SOlutions **TE**sting for **R**egions through

Insurance for Climate **A**daptation

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List of **Contributors**

Organization	Name	Contribution
UFZ	Oleksandr Sushchenko	Elaboration of the document
UFZ	Reimund Schwarze	Elaboration of the document
Climate Risk Advisory Ltd	Mia Ebeltoft	Main revision of the document
Municipality of Gabrovo	Mihaela Ivanova	Main revision of the document

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Executive summary

- Climate-related disasters caused over EUR 199 billion in losses across the EU-27 between 1980 and 2023, with more than 80% of these losses uninsured.
- Climate insurance protection gap is most severe in countries like Bulgaria and Croatia (coverage around 2%) and lowest in countries like Norway (over 70% coverage).
- Traditional insurance models are increasingly inadequate to manage the scale and complexity of climate risks.
- Barriers to insurance uptake include lack of localized data, limited insurer capacity, high premiums, low awareness, and distrust in insurers (mostly on demand side).
- SOTERIA project explores innovative insurance systems (IIS) through practical case studies in Germany, Spain, Norway, and Croatia.
- Innovative solutions include parametric and multi-peril insurance, digital technologies (DLT, IoT, AI), and public-private partnerships.
- Valencia case study under SOTERIA uses co-created KPIs to integrate resilience into local wetland management and governance.
- In Germany, flood risk certification is linked to insurance access and subsidized adaptation loans, offering a model of integrated financing.
- Norway demonstrates the benefits of sharing insurance loss data with municipalities to improve planning and reduce risks.
- Zadar Case Study in Croatia (under SOTERIA) applies behavioral tactics to increase awareness, trust, and demand for insurance among farmers.
- Shared resilience frameworks with common indicators and stakeholder engagement help align efforts across sectors.
- Digital platforms like the Resilience Planet Data Hub and Norway's Knowledge Bank support data-driven decision-making and adaptation.
- Best practice criteria (from ECB and EIOPA) include rapid and fair payouts; inclusivity and accessibility; promoted improved resilience; alignment with sustainability criteria; facilitate access to private and public sustainable finance.
- Recommendations include scaling digital innovations (access to quality data), promoting inclusive insurance models, integrating insurance into climate finance, and aligning with ESG frameworks.

Introduction

Climate change is intensifying the frequency and severity of natural hazards – floods, droughts, storms, and heatwaves – across Europe and globally. These events are already inflicting profound economic, social, and environmental impacts. Between 1980 and 2023, extreme weather and climate-related events caused over EUR 199 billion in economic losses in the EU-27 alone, with the vast majority of those losses remaining uninsured (EEA, 2024). This growing disparity between actual damages and insured losses – known as the climate insurance protection gap – has emerged as one of the most pressing challenges for public authorities, private insurers, and

vulnerable communities.

Despite Europe's relatively advanced insurance markets, the region is far from uniformly protected. In some countries, such as Norway, more than 70% of climate-related losses are covered by insurance, whereas in others, such as Bulgaria or Croatia, coverage falls below 2 % (with an increasing trend) (EEA, 2024). This variation highlights not only geographic disparities but also systemic issues in the availability, affordability, and design of risk-transfer mechanisms. It is now clear that traditional insurance solutions alone are insufficient to meet the demands of a rapidly changing climate. Moreover, it requires transformation of a conventional insurance business by moving towards incentives for reducing risks.

In this context, innovation in climate insurance has become both an opportunity and a necessity. New tools, technologies, and institutional arrangements are being developed to improve coverage, increase resilience, and lower costs. These include parametric insurance schemes, eco-innovations, flood risk certification models, and public-private partnerships, all of which aim to expand access to protection while incentivizing proactive risk reduction – promoting sustainable insurance.

The European Commission, European Central Bank (ECB), EIOPA, UNEP-FI, and other international institutions have begun to identify critical criteria for best practices and climate insurance innovation: impactful (delivers tangible climate, environmental, and social benefits); scalable (efficient, replicable, and adaptable across contexts); integrated (complements existing systems and shares risks fairly); resilient (reduces long-term risks and strengthens adaptive capacity); innovative (applies novel or improved solutions across functions).

This report draws on a broad evidence base – from innovative insurance products to a share resilience through elaboration of a results-based framework – to present a synthesis of best practices, innovative approaches, and policy recommendations for bridging the climate protection gap. It aims to inform decision-makers, insurers, and implementers about what works, where innovations are already underway, and how cross-sectoral collaboration can deliver resilient outcomes for people, property, and the economy.

Climate insurance protection gap

According to the methodology used by the European Environmental Agency (EEA 2024), there are three major groups of weather and climate-related extreme events that might cause economic damages: meteorological (e.g., storms), hydrological (e.g., floods and mass movements) and climatological events (e.g., heatwaves, cold waves, droughts and forest fires) (see **Figure 1**).

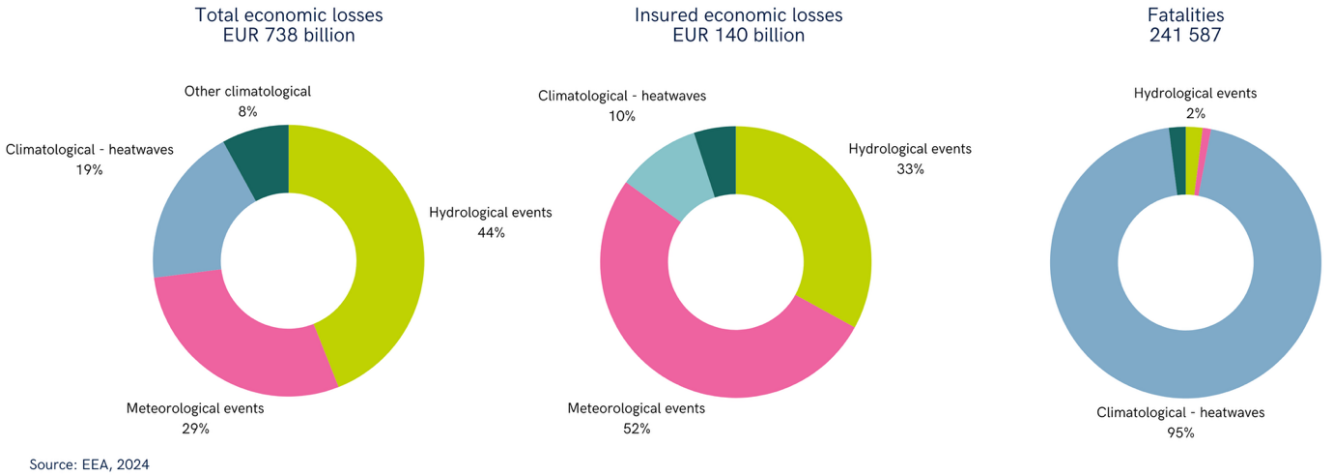


Figure 1. Economic losses and fatalities caused by weather- and climate- related extreme events, EU-27 (1980-2023), % and billion EUR.
Source: built by the authors, based on the data from EEA, 2024.

In the period 1980–2023, climate-related extreme events were responsible for about 27 % of total economic losses caused by natural hazards in the EU-27-member countries, amounting to over 199 billion EUR. At the same time, the share of insured climate-related losses is slightly exceeding 15%. In case of fatalities caused by the climate-related extreme events, the share is above 95% (see **Figure 2**).

Hence, climate change is already responsible for an increasing amount of material losses to the economy, the financial markets and society as a whole, most of which are uninsured, even in a prosperous continent such as Europe. In fact, according to the data provided by CATDAT and EEA, coverage for climate-related losses in the EU-27 is insufficient, where the best results having been achieved by Norway (NR), where insured losses accounted for over 70% of the total (flooding). In case of commercial and residential properties, it goes beyond 75% (EIOPA, 2024). The most critical situation with regard to covering climate-related risks and losses was identified in Bulgaria and Croatia (2%), where damages from climate-related events remained almost uncovered (EEA, 2024).

A lack of climate-related data and difficulties related to the evaluation of non-financial risks are the main obstacles blocking the way to extending insurance services and providing access to them. As a result, costs of insurance coverage are increasing, and it contributes to the so-called "climate insurance protection gap" (see **Figure 2**). The difference among the regions is quite significant – with 28,1% in the U.S. and 82% in the regions Europe, Middle East and Africa. Various initiatives are seeking to resolve this issue by formulating recommendations on how to improve data collection, processing and reporting related risks.

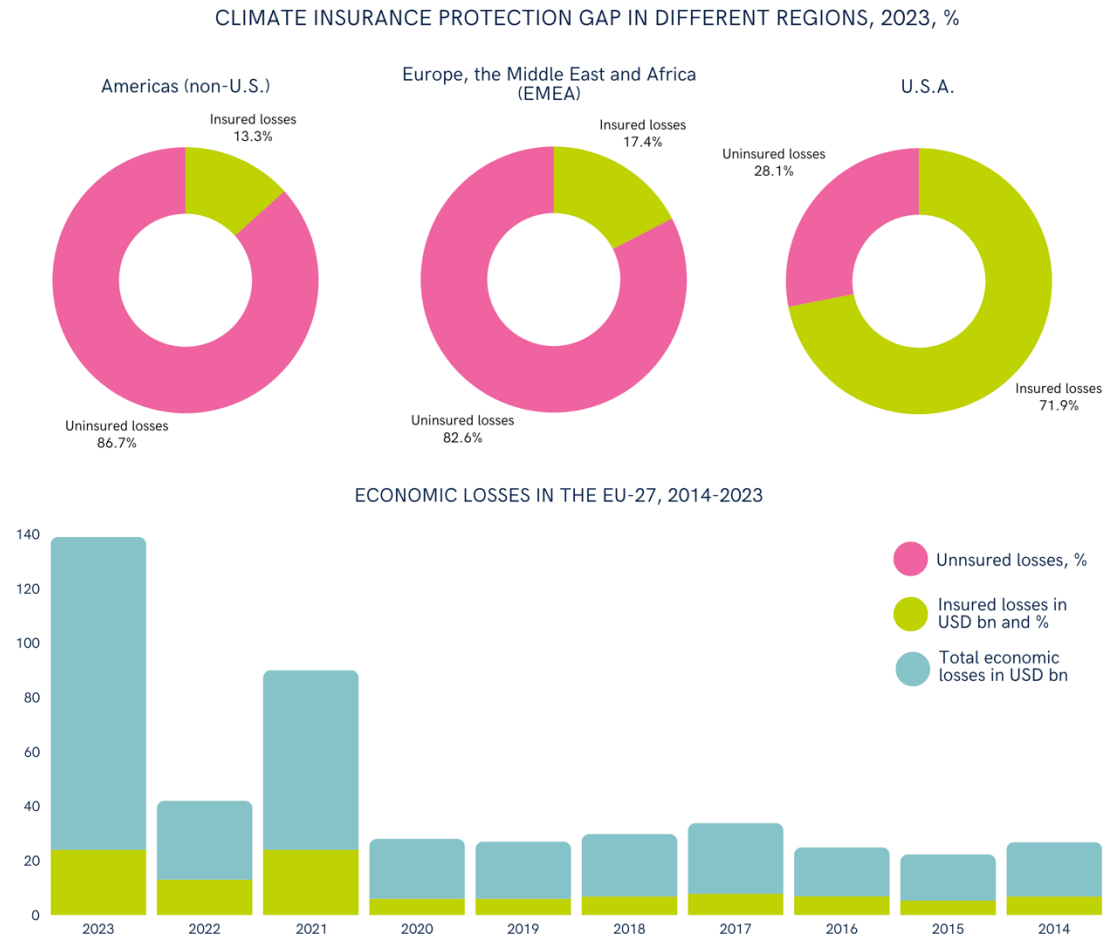
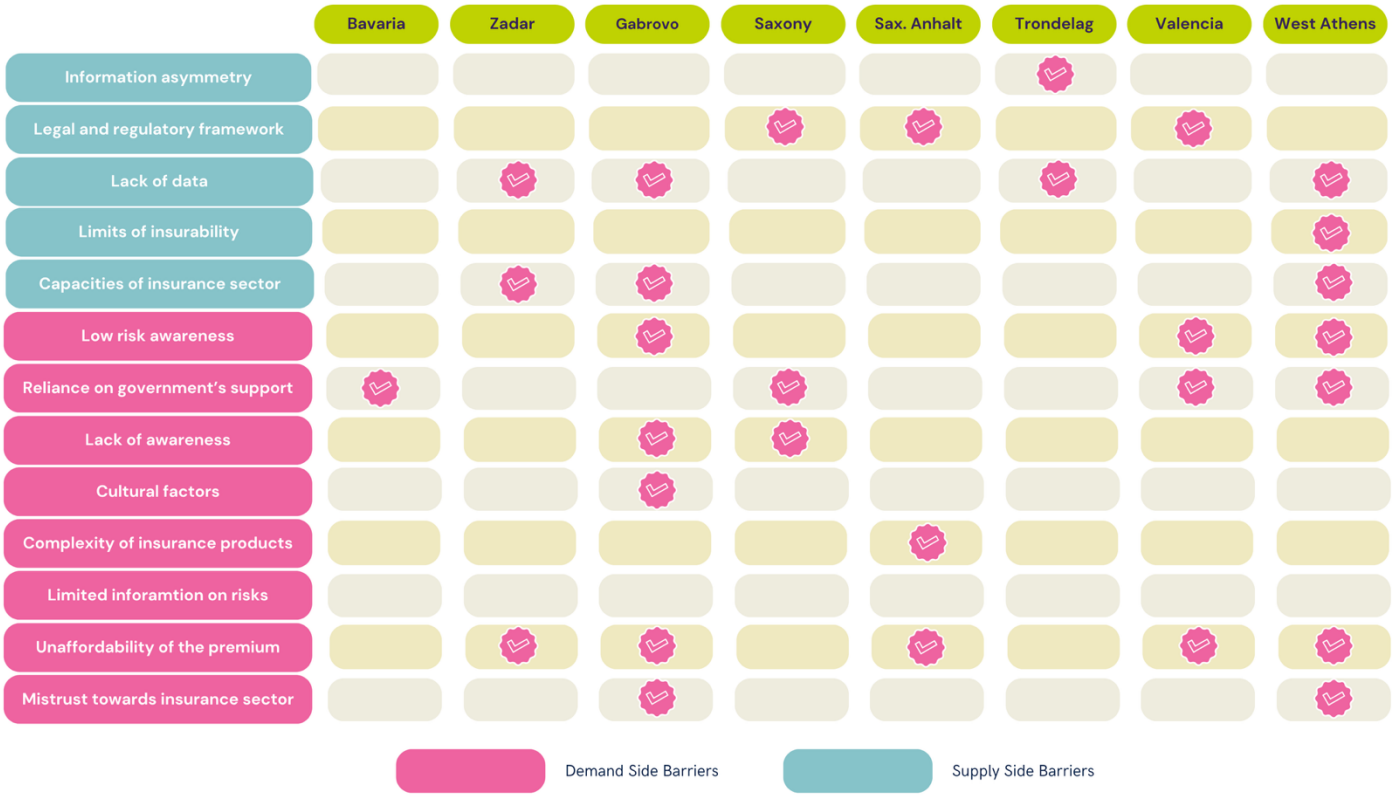


Figure 2. Climate insurance protection gap in different regions, % and billions of USD.
Source: built by the authors, based on the data from Swiss Re 2024 and Aon 2024.

Bridging the Gap: Barriers to Climate Insurance Coverage in SOTERIA

Based on the final report published by Climate resilience Dialogue (CRD), SOTERIA project conducted a survey among own Case Studies to identify the most pressing challenges (EC, 2024) (see **Table 1**). As a result, the challenges facing Inclusive Insurance Systems (IIS) stem from both supply and demand sides, each presenting distinct but interrelated barriers that hinder the development and uptake of climate and disaster-related insurance solutions.

Table 1. Supply and Demand Side barriers in the case studies under SOTERIA.



Source: built by the authors

Supply-side challenges include a lack of localized, accurate data, making it difficult for insurers to price products fairly – especially in climate-prone regions. This gap leads to poor risk assessment and low client trust. For example, the SOTERIA project in Bavarian Case Study showed that reliance on German Weather Service (DWD) data increased basis risk in multi-peril insurance schemes, highlighting the need for innovative IT solutions like remote sensing and satellite imagery (SOTERIA, 2024a). Outdated legal and regulatory frameworks often fail to accommodate innovative products such as parametric insurance. Additionally, rising climate-related claims are reducing insurer capacity, limiting their ability to offer or expand coverage.

Demand-side barriers include unaffordable premiums, particularly for low-income or high-risk groups. Government disaster aid reduces incentives to buy insurance, creating moral hazard. Low awareness of climate risks and insurance products further depresses demand, and cultural preferences for informal coping mechanisms also hinder uptake.

These preliminary findings have been confirmed as a result of a survey which was conducted among the farmers in Germany conducted by Helmholtz Center for Environmental Research. The goal was to capture diverse perspectives and assess regional representativeness and methodological effectiveness. In total, 1,275 German farmers were contacted for an online survey conducted from May 17 to May 27, 2025. To increase participation, respondents were entered into a randomized prize draw offering items such as pruning shears, a multifunctional Swiss Army knife, and insect bite relievers. Question coding followed a standardized approach developed in

collaboration with the Helmholtz Centre for Environmental Research (UFZ) (see **Figure 3**).

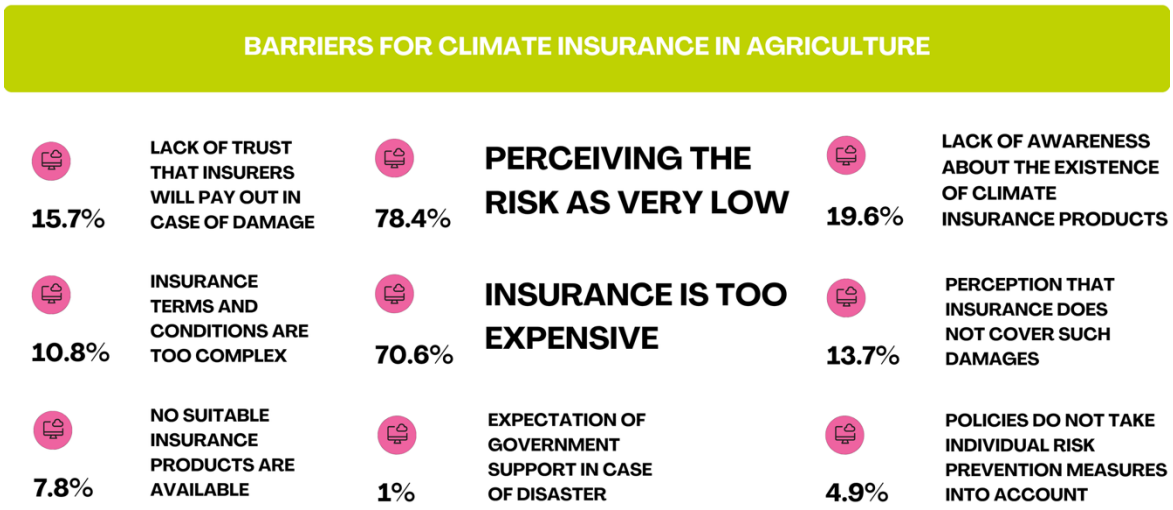


Figure 3. Climate insurance protection gap in different regions, % and billions of USD.
Source: built by the authors, based on the survey conducted by UFZ and AgriExperts.

A total of 102 valid responses were received, representing an overall response rate of approximately 8%. Respondents came from 13 federal states, providing reasonable geographic coverage. Despite limitations regarding sample size and regional representation, the survey dataset provides valuable initial insights into German farming communities. The provided data highlights key barriers preventing farmers from adopting climate insurance. The primary obstacle, identified by 78.4% of respondents, is the perception that climate-related risks are very low. Another significant barrier (70.6%) is the high perceived cost of insurance premiums. Additionally, 19.6% of farmers are unaware of the existence of suitable insurance products, while 15.7% lack trust in insurers' willingness to pay out claims. Further issues include overly complex insurance conditions (10.8%), absence of suitable products (7.8%), perceived insufficient coverage (13,7%), the belief that individual preventive measures are not rewarded by insurers (4,9%), and reliance on governmental assistance in disasters (1%).

Closing the climate insurance gap requires addressing both supply- and demand-side barriers simultaneously. Insurers must improve access to accurate, localized data and adopt innovative technologies to reduce basis risk and enhance the reliability of climate insurance products (e.g., parametric insurance products). In some cases (e.g., German legal framework) regulatory conditions need updating to better accommodate new solutions (e.g., privacy law, data protection). Additionally, the financial resilience of the insurance sector must be strengthened to sustainably manage rising climate-related claims.

On the demand side, affordability and risk awareness are critical challenges. High premiums, complexity of products, lack of awareness, and limited trust discourage adoption (see **Figure 4**). Moreover, reliance on government assistance in disasters reduces motivation for proactive

insurance purchases.

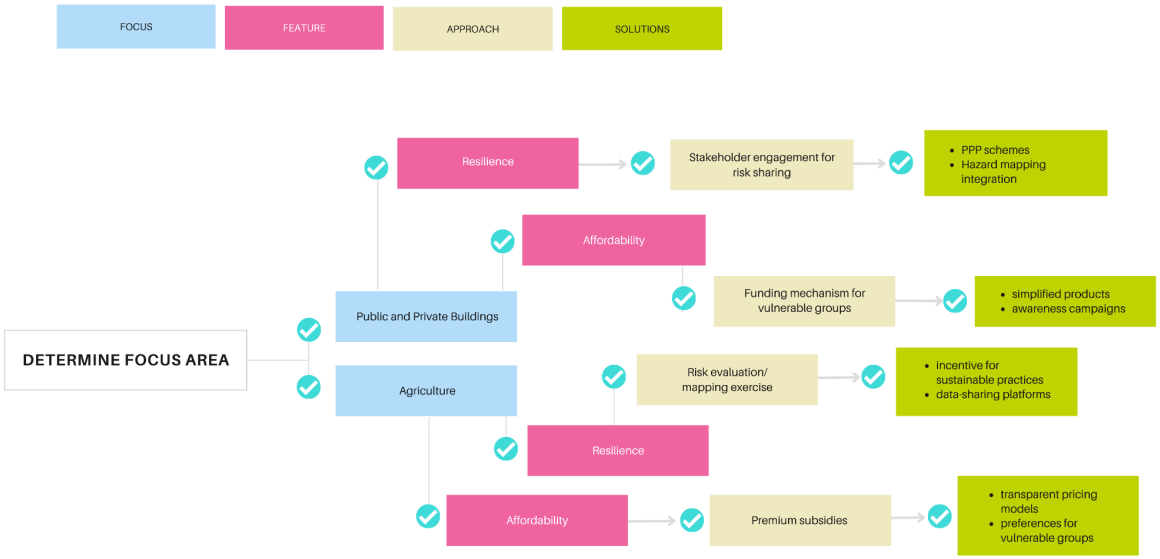


Figure 4. Decision-making tree for supporting selection of insurance solutions under SOTERIA project.
Source: built by the authors.

The decision-making tree developed under the SOTERIA project is a practical tool designed to support the selection and evaluation of climate insurance case studies. It guides users – such as policymakers, insurers, farmers and local authorities – through a structured process to identify the most suitable insurance solutions for specific contexts.

Ultimately, the decision-making tree supports informed, context-sensitive decision-making. It helps identify scalable, inclusive, and innovative insurance approaches that are best suited to support climate adaptation and risk reduction under the SOTERIA project.

Selecting best-suited climate insurance solutions and risk transfer mechanisms

Based on identified barriers and expectation of the case studies under SOTERIA project, approximately 80 innovative climate insurance solutions have been investigated. Filtering of identifying insurance solutions has been done by applying functions of climate insurance (Schwarze et al., 2025). To support selection of best practices and suitable solutions, alongside

with the functions of climate insurance criteria for innovative climate insurance solutions proposed by the European Central Bank (ECB) in cooperation with EIOPA have been applied as well (ECB, 2023):

- Promoting prompt insurance claim pay-outs following a natural disaster.
- Incentivizing risk mitigation and adaptation measures.
- Being complementary to existing insurance coverage mechanisms.
- Sharing costs and responsibilities across relevant stakeholders to reduce moral hazard.
- Reducing the share of economic losses from major natural disasters borne by the public sector over the long term.

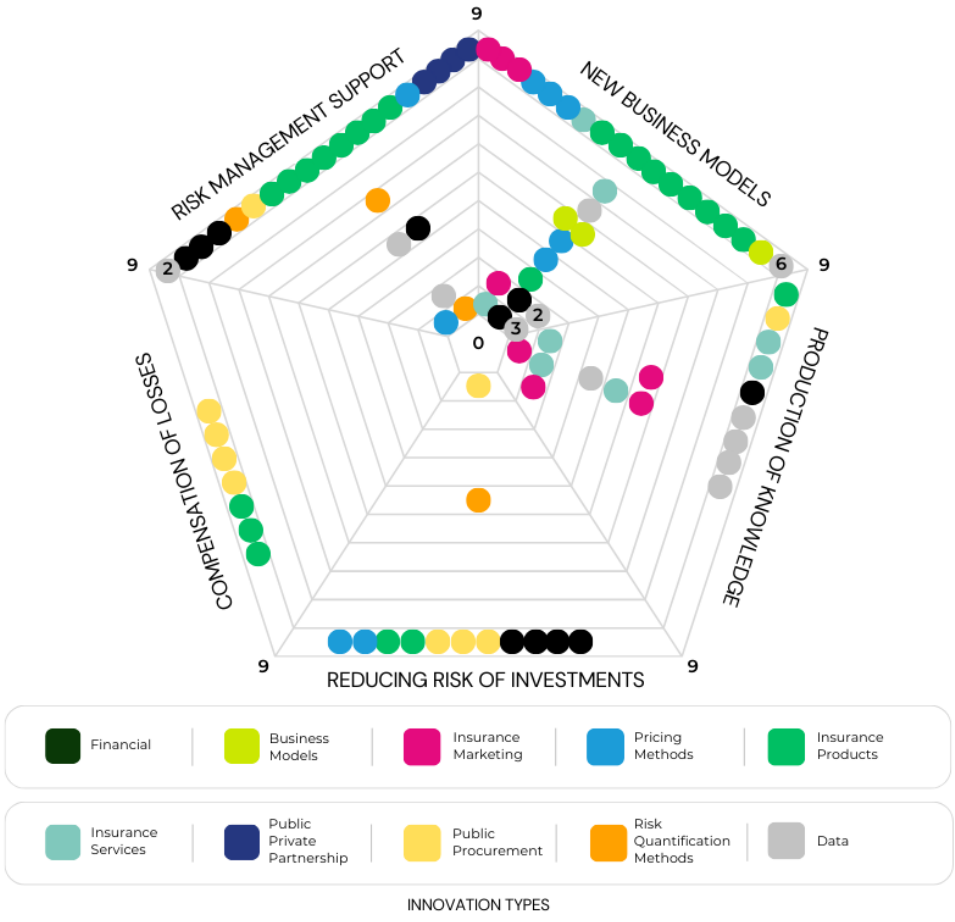


Figure 5. RADAR of available innovative solutions for climate insurance.
Source: built by the authors.

From the available set of solutions, several general trends have been summarized (see **Figure 5**):

- Two key climate insurance functions – compensation of losses and reduction of investment risks – are addressed by only a small number of innovative solutions.
- All types of innovative solutions cover at least one climate insurance function.

- Financial innovations, risk quantification methods, and public procurement practices make only a limited contribution to climate insurance functions.

To address the growing challenges of climate change and social vulnerability, insurance must evolve beyond traditional models. Future-oriented insurance should integrate climate resilience, social equity, and eco-innovation, aligning with EU requirements like the EU Taxonomy that promote sustainability in product design and investment strategies.

A key priority is to ensure rapid and fair payouts after extreme weather events. Innovative solutions such as parametric insurance – triggered by measurable indicators like wind speed or rainfall – can offer near-instant compensation, reduce uncertainty and accelerate recovery. At the same time, inclusiveness is vital: insurance must be accessible to vulnerable and underserved groups to ensure fairness during crises.

Insurance should also support long-term climate goals by covering adaptation measures like flood defenses and fire-resistant construction. This reduces future losses while actively contributing to resilience and sustainability. Furthermore, insurance can promote ecosystem health by incentivizing practices like regenerative agriculture and reforestation. Claims processes should align with circular economy principles – favoring repair over replacement and encouraging sustainable materials. Integration with broader data systems and planning strategies can amplify insurance's impact.

In summary, the following features of best insurance solutions have been identified: *rapid and fair payouts; inclusivity and accessibility; promoted improved resilience; alignment with sustainability criteria; facilitate access to private and public sustainable finance* (see **Annex 1**).

Understanding Innovations in the Context of Sustainable Insurance

According to the OECD Oslo Manual (2018), innovation is defined as "a new or improved product or process (or a combination thereof) that differs significantly from previous versions and has been made available to potential users or implemented within an organization."

This definition emphasizes that innovation is not solely about invention but about its practical application and adoption. It encompasses improvements to existing products or processes, not just entirely new developments. True innovation must generate impact – it must be implemented, tested, or actively used – rather than remaining a theoretical concept. This is particularly relevant in the field of sustainable finance, where applied innovation can deliver tangible environmental and economic benefits.

According to definition provided by UNEP, eco-innovation is a business strategy that integrates sustainability across the entire life cycle of a product, enhances collaboration along the value chain, and delivers value for business, the environment, and society. It goes beyond traditional innovation by focusing explicitly on environmental performance and aligning with the UN

Sustainable Development Goals (SDGs) (UNEP, 2020). Their objective is to decouple economic growth from environmental degradation. These innovations not only support business sustainability but also contribute to broader ecological and societal objectives, making them essential tools in the transition to green economies.

According to UNEP, the key drivers of eco-innovation encompass entry into new markets, improved profitability across the value chain, enhanced productivity and technical capacity, regulatory compliance, and investment attraction. These drivers illustrate that eco-innovation functions both as a response to external pressures and as a proactive strategy for growth. Regulatory demands and investor expectations are encouraging companies to adopt more sustainable practices, while advances in technology and access to emerging markets create strong incentives. As a result, eco-innovation can reduce costs, open new revenue streams, and enhance brand reputation – positioning it as a strategic advantage rather than merely a compliance requirement.

Relevant definition of sustainable insurance was provided by UNEP FI, as a strategic approach where all activities in the insurance value chain, including interactions with stakeholders, are done in a responsible and forward-looking way by identifying, assessing, managing and monitoring risks and opportunities associated with environmental, social and governance issues (UNEP FI, 2025). Innovation plays a crucial role in transforming the financial sector toward sustainability. It drives climate action, promotes resource efficiency, and fosters inclusive economic growth. This document presents an overview of the key definitions, requirements, drivers, and outcomes of innovation and eco-innovation, accompanied by contextual analysis.

Based on existing definitions of innovative the following types of Innovative Insurance Solutions (IIS) have been identified (under SOTERIA project): *new products and pricing* (encourages risk prevention, mitigation and adaptation measures); *new business models* (facilitates affordability, transparency and risk reduction); *new technologies, data and models* (supports cost reduction and collection of loss data); *shared resilience* (engagement of private and public stakeholders for risk sharing, awareness raising, capacity development and establishment of enabling conditions, etc.).

New products and pricing: parametric climate insurance (case of Germany, flooding certificate)

New products and pricing refer to the development of insurance solutions that encourage policyholders to take proactive steps in risk prevention, mitigation, and climate adaptation. By linking premium levels or coverage terms to the implementation of such measures, these products create financial incentives for reducing vulnerability. This approach supports long-term resilience and helps align insurance mechanisms with broader sustainability goals.

For instance, in Germany, the increasing frequency and severity of flooding, heavy rainfall, and related water damage have exposed significant gaps in insurance coverage and financial resilience, especially for properties located in high-risk areas. The German Insurance Association (GDV) developed the ZÜRS Geo system to classify flood risks and guide insurers in assessing

exposure (GDV, 2023). This system divides properties into four zones. ZÜRS Zone 1 includes areas with no identifiable flood risk, typically far from bodies of water. Zone 2 covers regions where a statistically significant flood might occur less than once every 100 years. These zones generally face few barriers in obtaining property insurance and financing.

By contrast, ZÜRS Zone 3 includes areas with a probability of flooding roughly once every 10 to 100 years. Zone 4, the highest risk category, refers to properties likely to experience flooding at least once every 10 years. These zones represent about 1,1 % (Zone 3) and 0,4% (Zone 4) of all buildings in Germany (GDV, 2023). In these areas, traditional insurance becomes expensive, limited, or entirely unavailable. Premiums increase significantly, and some insurers require high deductibles or decline coverage altogether – particularly in Zone 4.

SparkasseVersicherung recognizes Flood Risk Pass issued by the Hochwasser Kompetenz Centrum (HKC) in Cologne (HKC, 2018). This recognition enables personalized insurance premiums and improves the quality of claims payouts. It also allows insurance coverage to be extended to areas with high flood risk, based on individual risk assessments of homeowners (SV, 2022). The most important features of this solution are:

- The SV SparkassenVersicherung takes a differentiated approach, especially for high-risk zones (GK 4). Unlike many insurers that apply blanket exclusions or premiums in such areas, SV offers individualized risk-based pricing, using tools such as:
- The Hochwasserpass (Flood Risk Pass): a standardized certificate developed by industry experts to assess flood risks at the property level – similar in structure to an energy certificate (EUR 500 or EUR 800) (SV, 2023).
- An extended flood risk questionnaire, which can be completed with insurance brokers to assess property-specific vulnerabilities.
- A comprehensive risk analysis, conducted by SV's in-house engineering team (typically for insurance sums over 10 million EUR but available on request for smaller clients).
- On-site audits and recurring assessments to update and adapt flood risk prevention strategies.

What sets SV apart is that it not only accepts the Flood Risk Pass as a valid risk document – but can also issue it directly via its internal risk service team. This pass not only highlights current risks but also recommends mitigation actions. Once measures are implemented, the property can be re-evaluated, potentially lowering risk classification and premiums.

SV and Sparkasse are parts of the Sparkassen Finanzgruppe, where Sparkassen (saving banks in Germany) work in close partnership with SparkassenVersicherung by offering tailored insurance solutions – such as flood and property coverage – directly to their clients. In addition, Sparkassen facilitate access to subsidized financing in cooperation with public development banks such as KfW (Kreditanstalt für Wiederaufbau). Through Sparkasse branches, clients can apply for KfW programs 358 and 359, which provide low-interest loans of up to EUR 120 000 per residential unit to finance structural measures for flood protection and climate resilience. (KfW, 2024). These include backwater valves, sealing of walls and foundations, or flood barriers. The loans are especially favorable for

households with annual incomes under ERU 90,000, who may qualify for the lowest effective interest rates, ranging from 0,01% to around 3,58 4%, depending on the loan variant (KfW, 2024).

This combined insurance-credit approach represents a new business model for Sparkasse Group that directly links prevention, protection, and financing. Properties that were once deemed too risky can now become eligible for both insurance and affordable loans if owners invest in verified protection. The flood certificate serves as the connecting instrument, turning risk exposure into actionable information that unlocks financial solutions.

In contrast, under Saxonian Case Study a Saxonian Flood Preparedness Certificate (Saxonian Flood Certificate) introduced by Kompetenzzentrum Hochwasservorsorge (BDZ e.V.) is a public initiative supported by the Free State of Saxony and subsidized through Saxonian Development Bank (Sächsische Aufbaubank, SAB). This program was introduced after the catastrophic floods of 2002 and 2013 (SOTERIA, 2025a). It focuses on raising awareness, improving preparedness, and reducing the impact of future flood events. The program follows a two-phase process: first, a professional risk assessment is conducted at the building; second, mitigation measures are recommended and implemented. The state provides subsidies for both phases, covering 80 percent of the cost of assessment and 50 percent of the cost of implementing recommended measures (limited to EUR 20 000). Unlike the Flood Risk Certificate developed by HKC, this certificate is not directly tied to insurance policies, though it could improve a property's insurability (see **Table 2**).

Table 2. Comparison of the SV's and Saxonian examples as best practice solutions.

Source: built by the authors

The Flood Risk Certificate is a market-driven tool integrated into insurance products, whereas the Saxon certificate is a publicly subsidized program. The Flood Risk Certificate is available across Germany, while the Saxon model is region-specific. The SparkassenVersicherung solution is being offered also to the clients of Sparkasse across Germany. In contrast, the Saxonian approach operates independently from the insurance and banking sectors (direct reliance on SAB-Program). Furthermore, while SV customers may be encouraged to improve building safety, the Saxonian program directly supports homeowners with significant subsidies for obtaining this certificate (although the prices are comparable for both certificates). Moreover, connection to KfW-Program in case of SV's solution provides access to favorable credit conditions for up to EUR 120 000 (EUR 20 000 in case of Saxony).

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By aligning underwriting with mitigation, and credit access with resilience-building, SV model enables a shift from exclusion to conditional inclusion. It offers a replicable strategy for financial institutions and insurers facing similar challenges. With the dual pressures of climate change and rising urban density, such integrated models are essential for maintaining both the insurability and habitability of vulnerable areas.

Further improvements could be achieved through implementation of approach from Norway, where collected data are shared with the municipality or institution holding legal responsibility for preventive measures. This ensures that state grants and contributions can be effectively directed toward supporting vulnerable populations and enabling them to rebuild in a more resilient and sustainable way.

New business models: flood certificate for extending climate insurance coverage (parametric multi-peril insurance schemes)

New business models aim to improve the affordability and transparency of insurance while promoting risk reduction. These models may involve innovative partnerships, shared-risk arrangements, or community-based approaches that lower costs and increase access. By redesigning how insurance is delivered and financed, they help ensure that protection is both inclusive and aligned with proactive risk management.

A concrete example of a large-scale application of new products is parametric insurance in Bavaria (Federal State in Germany), which is aimed at helping to identify potential alignment with the pre-defined criteria for "best solutions". In 2022 Bavaria became one of the first regions in the EU to implement a Private Public Partnership (PPP) climate insurance model, where farmers are eligible for receiving cover against a predefined set of climate- and other related risks such as drought ("multiperil insurance"). The Common Agricultural Policy (CAP) is the main source for funding (second pillar) and Bavarian State Ministry of Food, Agriculture, Forestry and Tourism (BSMFAFT) is the administrator of such a scheme – responsible for passing on subsidies to the policyholders. To make the scheme operational, insurance companies are signing a framework agreement with BSMFAFT to give their clients an option to apply for subsidy. By the beginning of 2024, the following insurance companies had already signed such framework agreements with the ministry: Allianz Agrar AG, Gartenbauversicherung VVaG, Vereinigte Hagelversicherung VVaG and Versicherungskammer Bayern VAdöR (STMELF 2024).

An elaborated subsidization mechanism is aimed at making parametric insurance products affordable. Such a scheme relies on parametric insurance solutions divided into several packages. There are three types of products offered to the farmers (BayMBI 2022):

- in arable farming (excluding vegetables), the risks include hail, storm, heavy rain, severe frost, drought, and damage caused by wild geese and rooks (no option to choose);
- in grassland, the risks include hail, drought, and damage caused by larvae of the May and June beetles (no option to choose);
- in fruit and wine cultivation, nurseries, and hop farming, the risks include hail, severe frost, storm, and/or heavy rain (with an option to choose, but at least two of the mentioned risks must be covered).

The aim of the funding is therefore to strengthen the independent risk management of Bavarian farmers in order to counteract the increasing destabilization of agricultural incomes and increased risks of income loss, particularly due to the increasing frequency and severity of extreme weather events and other dangers that occur more frequently as a result of climate change. As per 2023, over 18 million EUR have been spent to provide subsidies for 5 000 farmers with over 150 000 Hectares. According to existing plans, till 2027 around 130 million EUR will be spent to support Bavarian multiperil scheme (Gabot, 2023).

At the same time, available information on the Bavarian insurance scheme gives a clear indication of different aspects contributing to basis risk. Firstly, the above-mentioned scheme is mandatory with some exceptions, with only farmers with less than 0.3 hectares are excluded from the coverage. So, there is a clear linkage to the spatial aspect of basis risk and the application of innovative IT-solutions (like Distributed Ledger Technologies (DLT) could facilitate inclusion of very small farmers (less than 0.3 hectares) and make sure that all participants will be sharing the data for the purpose of ensuring its quality and finetuning the scheme. Collection of the physical parameters could be facilitated though application of remote sensing (RS) or internet of Things (IoT with sensors) (see **Table 3**).

Additionally, the multiperil character of the scheme contributes significantly to the overall level of risk embedded into the underlying products (design, temporal aspects of basis risk). For this

purpose, collected quality data through application of a DLT platform could be processed by Machine Learning (ML) or Artificial Intelligence (AI), including Automated Protocol Initiation (API). At the same time, ML of AI could optimize the DLT platform by identifying shortages and weaknesses to prevent potential breaches or leakages.

Table 3. Main bottlenecks of Bavarian insurance model and potential for application of IT-solutions

Characteristics	Basis Risk	DLT + IT Solutions
Mandatory scheme	spatial, design	IoT/RS
Multiperil	design, temporal	API/ML/AI
Subsidised (up to 50%)	design	API/ML/AI
Farmers with over 0,3 Ha	spatial	IoT/RS
3 Packages	design	API/ML/AI
Self-coverage (up to 80%)	design	API/ML/AI

Source: built by the authors

Provision of the subsidy for participants of the Bavarian scheme is an important prerequisite to make sure that all farmers could participate at this initiative. In this case, DLT will not only facilitate provision of such subsidies to very small policyholders, but also ensure integrity of collected data (e.g., confirmation on implemented sustainable activities, Environmental, Social and Governance data, etc.). Moreover, DLT-based platform could also enable application of AI, API and ML to improve design of the product – support the self-contributing risk management and reduce the share of losses to be covered by farmers. This could also contribute to reducing the

level of subsidy for making the scheme affordable.

Lack of sustainability criteria in case of Bavarian multi-peril model was considered in case of Lower Saxony, where a publicly funded program was introduced to support agricultural multi-peril insurance, covering risks such as storm, heavy rain, flooding, frost, drought, and more. The program excludes hail but allows it as part of broader contracts. Farmers can apply annually (typically between March 15 and May 15) for participation in the scheme for the coming year. Applications must include an insurance offer from an approved insurer and, where required, evidence of climate-adapted farming practices to gain prioritization in case of limited budget (EUR 15 million). The total subsidy period spans between 2025 and 2029.

Approved contracts can be either indemnity-based or index-based and must include at least a 20% deductible and a maximum pay-out up to 80% of the insured sum. The program reimburses up to 50% of the eligible annual premium, capped at EUR 25 000 per farm per year (LWK, 2024).

The Bavarian model is a public-private partnership offering parametric multi-peril insurance with mandatory participation (except for very small farms). It covers various weather-related risks in crop-specific bundles and is heavily subsidized through EU-funds, with EUR 130 million allocated through 2027. It could be improved through application of digital innovation (e.g., DLT, AI, IoT) to reduce basis risk and improve efficiency but lacks embedded sustainability criteria.

In contrast, Lower Saxony's model is a voluntary, publicly funded scheme supporting both indemnity and index-based insurance. It prioritizes farms with climate-adapted practices and excludes hail from subsidized coverage. Subsidies cover up to 50% of premiums, capped at EUR 25,000 per farm annually, with a total budget of EUR 15 million per year (see **Table 4**).

Table 4. Comparison of Bavarian and Lower Saxony examples as best practice solutions.

Source: built by the authors

As a result, Bavarian scheme offers scale and with potential for digital integration but limited flexibility and sustainability alignment. Lower Saxony emphasizes adaptability and climate incentives but faces budget and scope limitations.

New tools and methods for loss data sharing: Knowledge and data sharing solutions to facilitate implementation of climate insurance solutions (loss data sharing)

As it was mentioned in the previous subchapter, *new technologies* such as remote sensing, IoT sensors, and satellite imagery, combined with advanced data models like AI and machine learning, play a crucial role in reducing insurance costs and improving the accuracy of loss data collection. These tools enable real-time monitoring of weather events and on-the-ground conditions, automate damage assessment, and support more precise risk modeling. By improving data quality and reducing administrative overhead, they enhance efficiency and transparency in climate risk insurance systems.

Knowledge sharing activities are beneficial from different perspectives and the key stakeholders are working on establishing various platforms or Hubs aimed at collecting and disseminating best practices. Such initiatives could be found on different levels: international, national, and regional.

During COP28 a dedicated initiative has been announced by UN Office for Disaster Risk Reduction, the Insurance Development Forum, and the University of Oxford – The Resilience Planet Data Hub (RPDH). The main goal is to support the process of measuring progress on the way of building up resilience to climate change. For this purpose, a standard set of metrics should be developed. Such a Hub given an opportunity to access GRI Risk Viewer developed by Global Resilience Index Initiative – globally unified set of impact indicators based on the insurance modelling

methodologies. Additionally, the platform offers a set of best-case studies for sovereign governments, financial institutions, investors and regulators (Resilient Planet Data, 2023).

On the regional level, knowledge sharing activities are being supported to solve specific problems relevant for a selected area. For instance, European Commission established Climate Resilience Dialogue (CRD) to find solutions on closing the climate insurance protection gap in the EU. This should be achieved through an active participation of different stakeholders from the climate insurance market at an exchange. Such an exchange should provide more ideas and solutions towards ensuring more active contribution of insurance sector to climate adaptation – increasing the penetration rate on the insurance market, improving conditions for more investment in good adaptation solutions (EC, 2022).

The entire work under CRD is split into two streams, where insurance underwriting and adaptation investment issues are being covered. Final report with recommendations on how to close the climate insurance protection gap should be published in the mid of 2024. An interim report from 2023 provided insights into the current situation around penetration rate in the EU, as well as highlighted the main driving forces contributing to a widening of existing gap.

The biggest advantage of RPDH is that it offers a data set provided by various technical partners. Such a data set is based on an open data approach and facilitates relevant resilience building actions, as well as facilitates mobilization of funds. The main goal is to support resilience-building efforts on international, local and system levels for People, Planet and Prosperity (Resilient, Planet Data, 2023).

Norway is an example, where corporate sector is successful in establishing an effective channel for communication with other stakeholders. For instance, the insurance sector is ready to share their loss and damage data (e.g., claims data) on the asset level with selected municipalities (Bærum, Grue, Kongsvinger, Løten, Nord-Odal, Ringsaker, Stavanger, Tromsø and Trondheim) (Climate Adapt, 2020).

In Norway, a pilot project started between Finance Norway, and ten municipalities tested the value of sharing insurance loss data for climate change adaptation (CCA) and disaster risk reduction (Breivik & Aall, 2014). Funded jointly by the insurance industry (via Finance Norway's Non-life Executive Board) and the government initiative *Cities of the Future* (Nordregio, 2016), the project demonstrated that local loss data significantly improve the knowledge base for prioritizing operations, maintenance, upgrades, and investments. It also strengthened collaboration within municipalities, particularly between water/wastewater and urban planning departments.

However, insurance companies were initially reluctant to share data on a permanent basis due to concerns about competition distortion. Further dialogue explored the conditions required for long-term data sharing (Hauge, 2018). Eventually, the industry agreed, provided data remained anonymized, protected from competitors, and contributed collectively without being traceable to individual customers.

This cooperation allowed the Norwegian Water Resources and Energy Directorate (NVE) to

calibrate flood models and improve national flood maps, thereby enhancing local awareness and guiding investments in preventive measures. It also inspired new initiatives combining local weather data with insurance loss data to improve early warning systems and identify priority areas for emergency response (OECD, 2016).

A key lesson was the importance of trust-building and institutional anchoring. Informal forums facilitated by Finance Norway evolved into the Natural Hazard Forum in 2016, which became the national platform for natural hazard knowledge, aligning with the Sendai Framework (NVE, 2016). The data is compiled and made accessible for selected municipalities in the public Norwegian data bank established in 2020 and also known as the "Knowledge Bank" (KB). The regulation enabling the public institution running the KB (Civil Protection Agency, DSB) to collect, compile and share this granular insurance data is also in place.

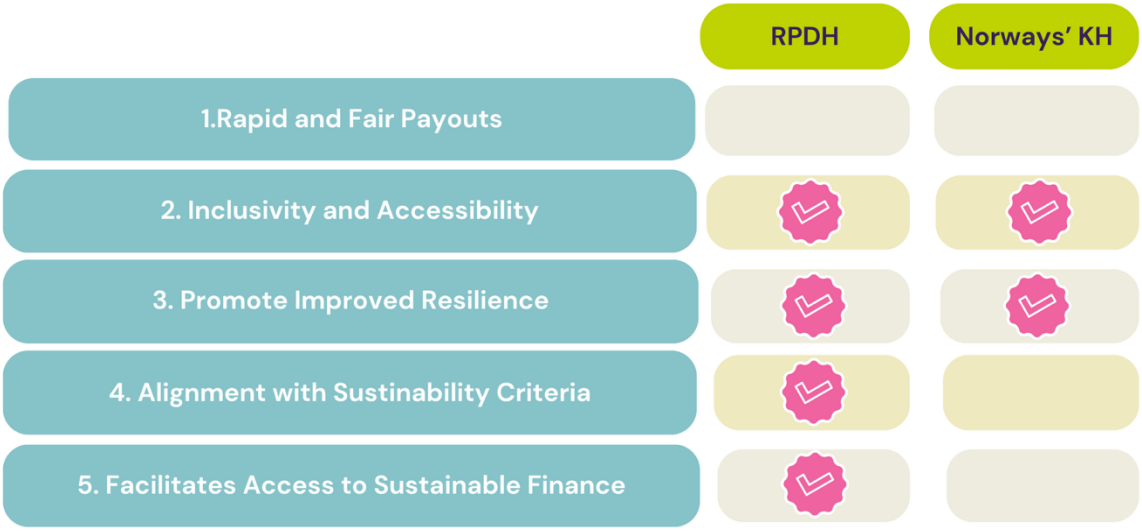
The insurance data are valuable for the municipalities in several areas:

- to do risk and vulnerability analyses;
- to understand the cost of natural disasters (to be used in the budget negotiations);
- to evaluate the effect of investments in preventive measures (e.g. upgrade of the sewage and water pipes in exposed areas and hot spots etc.).

As a result, the Resilience Planet Data Hub (RPDH) and Norway's Knowledge Bank (KB) both support resilience-building but differ in scale and structure. RPDH is a global platform launched at COP28, offering standardized resilience metrics, open-access risk data, and best practices for governments and financial institutions. It promotes inclusivity, supports sustainability alignment, and facilitates access to private and public finance through data-sharing and the GRI Risk Viewer.

Norway's KB is a national initiative providing asset-level insurance claims data from all insurance companies to selected municipalities. It enables localized risk analysis, disaster cost assessments, and evaluation of preventive investments. The system is highly targeted, aligns with regulatory frameworks, and promotes local adaptation, but its scope and accessibility are limited compared to RPDH (see **Table 5**).

Table 5. Comparison of RPDH and Norwegian examples as best practice solutions.



Source: built by the authors

RPDH scores higher on global accessibility, sustainability alignment, financing facilitation, and standardized metrics – while Norway's KB excels in operational integration and local impact.

Shared resilience: establishing a common results-based framework

Shared resilience refers to the collaborative engagement of public and private stakeholders to strengthen society's ability to manage and recover from climate-related risks. It involves joint efforts in risk sharing (such as insurance schemes), raising awareness, building local capacity, and creating the legal, financial, and institutional conditions needed for effective adaptation. By aligning incentives and responsibilities across sectors, shared resilience ensures more inclusive, coordinated, and sustainable approaches to disaster preparedness and long-term climate resilience.

Shared resilience requires coordinated efforts from all relevant stakeholders – such as communities, insurance providers, the financial sector, and the corporate sector – to strengthen

preparedness for disruptions in environmental, social, and governance (ESG) areas. To achieve this, stakeholders must be able to assess and communicate resilience using a common language and shared metrics. This calls for the development of a dedicated, results-based framework that supports a mutual understanding of planned actions and collective efforts.

Establishment of the Principles for Sustainable Investments (PSI) was a first attempt on the international level to coordinate the process of integrating Environmental, Social and Governance (ESG) issues into the insurance sector. In 2012 UNEP FI presented a framework, which should serve as a guidance for the insurance companies while mainstreaming ESG aspects into their businesses. Such a document supports insurance companies while identifying, assessing, managing, and monitoring risks and opportunities associated with ESG issues (UNEP FI, 2012).

Existing frameworks with a clear emphasize on resilience-building efforts are covering some concrete elements and have clear bottlenecks. For instance, comparing the UAE Framework for Global Climate Resilience (agreed during COP28) with the Sendai Framework and the ISO standard on ESG indicators for resilient communities, shows that the following elements of GCR are not fully covered by Sendai Framework and available ESG indicators:

- improvements of resilience against climate change and related health impacts;
- increase of resilience of infrastructure and human settlements to climate change impacts to minimize climate-related impacts on infrastructure and human settlements;
- protection of cultural heritage from the impact of climate change;
- conduction of impact, vulnerability, and risk assessment;
- elaboration and implementation of country-driven, gender-responsive, participatory, and fully transparent national adaptation plans.

At the same time, SFDRR contains a clear signal towards more active mobilization of funds to support implementation of resilience-related efforts. This element is missing both in GCR and in the draft version of ISO/DIS 37125. The two first points under GCR are covered by indicators envisaged in SFDRR and such indicators could enhance the ISO/DIS 37125 (ISO, 2024).

One of the best cases of adopting a comprehensive results-based framework is a green and sustainable public procurement in the city of Toronto (Canada), which integrates ESG principles into the procurement processes. In this case, supplier management includes rigorous sustainability assessments, high-risk audits, and strict sustainability criteria in sourcing. Sustainability reporting is enhanced with well-defined KPIs that cover environmental metrics like carbon budgeting, circular economy practices, and climate adaptation measures; social metrics such as fair labor standards, public climate awareness, and social inclusion; and governance metrics that ensure transparency to enforce green procurement mandates, and integrate ESG considerations into financial decisions (Sievo, 2025).

The experience of Toronto is based on a well-defined strategic action which outlines procurement priorities, fosters dynamic stakeholder engagement, and institutionalizes mechanisms for continuous knowledge transfer and innovation (see **Figure 6**).

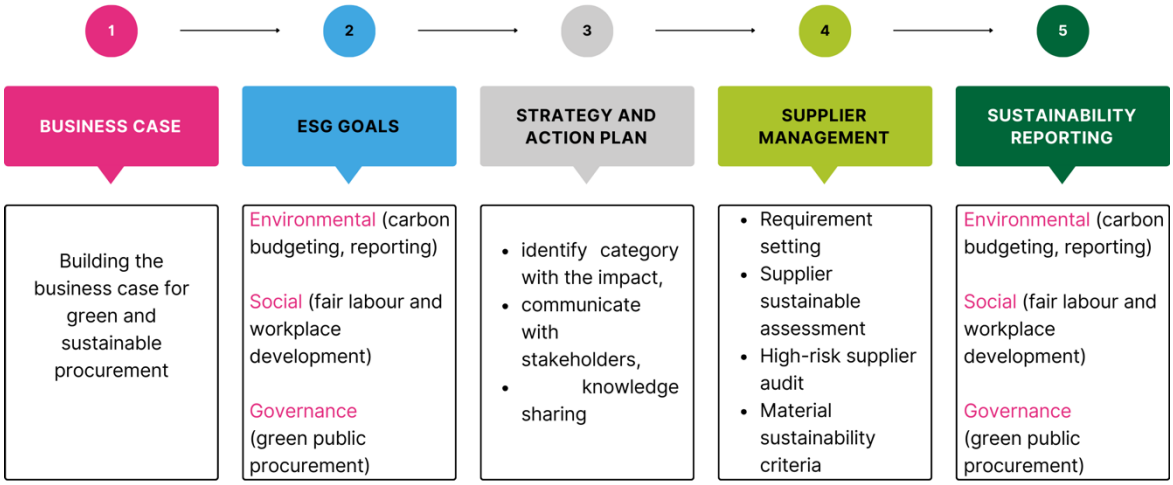


Figure 6. Step-by-step guidance on implementing green and sustainable public procurement.
Source: built by the authors.

The integrity of sustainability reporting mechanisms is reinforced through the establishment of precise and actionable key performance indicators (KPIs). These metrics are leveraging international best practices to facilitate empirical assessments of procurement performance, ensuring compliance with both national and international sustainability mandates (see ISO Standard 37125). Toronto's Environmentally Responsible Procurement Policy (Toronto, 2024) prioritizes sustainability in purchasing decisions, as well as the Local Food Policy that promotes locally sourced, low-carbon products. Toronto's Fair Wage Policy and Social Procurement Policy, promotes fair labor standards, equitable economic opportunities, and supplier diversity in procurement contracts.

As outlined in the City of Toronto Environmental, Social & Governance (ESG) Performance Report (Toronto, 2025), procurement policies emphasize sustainability, transparency, and social responsibility. Such reports enforce sustainability requirements for suppliers, prioritize supplier diversity to enhance economic inclusion, and mandate adherence to environmental and ethical sourcing policies. The procurement process is guided by clear ESG priorities, particularly in mitigating climate change, promoting social equity, and ensuring ethical business practices.

Another example demonstrates that In Norway, the 30% rule is incorporated into the municipalities' procurement strategy, often driven by purchasing partnerships. Best practice examples are Lillestrøm Municipality's green procurement strategy, and requirements for special expertise in climate and environment in purchasing processes. (Innlandetfylke, 2020). Nordre Follo Municipality has employed a dedicated climate and environment advisor in the procurement department. (Lillestrom, 2020). Furthermore, several municipalities have agreements with insurance companies for advice. There has, naturally, been a focus on emission reductions and social responsibility. Climate risk and climate adaptation must be more integrated into municipalities' and county authorities' procurement strategies. It could be linked to goals of

extended lifespan and social responsibility (Lillenstrom, 2019, Innlandetfylke, 2020).

Case study of Valencia under SOTERIA project explores a collaborative effort to build climate resilience in the Marjal dels Moros wetland area near Valencia (Spain) (SOTERIA 2025). The project aims to co-create and implement quantitative resilience indicators as part of a long-term strategy to foster shared resilience among key stakeholders – municipalities, financial institutions, regional authorities, and the private sector.

Using a participatory and evidence-based approach, local actors jointly developed a framework of 34 Key Performance Indicators (KPIs) aligned with the ISO 37125 ESG standards and European/regional climate policy frameworks (e.g. EU Green Taxonomy). These KPIs are categorized into four domains: environmental, social, economic, and governance. A major workshop held on June 5, 2025, with 52 participants, served to prioritize these indicators both individually and in thematic groups. Stakeholder feedback led to refinements in the definitions and measurement units of the KPIs. The indicators will be embedded in the Plan Director de la Marjal, the official wetland management plan, and monitored through the ROSSETA-UV Lab, which will serve as the platform for participatory governance in autumn 2025 (Restore4cs, 2025).

This case demonstrates how integrating financial innovation, nature-based solutions (NBS), and cross-sector collaboration can create a scalable, actionable model for resilience planning – one that supports adaptation strategies, investment risk management, corporate sustainability, and coordinated governance across levels.

Slightly different approach towards improved shared resilience has been selected in another case study under SOTERIA project – Zadar (Croatia). Climate change has increased the risk of extreme weather events in Croatia, yet many farmers remain reluctant to purchase climate risk insurance. This case study examines the behavioral and perceptual obstacles that hinder insurance uptake and explores targeted strategies designed to shift attitudes and increase adoption (SOTERIA, 2024b).

Farmers often underestimate the likelihood and potential impact of climate events, leading to what is known as probability neglect. Many also perceive insurance as costly, with unclear or delayed benefits, which creates a distorted view of its true value. The long wait times for payouts further diminishes its perceived usefulness. Social norms in rural communities can reinforce hesitation, as farmers tend to align their behavior with peers who traditionally avoid insurance. Additionally, a lack of clear, accessible information about insurance mechanisms – particularly parametric models – contributes to confusion and disengagement. Perhaps most critically, there is a persistent lack of trust in insurance companies, with farmers questioning both the reliability of products and the intentions of providers.

To address these challenges, the study applies a randomized experimental approach through digital surveys distributed in the Zadar region. Respondents are exposed to different types of messaging, each crafted to counter a specific barrier. The framing of insurance is modified to present it as either an investment or a form of risk sharing. Some versions offer shorter payout timelines, albeit at higher premiums, to test how timing influences perceived value. Stories and testimonials from other farmers are used to build relevance and relatability, while comparisons

with trends in other regions, such as Germany, are shared to reduce conformity bias. Finally, by introducing trusted local banks as intermediaries, the study seeks to improve credibility and address concerns around trust (BeSmart, 2025).

Table 6. Comparison of RPDH, Norwegian, Spanish and Croatian examples as best practice solutions.

	Toronto	Lillestrøm	Valencia	Zadar
1.Rapid and Fair Payouts				✓
2. Inclusivity and Accessibility	✓	✓	✓	✓
3. Promote Improved Resilience	✓	✓	✓	✓
4. Alignment with Sustinability Criteria	✓	✓	✓	✓
5. Facilitates Access to Sustainable Finance	✓		✓	✓

Source: built by the authors

All of the approaches mentioned above for fostering shared resilience demonstrate significant potential in addressing key challenges across various contexts – whether through green and sustainable procurement of insurance services or by creating enabling conditions for greater insurance penetration. Each approach contributes to establishing a common language for resilience (see **Table 6**). What sets the Zadar case apart, however, is the application of behavioral strategies that align particularly well with best practice standards. This is largely due to the availability of parametric insurance products tailored to farmers, which effectively connect climate resilience efforts with broader financial market opportunities and ensures quick and fair payouts.

Conclusions

Climate change is intensifying the frequency and severity of natural hazards, contributing to increasing economic losses across Europe – most of which remain uninsured. This widening climate insurance protection gap presents a major challenge to governments, insurers, and vulnerable communities alike. While traditional insurance solutions remain essential, they are no longer sufficient on their own. Bridging this gap requires innovative, scalable, and sustainable insurance mechanisms that actively support climate adaptation and resilience-building.

The SOTERIA project has demonstrated that a range of innovative approaches can help overcome both supply- and demand-side barriers to climate insurance uptake. On the supply side, improving access to accurate, localized data and integrating digital technologies – such as remote sensing, IoT, and distributed ledger technologies – can reduce basis risk, enhance pricing accuracy, and support the development of more inclusive products. Regulatory modernization and cross-sector cooperation are also essential for enabling new types of climate insurance products, including parametric and multi-peril schemes.

On the demand side, the report confirms that psychological, social, and financial barriers limit insurance uptake – especially among smallholder farmers. Case studies like Zadar (Croatia) show that applying behavioral insights and framing strategies – tailored messages, trusted messengers, relatable use cases – can shift perceptions and increase interest in insurance. Aligning insurance with local values, trusted institutions, and economic incentives is key.

Case studies from Germany, Spain, Croatia, and Norway illustrate the value of context-sensitive innovations. In Valencia, a shared resilience framework was developed through co-created KPIs embedded in the local wetland management plan, aligning environmental, social, economic, and governance dimensions. In Germany, a combination of parametric insurance, risk-based pricing, and flood certification connected insurance eligibility with resilience investments, while linking insurance access to subsidized public financing. Norway offers a compelling model for data-sharing partnerships between insurers and municipalities, which improve local risk awareness and planning capacity.

Across all examples, the principles of shared resilience – cross-sector collaboration, co-designed metrics, and joint risk ownership – prove essential. Innovative solutions are most effective when they establish a common language, align incentives, and are embedded in broader climate, finance, and governance systems. Successful models integrate rapid and fair payouts, inclusiveness, risk reduction incentives, and alignment with sustainability criteria, including the EU Taxonomy and ESG frameworks.

In summary, the report confirms that sustainable and innovative insurance solutions can:

- Narrow the protection gap by making climate insurance more affordable, accessible, and impactful.
- Support systemic resilience by promoting proactive risk reduction, ecosystem

preservation, and social equity.
- Bridge financial and institutional divides through shared frameworks, co-created tools, and inclusive practices.

To scale these efforts, further institutional support, regulatory flexibility, knowledge exchange, and investment in enabling infrastructure – particularly data systems – are required. Insurance is no longer just a tool; it is a strategic solution for climate adaptation, development, and long-term resilience.

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Annex 1. Framework for evaluating or designing best practice insurance solutions

Feature	Description	Purpose	Indicator
1. Rapid and Fair Payouts	Timely and equitable disbursement of insurance claims following a disaster	Enables faster recovery; builds trust and credibility	Average time to payout; % of claims resolved within 30 days
2. Inclusivity and Accessibility	Ensures broad access across regions, income levels, and vulnerable populations	Enhances equity and social protection	Coverage rate in rural/low-income areas
3. Promotes Improved Resilience	Incentivizes or supports risk reduction and climate adaptation actions	Reduces long-term exposure and loss	% of clients undertaking risk mitigation
4. Alignment with Sustainability Criteria	Adheres to ESG principles and supports environmental and social goals	Ensures alignment with sustainable development frameworks	ESG compliance status; use of green underwriting principles
5. Facilitates Access to Sustainable Finance	Links insurance with investment or credit channels from public and private sources	Mobilizes capital for resilience and adaptation initiatives	Volume of climate/resilience-related finance leveraged

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