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VALIDATED LOCAL RISK ACTIONABLE DATA FOR ADAPTATION



D1.5

Synthesis on the most commonly used indicators, their performance and inconsistencies, and tackling potential problems

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KEY CONCEPTS

Climate risk indicator (i.e. adaptation indicator)

A climate risk indicator is a figure depicting a state or development of a certain entity related to climate risk reduction, e.g., number of people living in flood-prone areas or land surface temperature (VALORADA definition).

A standardised categorisation splits indicators according to the stage in the change process that they refer to (i.e. whether they indicate the potential or realisation of adaptation). Furthermore, an adaptation indicator can also depict steps towards adaptation, like improvements in adaptive capacity (Leiter & Olhoff, 2019).

Adaptation indicators can be categorised in multiple different ways. For instance, Goonesekera et al. (2022) sort them by level of detail (objective, indicator, metric), type (input, output, outcome, impacts, target), dimension (social, economic, infrastructure, governance), unit of measurement, timeframe, and target.

In this deliverable we refer to climate risk indicators as synonyms with adaptation indicators. Following the listing from Mäkinen et al. (2018) adaptation indicators (i.e. climate risk indicators) can be further categorised by their content into exposure, adaptive capacity, sensitivity, and composite vulnerability indicators.

In VALORADA indicators provide context for the following four content sections

- ***Hazard:*** The potential occurrence of a natural or human-induced physical event or trend that may cause, for instance, loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (IPCC glossary).
- ***Exposure:*** The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC glossary).
- ***Sensitivity:*** The propensity or predisposition to be adversely affected. Sensitivity (or vulnerability, as interpreted in this deliverable) encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC glossary).
- ***Adaptive capacity:*** Potential or ability of a system, region, or community to adapt to the effects or impacts of climate change (IPCC glossary).

Index (pl. Indices)

An index is a series of aggregated or weighted variables (D1.3). In other words, indices combine variables into a single number (Leiter & Olhoff, 2019).

Adaptation metrics

Adaptation metrics cover both individual indicators and indices, that can be either quantitative or qualitative (Leiter & Olhoff, 2019).

Climate service

Climate services refer to “the transformation of climate-related data together with other relevant information — into customised products such as projections, forecasts, information, trends, economic analysis, assessments (including technology assessment), counselling on best practices, development and evaluation of solutions and any other service concerning climate that may be of use for the society at large. These services include data, information, and knowledge supporting adaptation, mitigation, and disaster risk management” (EC, 2015).

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1 Executive summary

1.1 Description of the deliverable content and objectives

The use of climate risk indicators in local adaptation remains insufficiently understood, despite growing interest in their potential. To contribute to this limited evidence base, the deliverable draws on a literature review, an online questionnaire, and expert interviews to identify commonly used indicators, examine factors influencing their performance, and explore enablers and barriers to their use in adaptation. In addition, recommendations to address challenges related to indicator application are provided.

1.2 Deviation from objectives, corrective action (if applicable)

Participant recruitment for the online questionnaire resulted in a lower response rate than expected. To ensure sufficient input and maintain the quality of the analysis, semi structured interviews were added. This adjustment proved valuable, as the interviews provided more detailed insights and enabled a deeper understanding of participants' perspectives.

1.3 Major outcome

The literature indicates that climate risk indicators hold potential for local adaptation, for example, by improving the identification of adaptation needs and supporting the monitoring and evaluation of adaptation progress and their effectiveness depends on factors such as context-specific design, integrating suitable, and long-term data sources, transparent communication of data and methods, and alignment with decision-making processes. Based on the interview and survey responses, a set of characteristics of well performing indicators emerges. Indicators that are purpose driven, meaningful to users, and appropriately scaled to local contexts, while incorporating dimensions of risk beyond hazards, provide clear added value in supporting planning, risk assessment, and decision-making. These characteristics are complemented by requirements for scientific robustness, transparency, continuity over time, and integration into policy processes.

The analysis further demonstrates that improving the use of climate risk indicators requires coordinated action across user, institutional, and governance levels. Key challenges include gaps in user capacity, limitations in data availability and quality, and fragmentation across systems and policy frameworks. Addressing these challenges calls for strengthened capacity building, improved data infrastructures, and greater alignment between scientific outputs and policy needs. More broadly, the findings highlight the need for clearer conceptual understanding of what constitutes a climate risk indicator and for greater attention to real-world use cases alongside methodological development. The VALORADA project contributes to this emerging field by identifying characteristics of effective indicators and by demonstrating a replicable co-development approach that supports context specific, user-oriented indicator design. Finally, the inherent trade-off between context specificity and comparability suggests a need for governance frameworks to more explicitly define where standardisation is required and where flexibility is necessary to support local adaptation practice.

2 Introduction

2.1 About VALORADA

VALORADA aims to help the EU transform 150 European regions into sustainable and climate-resilient areas by 2030. It develops customizable tools for accessing and manipulating climate and non-climate data, fostering community validation and data sharing. Using a transdisciplinary approach, it analyses climate risks with local actors across five European demonstrators, integrating data from repositories like Copernicus Climate Change Data Store and local catalogues. VALORADA targets Technology Readiness Levels (TRL) 7+, creating interoperable tools for harmonizing data and assessing climate risks. It plans to scale up with 10 European regions and collaborate with other Horizon projects, enhancing data portals and capacity-building for climate services.

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VALORADA's vision statement: VALORADA wants to empower European regions and cities to steer the upcoming societal transformation towards sustainable and climate-resilient development through their own actions.
VALORADA's mission statement: VALORADA will enable the integration of diverse datasets that enable merging local knowledge with climate and non-climate datasets by means of co-developed data manipulation tools and climate data.

2.2 Task 1.5

In this deliverable, we aim to contribute to the lack of general knowledge on the use and performance of climate risk indicators in local adaptation. Since it is not feasible to assess the performance of each indicator individually, we focus, instead, on identifying the shared enablers, barriers, and factors that influence indicator performance in local adaptation. We applied a three-fold data collection process to gather information on the use of climate risk indicators by local authorities across Europe: an online questionnaire targeted at actors involved in local adaptation work, a review on climate risk indicators in use for local adaptation based on recent literature, and interviews with those working across the climate risk indicators landscape. In the interviews, adaptation researchers, policy officers, producers, and practitioners were consulted. Through these inputs, we seek to capture recent developments in this field by collecting descriptive information on the production and performance of climate risk indicators. In addition, through the interviews, were received targeted recommendations on how to tackle potential problems across user, institutional, and governance levels.

In summary, Task 1.5 aims to do the following:

- Provide an overview of the recent literature related to the use and development of climate risk indicators for local climate adaptation.
- Assess the characteristics of a well-performing climate risk indicator in adaptation.
- Provide recommendations on how to tackle potential problems in indicator use across user, institutional, and governance levels.

2.3 How T1.5 fits the overall WP1

This task provides insight into how climate risk indicators are used and produced outside the VALORADA demonstrator regions. Based on this, the task can inform the refinement of current indicators and address identified limitations. In doing so, it complements the work conducted in D1.3 (Selected climate risk indicators with detailed computing metrics).

2.4 Report structure

The report is structured as follows: Section 3 presents the background on the use of climate risk indicators in local adaptation across Europe based on recent literature. Section 4 describes the methodological approach. Sections 5 and 6 present the survey and interview results, covering indicator use, perceived value and performance, and factors influencing their application. The findings are discussed in section 7. Section 8 concludes the report.

3 Background on the current use of climate risk indicators in local adaptation in Europe

This background review explores the use of climate risk indicators in local adaptation in Europe through a synthesis of recent research. The review focuses primarily on peer-reviewed journal articles published in English (in Web of science portal) between 2021 and April 2026. A keyword-based search was conducted using the terms climate risk, indicator, local, adaptation, and climate change, covering European countries. The review is deliberately scoped to literature from the past five years in order to capture examples of current developments and trends in the use of climate risk indicators, rather than to provide a fully comprehensive or historical overview of the field.

Overview

Climate risk indicators have gained attention in recent years across various levels, sectors, and landscapes due to the accelerating impacts of climate change. As this interest grows, it is important to understand how these

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indicators operate within real-world adaptation contexts. Due to the inherently local nature of the impacts of climate risks, adaptation actions are the most effective when targeted locally, making the role of local actors very important. They are closest to affected communities (Amundsen et al., 2018), possess contextual knowledge (EPRS, 2024), and oversee key functions such as land use and emergency management (Vogel & Henstra, 2015). Hence, emphasis on understanding the obstacles, enablers, and other factors affecting climate adaptation must focus on the processes, capabilities, and resources on a local level.

Yet, it remains unknown how these indicators are applied in adaptation on a local level, despite the importance of this information (Goonesekera & Olazabal, 2022). One of the most promising use cases of climate risk indicators is to measure adaptation progress. Currently, no quantified metrics exist to assess progress toward resilience, which increases the risk of maladaptive decisions and inefficient use of funding (ECA, 2024).

Impacts, and therefore the value, of the climate risk indicators is determined by how they are applied. Arnott et al. (2016) note that work in climate risk indicators in the academic domain often focuses on the idealised rather than pragmatic, meaning that the discussion revolves more around what is a good indicator instead of what is achievable for each specific context. This may reduce focus on their pragmatic application and contribute to a primarily theoretical understanding of benefits.

The assessment of the practical application of climate risk indicators in adaptation is hindered by the variety of use cases and users, with no established consensus on the used definitions. Several typologies for categorisation of climate risk indicators have been proposed. The categorisation can be based on the dimension of adaptation they aim to portray (social, economic, environmental, infrastructure, governance) (assessed e.g., by Salehi et al., 2019), their type (target, input, output, outcome, impact) (typology proposed by Hale et al., 2021), their scope (general, goal-specific), or level of detail (objective, indicator, metrics) (typology proposed by Goonesekera & Olazabal, 2022).

The terminology used in the literature on climate risk indicators is not applied consistently across academic and practitioner contexts. As highlighted by Oloff and Leiter (2019), the terms metric, indicator, and index often appear as synonyms, with metric sometimes used as an umbrella term encompassing both indicators and indices. As a result, studies relevant to climate risk indicators may not explicitly use this exact terminology, instead referring to similar concepts (e.g., metrics, variables, proxies, measures, climate services, monitoring and evaluation systems). To enhance clarity and consistency in this review, *key concepts* are provided at the beginning of this document.

Context dependency

The use of climate risk indicators by local authorities for local adaptation is shaped by the context-dependent nature of climate adaptation and its evaluation. Christensen et al. (2018) note that both the purpose of measuring adaptation and what is being measured are highly dependent on the context. Indicators often need to be tailored to particular regions, communities, sectors, or adaptation interventions (e.g. Michalak, 2026), making a single standardised set of metrics insufficient to capture the diverse realities and needs of adaptation practice across different contexts (Leiter & Olhoff, 2019).

At the same time, identifying suitable and context-specific indicators for climate change adaptation remains challenging. Leiter and Olhoff (2019) argue that the diversity of goals, contexts, and scales makes a universal approach to adaptation metrics unrealistic, while also limiting comparability across contexts. This imbalance is also highlighted by UNECE (2024), which points out the difficulty of developing indicators that are both internationally comparable and policy relevant. In the context of heat, Turner et al. (2025) identify the lack of internationally consistent and accessible heat vulnerability metrics which creates barriers to assessing inequities and benchmarking urban heat vulnerability between cities worldwide. Similarly, at the local level the spatial and temporal scale of indicators do not always match with local decision needs. To address this tension, recent approaches such as the one by Reyes-García et al. (2024) introduce a place-specific but cross-culturally comparable protocol to document climate change indicators and impacts as locally experienced and analyse their distribution.

Role and purposes

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The intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5) identifies three primary functions of adaptation metrics: 1) identifying adaptation needs (usually by assessing vulnerability or risk), 2) tracking the implementation of adaptation, and 3) assessing the effectiveness. Additionally, indicators can be utilised in improving awareness on climate change adaptation and communicate climate risks (e.g., Arnott et al., 2016; Riach et al., 2023; Leiter & Oloff, 2019).

The literature shows that indicators are increasingly embedded in policy and planning processes where they support the communication of climate risks, the identification of adaptation needs, gaps and priorities of adaptation efforts, and the monitoring of adaptation effectiveness and progress over time (e.g., Arnott et al., 2016; Riach et al., 2023). As mentioned above, despite the growing use of indicators, their application at the local level remains unknown (Goonesekera et al., 2022), reflecting the early stage of development of adaptation tracking frameworks and the still limited body of practical experience. Recent evidence suggests that indicator use in European cities most often focuses on impacts related to urban heat and changing precipitation patterns (Buzási et al., 2022).

Indicator-based frameworks support the development of regional adaptation strategies and local decision-making by providing risk assessments and scenario analyses (Mereu et al., 2024). Frameworks such as the Sustainable development goals (SDGs) have a significant impact on global policies. Although many SDG indicators are directly or indirectly linked to adaptation, resilience, and vulnerability, Falasca and Marucci (2024) note that some SDG targets lack appropriate indicators to be quantified, indicating a persistent gap between indicator provision and policy objectives. In their study, Falasca and Marucci introduce an approach for evaluating the SDGs and their implementation through regulation and maintenance of ecosystem services, which may also provide a basis for strengthening the integration of climate risk indicators within policy frameworks. Similarly, Mereu et al. (2024) integrated statistical socio-economic indicators with dynamic crop simulation models and climate change scenarios to investigate risk components, following the IPCC framework for the agricultural sector by 2050. The assessed level of risks has been used to develop the regional adaptation strategy to climate change for the Sardinia region in Italy.

Indicators are also widely used directly within scientific research, beyond their role as end-user decision-support tools. For example, Kinnunen et al. (2022) applied gridded indicators of anthropogenic factors, such as the Human Development Index, irrigation infrastructure, and fertilizer use, to examine how adaptive capacity influences crop yield variability under climatic stress. Using the machine learning algorithm XGBoost, the study assessed the explanatory power of these indicators across climatically similar regions globally. Similarly, Laino et al. (2024) use a multi-hazard risk assessment framework for coastal cities that applied a systematic and standardised indicator-based approach to evaluate climate-related hazards. The framework integrated remote sensing datasets, local studies, and historical climate events with local expertise gathered through a Coastal City Living Lab in Benidorm, Spain. In another example, Lueckerath et al. (2023) proposed a participatory, indicator-based approach combined with a semi-quantitative risk matrix methodology to assess climate risks impacts affecting interconnected infrastructure in Germany. Also, Lundin-Frisk et al. (2026) proposed indicators for mapping geosystem services in Malmö, Sweden, to support urban climate resilience planning.

Examples of application of indicators-based approaches across sectors, hazards and countries

Table 1 Examples illustrate the diversity of application of climate risk indicators used recently in Europe (not comprehensive listing, literature from 2021 to April 2026).

Sector or hazard	Reference and region
Cities and urban planning	Diaz-Lopez et al., 2026 (Barcelona, Amsterdam, and Copenhagen); Farkas et al., 2024 (Hungarian and Slovak cities); Laino et al., 2024 (Spain): Lueckerath et al., 2023 (Germany); Lundin-Frisk et al., 2026 (Sweden); Michalak, 2026 (Europe's secondary cities); Rod et al., 2025 (Norway); Szalinska et al., 2021 (Poland)

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Communities	Papadopoulos et al., 2026 (Greece, Spain, Turkey, and Portugal); Reyes-Garcia et al., 2024 (Indigenous people and local communities)
Agriculture	Mereu et al., 2024 (Italy); Sofia et al., 2024 (Italy); Kinnunen et al., 2022 (global); Paeth et al., 2023 (Germany)
Desertification, drought, water scarcity	Salvati, 2023 (Italy); Stamou et al., 2025 (Greece, France, Italy, and Spain); Ferreiro-Crespo et al., 2026 (Spain)
Storms and wildfires	Mihliardic et al., 2024 (Turkiye); Papathoma-Koehle et al., 2025 (Austria)
Health and heat	Olano Pozo et al., 2026 (Spain); Ellena et al., 2023 (Italy); Falchetta et al., 2026 (global); Alfano et al., 2023 (Italy); Rockloev et al., 2023 (Europe); Lipsanen et al., 2025 (Finland); Turner et al., 2025 (global)
Ecosystems	Falasca & Marucci, 2024 (Italy); Vignieri, 2023; Samborska-Goik et al., 2025 (Poland); Van Loon-Steensma & Goldsworthy, 2022 (Netherlands)
Tourism and cultural heritages	Goledzinowska & Ganczarek, 2025 (Poland); Hyytiäinen et al., 2022 (Finland); Olefs et al., 2021 (Austria); Freitas & Silva, 2025 (Portugal)
Coastal systems (erosion, flood, shoreline change, shipping	Usai et al., 2025 (Italy); Poo & Yang, 2024 (global); Dada et al., 2026 (Spain), Townend et al., 2021 (England)
Floods	Ajtai et al., 2023 (Romania)

Indicator development and use of data

Climate risk indicators are often used to assess climate risk by combining information on hazards, exposure, and vulnerability (Rod et al., 2025; Rockloev et al., 2023; Mereu et al., 2024; Ellena et al., 2023; Barilari et al., 2025). Typically, indicators are developed to represent each of these components, which are then integrated within a broader risk assessment framework. For example, Barilari et al. (2025) assess climate risk across sectors at the municipality level by integrating these three components. In their study, exposure and vulnerability indicators are based on regional, national, and European datasets, while hazards are characterised using downscaled Essential Climate Variables (ECVs).

In the context of agriculture, Leiter & Oloff (2019) introduce an overview of the main challenges related to the development of indicators including that 1) there are too many indicators, 2) there is no one-size fits all indicator for adaptation/resilience, 3) it remains a challenge to understand exactly how CSA indicators map to SDGs (Sustainable Development Goals) and NDCs (Nationally Determined Contributions), 4) many countries do not have specific targets for agriculture, making the selection of indicators difficult, and 5) it remains challenging to scale project-level indicators for national-level aggregation. As further challenges related to data in the context of indicators and national Adaptation Modelling and Evaluation (M&E) systems they mention 1) availability and accessibility of data, 2) sustainability of data collection, 3) lack of capacity to conduct quality assurance, 4) legal aspects of data sharing, and 5) inadequate baseline data.

The choice and quality of input data strongly influence indicator performance. For example, in the context of water scarcity in Spain, conventional indicators frequently rely on historical data, which can limit their accuracy under current hydrological conditions. Ferreiro-Crespo et al. (2026) address this limitation by developing an improved methodology that incorporates current reservoir data and refined estimates of water demand, thereby enhancing both spatial and temporal precision and resulting in an 8.3% increase in water scarcity characterisation factors compared with assessments based on historical baselines.

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Similarly, Szalinska et al. (2021) emphasise the importance of analysing long-term variability, including frequency and trend analysis, to better estimate hazard levels. Their work focuses on the development of a multi-hazard framework that establishes a set of metrics for monitoring hot and dry hazards, with the aim of supporting improved management and sustainable urban development over the long term.

Indicator selection

Indicator selection must respond to user needs. As indicated earlier, there is a strong need among public actors for indicators on climate impacts and risks. Yet, stakeholders require climate information for diverse purposes, including awareness, diagnosis, decision support, and evaluation, which translates into demand for different types and formats of indicators even inside a single city like Paris (Andre et al., 2025). Consequently, indicator selection must ensure that indicators are tailored to specific user needs and decision-making contexts.

Leiter & Oloff (2019) recommend that the selection of adaptation metrics should begin with a clear definition of purpose, what one intends to measure with it, the types of decisions the metric will be used, its meaningfulness to its audience, and the scale it will be communicated. They emphasise that metrics should be purpose-driven rather than selected generically, as has been the case in adaptation practice. The Okanagan Climate Indicators framework provides an example of indicator selection based on three main criteria: data availability, relevance to local issues, and compliance with predefined quality criteria, including representativeness, traceability, interpretability, diversity, general applicability, and timelessness.

Indicator selection is also affected by production-phase decisions and how these decisions have been communicated. As highlighted by Leiter and Olhoff (2019), even when the same indicator is used, results are not necessarily comparable unless underlying methodologies, calculations, and data sources are consistent and of similar quality. Thus, clear documentation of indicator design, including definitions, data sources, and calculation methods, is essential. Beyond this, methodological choices related to data transformation (e.g. normalisation, aggregation, weighting of indicators) can significantly influence results and interpretation (e.g. Ajtai et al., 2023; Leiter & Oloff, 2019) and introduce uncertainty. These uncertainties, if not transparently communicated, can reduce the usability of indicators for decision-making (Leiter & Olhoff, 2019). Also, clarity and transparency in terminology should be used to avoid misinterpretations. Finally, Leiter & Oloff (2019) highlight the need for critical reflections regarding what indicators can do and where alternative or complementary ways of assessment might be required. For instance, indicators do not explain why and how changes in indicator value occur, yet such insights are essential for understanding and learning, which in turn underpin evidence-based decision-making.

Co-design and stakeholder engagement

Co-design processes are becoming increasingly central to the development and application of climate information, including climate risk indicators. Interaction between scientists and decision-makers is widely recognised as essential for producing usable climate services (Andre et al., 2025). In the context of climate services, frameworks such as Tandem (orig. Daniels et al., 2019) illustrate how co-design strengthens trust, institutional embedding, and the uptake and use of climate information. These processes also enhance users' capacity and understanding, while fostering collaborative learning and action among stakeholders (Bharwani et al., 2024). Similarly, participatory approaches between science and practitioners, including surveys, interviews, and mapping exercises, contribute to identifying locally relevant indicators and improving understanding of vulnerability dynamics (Jurgilevich et al., 2021; Stephan et al., 2023).

Co-creation approaches further support the development of sustainability indicators across sectors. In tourism, for example, co-creation has produced recommendations for coordinated monitoring of ecological, economic, social, and cultural indicators (Hyytiäinen et al., 2022). Paeth et al. (2023) present a demand-driven approach to assessing regional climate change impacts on agriculture, viticulture, and fruit and vegetable production in Lower Franconia, southern Germany. This approach combines an ensemble of high-resolution regional climate model projections, a bias correction tool, and a comprehensive set of meteorological indicators identified as relevant to Central European agriculture through a stakeholder survey.

However, co-design processes are often time- and resource-intensive, requiring sustained engagement, coordination, and iterative interaction among diverse stakeholders (Neset et al., 2021). These processes also demand institutional capacity and long-term commitment to transdisciplinary collaboration (Jacob et al., 2025).

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Operating environment

The institutional and policy environment in which climate risk indicators are applied strongly shapes their development and use. This is particularly important since climate change adaptation challenges can be conceptualised as "super wicked problems" which according to Levin et al.'s (2012) are defined by four features: 1) time is running out, 2) those who cause the problem also seek to provide a solution, 3) the central authority needed to address them is weak or non-existent, and 4) irrational discounting occurs that pushes responses into the future.

The implementation of adaptation related policies and strategies have made it necessary for governments to understand the risk level and how well they are adapting increasing the demand for adaptation metrics. Goonesekera et al. (2022) show that 59 cities out of the largest 136 coastal cities worldwide have an adaptation plan and only 11 of them list indicators and metrics (of which three are located in Europe: Athens, Barcelona and Glasgow), highlighting the still limited integration of indicators into planning processes. In the European context, Buzasi et al. (2024) find that there are higher average local adaptation plan quality scores and more consistent strategies across cities in Central and Eastern Europe, while Western European and Nordic cities tend to have lower scores and less structured local climate adaptation plans, indicating the regional differences in adaptation planning.

Vignieri (2023) highlights that stakeholders' prior knowledge acts as an enabling condition for adaptation processes, supporting both the uptake of recommendations and broader cultural change within communities. Building on this, cultural change and evolving attitudes towards adaptation may be a key factor in shaping how climate change indicators are integrated into practice. Leiter & Oloff (2019) further note that formulating adaptation indicators is influenced by different framings, social norms, and power dynamics, which shape what the indicators should measure and who is allowed to define it.

At the same time, important capacity and governance challenges persist. Leiter and Oloff (2019) highlight that developing adaptation metrics is often complex due to fragmented responsibilities across sectors and governance levels, requiring coordination among multiple actors and alignment with existing monitoring and evaluation (M&E) systems. In practice, countries often face difficulties in defining the purpose of M&E systems, designing operational methodologies, and securing acceptance for its implementation. These challenges are compounded by limited human and financial resources and the need to align adaptation monitoring with broader policy frameworks, such as national and international development plans and agendas.

4 Methods

4.1 Data collection methods

Data on the use and performance of climate risk indicators in local adaptation were collected through (1) an online questionnaire to identify usage patterns and (2) interviews to provide deeper information on the performance and the factors influencing their use.

Online questionnaires

The questionnaire was disseminated during summer and late 2025 over a period of approximately five months to 26 projects, 5 newsletters, one NGO, and 3 networks related to climate services and adaptation. Additional invitations were sent directly to VALORADA partners' contacts in other European cities, as well as to large European cities. The questionnaire was also shared through a seminar, presented at five conferences, and distributed via the project newsletter and LinkedIn. The target audience was broad and consisted of actors involved in local adaptation planning and decision-making, including city officials, research institutions and other intermediaries. The questionnaire was translated into all EU languages using the EU Survey platform's machine translation function. **In total, 32 responses were collected.**

Respondents were first asked whether their organisation uses a defined set of climate risk indicators. If they answered yes, they were asked which themes the indicators address, via multi-selection question, and what concrete value the indicators provide, with an open-ended question. They were then presented with statements on indicator performance and asked to indicate their level of agreement on a four-point Likert scale, including an

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"I do not know / not applicable" option, followed by a question inviting them to explain what makes their most used indicators effective. Respondents were also asked whether they rely on any indicator reference frameworks and were given the option to upload relevant files. If respondents reported not using indicators, they were asked whether indicator development is under consideration and to elaborate on the reasons for either planning or not planning such work. If respondents were unsure whether indicators exist in their organisation, no follow-up questions were posed. At the end of the survey, participants were informed about the upcoming interview phase and could volunteer for follow-up interviews. The T1.5 questionnaire was also used to collect data for T1.4 but allowed participants to complete only the sections relevant to their expertise. The survey instrument is included in the Annex.

Interviews

In total, 10 interviews were conducted with researchers (4), indicator developers (3), policy domain experts (2), and one practitioner. The practitioner was recruited based on their stated willingness to participate from the online survey, while researchers, data providers, and policy officers were identified through purposive sampling using established networks within adaptation research and data communities. All interviews were conducted online in English or Finnish, recorded, and transcribed, with durations ranging from 20 to 60 minutes. A set of guiding questions structured the discussions, while allowing flexibility to follow each interviewee's expertise and perspectives.

Interview data were analysed using a framework analysis approach, which offers a systematic and transparent way to examine qualitative data and identify patterns within and across cases (Goldsmith et al., 2021; King & Brooks, 2018; Parkinson et al., 2016; Ritchie & Spencer, 1994). Coding followed a primarily deductive strategy based on literature (e.g. Celliers, 2021) and results from T1.2, complemented by inductive insights emerging from the data. The analysis followed five steps: familiarisation, framework development, coding, charting, and interpretation. The initial framework was tested on the full dataset, refined as needed, and then consistently applied. Each interview was analysed independently by two researchers, with an iterative process that included revisiting earlier data to ensure consistency.

4.2 Limitations

The following limitations should be considered when interpreting the results. First, the online survey provides indicative insights rather than generalisable conclusions due to the relatively small number of respondents. Recruiting respondents proved challenging. This may be partly explained by limited reach to the intended target groups, as many contacts were primarily from research contexts. In addition, the focus on climate indicators further narrowed the potential respondent pool, as not all practitioners working on adaptation currently engage with indicator-based approaches. These limitations were solved by undertaking interviews with relevant stakeholders and conducting an overview based on recent literature.

The analysis is also affected by the wide variation in how respondents define climate risk indicators. A deliberately broad definition was used to accommodate this diversity, but, as a consequence, the ability to draw conclusions about specific indicator types is reduced. The findings should be understood as reflecting broad patterns across diverse conceptualisations rather than a single, uniform definition.

Minor shifts in meaning may have occurred due to the use of AI-supported translation in the questionnaire. In addition, as climate indicator and adaptation practices evolve rapidly, developments occurring after the data collection period are not captured in this analysis.

The background review is deliberately scoped to literature from the past five years, enabling a focused and up-to-date background review while potentially underrepresenting earlier foundational studies or relevant insights. Additionally, the review relies on a single portal (Web of Science) and on English-language scientific literature which may lead to the exclusion of relevant research and practical knowledge, as local adaptation may be documented in national or local languages and disseminated through municipal websites, policy documents, and other forms of grey literature. As a result, important insights from practice-based and locally embedded knowledge sources may not be fully captured in the review.

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5 Survey results

5.1 Backgrounds of respondents

The majority of respondents live in Finland (14), with rest of the respondents living in Sweden (3), France (3), Portugal (2), Greece (2), Romania (1), the Netherlands (1), Luxembourg (1), Germany (1), Bulgaria (1) and Austria (1). Two respondents reported living in Turkey. The respondents' working experience with climate risk management varies widely. Over one-third report more than 10 years of experience (34%), while 3–5 years and 1–2 years of experience are each represented by 25% of respondents. Smaller groups report 6–10 years (6%), less than one year (6%), or no prior experience (3%).

As illustrated in Figure 1, most respondents work with themes related to governance and policy (34 %), public services and infrastructure (30 %) or environment and ecosystems (19%). Only 8 % reported working with business and economy, 4 % with human health and safety and 2 % in agriculture. Respondents who selected "Other" stated working with tourism, adaptation, urban planning, land use planning, GIS, climate, sustainability and environment. Respondents were allowed to select multiple options.

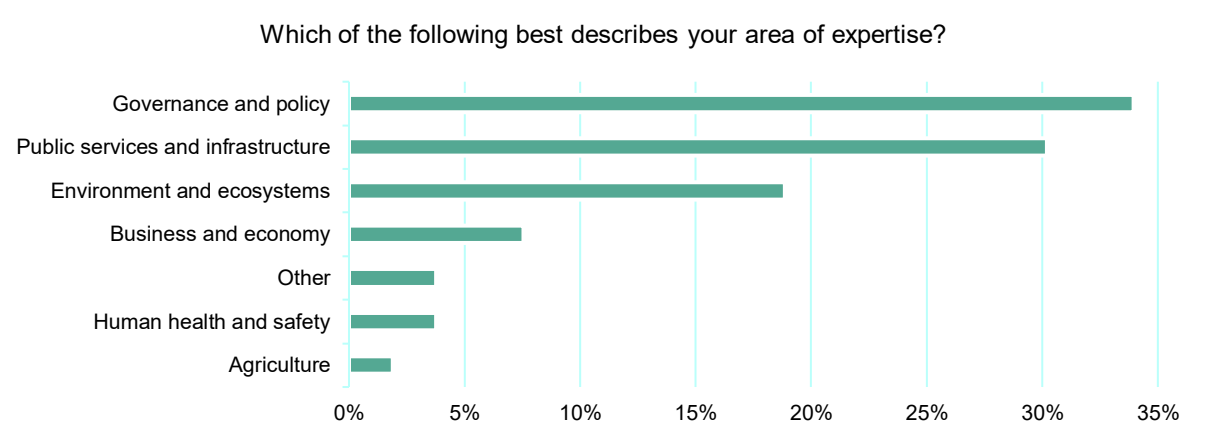


Figure 1 Reported area of expertise. Respondents were allowed to select multiple.

Most respondents reported working research and academia (41%) or within public sector, including governmental agencies (19%) and local and regional decision making (19%) (Figure 2). Out of rest of the respondents, 6 % reported civil society or NGOs and 6 % in private sector or industries. 9 % selected "Other" and specified work in municipality, city, and cross-border cooperation with regional development focus via authorities.

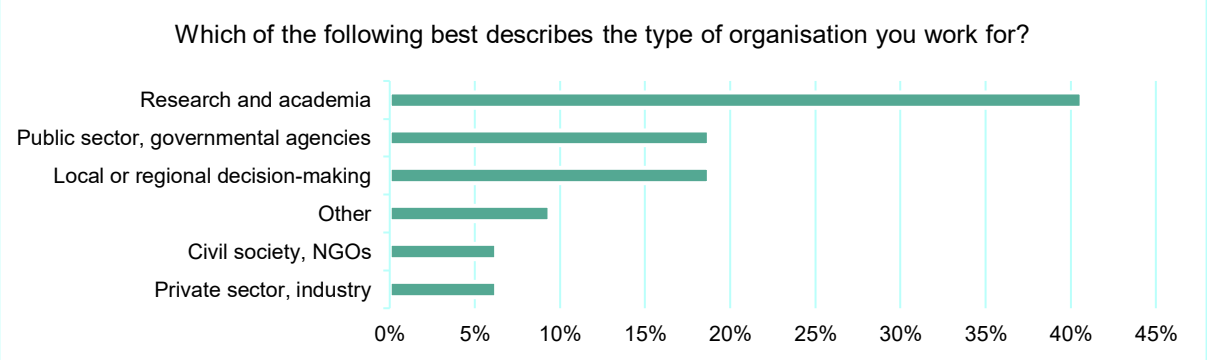


Figure 2 Reported type of organisation.

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Respondents reported a range of climate risks as most visible in their regions. Increased temperature was identified most frequently (21%), followed by changes in precipitation (19%) and short-term extreme precipitation flooding (17%) (Figure 3). Drought and extreme heat waves were each mentioned by 14% of respondents. Smaller shares pointed to coastal flooding and coastal erosion (6% each), while 3% selected 'other' risks and 1% indicated they did not know.

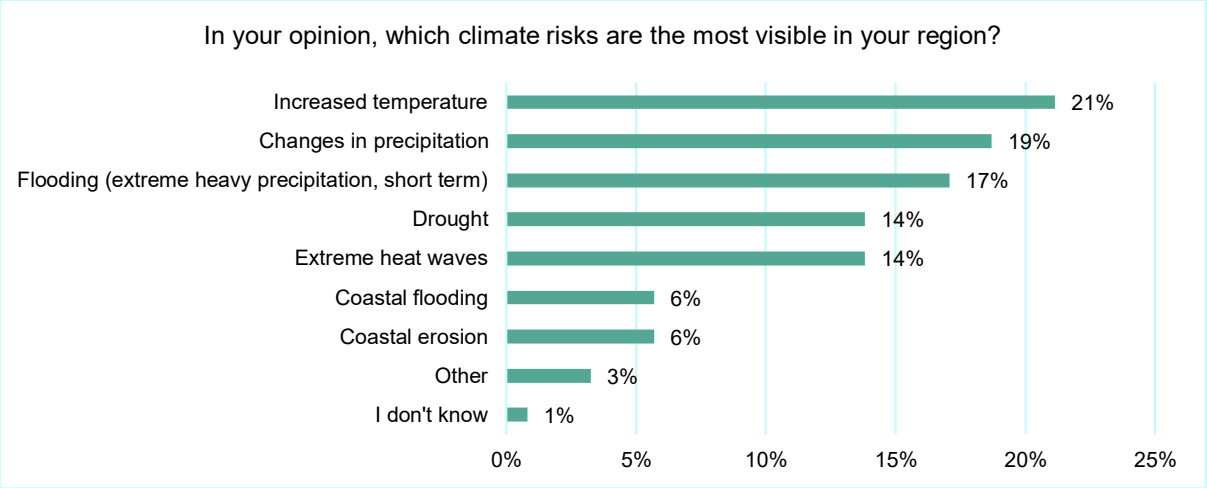


Figure 3 In your opinion, which climate risks are the most visible in your region? (Respondents were allowed to select multiple).

5.2 Use of climate risk indicators

Out of the total 32 respondents, 13 reported having a defined set in use, 13 reported not using indicators, and 6 were unsure. When asked to elaborate on the reasons, one respondent noted that the question was not relevant for their type of organisation, two reported a lack of knowledge on indicators, and one explained that a lack of synchronisation between actions had prevented their use. The themes of indicators in use reported by those having a set of indicators in use are illustrated in Figure 4. In addition, use of indicators related to tourism, transport, communication, social determinants, cross cutting issues, agriculture, water quality, air quality, food quality, and sea level were listed. Reported reference documents can be found in Figure 5. Additional reference materials included sectoral reports (e.g. WHO climate and health, Lancet Countdown), national documents (e.g. PNACC3, risk and flood management regulations), and jointly developed national and city-level principles.

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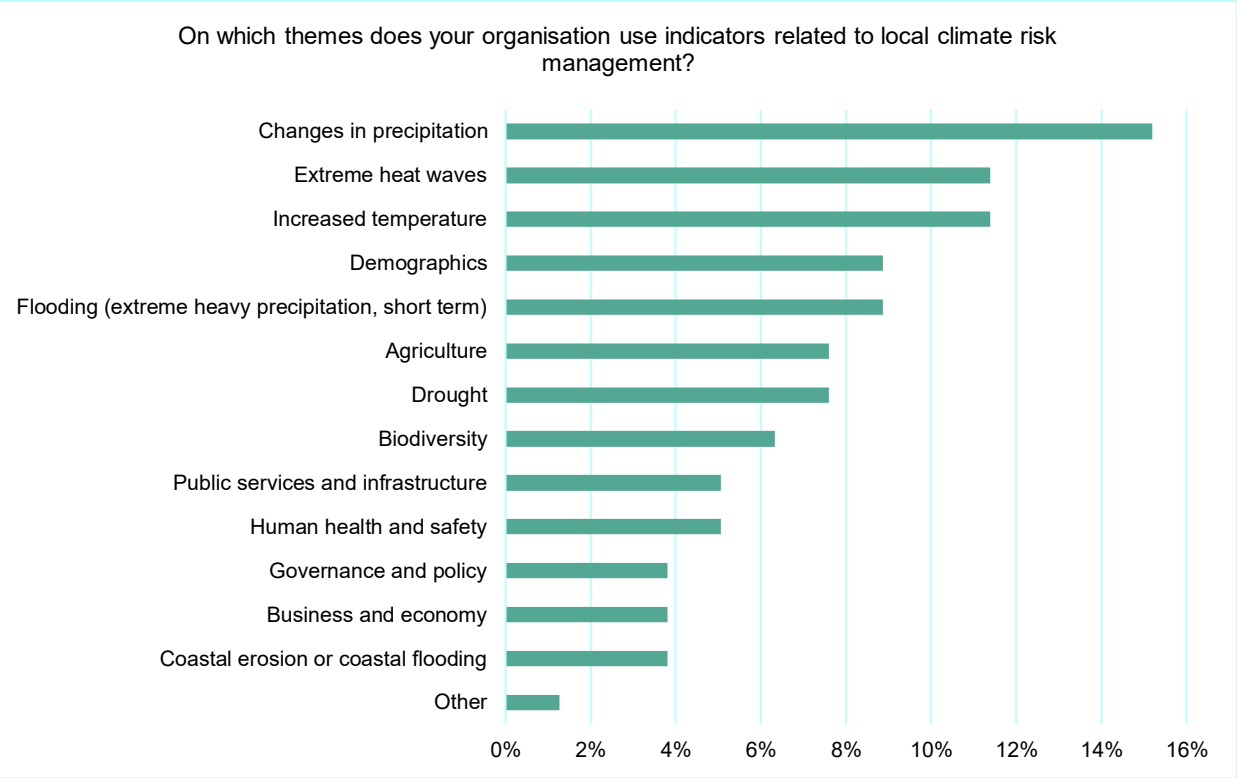


Figure 4 On which themes does your organisation use climate risk indicators related to local climate risk management? (Respondents were allowed to select multiple.)

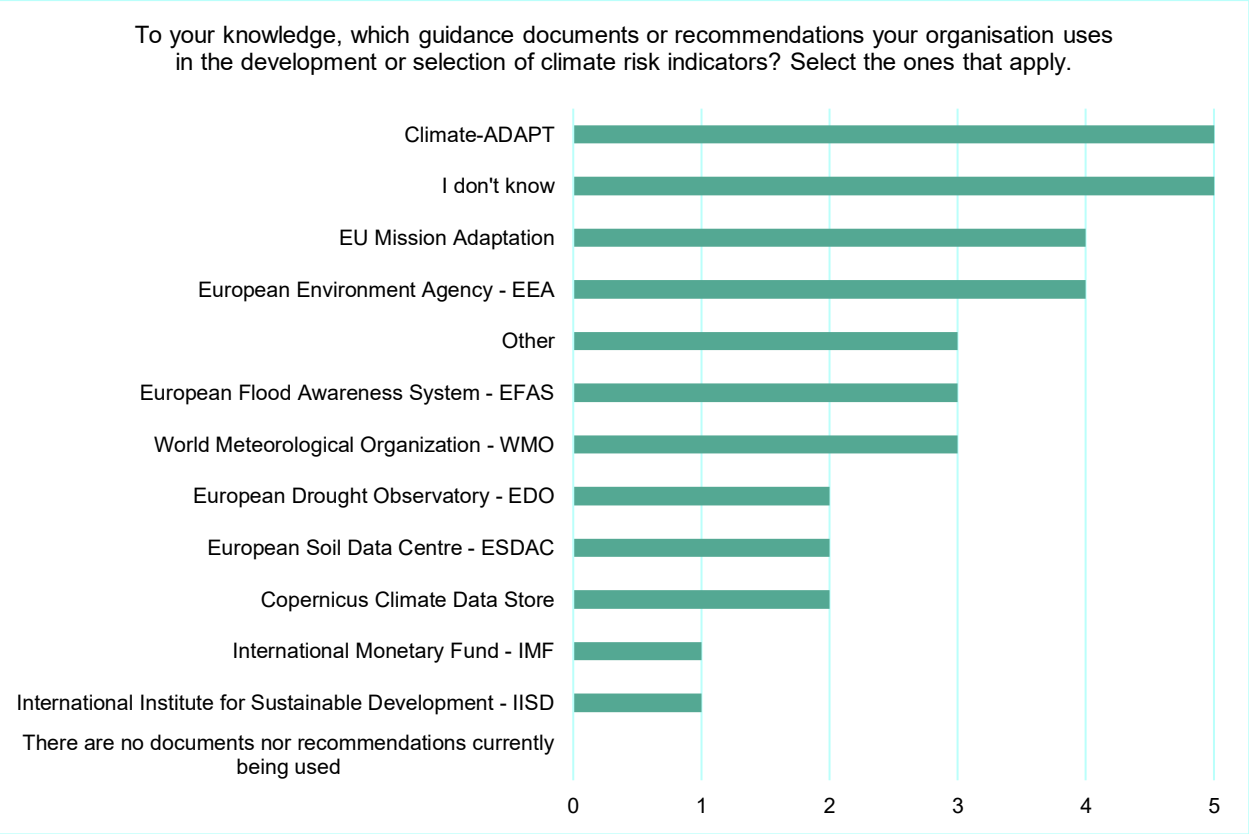


Figure 5 To your knowledge, which guidance documents or recommendations your organisation uses in the development or selection of climate risk indicators? Select the ones that apply. (Respondents were allowed to select multiple.)

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5.3 Perceptions of value, adequacy, and performance of climate risk indicators in use

When respondents were asked about concrete value the indicators create, it was reported that climate risk indicators support the preparation of land use regulations and they facilitate vulnerability assessments, risk analyses, and adaptation planning and targeting at local and city levels. Two respondents described ongoing work where indicator selection and use are still being defined as part of a broader adaptation strategy. Another one of these respondents reported that relevant impact metrics have already been identified, but that work is only beginning on developing a monitoring system. As part of this process, they are assessing different types of climate related risk to extract suitable indicators for continuous monitoring, decision making, and the review cycles of municipal plans.

According to the survey respondents, the most useful climate risk indicators are those that are relevant, reliable, and clearly linked to specific risks or actions. Practical usability is also essential: indicators should be based on accessible and reasonably up-to-date data, require limited effort to produce and maintain, and be easy to interpret. Respondents mentioned the importance of spatial and temporal accuracy, the ability to automate calculations, and the capacity to assess the effectiveness or costs of actions versus inaction. Additional inputs from survey respondents indicated challenges in developing and maintaining climate adaptation indicators, particularly due to limited resources and the need for indicators that can be updated with reasonable effort.

Figure 6 captures how respondents assessed a set of statements related to the climate risk indicators currently in use at the local level. Respondents agreed most strongly with statements related to the relevance and understandability of the indicators in use, with 11 out of 13 respondents selecting “agree” or “strongly agree” (the remaining two selected “I don’t know / not applicable”). The second highest level of agreement concerned the linking of indicators in use to local adaptation management goals or actions, with 10 out of 13 respondents agreeing or strongly agreeing and one respondent disagreeing. A majority of respondents also agreed that appropriate indicators are in place for policy goals and that these indicators are locally validated and relevant. Views were evenly split between agreement and disagreement for statements related to the existence of local high-quality data and the ability of the indicators in use to capture and represent different aspects of climate risk. The lowest level of agreement concerned the timeliness of the indicators in use: a narrow majority disagreed or strongly disagreed that the indicators are up to date.

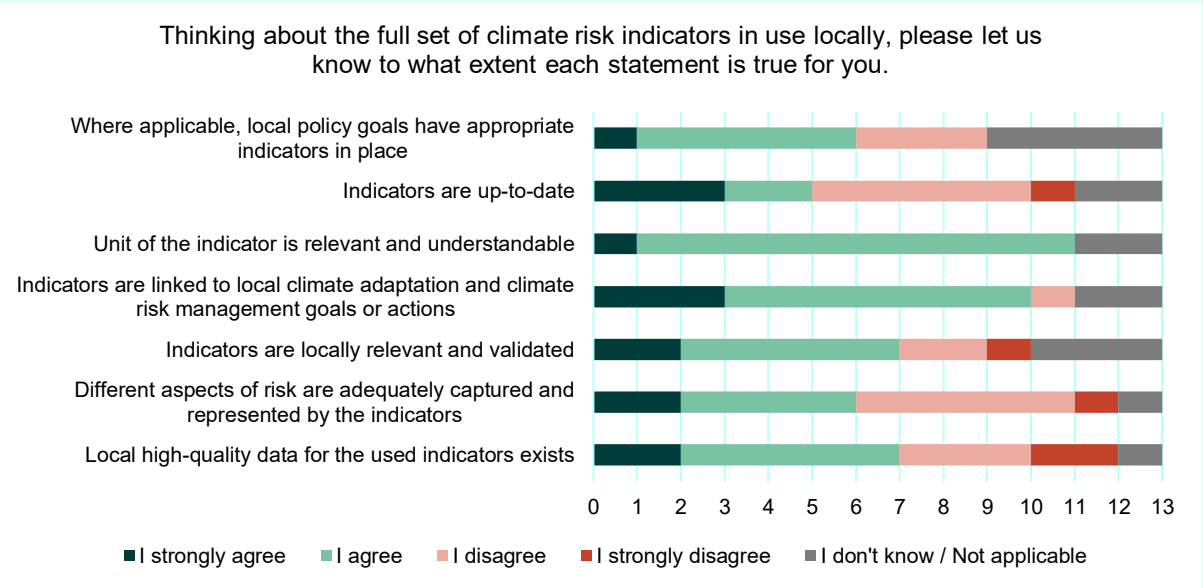


Figure 6 Thinking about the full set of climate risk indicators in use locally, please let us know to what extent each statement is true for you.

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6 Interview results

This section presents the interview results. It begins with an overview of the interviewees' backgrounds, followed by their experiences with climate risk indicators. The section then outlines their views on the characteristics of well-performing indicators and the factors influencing their use at the local level. Finally, it presents future outlooks and recommendations.

6.1 Background of the interviewees and connections to local adaptation

Three indicator developers, four researchers, two policy domain experts, and one representative from local administration were interviewed. Some of the interviewees could have fitted several categories (e.g., indicator developer could also be a researcher) but for the purposes of this analysis, each individual was assigned to the category that most closely reflects their primary role.

The indicator developers worked on producing climate risk indicators and regional climate model outputs, contributing to applications such as territorial monitoring, sectoral assessments, and climate related infrastructure planning. The researchers had backgrounds in climate science, climate modelling, and climate change adaptation, and were involved in developing climate services, processing climate data, and translating scientific results into actionable information for different user groups. The policy domain participants worked at European level on climate change adaptation, climate risk assessment, and preparedness, drawing on both scientific training and experience with policy processes. The local administration interviewee supported regional development and stakeholder coordination, particularly in rural areas in the field of tourism.

6.2 Selection, production and use of climate risk indicators

The examples on selection, production and use of climate risk indicators presented in this section are based on the interview material and do not aim to represent all possible use cases. They are included to support interpretation of the results presented in the following sections.

Users of climate risk indicators

As anticipated given the study scope, local and regional public authorities were most frequently referenced across groups. Indicator developers referred also to private companies and public utilities. Within local public authorities, researchers specified user roles such as technical staff, including engineers and infrastructure related functions. They also referred to regional public authorities and, among sectors, the health sector. Policy focused respondents mentioned regional, national and international authorities, and local administration respondents referred to local public authorities. Local administration respondent reported not having a defined set of indicators in use but they are interested in their uptake.

Reasons for the use of climate risk indicators

Respondents provided several examples of reasons for the use of indicators but few examples of concrete practice of the application of the indicators in these contexts. This is due to the fact that the respondents are not themselves users of the indicators in these cases. Identified use cases include communication by public administrations, decision making, private sector use related to accessing EU funding, knowledge building and improved spatial understanding of climate hazards, national reporting and international monitoring and comparison, and decision making more generally. These uses were referenced across responses from indicator developers, researchers, policy actors, and local administration staff, with communication uses most frequently mentioned by public administrations and local authorities.

Indicator selection and production process

Table 1 describes how indicator development processes were characterised by different respondent groups. Indicator developers described largely developer led processes, drawing on existing indicator lists, IPCC indices, downscaled climate data, and established methodologies, alongside practical challenges related to client demands and downstream use. Researchers described co-design approaches with users and experts, the development of indicators from impact chains and literature, and challenges related to data transformation and user expectations. Policy domain responses referred to supporting indicator selection, assessing data availability, defining use thresholds, and communication challenges, including uncertainty and spatial specificity. Local

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administration responses referred to a coordinating role for national level guidance, limitations in the usefulness of national scale data at local level, gaps in data access and expertise, and a preference for processes with greater stakeholder involvement.

Overall, indicator developers and researcher respondents saw themselves as directly involved in the production of the indicators and could describe this process in detail. The policy domain took a more general advice standpoint. The local administration representative described a situation in which the needed data and indicators are not available and the desired support from the national level not existent.

Table 2 Indicator development processes as described by different respondent groups.

(as mentioned by)	Indicator Developers	Researchers	Policy Domain	Local Administration
Leadership of the process	Developer selects indicators for client	Co-design process with the end user and experts	Helping the user select indicators	Role of national level to provide strategic guidance and capacity building for local level
Source of indicators	National environmental agency list IPCC indices	Developed from impact chains		
Source of data	EURO-CORDEX downscaled data	Include other additional non-climate factors (although often this is not the case) Data can require transformation (challenging)	Availability of climate data more consistent than non-climate data	National scale data available but not useful at the local level Local level lacks knowledge on what data is needed and how to access it
Methodology	IPCC report User demands for customization are followed (with some reservations)	Draw on literature and cases of how the hazard has been dealt with in similar contexts	Determine impact threshold and purpose of use of the indicator, then decide further "Storylines" for presenting uncertainty	
Comments on what the process is like	Has to navigate differing client demands and scientific standards As a private company, it is easier to explain the activities to clients when there are consistent company values	Users have unrealistic expectations about what indicators can do Co-design process takes the longest time	Difficult in general Communication is challenging, incl. about uncertainties Making "place-based" indicators is a challenge for the international community	Expressed a desire for process with more discussion and input from stakeholders

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	Lack of knowledge about how the users then proceed to apply the indicators in practice			

6.3 Characteristics of a well-performing indicator in local adaptation

This section provides an overview of the characteristics of well performing climate risk indicators as reported by the respondent groups. The characteristics reported reflect perspectives informed by respondents' work with users and known use cases, rather than direct use of indicators for adaptation decision making.

Table 2 lists the characteristics of well-performing indicators and denotes which respondent type mentioned each. Almost all characteristics were mentioned by multiple types of respondents. The local administration respondent had the fewest concrete suggestions to describe a well-performing indicator due to not having indicators in use. This implies that personal experience and contact with indicators and their use is significant to building an understanding of the aspects of their performance.

In addition, some characteristics were difficult to specify consistently. The scientific publishing process was mentioned as one way to support indicator credibility through the use of published data; however, the time required for publication may reduce the timeliness of results. Comparability, understood as the use of consistent thresholds and results for a given indicator, was mentioned by indicator developers and researchers, typically in relation to trade-offs with indicator specificity, scale, and localisation. Indicator developers referred to comparability more frequently, while researchers more often mentioned context specificity. Comparability was not consistently described as a requirement for a well performing indicator, as relevance to the local context was commonly regarded as more important for users. Where feasible, however, comparability was noted as a potentially useful consideration.

Table 3 Characteristics of a well-performing climate risk indicator as reported by the interviewees.

	Indicator Developers	Researchers	Policy Domain	Local Administration
Targeted to purpose (impacts on sector or feature of concern)		X	X	X
Meaningful to the user		X		
Measures risk reduction level, not just hazard		X	X	
Reflects social vulnerability and coping capacity			X	
Spatially explicit		X		
At appropriate scale (localization)	X	X	X	X
Robust results (scientifically; used high quality data)	X	X		
Transparency of design/production process	X	X	X	
Transparency of limitations of indicator		X	X	
Can be applied over time/long term	X	X		
Easy to integrate in public policies	X			

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Up-to-date data is used				X

6.4 Factors affecting the use and performance of climate risk indicators in local adaptation

The results on factors affecting the use and performance of climate risk indicators are presented here. Factors are categorised into individual level (producers and users), organisational level as well as governance and politics level factors. Some of the factors can apply at multiple levels.

Producer-level factors

Collaborative or co-design processes were described as having different effects depending on how collaboration was structured. Collaboration among developers was associated with improved comparability, while involvement of users or stakeholders was described as contributing to greater context specificity and making indicators more meaningful to intended users. Targeting indicators to specific local cases and impact thresholds was described as increasing usefulness for users and applicability within the selected context, but also introducing challenges related to comparability and scientific robustness (IPCC and other standard thresholds are not localised). When targeting indicator to the local case, the scale of available data may introduce challenges.

Inconsistencies in terminology between modellers and data collectors were noted by indicator developers as creating challenges for the comparability. No direct effects of such terminology choices on indicator use or performance were explicitly described.

Variation in uncertainty across different climate hazards was mentioned by both indicator developers and researchers as an obstacle to communicating about and building understanding of indicators. For instance, the reliability of precipitation data was identified as a limitation, with lower data reliability associated with reduced indicator performance. Overall, uncertainty was described as difficult for indicator developers to communicate effectively.

Documentation of methodologies, data sources, data transformations, and associated uncertainty was described as supporting understanding among different audiences. Yet overly complex information was described as potentially reducing understanding among users. Differences in transparency between sectors were mentioned, with private sector indicator methodologies and data sources generally not shared openly, while public-sector indicators are subject to transparency requirements; yet no direct effects on indicator use or performance were specified in this context. In addition to data access limitations, licensing restrictions were mentioned by indicator developers as limiting the replication of indicators for new use cases or geographic areas, even where methodological transparency is maintained.

User-level factors

While user understanding of climate risk indicators is improving, challenges related to knowledge, data literacy, and expectations persist. However, no direct effects of these data literacy and skills gaps, or of the observed changes in understanding, on indicator performance were identified. Current hazards were described as being better understood than future ones. Expectations of indicators were also stated as sometimes being too high or misplaced, with local authorities potentially viewing indicators as complete solutions and experiencing difficulties in applying them in practice.

Organisational-level factors

A lack of up-to-date local data was associated with reduced ability to localise indicators and with lower robustness, which may in turn affect the ease of communicating indicator accuracy and user understanding. In response, indicator developers referred to the use of global datasets as substitutes, while local administration respondents referred to reliance on national scale data, which was considered inadequate for local applications. In addition, limited availability of non-climate data at any scale was described as constraining the ability to assess impacts beyond the hazard itself, thereby affecting the targeting and scope of indicators, particularly from a policy domain perspective.

A lack of good practice examples, including high-quality indicators or indicators addressing specific topics, was mentioned as a constraint on indicator use in practice. The IPCC was referred to as a commonly used standard,

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particularly by indicator developers, due to its contribution to robustness and comparability. The transfer of good practice and knowledge exchange was also mentioned, with policy domain responses referring to the importance of a national contact point to support exchange across and within countries.

Capacity gaps at the local level were associated with limited ability to use indicators, particularly for strategic planning. Funding constraints were described as affecting both users and use cases, with insufficient staffing and resources limiting indicator application. Assignment of responsibility for climate adaptation to specific staff was described as supporting indicator use, but that may introduce challenges related to the time and resources required to establish such positions and the potential loss of capacity and knowledge if roles change or are discontinued. In addition, it was mentioned that current EU funding structures are oriented more toward research and indicator development than toward implementation.

Time pressures were described as affecting workflow quality. Limited time was associated with quick acceptance of simplified results, reduced critical assessment, and negative effects on indicator quality and performance.

Continued use of the same indicator over time was associated with increased user familiarity and improved comparability of results over time. Ongoing maintenance of indicators, tools, or products was described as determinative for their continued availability. Challenges to maintenance were linked to limited funding durations and constraints associated with project-based development cycles.

Governance and politics-level factors

The impact of indicators depends on how they are used in decision-making and varies depending on the decisions they support. Policies requiring consideration and monitoring of climate risk were described as promoting the use and production of indicators by defining use cases and supporting long-term maintenance, while also introducing additional requirements that may increase production complexity, reduce flexibility, and require dedicated organisational capacity. While not cited as influencing indicator performance directly, conflicting policy demands, including competition with other policy areas and politicisation of climate adaptation as a topic, were described as influencing the prioritisation of climate adaptation work. On EU-level, intentional variation or adaptation of terminology was also mentioned. The use of more technical terms rather than politically loaded language was described as a strategy to respond to changing political priorities.

The level of interest among stakeholders and politicians was described as shaping indicator use, with increased interest supporting use across governance levels; for example, major events such as natural disasters were noted as temporarily increasing political attention, while limited national level interest was described as contributing to lower engagement at subnational levels. Perceived lack of clear solutions also affecting interest of local administrations.

A mismatch between science and policy cycles was also mentioned, with differences in data production timelines and policy cycles described as creating challenges for policy consistency and the use of indicators required by specific policy processes, although no direct effects on indicator performance were specified.

6.5 Future outlook and recommendations

Respondents outlined several forward-looking needs and anticipated developments related to climate risk indicators. Researchers referred to the potential value of building communities of practice around climate indicators to improve access, capacity building, and sustained use. Indicator developers expressed a need for increased funding, particularly to improve data resolution for hazards such as extreme precipitation, as well as for enhanced validation of climate models through additional observational data. Expectations of increased indicator use in the future were mentioned by indicator developers, linked to improved data availability and the development of more practical indices for municipal use. Researchers and policy domain respondents referred to ongoing efforts to improve their own work, including combining impact and vulnerability information and standardising climate risk language and terminology. Policy domain responses also mentioned the potential value of greater synchronisation of indicators between international and European frameworks. Local administration responses referred to expectations of improved data access in the future.

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7 Discussion

A synthesis of the literature review, survey results, and interviews points to several shared characteristics of well-performing climate risk indicators in local adaptation practice: Well-performing indicators are combinations of local relevance, scientific credibility, transparency, and usability. In practice, these characteristics are reflected in the added value indicators provide, supporting land use planning, vulnerability assessments, risk analyses, and the targeting of adaptation measures, while also contributing to monitoring processes and decision-making. Additional important characteristics include scientific robustness, transparency in both design and limitations, the ability to be applied consistently over time, ease of integration into public policy processes, and reliance on up-to-date data. Further factors of practical usability include ease of use, limited effort required for production and maintenance, and the possibility for automated calculation.

The literature shows that climate risk indicators are used primarily to assess vulnerability and risk to identify adaptation needs, to monitor adaptation implementation, and to assess the effectiveness of adaptation. Our survey and interview results also found examples of these applications but reveal that the use of climate risk indicators is not widespread in practice. Less than half of the survey respondents reported having a defined set of climate risk indicators in use, and those without such experience often lacked the basis to provide detailed assessments. This is in line with the findings of other researchers that indicators are not yet systematically embedded in local adaptation practice.

The academic community offers several different understandings and definitions of indicators (e.g., Leiter & Olhoff, 2019). Among the interview participants we also found a variation in the conceptionalisation of climate risk indicators, with some respondents describing hazard measures and indices and others rather social or financial impacts. Indicators of adaptive capacity were hardly mentioned in these conversations, which is a contrast from the literature.

When discussing practical use in the interviews, relevance and meaning in the local case context was emphasised. But, it became clear that different types of actors set conflicting priorities. Indicator developers prize scientific robustness and comparability. Researchers, on the other hand, emphasised detailed context specification in co-creation processes, not only for the indicator design but in order to understand the users and their use cases; at the same time, they described this as a highly time-consuming process as also acknowledged in the literature (Neset et al., 2021). Policy actors were more focused on multi-variate considerations, including risk reduction and social vulnerability, which, in turn, would increase complexity and effort of indicator development. Finally, the public administration representative was concerned with capacity and resource limitations at the local level that prevent them realistically achieving any of these objectives. Among the users of indicators in the survey, these real-world limitations are also clear, e.g. 6 of 13 respondents disagreed that the indicators in use adequately represent different aspects of risk and 5 of 13 disagreed that high-quality local data was available.

The identified challenges relating to climate risk indicators can be addressed through a set of targeted recommendations across user, institutional, and governance levels. At the individual level, gaps in knowledge, understanding, and application highlight the need for capacity building measures such as communities of practice, clearer terminology, and more practical, user-oriented indicators that are timely, relevant, and understandable. These needs are consistent with literature emphasising the importance of incorporating user perspectives into the design of adaptation metrics (e.g. Leiter & Olhoff, 2019). At the institutional level, constraints related to data availability, quality, and continuity point to the importance of increased funding, improved data resolution, enhanced model validation, and better access to datasets and metadata, alongside stronger integration of hazard, impact, and vulnerability information to support more comprehensive indicators. Previous studies also demonstrate that the choice and quality on input data strongly influence indicator performance (e.g. Ferreiro-Crespo et al. 2026; Szalinska et al. ;2021). At the governance level, fragmentation and inconsistencies across systems suggest the need for standardised terminology, stronger alignment between international and European frameworks, and improved coordination between scientific outputs and policy processes. Across all levels, strengthening data infrastructures and ensuring long-term support for indicator systems are critical for enabling more consistent, effective, and sustained use in practice.

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8 Conclusions

In conclusion, the findings point to several overarching considerations for strengthening the use of climate risk indicators in policy and practice. A fundamental need emerges for clearer conceptualisation of what constitutes a climate risk indicator, as such clarity underpins the development of coherent and supportive policy frameworks. At the same time, the analysis highlights that the technical or scientific performance of indicators is distinct from, yet closely linked to, their practical usability. This emphasises the importance of not only improving indicator methodologies, but also better understanding real world use cases as also recognised in other work within the project (D3.2). The limited availability of practitioners engaged in indicator use, alongside identified constraints related to capacity, time, and funding, points to a gap in current knowledge that limits the ability to define specific user requirements. Addressing this gap would enable more targeted support measures, including tailored methodological guidance and opportunities for learning and exchange focused on indicator application, not only production. In this context, VALORADA contributes a replicable co-development approach that can support the development and application of indicators in other settings. Finally, the results highlight an inherent trade-off between context specificity and comparability: as indicators become more locally tailored, their comparability across scales may decrease. This indicates a need for governance frameworks to more explicitly define at which levels consistency should be prioritised, and where flexibility for local adaptation is appropriate.

Disclaimer on the Use of Generative AI

Microsoft Copilot (Generative AI) was used to support the editing and refinement of language in this deliverable. The use of this tool was limited to improving clarity and readability; content, analysis, and conclusions are solely the responsibility of the authors.

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Annex

Online questionnaire

The Use of Climate Risk Indicators and European Data Platforms

You can change the survey language using the menu in the upper right corner.

This survey is for people working with tasks related to local or regional climate risk management, climate adaptation, or related fields. The aim of the survey is to gain understanding about your experiences and needs when using data, tools, and services from European data platforms. We are also interested in how you use climate risk indicators and how well they work for you.

Your input is important, even if some questions do not fully apply to your work. Please answer with as much detail as possible and give concrete examples.

The survey is part of the EU-funded VALORADA project, which aims to empower European regions and cities to lead societal and systemic transformations and enhance access to climate and non-climate data.

Completing the survey will take about **5-10 minutes.** You will not be asked to provide your name and **your participation is anonymous.** The data collected will be available only to the partners of the VALORADA project and not shared with external parties. Results of the survey will be used in publications from the project, but it will not be possible to identify individual survey respondents.

We plan to publish a research article based on the results. If you are interested in being acknowledged in that article, please contact Enni Lehtinen (enni.lehtinen@fmi.fi) or Saara Korjonen (saara.korjonen@fmi.fi) from the Finnish Meteorological Institute. Send us an email also in case of any questions or further information.

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By clicking "I accept" you confirm that you have read and accepted the information given above and the privacy policy.

Background information

* In which country do you live?

* Which of the following best describes the type of organisation you work for?
- Research and academia
- Local or regional decision-making
- Public sector, governmental agencies
- Private sector, industry
- Civil society, NGOs
- Other

* Which of the following best describes your area of expertise?
- Agriculture
- Business and economy
- Environment and ecosystems
- Public services and infrastructure
- Human health and safety
- Governance and policy
- Other

* How many years of working experience with climate risk management activities or similar do you have?
- no experience
- less than 1 year
- 1-2 years
- 3-5 years
- 6-10 years
- more than 10 years

* In your opinion, which climate risks are the most visible in your region?

- Increased temperature
- Extreme heat waves
- Changes in precipitation
- Flooding (extreme heavy precipitation, short term)
- Drought
- Coastal erosion
- Coastal flooding
- Other
- I don't know

If you chose "other", please specify.

QUESTIONS RELATED TO TH FACTORS AFFECTING THE USE OF EU-SOURCED PLATFORMS OMITTED WITHIN THIS DELIVERABLE (see D1.4)

Use of climate risk indicators

A climate risk indicator refers to a numerical value depicting a state or development of a certain entity related to climate risks, e.g., number of people living in flood-prone areas or land surface temperature.

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* Does your organisation have a defined set of climate risk indicators? For example, as part of a local climate strategy or regional or national climate guidance documents.

- Yes
- No
- I am not sure

IF ANSWER IS NO

To your knowledge, are any climate risk indicators currently under development or is their uptake under consideration?

- Yes
- No
- I am not sure

If you wish, specify what has been discussed or planned related to climate risk indicators.

In your opinion, what has prevented the use of climate risk indicators in your organisation?

IF ANSWER IS YES

* On which themes does your organisation use indicators related to local climate risk management?

- Increased temperature
- Extreme heat waves
- Changes in precipitation
- Flooding (extreme heavy precipitation, short term)
- Drought
- Coastal erosion or coastal flooding
- Biodiversity
- Demographics
- Human health and safety
- Business and economy
- Governance and policy
- Public services and infrastructure
- Agriculture
- Other

Which kind of concrete value do the climate risk indicators in use create? For example, how do they support achieving your organisation's policy goals?

Thinking about the full set of climate risk indicators in use locally, please let us know to what extent each statement is true for you.

	I strongly disagree	I disagree	I agree	I strongly agree	I don't know / Not applicable
*Local high-quality data for the used indicators exists					
*Different aspects of risk are adequately					

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	I strongly disagree	I disagree	I agree	I strongly agree	I don't know / Not applicable
captured and represented by the indicators					
*Indicators are locally relevant and validated					
*Indicators are linked to local climate adaptation and climate risk management goals or actions					
*Unit of the indicator is relevant and understandable					
*Indicators are up-to-date					
*Where applicable, local policy goals have appropriate indicators in place					

Think about the most useful climate risk indicators in use. What qualities and features make them most useful and valuable?

To your knowledge, which guidance documents or recommendations your organisation uses in the development or selection of climate risk indicators?

Select the ones that apply.

- I don't know
- There are no documents nor recommendations currently being used
- Copernicus Climate Data Store
- International Institute for Sustainable Development - IISD
- World Meteorological Organization - WMO
- European Environment Agency - EEA
- International Monetary Fund - IMF
- Climate-ADAPT
- European Soil Data Centre - ESDAC
- European Flood Awareness System - EFAS
- European Drought Observatory - EDO
- EU Mission Adaptation
- Other

If you wish to give more detailed information, you can upload any relevant documents that list or describe the used indicators or provide a link to an online resource here.

We would like to hear from you!

If you are open to a short interview on the topics of this survey in late 2025, simply leave your email below. The registration here is not binding. No preparation needed – just your thoughts.

- Yes, I'll write my email address below.

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- No, not this time.

Thank you

For any questions or further information, please contact Enni Lehtinen (enni.lehtinen@fmi.fi) or Saara Korjonen (saara.korjonen@fmi.fi).

Use this section for any additional thoughts, specifications, or other relevant comments.

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