off between exploitation and exploration. Research shows that ambidextrous capabilities enable faster strategic decision-making under uncertainty, which is particularly crucial in dynamic contexts where windows of opportunity for effective action may be limited. Moreover, multidextrous organisations develop what scholars term "strategic agility"—the ability to calibrate dynamically and sequence transformation efforts based on changing environmental conditions. This capability becomes essential for climate adaptation initiatives that must balance competing demands: delivering immediate benefits to stakeholders while building long-term adaptive capacity, addressing local specificities while maintaining transferability, and ensuring operational efficiency while fostering innovation. The multidextrous approach enables organisations to navigate these paradoxes by developing parallel capabilities rather than making binary choices, ultimately creating more resilient and flexible response systems that can perform effectively across multiple future scenarios.

Based on this multi-disciplinary literature review, robust solutions for local climate change adaptation would benefit from following these principles:

1. Embrace uncertainty as a design factor. Rather than attempting to predict specific climate outcomes, robust adaptation solutions should be designed to perform adequately across a range of plausible future scenarios.
2. Design for flexibility and adaptive capacity. Robust solutions should prioritise building adaptive capacity over implementing fixed interventions. This involves creating "modular" measures that can be scaled up, scaled down, or reconfigured as conditions change. The goal is to enhance the lab's adaptive capacity (discussed in the following subsection).
3. Leverage the living lab to foster multi-stakeholder collaboration and learning. Robust adaptation solutions in FARCLIMATE will require negotiations, coalition building and dialogue among stakeholders. This collaborative approach should enable joint sense-making processes that allow different stakeholders to contribute their perspectives and knowledge while building a shared understanding of adaptation challenges and opportunities. The solutions should be designed to be "multi-vocal"—interpretable and actionable by different stakeholder groups while maintaining overall coherence.
4. Ground strategies in the present while preparing for the future. This means ambidexterity: addressing already-materialised climate impacts while building capacity to deal with potential future changes. Solutions should provide immediate benefits to stakeholders while creating foundations for longer-term adaptive capacity.
5. Ensure cross-organisational coherence to warrant consistency across different areas. Solutions should align with and reinforce other objectives, particularly climate mitigation, sustainable development, and social equity goals. This is closely related to what was discussed in Section 2.5 for RAST steps 5.1 and 5.2.
6. Balance specificity with generalizability. While robust solutions must be tailored to local contexts and stakeholder needs, they should also be designed with sufficient modularity and transferability to inform adaptation efforts in similar contexts. In the long term, the sharing of experiences, cross-fertilisation of innovation and the opportunities for collaboration or coalition-building may help consolidate local solutions. This involves identifying core principles and approaches that can be adapted to different settings while maintaining their essential robustness characteristics.

2.5.2 Building adaptive capacity in FARCLIMATE Living Labs

FARCLIMATE living labs operate within an increasingly complex environment characterised by Volatility, Uncertainty, Complexity and Ambiguity (VUCA). This context extends beyond the core topic of climate change adaptation to encompass rapidly evolving business environments, shifting funding and political landscapes, and dynamic opportunities for collaboration. Volatility manifests in rapid changes across multiple dimensions: climate conditions create urgent adaptation needs, policy landscapes shift regulatory frameworks, and funding opportunities appear and disappear with political cycles. Uncertainty pervades stakeholder engagement outcomes, technology effectiveness assessments, and the unpredictable nature of climate impacts themselves. Complexity emerges from multi-stakeholder environments where interdependent systems require cross-sectoral collaboration and coordination. Ambiguity creates challenges through multiple interpretations of climate risks and conflicting adaptation priorities among diverse stakeholders (Minciu et al., 2025).

Given the complexity and uncertainty of this operating environment, another strategic goal should be to enhance the living labs' adaptive capacity. Plans themselves are less important than the resilience, flexibility, and responsiveness they create, allowing the organisation to pivot as events unfold. For small, emerging living labs like those in FARCLIMATE, this VUCA environment demands more than traditional planning approaches. It requires developing what strategic and management experts call dynamic capabilities. This is a management perspective that emphasises understanding how organisations can build adaptive capacity, especially relevant when facing VUCA environments. The Dynamic Capabilities view proposes three interconnected dimensions that enable organisations to "integrate, build, and rearrange internal and external competencies to face rapidly changing environments" (Teece et al., 1997). In other words, it involves the following capabilities:

- Sensing capabilities involve environmental scanning, opportunity identification, and threat detection. For FARCLIMATE living labs, this means developing systematic approaches to monitor climate risks, policy and market changes, funding opportunities, and changes in stakeholders or their needs.
- Seizing capabilities focus on opportunity capture, resource mobilisation, and partnership formation. This involves the ability to assemble resources quickly, form strategic alliances, and implement adaptation solutions when windows of opportunity emerge.
- Transforming capabilities enable resource reconfiguration, organisational restructuring, and capability renewal. This dimension is crucial for living labs that must continuously adapt their approaches based on learning and changing circumstances.

The effectiveness of dynamic capabilities depends on what is called microfoundations—the underlying individual skills, organisational processes, decision-making structures, and knowledge management systems that enable capability development. For small living labs, these micro-foundations are particularly critical because they must maximise impact with limited resources (Ding et al., 2023).

Organisational processes must be designed for flexibility rather than efficiency, enabling rapid pivoting when conditions change. Decision-making structures should balance participation with agility, allowing for quick responses while maintaining stakeholder engagement. The implementation of the living lab methodology itself may help develop organisational micro-foundations required to build the adaptive capacity necessary for developing and implementing climate adaptation solutions successfully. It is an open innovation methodology, in which the participation, transparency and experimentation may help foster the organisational agility required for such adaptive capacity.

Individual learning capabilities form the foundation for organisational adaptation. Small living labs, such as FARCLIMATE's, should invest in developing team members' abilities to scan environments, synthesise complex information into actionable proposals, and facilitate stakeholder engagement.

Knowledge management systems must capture and disseminate learning effectively, both within the organisation and across networks. In this context, another critical component of adaptive capacity is absorptive capacity—the ability to recognise, assimilate, and apply external knowledge (Ding et al, 2023). For FARCLIMATE living labs, this capability is essential for leveraging best practices from other contexts, integrating scientific knowledge, and learning

from stakeholder experiences. Small organisations can build absorptive capacity through several mechanisms: establishing connections with research institutions and other living labs, creating systematic processes for capturing and analysing external information, developing translation capabilities to adapt external knowledge to local contexts, and fostering a culture of continuous learning and experimentation. Furthermore, the absorptive capacity may help to refine the potential evidence base the living lab may build (discussed in RAST step 1.1 in Section 2.3). The lenses of absorptive capacity help determine the type of information that the organisation requires and can collect and sustain.

Overall, building the adaptive capacity of a small living lab, such as those within FARCLIMATE, requires a systematic, phased approach tailored to its specific resource constraints and developmental stage. Therefore, while enhancing this capacity is not a direct climate adaptation solution in itself, it is a crucial enabling step for climate adaptation. It would ensure the sustainability of the labs, ultimately strengthening their ability to generate more effective adaptation solutions. As such, another set of potential solutions that may be cocreated or promoted in the FARCLIMATE case studies are learning programs targeted to improve team members' abilities associated with building adaptive capacity for the organisation.

2.6 Monitoring, evaluation and learning

Monitoring, evaluation and learning (RAST steps 6.1-6.3)

Step 6 focuses on ensuring adaptation measures stay on track and deliver their intended results: Monitoring to track progress made in implementing adaptation measures against objectives; evaluation to assess outcomes of planned adaptation measures to increase effectiveness; and learning to use lessons learned from monitoring and evaluation activities to improve the adaptation measures.

Analysis: T2.4 includes the evaluation of the living labs. The living lab strategy of T2.1/D2.1 also includes a methodology to evaluate the solutions developed in a living lab. As established in T3.6/D3.9, the development of adaptation solutions will be subject to monitoring and evaluation. In this case, each of the monitoring and evaluation criteria shall be selected based on the type of solution targeted. For instance, Nature-based solutions (NbS, WP5) will employ the established criteria by IUCN for such a type of solution.

Recommendation: In line with what was established in Section 2.5 for the assessment and selection criteria for adaptation options, we propose to employ the criteria indicated in RAST step 4.1 to define potential monitoring and evaluation criteria for the solutions:

- Effectiveness in reducing climate risks.
- Efficiency in addressing the various potential futures and bringing about significant benefits (i.e., robust strategies).
- Determine if the option leads to incremental improvements or transformative changes to existing systems.
- Avoidance of maladaptation.
- Coherence with broader strategies.
- Interactions with other social objectives.
- Just resilience.
- Political and cultural acceptability.



- Urgency for action.

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