Deliverable Phase 2 – Climate risk assessment

CIVAL – CLIMAAX in Valcerrina

Unione dei Comuni della Valcerrina

Version 1.0 | July 2025

HORIZON-MISS-2021-CLIMA-02-01 - Development of climate change risk assessments in European regions and communities based on a transparent and harmonised Climate Risk Assessment approach

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Abbreviations and acronyms

Abbreviation / acronym	Description
a.s.l.	above sea level
AWC	Available water capacity
CIVAL	Climaax in Valcerrina
CRA	Climate Risk Assessment
CREA	Council for Agricultural Research and Economics
(I)MCPP	Inter-Municipal Civil Protection Plan
ISTAT	Istituto Nazionale di Statistica (National Institute of Statistics)
NUTS	Nomenclature of Territorial Units for Statistics
SI	Supporting Information
UAA	Utilized Agricultural Area
UoM	Union of Municipalities

Executive summary

The CIVAL project (CLIMAAX in Valcerrina) develops actionable knowledge on the climate risks faced by the Valcerrina Union of Municipalities (UoM), a rural area of twelve municipalities and approximately 7,500 inhabitants in south-eastern Piedmont, Northern Italy. Through a bottom-up approach, the project aims to complement the more top-down climate adaptation and civil protection strategies set at regional and national level. This deliverable presents the results of Phase II, in which the standard CLIMAAX risk workflows were fine-tuned to the local context to address the gaps and priorities identified by stakeholders during Phase I. The document outlines the methods, results and stakeholder evaluation of a local, economically grounded multi-hazard climate risk assessment (CRA), together with the tools developed to support its use in local decision-making.

Building on Phase I feedback, Phase II refined the assessment of four hazards. The agricultural drought workflow was enriched with local crop, soil and economic data, estimating an annual revenue loss across the UoM of about €850,000 by 2050, driven mainly by maize, soybeans and alfalfa, with permanent crops such as hazelnut and grape becoming substantial contributors towards 2080 owing to their high economic value. The riverine flood workflow was extended beyond the Po River to the secondary hydrographic network and combined with property- and parcel-level economic data, yielding estimated damage of €4.54m, €10.27m and €17.88m for high-, medium- and low-probability events. A new landslide damage workflow estimated around €8.9m of economic value exposed to very high hazard, mostly affecting the agricultural sector. For wildfire risk, confirmed as a low priority, the Phase I results were compared with the Wildfire Risk Plan developed by the regional authority; both converge on a currently low risk with only a moderate near-future increase. Results were integrated into an interactive WebGIS platform — a novelty for the UoM — enabling visualisation, exploration and validation of risks at asset and municipal scale, and were discussed and evaluated with over 40 local actors, experts and technical officers during three engagement events. The resulting prioritisation ranks drought as the highest priority, followed by river flooding and landslides, with wildfire lowest.

Phase II confirms the added value of integrating local data into the CLIMAAX framework, particularly for producing realistic economic damage estimates that were previously unavailable at municipal level and that complement the Inter-Municipal Civil Protection Plan adopted by the UoM in 2025. It also surfaced clear limitations, including restricted access to wildfire exposure data and knowledge gaps on the impact of climate change on hydrogeological risks. While local actors readily recognised the value of the new evidence for awareness-raising and advocacy, embedding the results into formal planning processes remains a challenge of timing, legitimacy and political coordination to be pursued further.

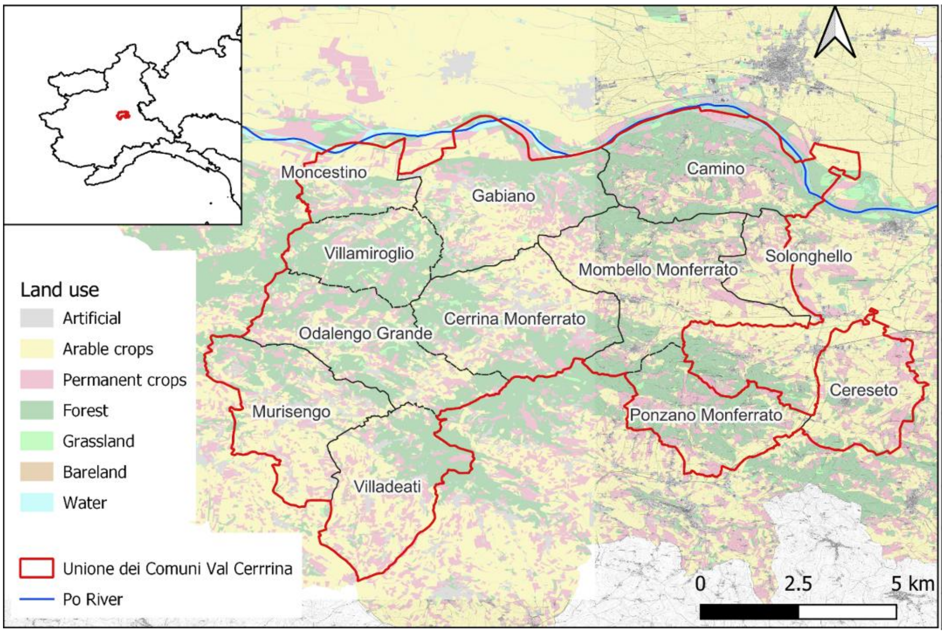
Phase III (July 2026 – December 2027) will consolidate and validate these results, focus on co-developing and testing adaptation measures — notably irrigation options for drought — develop an integrated multi-risk index, and pursue uptake of the CRA into local and regional decision-making.

1 Introduction

1.1 Background

L'Unione dei Comuni della Valcerrina, hereafter Valcerrina UoM, is a Union of Municipalities located in the southeastern Piedmont region, Northern Italy. It comprises 12 municipalities (Figure 1-1) with a total population of approximately 7,500. It borders the plain of the Po River to the north and the rolling hills of Monferrato to the south, with an elevation ranging from 100 to 400 metres above sea level (a.s.l.). It falls under the Piedmont Region (NUTS-2) and Alessandria Province (NUTS-3) administrations.

The area forms part of the "Langhe-Roero and Monferrato" UNESCO World Heritage site, renowned for its wine-producing landscapes, hilltop villages, castles, and farms[1]. Covering an area of around 162 km², land use in Valcerrina includes agriculture (56%), woodlands (36%), artificial surfaces (7%), and water bodies (1%), Figure 1-1. The region's clay-calcareous hills support premium crops such as vines and hazelnuts, alongside forage crops. In contrast, maize, soybeans, barley, and other cereals predominate closer to the Po River plain.



Municipality	Population
Camino	730
Cereseto	372
Cerrina	1290
Gabiano	1021
Mombello Monferrato	919
Moncestino	190
Murisengo	1269
Odalengo Grande	407
Ponzano Monferrato	328
Villadeati	461
Villamiroglio	292
Solonghello	193

Figure 1-1: Location, boundaries and land use in Valcerrina (left). The red line delineates the boundary of the Valcerrina UoM. Names of member municipalities alongside their population are provided (right) (ISTAT, 2021).

The demographic profile is characterized by an ageing population, with approximately 25% of inhabitants over the age of 65. The local economy is largely based on agriculture and the agri-food sector, with notable emphasis on viticulture and hazelnuts. In recent years, tourism and the hospitality sector have witnessed growth thanks to the international acclaim of the "Langhe-Roero and Monferrato" UNESCO site. Factors such as low population density, an ageing demographic, land abandonment, and strong dependence on agriculture render Valcerrina susceptible to social and environmental shifts, including those resulting from climate change.

[1] https://whc.unesco.org/en/list/1390/

1.2 Main objectives of the project

The overarching goal of the Climaax in Valcerrina (CIVAL) project is to develop actionable knowledge on the climate risks faced by the Valcerrina UoM and to promote the resilience of the local community through a bottom-up approach. This process complements the more top-down approach implemented by the public authorities at regional and national level to adapt to climate change and to develop civil protection services, Figure 1-2.

The goal is achieved by working on three main specific objectives:

- assessing multiple climate risks enriched with local information on hazard, exposure and vulnerability
- raising awareness among the local community of the impact of climate change
- co-developing adaptation measures

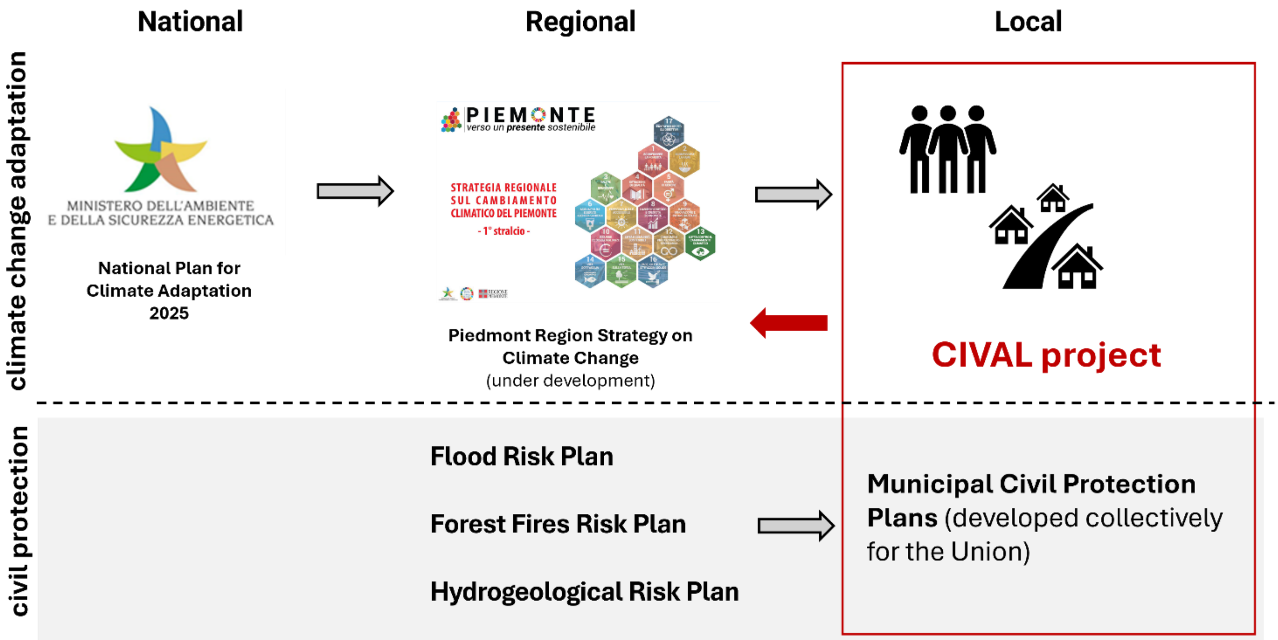


Figure 1-2: The area of influence of the CIVAL project in relation to climate change adaptation and civil protection.

1.2.1 Recap of Phase I

During Phase I of the project a preliminary multi-hazard risk assessment (riverine floods, drought and wildfire) was conducted using the standard CLIMAAX workflows, while the local community was engaged to prioritize risks, evaluate the results of the assessment and gather needs for the development of Phase II. Table 1-1 summarizes the main feedback gathered from local stakeholders during Phase I of the CIVAL project.

Table 1-1: Lessons learnt and feedback received from stakeholders on the climate risk assessment in Phase I

Topic	Feedback and needs
Flood risk	• knowledge gap on the potential impact of climate change on the frequency of extreme flood events • assessment is limited to the flood risk generated by the Po River along the northern boundary of Valcerrina. Yet, flood risk is more widespread throughout the area and mostly associated with the secondary hydrographic network • the method for estimating economic damage from river flooding relies on national monetary value of different land uses, without reflecting the local context
Drought risk	• only some of the crops present in Valcerrina are included in the assessment • the spatial variation of drought risk across Valcerrina cannot be appreciated due to the low resolution of input datasets (climate and crop distribution) •
Wildfire risk	• the wildfire risk is considered a low priority by stakeholders • the Regional Wildfires Risk Plan already provides a detailed assessment of wildfire risk at local scale
Other risks	• would be interesting to explore landslide risk since it is already causing extensive damage to road infrastructure and private properties
Stakeholder involvement	• local actors have a great interest in the CRA and they highlight the role the project can have in increasing awareness on climate change • the involvement of stakeholders at higher governance levels (i.e., regional authority) will be sought as the project results are consolidated •

1.2.2 Objectives, significance and benefits of Phase II

Building on the results of Phase I, the objectives of Phase II are defined as follows:

- generating climate risk information that is more aligned with local needs, risk priorities and context
- raising awareness of the impact of climate change and initiating the discussion on local adaptation measures
- exploring opportunities to integrate the results of the fine-tuned climate risk assessment (CRA) into local decision-making and policy processes (to be continued in Phase III)

The significance of Phase II for the local governance landscape on climate change adaptation and civil protection is two-fold. On one hand it deepens the analysis of climate risks for which a specific adaptation and risk management plan has not been developed yet at the regional level. This is the case of drought which is considered an emergency risk in Northern Italy and for which the region is still largely unprepared. By integrating the CLIMAAX Handbook with local agricultural data, the CIVAL project promotes a bottom-up approach to fill knowledge gaps that are relevant to the wider Piedmont Region, thus representing a role model that can be adopted and scaled up by similar local authorities and communities. On the other hand, Phase II generates data on the expected economic damage of extreme climate events that is currently unavailable at the municipal level. This is an information gap identified in the Valcerrina Inter-Municipal Plan for Civil Protection (IMPCC), which was recently developed and formally adopted by the UoM in 2025. By including local economic data in the CLIMAAX workflows the CIVAL project creates information on economic exposure and vulnerability that can complement the risk profiles already included in the IMPCC and can eventually inform the update of the Plan. This will allow the municipalities to prioritize interventions in areas of higher expected economic damage.

1.3 Project team

The project is implemented through the collaboration of three main entities: Valcerrina UoM, UrbyetOrbit, and TR2. Valcerrina UoM coordinates the project and leads stakeholder engagement. UrbyetOrbit supports the climate risk assessment through geospatial analysis and WebGIS development. TR2 conducts environmental data analysis and supports the integration of technologies for climate risk assessment and monitoring.

Dr. Fabio Olivero, President of Valcerrina UoM, serves as Coordinator and Community Engagement Lead. Dr. Andrea Bertolotti, Environment Department Manager and Coordinator Assistant, supports local data collection and communication with municipal technical offices.

Dr. Marco Bonamente, Senior GIS Analyst at UrbyetOrbit, integrates geospatial datasets for multi-risk visualization, hazard mapping, and scenario simulations. Mauro Venanzi, ICT Software Engineer at UrbyetOrbit, develops the platform backend and ensures integration, data visualization, interoperability, and security.

PhD Eng. Enrico Lucca, Climate Data Analyst at TR2, implements and enriches risk workflows, models future scenarios, and develops risk indicators. Dr. Maroussia Terrana, Data Analyst and Dissemination Manager at TR2, supports data harmonization, documentation, and dissemination to scientific and public audiences.

1.4 Outline of the document's structure

This document describes the results of the second phase of the CRA undertaken in Valcerrina and is organized into three main sections. Section 1 introduces the CIVAL project, its objectives and project team; Section 2 presents the results of the fine-tuned CRA following the CLIMAAX Framework, including scoping, risk exploration, regionalized risk analysis, monitoring and evaluation; Section 3 draws the main conclusions of Phase II and lays out the way forward for the third phase of the project.

2 Climate risk assessment – phase 2

2.1 Scoping

2.1.1 Objectives

The overall two objectives of the CRA remain unchanged from Phase I: i) providing the Valcerrina UoM with the information and tools needed to manage climate risks and develop adaptation measures in their territories, ii) providing evidence that a bottom-up approach to CRA and adaptation can complement and reinforce the operationalization of the regional strategy on climate change. Phase II allowed the project to make significant progress on each objective by developing climate risk data and tools that are tailored to the local context and that consider the operational needs of the UoM. As such, the CIVAL project is already showing the complementarity of the local CRA with on-going policy and planning processes implemented at higher governance level.

While local actors have already recognised the benefit of the CRA undertaken in Phase II in terms of new awareness and knowledge on local climate risks, the effective integration of the CRA results into formal policy and planning processes is a challenge that the project is facing and that will continue to be actively addressed during Phase III. This is due to two main reasons: policy processes at the local level follow well-established guidelines, methodological standards and timelines set by regional and national laws. A key example is the development of the MCPP, which is informed by the 2004 Piedmont Region Decree and largely relies on risk scenarios generated at the regional level. The MCPP is therefore seen as an implementation instrument rather than an opportunity to generate new knowledge on local risks. While the CIVAL project is providing a new perspective on this otherwise standard practice, the effective integration of the CRA results into the development of local plans not only requires rigorous technical analysis but also political coordination. Towards the end of Phase II, the project team presented the results of the fine-tuned CRA to the technical officers of the UoM who had been involved in the development and approval of the last update of the IMCPP in 2025. This enabled them to assess the added value of the information generated and brainstorm initial ideas on how to embed these into future revisions of the Plan. Other options for the uptake of the CRA results into planning and policymaking processes are also being considered, as outlined in Section 2.6. Secondly, there is a challenge of legitimacy and reliability of the results obtained through the CIVAL project. While the risk scenarios made available by the regional authority are regarded as well established, the results of the CIVAL project hold less authoritative value. The project team is therefore paying close attention to applying the principles of technical rigour and transparency in the risk analysis and to making sure that the information generated is discussed and validated with local actors.

2.1.2 Context

Compared to Phase I, two governance contextual conditions have changed. The first pertains to the publication of the Valcerrina IMCPP in 2025. It was issued to update the individual MCPPs of the 12 municipalities in line with the requirements set by the regional authority. The technical development was commissioned by the UoM to an external consultancy company and it largely relied on hazard and exposure data provided by the regional authority or identified in the municipal development plans. The IMCPP covers landslide, flooding and wildfire hazards, but it does not provide insights into the estimated economic damage resulting from these extreme events, nor does it address drought risk. These are two gaps the CIVAL project is set to address in Phase II. The release of the

IMCPP during the project duration allowed the team to: i) gain further visibility on the political and technical processes that led to the IMCPP; ii) explore the integration of the information contained in the IMCPP with the results of the CRA. This is a process that started only at the end of Phase II and that will continue in Phase III. The second governance condition concerns the revision of the Flood Risk Management Plan of the Po River Basin. In line with the Water Framework Directive, the Flood Risk Management Plan is developed by the Po River Basin Authority every six years. The last edition is dated 2021. In preparation for the 2027 update, the Po River Basin Authority published a flood depths dataset in January 2026 at 20m resolution for the entire primary hydrographic network of the basin. It includes the stretches of the River Po bordering the UoM to the north. Given the high spatial resolution and the recent release, these maps represented a valuable source of local data that was integrated into the CRA.

2.1.3 Participation and risk ownership

The composition of stakeholders relevant to the CIVAL project has not changed since the end of Phase I in July 2025. As such, their involvement in Phase II built upon the activities already commenced and it pursued two main aims: raising awareness of the local population on the impact of climate change and involving key stakeholders in the CRA process. Two main groups of actors were thus targeted in Phase II: local environmental organizations and the staff of the municipalities who are responsible for urban planning, civil protection and environmental monitoring. The first group has a long standing experience of working on environmental topics and can help the project raise awareness on the impact of climate change, while the second knows the operational needs of local municipalities and can support the project in ensuring the results of the CRA are validated and uptaken.

2.1.4 Application of principles

Despite the focus on key stakeholder groups, the engagement process in Phase II remained open to anyone interested in the project and in its results. This was achieved by extending the invitation to key stakeholder meetings to all citizens, thus capturing the diversity of people living in Valcerrina. Moreover, the project is trying to reach new audiences by building collaborations with local environmental organizations and by contributing to creating a local culture around climate change adaptation. The quality of the CRA and its relevance to local decision makers was pursued by combining state-of-the-art scientific methods provided in the CLIMAAX workflows with local datasets and by comparing the results of different approaches (see for example Section 2.3.3.1) to create redundancy on the assessed risks. Furthermore, the results of the fine-tuned CRA are published on WebGIS platforms [CIVAL — Piattaforme Climatiche Val Cerrina] which can be easily accessed by local actors for consultation and validation.

2.1.5 Stakeholder engagement

Throughout Phase II, the project team carried out extensive stakeholder engagement and dissemination activities targeting two main audiences: national and international actors who may be interested in the process and solutions developed by the CIVAL project, and actors in Valcerrina who can provide feedback on the results of the CRA and on their usability for local decision-making processes. At the local level, three main stakeholder engagement events were organised in January, April and June 2026.

On 22/01/2026, an interactive workshop to explore the causes and consequences of climate change was organised with three local environmental organisations (i.e., Legambiente, Madre Selva, Parco

Naturale del Po Piemontese). The event was held in Gabiano and gathered over 15 participants from the three organisations (see detailed report in Supplementary Information SI-2). The workshop used the Climate Fresk methodology, a serious game that allows participants to work in teams and use cards to understand the cause-effect relationships of climate change. The methodology was customised to guide discussion on the key climate risks for Valcerrina and possible adaptation measures. A first set of ideas for adaptation measures was collected at the end of the workshop in relation to flood, landslide, drought and wildfire risk. The event allowed the participants to reflect on the local impact of climate change, on what the high-priority risks are for the UoM, and to learn a new pedagogical tool that they can use to raise awareness of climate change.

On 29/04/2026 a technical online meeting was organized with the officers of the UoM to present the results of the fine-tuned CRA and the WebGIS platforms (see report in SI-2). The objective was to show how the CRA was enriched with local data, to gain feedback on the results obtained and discuss how the results can support local decision-making processes. Attendance at the meeting was lower than expected but it saw the participation of the Villadeati municipality which is the local hub for the civil protection services of the UoM. To overcome the issue of low attendance, another stakeholder meeting was organized in person on 16/06/2026 in Gabiano (see SI-2). The meeting was entitled “The Voices of Valcerrina” and it gathered over 35 participants, including general public, the mayors of Gabiano, Odalengo Grande and Ponzano, and various local experts. After a presentation of the fine-tuned CRA results by the project team, the experts shared sectoral perspectives on the impact of climate change and possible adaptation measures in Valcerrina. Presentations focused on: geology and landslide risk, impact of climate change on fruit trees and hazelnut, landscape approaches to mitigating heatwaves in rural areas, disaster risk management, ecosystems preservation. The event was successful in two ways: first it exposed the results of the CRA to a wide range of local actors, including mayors and the Valcerrina UoM civil protection team, second it promoted dialogue across sectors creating further opportunities to integrate scientific and experiential knowledge. At the end of all presentations a questionnaire was shared to gather the audience’s perception on the severity, urgency and resilience capacity of the climate risks discussed during the meeting.

At the national and international level, the project team took part in several events where the process and outputs of CIVAL were showcased. Nationally, the CRA methodology and the WebGIS platforms developed to support data sharing, validation and informed decision-making were presented at the ESRI Italia Conference 2026 in Rome on 13/05/2026 and at Politecnico di Milano on 10/10/2025. Internationally, the implementation of the drought risk assessment was highlighted in the CLIMAAX Community of Practice webinar “Agriculture Drought Risk Assessment: Learning from Regions” on 16/04/2026 and the experience of the UoM and its partners in participating in the CLIMAAX cascading funding was shared during the Adaptation Hub Italia webinar “Adaptation Mission: Cascade Funding, Italian Experiences and Opportunities” on 22/05/2026. A full list of communication and dissemination outputs is included in SI-3.

2.2 Risk Exploration

2.2.2 Screen risks (selection of main hazards)

In line with the results and recommendations set out in Phase I (Table 1-1), Phase II focused on the following main hazards:

- **Drought.** Phase II expands the standard workflow to local crops in Valcerrina and integrates local data on cropping pattern, soil types and crop economic value.
- **River flood.** Phase II expands the standard workflow to the secondary hydrographic network and integrates local data on hazard and economic exposure.
- **Landslide.** Phase II combines local data on landslide susceptibility with economic exposure to assess potential damage.
- **Wildfire.** Since it is considered a low-priority risk, no further analysis is undertaken in Phase II. However, a comparison is conducted between the results obtained in Phase I and the risk scenarios generated by the regional authority.

2.2.3 Choose Scenario

The socio-demographic characteristics of Valcerrina are expected to remain stable in the near future (2050) or to follow the trends observed in the recent past. Even if more moderately than over the second half of the 20th century, population ageing and the abandonment of rural areas are likely to continue in the future, potentially lowering exposure to climate risks. On the other hand, lower levels of monitoring and management due to declining population could potentially increase some hazards and their impacts, such as wildfire and landslides. The agri-food sector will continue to play an important role in the local economy, but its flourishing will partly depend on future climate conditions, investment in irrigation infrastructure and resilient cropping patterns. Different scenarios of cropping patterns will be tested in Phase III as a climate adaptation measure alongside irrigation. In terms of climate change scenarios, the time horizon most relevant for Valcerrina is the mid-term (2050), given the average age of local residents and the mandates of local politicians, which usually last no more than 8 to 10 years. However, the long-term horizon (2080) will be considered for some key risks to evaluate the expected trend over time. Over such time horizons, the intermediate RCP 4.5 scenario was considered the most appropriate by local actors.

2.3 Regionalized Risk Analysis

2.3.1 Hazard #1: Agricultural drought - fine-tuning to local context

Figure 2-1 shows how the standard agricultural drought workflows was enriched with local information on hazard, exposure and vulnerability. Local data were derived from regional and national datasets as detailed in Table 2-1. The objective of the integration was to produce estimates of revenue loss that are more aligned to the predominant crops in Valcerrina and to their local economic value.

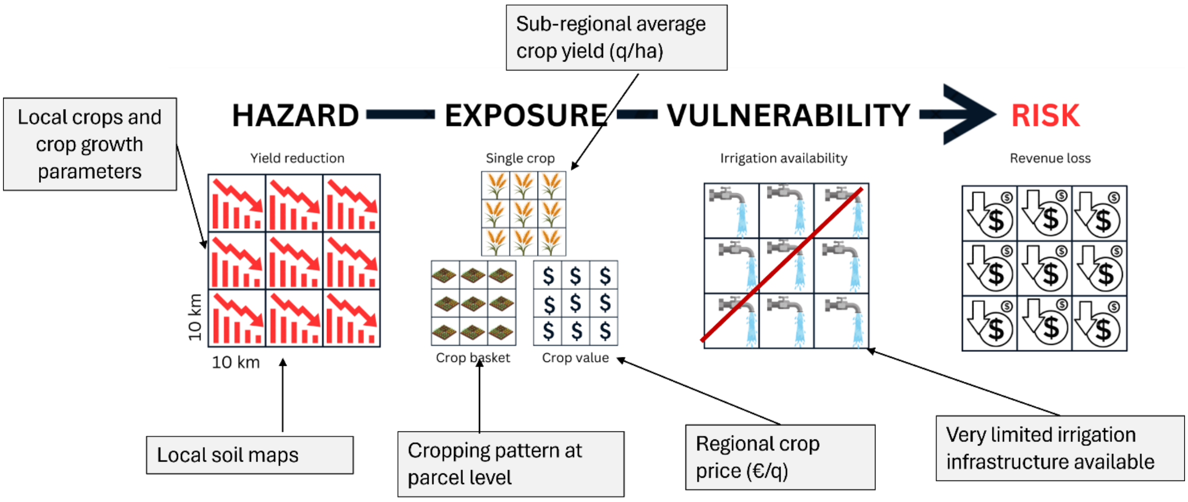


Figure 2-1: The integration of local data into the CLIMAAX agricultural drought workflow

Table 2-1: Data overview workflow #1 – Agricultural drought

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
EURO-CORDEX climate projections Time horizon: 2050 (2036 – 2065) and 2080 (2070 – 2090) Scenario: RCP 4.5 Model combination: NCC-NorESM1-M + GERIC-REMO2015	Irrigation is mostly not practiced in Valcerrina. Was thus excluded from the analysis.	Uso del suolo agricolo su mosaicatura catastale di riferimento regionale 2025 [2] *(regional cropping pattern at parcel level)*	Revenue loss (€)
Carta dei suoli 1:250000 Regione Piemonte [3] *(regional soil map)*		"Stima delle superfici e produzioni delle coltivazioni agrarie – 2020 - 2025" ISTAT[4] *(national census of cultivated areas, in ha, and crop production, in q)*	
Elevation data from USGS GDTEM 2010 digital elevation model (Danielson & Gesch, 2011)		"Produzione ai prezzi base dell'agricoltura piemontese 2021-2023" in Agricoltura nel Piemonte in Cifre 2025, CREA[5] *(regional census of crop production and selling price)*	
Crop growth characteristics (various sources – see Appendix I)			

[2] Avilable at: https://www.geoportale.piemonte.it/geonetwork/srv/ita/catalog.search#/metadata/r_piemon:d1252f4d-8c29-4995-b85b-4bbfb179cc70
[3] Available at https://www.geoportale.piemonte.it/geonetwork/srv/ita/catalog.search#/metadata/r_piemon:dl45po47-sh45-p44w-854d-58fdq6p9iu45
[4] Avilable at: Stima delle superfici e produzioni delle coltivazioni agrarie, floricole e delle piante intere da vaso – Istat
[5] Available at: Online l'opuscolo "L'agricoltura nel Piemonte in cifre 2025" - Online l'opuscolo "L'agricoltura nel Piemonte in cifre 2025" - Politiche e Bioeconomia - CREA

2.3.1.1 Hazard assessment

The first step in the hazard assessment was the selection of the climate model through the CLIMAAX model bias explorer. The combination of NCC-NorESM1-M and GERICS-REMO2015 showed the smallest bias for the Piedmont Region of 0.105°C and -11.42% for temperature and precipitation, respectively (Appendix I). Secondly, the standard crop table was expanded to include hazelnut, grape and alfalfa crops, and was integrated with crop growth parameters derived from scientific and grey literature focusing on Northern Italy. If not available, the standard FAO parameters were used. The final crop characteristics used in the workflow are reported in Appendix I. The hazard assessment was thus run for the following seven crops: barley, vine, maize, hazelnut, alfalfa, wheat and soya. Altogether, these crops account for 55% of the Utilized Agricultural Area (UAA) of Valcerrina UoM. Of the remaining UAA, 39% is either fodder and permanent grassland for which a specific crop type could not be identified or set-aside land. To account for the multi-cycle cutting of alfalfa, each of the five cycles (the most common practice in Northern Italy) was simulated as an individual crop with different sowing and harvesting dates. Third, regional soil maps were used to derive the available water capacity (AWC). Two main soil types were identified in Valcerrina: clayey shallow soil on the hill slopes with an AWC of 200mm and alluvial, sandy deep soil on the plains along the main watercourses with an AWC of 300mm. The hazard workflow was thus modified to run under these two AWC scenarios for all crops and all grids of the climate projections. Figure 2-2 shows the estimated mean yield loss across Valcerrina UoM under scenario RCP 4.5 for the 2050 and 2080 horizons. The data for alfalfa represent the sum of the yield loss across the five growing cycles. Results show that summer arable crops such as maize, soya and alfalfa are expected to experience greater yield loss than winter crops such as wheat and barley. Premium permanent crops such as grape and hazelnut are shown to experience lower yield losses than arable crops, but the loss is projected to increase towards the 2080 horizon.

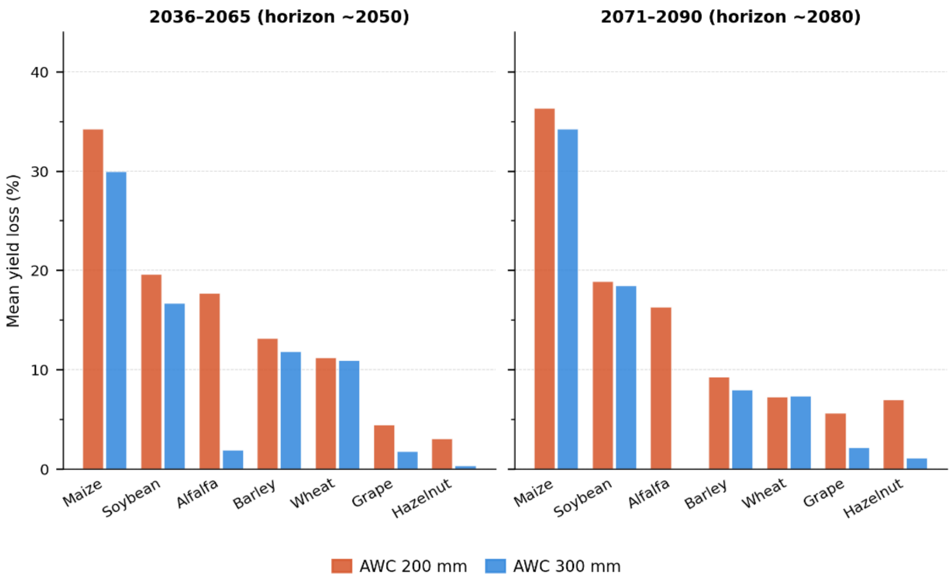


Figure 2-2: Estimated mean yield loss for major crops in Valcerrina under scenario RCP 4.5, two time horizons and the two AWC model set-ups.

Finally, the yield losses calculated for different AWC and different crops were mapped against a parcel-level cropping pattern. This dataset is made available by the regional authority and updated every year based on agricultural census and subsidies data. It was thus possible to assign to each parcel the estimated yield loss based on crop, soil type and proximity to the climate projection grid cell.

2.3.1.2 Risk assessment

The parcel-level information on yield loss was combined with crop yield and crop economic value data derived from national and regional sources. The National Institute for Statistics (ISTAT) publishes annual data on crop surface area (ha) and agricultural production (q) at the province level (NUTS-3). Considering the period 2020–2025, an average yield (q/ha) was calculated for the Valcerrina UoM. The average crop economic value for the same period was derived from the regional dataset compiled by the Council for Agricultural Research and Economics (CREA). These data were integrated to calculate revenue loss at the parcel level and then aggregated to the municipality scale. In line with the feedback received from stakeholders, the presence of irrigation was excluded because of the lack of irrigation infrastructure as well as readily available water resources. The parcel-level results are provided in the WebGIS dashboard Yield Loss & Irrigation — Val Cerrina (RCP 4.5). Figure 2-3 shows the contribution of each crop in Valcerrina UoM to the estimated annual revenue loss, highlighting that maize, soybean and alfalfa are driving drought risk, followed by wheat and hazelnut. The increase in yield loss that hazelnut might experience by 2080 would result in a significant increase in revenue loss due to its high economic value. Figure 2-4 presents the revenue loss estimated for the year 2050 for each municipality in Valcerrina. The same data for the year 2080 are included in Appendix I. The total revenue loss across the UoM is estimated to reach €890,000 and €950,000 in 2050 and 2080 respectively.

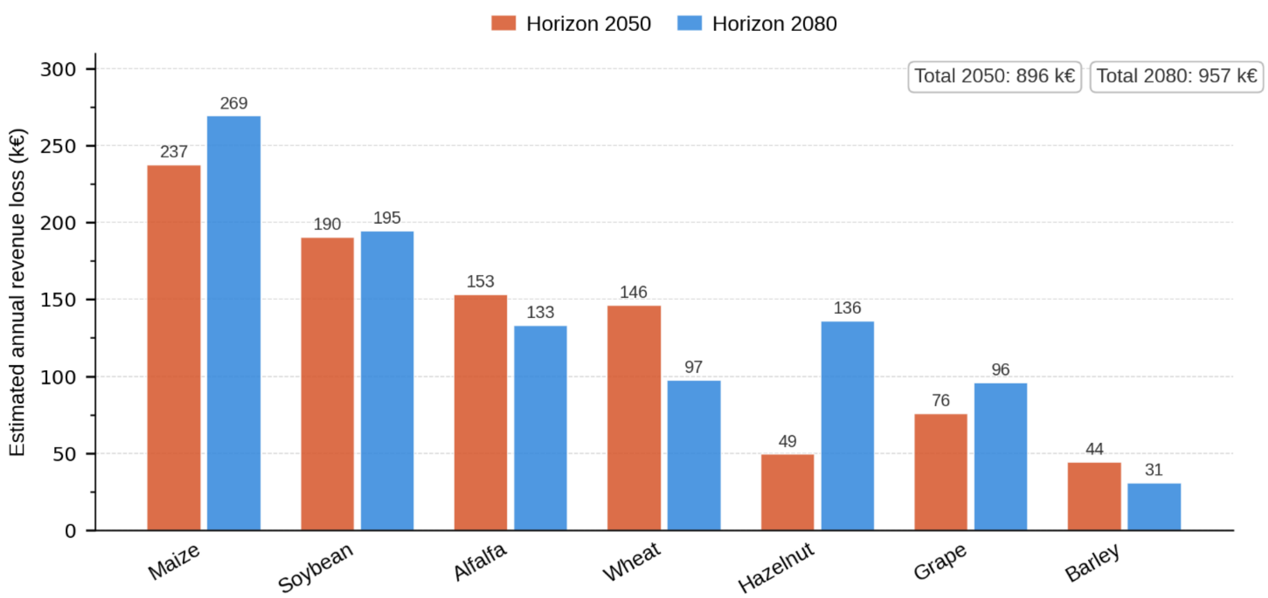


Figure 2-2: Estimated annual revenue loss (k€) for the entire Valcerrina UoM under scenario RCP 4.5 and the two time horizons.

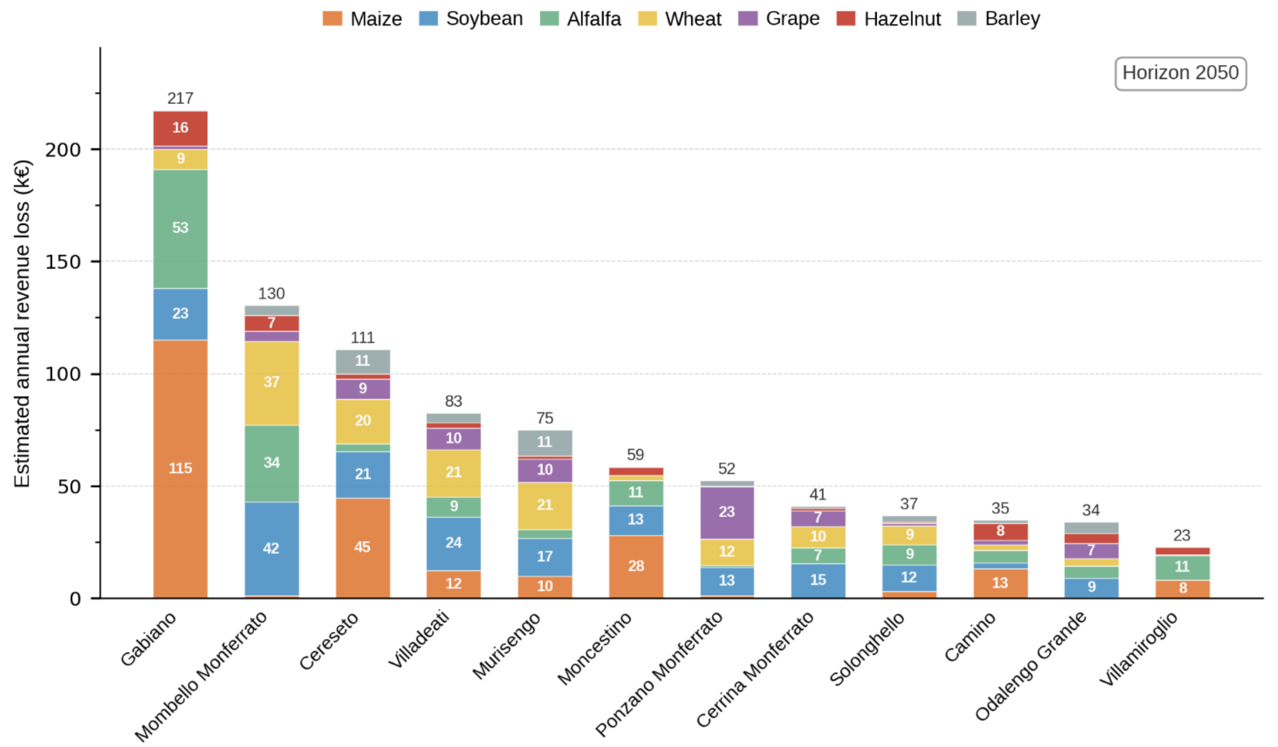


Figure 2-3: Estimated annual revenue loss for each municipality in Valcerrina UoM under scenario RCP 4.5 and the time horizon 2050.

2.3.1.2.1.1 2.3.2 Hazard #2: Riverine flood risk - fine-tuning to local context

Figure 2-4 shows how the standard river flood risk workflow was enriched with local information on hazard and exposure. Local data was derived from regional and national sources as outlined in Table 2-2.

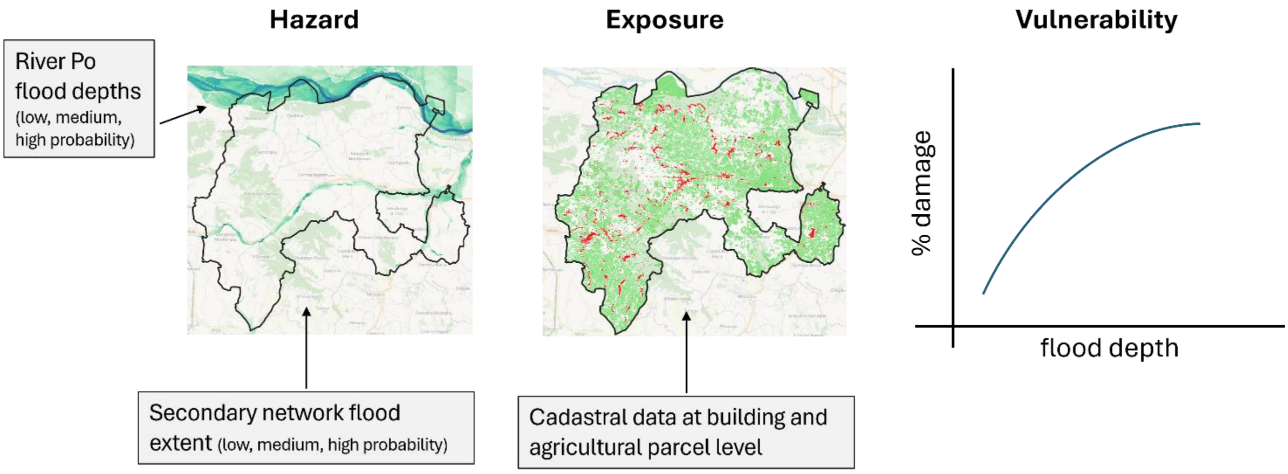


Figure 2-4: The integration of local data into the CLIMAAX river floods risk workflow

Table 2-2: Data overview workflow #2

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
Po River – flood depth maps at 20m resolution provided by the River Po Basin Authority[6]	JRC damage-flood depth curve	Cadastral data for buildings and agricultural fields[7]	Estimated economic damage (€)
Secondary hydrographic network – flood zone extent provided by the Piedmont Region[8]			

2.3.1.3 Hazard assessment

Flood hazard in Valcerrina originates from the Po River along the northern boundary and from a network of smaller watercourses across the territory. Given that the JRC flood maps used in Phase I only covered the Po River, the workflow was expanded to integrate local data on flood hazard along the secondary hydrographic network. Specifically, flood zones for three probability scenarios (low: 500-year return period; medium: 100–200-year return period; high: 10–20-year return period) included in the 2021 Regional Flood Risk Management Plan were used. The zones were converted into 20x20m flood depth maps using a digital elevation model of the study area. First, the elevation along the boundaries of the flood zones was extracted and spatially interpolated to recreate the surface of the floodwater. From this surface, the terrain elevation was subtracted to calculate flood depths. Although the reconstructed flood depths do not account for flooding pathways and dynamics, which would be captured in a detailed 1D–2D hydraulic modelling study, this procedure allowed hazard data compatible with the workflow applied to the Po River to be obtained. It was thus possible to calculate the extent of damage based on the flood depth. Finally, the JRC flood maps used in Phase I for the Po River were updated to the new flood maps made available by the Po River Basin Authority as part of the 2027 revision of the Flood Risk Management Plan.

2.3.1.4 Risk assessment

Cadastral data were integrated into the risk workflow to perform a property-level damage assessment. For each building in Valcerrina, the cadastre provides information on the use category (residential, industrial or commercial) and its tax value, which was used as a proxy for its economic value. For each agricultural parcel, it provides the major crop class (i.e. arable crops, permanent crops or arboriculture) and the average economic value at the provincial level (NUTS-3). The refined workflow therefore accounts for parcel- and property-level economic data rather than average national values for different land-use classes. The JRC vulnerability curves relating percentage damage to flood depth were maintained. Flood depths for the three probability scenarios were mapped against the footprints of buildings and agricultural parcels to derive the maximum flood depth. Economic damage was then estimated based on the maximum flood depth, the associated

[6] Available at https://pianoalluvioni.adbpo.it/mappe-della-pericolosita-e-del-rischio-di-alluvione-2027/
[7] Available at https://www.agenziaentrate.gov.it/portale/cittadini/fabbricati-e-terreni
[8] Available at https://www.geoportale.piemonte.it/geonetwork/srv/ita/catalog.search#/metadata/r_piemon:408e8ca1-1913-4a32-813e-75873669a432

percentage of damage and the exposed economic value. For buildings, a 20% overlap threshold between the flood map and the building footprint was used, above which the total economic value of the property was considered exposed to flooding. For agricultural parcels, only the portion of the parcel intersected by the flood map was considered exposed. The parcel- and building-level results are provided in the WebGIS dashboard [Danno Economico da Esondazione — Val Cerrina](). Figure 2-6 reports the estimated economic damage/event probability curves for the entire Valcerrina UoM, while Figure 2-7 and Figure 2-8 show the estimated cumulative economic damage for each municipality under the medium-probability scenario (100–200-year return period). The values are one order of magnitude lower than the results obtained in Phase I (i.e. €150m), emphasising the benefit of integrating local data to align with stakeholder needs and expectations.

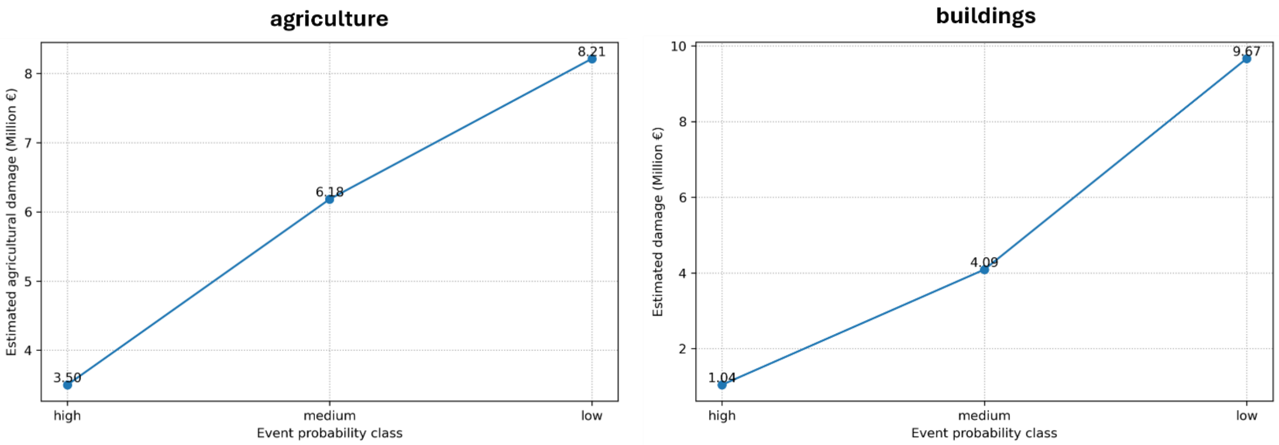


Figure 2-5: Estimated damage vs event probability class for the entire Valcerrina UoM associated with agricultural parcels (left) and buildings (right)

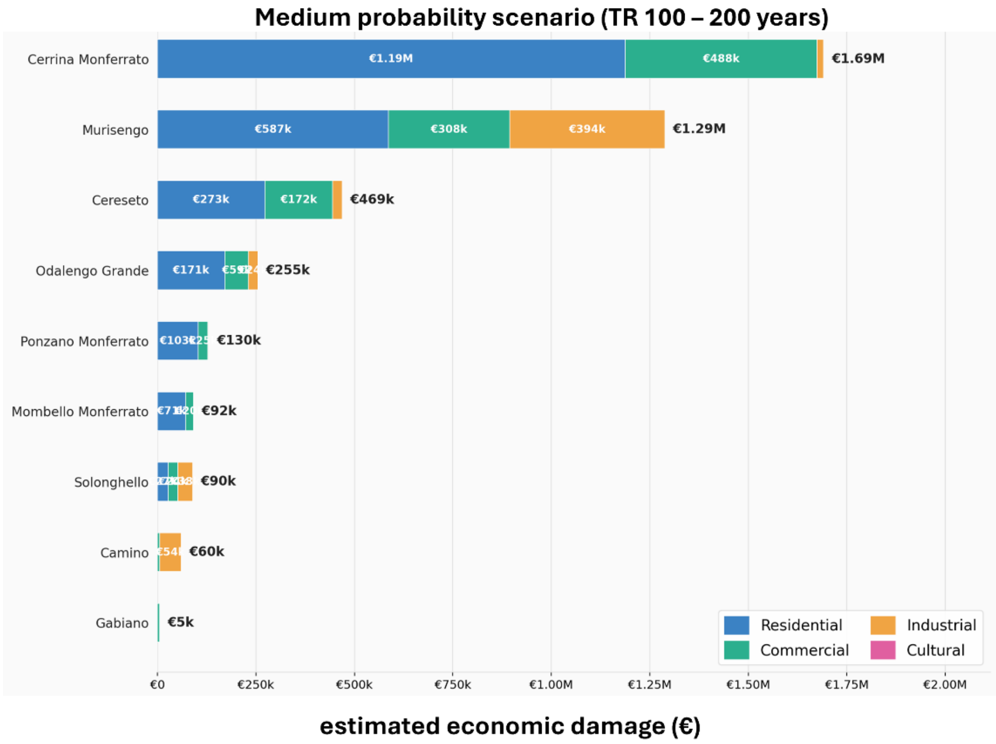


Figure 2-6: Municipality-level estimated economic damage associated with buildings under the medium probability scenario.

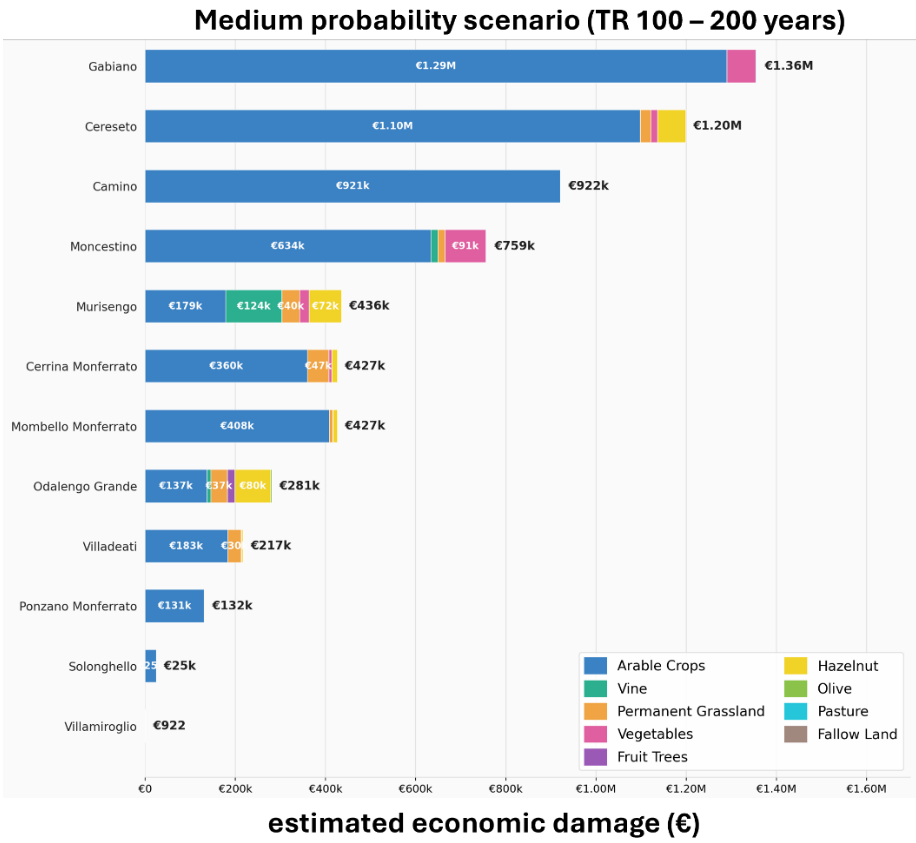


Figure 2-7: Municipality-level estimated economic damage associated with agricultural parcels under the medium probability scenario.

2.3.2 Hazard #3: Landslide

In line with the results of the risk screening step, the project developed a new workflow to assess landslide risk. Landslides are considered a key hazard in Valcerrina that has already caused extensive damage to agricultural lands, buildings and infrastructure. The damage assessment workflow used for river flooding was adapted to estimate the potential economic damage from landslides under different hazard scenarios.

Table 2-3: Data overview workflow #3

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
Aree Frane Piano Assetto Idrogeologico by Piedmont Region (map of landslide susceptaibility areas)[9]	-	Cadastral data for buildings and agricultural fields[8]	Estimated economic damage (€)

2.3.2.1 Hazard assessment

The hazard assessment relied on the map of areas prone to landslides compiled by the regional authority as part of the 2021 Hydrogeological Risk Plan[10]. The map provides the boundaries of areas susceptible to landslides based on geological and pedological characteristics and records of past events. It assigns a susceptibility level based on whether the landslide is active (very high hazard) or dormant (high hazard). As shown in Figure 2-9, very large portions of the UoM are exposed to landslide risk.

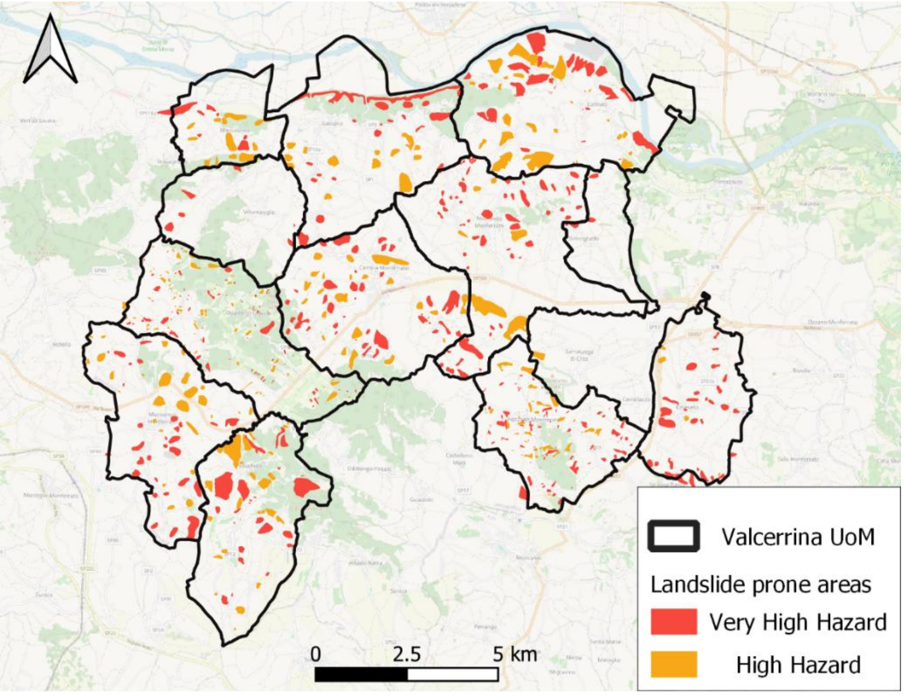


Figure 2-8: Landslide prone areas in Valcerrina UoM

[9] Available at https://www.geoportale.piemonte.it/geonetwork/srv/ita/catalog.search#/metadata/arlpa_to:07-04-01_f-D_2013-11-20:11.35

2.3.2.2 Risk assessment

The map of landslide-prone areas was combined with cadastral data for buildings and agricultural parcels to estimate the total exposed economic value. For buildings, a 20% overlap threshold between the landslide-prone areas and the building footprint was used, above which the total economic value of the property was considered exposed to landslide. For agricultural parcels, only the portion of the parcel intersected by the landslide-prone areas was considered exposed. The workflow then assumes that the exposed economic value is fully damaged in the case of a landslide, thus excluding vulnerability curves from the risk calculation. Figure 2-10 reports the estimated damage to buildings and agricultural parcels for the entire UoM. It highlights agriculture as the key impacted sector. Overall, the workflow does not generate new knowledge on the hazard, but it provides new insights into potential economic damage resulting from landslides. This information is currently not available in the MCPP.

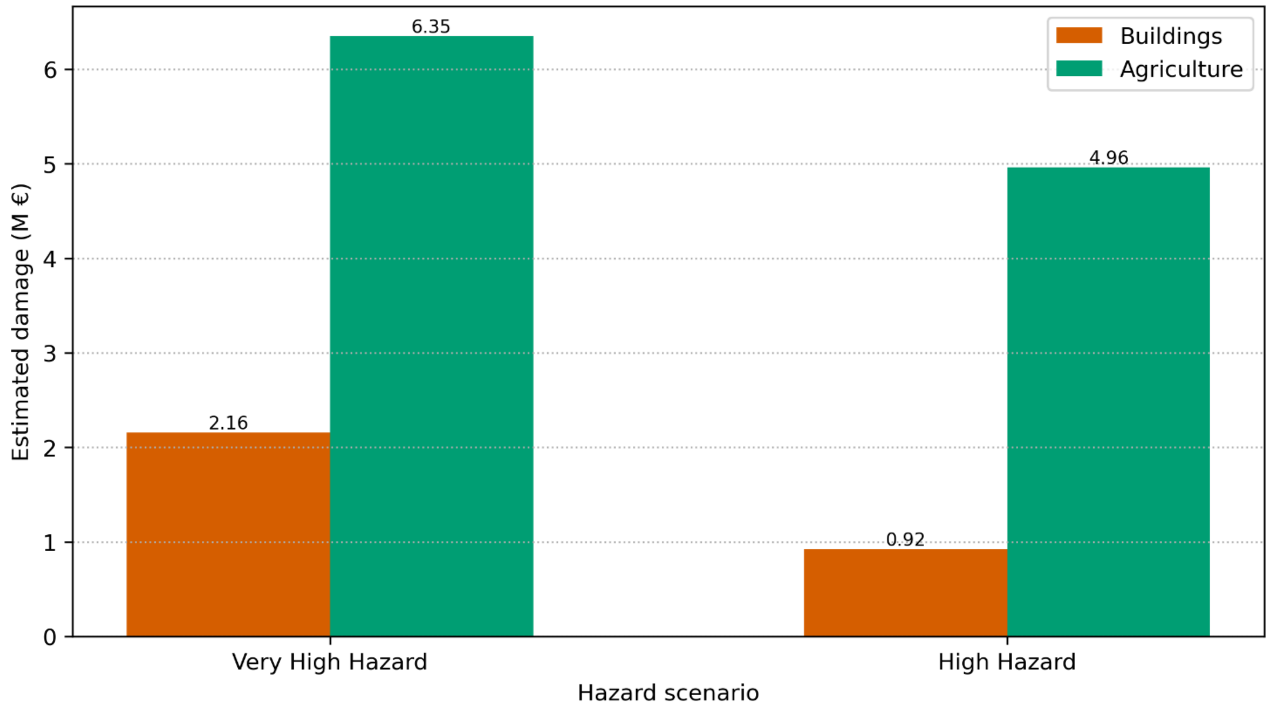


Figure 2-9: Estimated damage from landslide in Valcerrina for two levels of hazard: very high (active landslide) and high (dormient landslide)

2.3.3 Hazard #4: Wildfire risk

2.3.3.1 Comparing CLIMAAX results with the Regional Wildfire Risk Plan

The wildfire risk assessment undertook in Phase I produced the following insights:

- The spatial resolution of the risk output, driven by the 11x11km climate projection grid, is too low to appreciate spatial variation of the risk across the Valcerrina UoM (approx. 161km^2) and to identify hotspots
- The current wildfire risk is low, but a moderate increase may be expected in the near future because of the lengthening of the wildfire season

Given the low priority assigned to this risk during Phase I, no further risk analysis was undertaken in Phase II. However, a comparison was conducted between the results of the CRA against the risk assessment developed by the regional authority as part of the Regional Wildfire Risk Plan[10], last updated in 2024. The Plan outlines the activities to be implemented by the regional authority over the period 2021 – 2025 for the prediction, prevention and mitigation of wildfires. It includes a high-resolution risk assessment integrating weather scenarios, fuel models, forest characteristics, and simulation of wildfire propagation, Table 2-4. Despite the two approaches using different methods and data sources for hazard, vulnerability and exposure, they both converge on the level of risk currently experienced and expected in the near future (2050). Such analysis confirms the current low risk level of wildfire compared to other risks faced by the Valcerrina UoM but also a future lengthening of the favorable conditions for wildfires.

Table 2-4: Comparing methodology and results of the CIVAL Phase I and the Regional Wildfire Risk Plan approaches to wildfire risk assessment

Compared element	CLIMAAX approach	Regional Wildfire Risk Plan
Methodology and dataset used	*hazard* EURO-CORDEX Canadian Fire Weather Index (FWI) System dataset *vulnerability* European Wildfire Information System datasets: population at the wildland-urban interface, fraction of protected area, ecosystem irreplaceability index, population density, ecosystem restoration cost index *exposure* bare areas data from ESA-CCI Land Cover	*hazard - current* numerical simulations of wildfires based on high spatial resolution data on elevation, slope, fuel models maps tree canopy distribution, weather scenarios *hazard – future* projections of the Fire Weather Index using the COSMO-CLM model outputs *vulnerability* regional datasets on ecological and functional vulnerability: forest type characteristics, soil erosion, functional role of the forest (preservation, recreational, production) *exposure* included in hazard assessment as through fuel models map
Current risk	Low to moderate	Low to moderate
Future risk	By 2050: • increase by 25% of the FWI • increase between 25% and 50% of the wildfire season	By 2050: • increase by 15/16 days of the wildfire favorable conditions in the months of July and August

2.3.4 Integrating the CRA results into a WebGIS platform

A webGIS solution was developed to allow the UoM to visualise, analyse and validate the results of the fine-tuned CRA. It facilitates exploration of local risks and create awareness on risk hotspots. Such a GIS-based system is a novelty for the UoM, who mostly rely on paper documentation and

[10] Piano regionale per la programmazione delle attività di previsione, prevenzione e lotta attiva agli incendi boschivi 2021-2025 | Regione Piemonte

records. While the IMCPP approved by the UoM in 2025 contains spatial information on risks, it is published as a report and it does not include a tool for visualization and exploration. The webGIS solution contains two dashboards integrating the results of the drought and flood risk assessments with spatial information at the parcel and building level, **Error! Reference source not found.**.

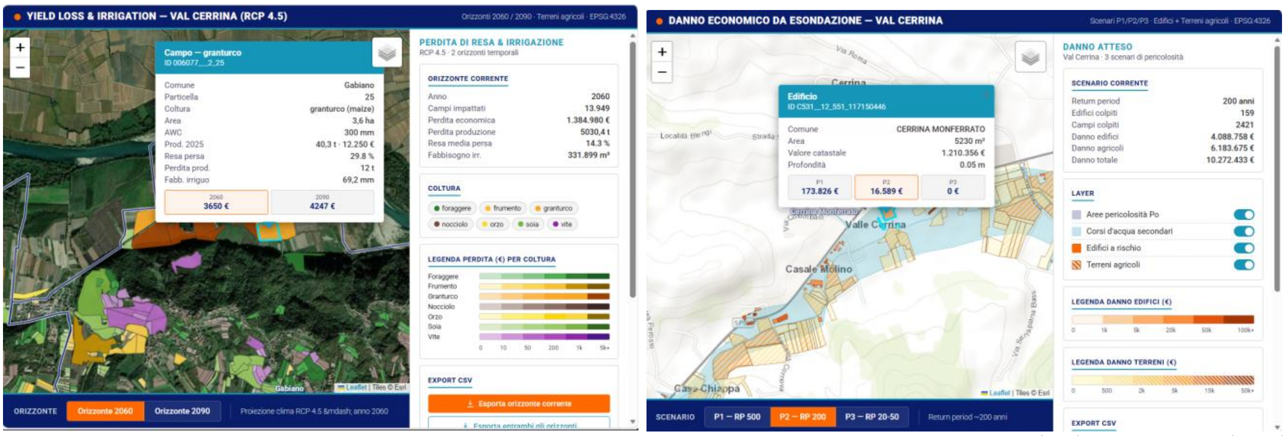


Figure 2-11: WebGIS dashboards for visualisation, exploration and validation of the fine-tuned CRA: (left) drought risk, (right) flood risk.

Two additional dashboards were integrated into the WebGIS solution to monitor drought and flooding events in Valcerrina. Both rely on satellite-based indicators developed and made publicly available by third-party organisations. The Vegetation Condition Index dataset from Eurac Research is used to monitor vegetation stress due to drought at a spatial resolution of approximately 250 m (Zellner and Castelli, 2022). The Normalised Difference Water Index dataset from the European Copernicus Data Space Ecosystem is used to monitor flooded areas along the River Po. The two dashboards are currently implemented as demos with time series of the indicators, rather than as real-time operational tools, to preliminarily assess their usability by the technical officers of the UoM. The further development of the monitoring dashboards will therefore be discussed in Phase III.

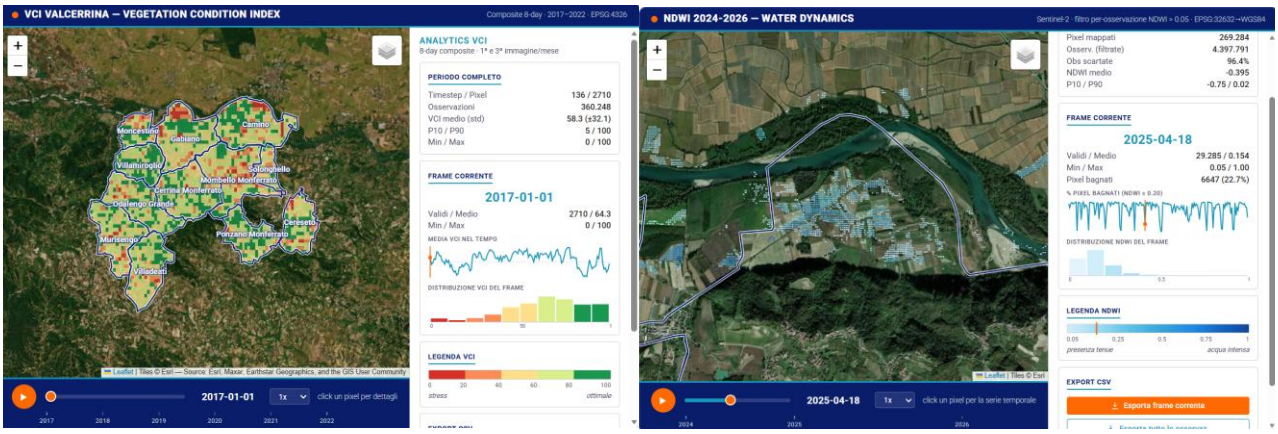


Figure 2-12: WebGIS dashboards to monitor drought (left) and floods (right).

The dashboards can be accessed online [CIVAL — Piattaforme Climatiche Val Cerrina](), and a demonstration video is included in SI-5.

2.4 Key Risk Assessment Findings

2.4.1 Mode of engagement for participation

The risk evaluation step was conducted through the engagement of local actors, including sectoral experts, the general public and the technical officers of the UoM. The results of the fine-tuned CRA and the WebGIS platforms were presented in an online meeting on 30/04/2026 and in an in-person meeting on 16/06/2026. Across the two meetings, over 40 stakeholders were exposed to the outputs of the CRA and more will be reached in Phase III as the WebGIS platforms are further distributed to all municipalities. In addition, during the event on 16/06/2026 sectoral experts presented their perspective on the impacts of climate change they are already experiencing and on adaptation measures that could be implemented. This provided further evidence for the risk evaluation step, which was discussed in plenary and through a written questionnaire. The quantitative results of the questionnaire combined with the qualitative information gathered through the discussion informed the risks prioritization in Section 2.4.6. Specific feedback on key risks was also gathered, and these are presented in Table 2-5.

Table 2-5: Feedback received from stakeholders on key aspects of the CRA in Valcerrina

Topic	Feedback
Flood risk	Information on the estimated economic damage at the municipality level help identify priority areas for intervention and plan investment. Yet, a further validation step on the property's economic value used in the assessment is required before the results are integrated in local plans. This step will be conducted by the technical officers of the UoM using the WebGIS platforms. In addition to buildings, it would be important to explore which transport infrastructure are potentially impacted by flooding events, since these are a key asset for emergency response. The assessment of the damage to agricultural fields represents a novelty compared to the information contained in the civil protection plans, which are focused on buildings and exposed population only. They shed light on the impact in a sector often underexplored in flood risk planning.
Drought risk	It is an emerging risk in Valcerrina for which the community is largely unprepared. There is agreement that maize, soybeans and forage are the most affected crops, but permanent crops such as hazelnut and grape are also already experiencing the impact of climate change. Yet their response to a changing climate is far more complex and goes beyond the impact of water scarcity on crop production. For instance, it was reported that the quality of wine has increased in recent decades as a consequence of a warmer climate, and that a more erratic alternation of warm and cold temperatures in early spring is having a detrimental impact on the flowering of fruit trees, including hazelnuts. Thus, while the drought risk assessment provides insights on water stress driven production loss, other climate-driven processes shall also be considered. The results emphasize the role that irrigation could play in mitigating the impact of water scarcity. Yet few are the water resources available for irrigation. It would

	therefore be insightful to estimate the total volume of water needed for irrigation and compare it with the available surface and groundwater resources.
Wildfire risk	The civil protection team of the UoM reports that the number of interventions for wildfires have decreased over the past two/three decades, confirming the low current severity and the effectiveness of prevention measures already in place. Yet, land abandonment and low level of forest management represent a local vulnerability that may lead to higher risk even if the hazard is expected to remain low to moderate.
Landslide risk	As shown in the landslide-prone areas map developed by the regional authority, a large portion of the UoM is exposed to landslides. Yet a knowledge gap was emphasised on the ability of pinpointing which specific areas are characterised by higher levels of hazard and which meteorological conditions trigger landslide movements. More research on land susceptibility and trigger conditions is deemed required.
Risks not assessed	One of the local experts participating to the event raised the attention on heatwaves that although are often associated with urban areas are becoming a concern also in rural areas, both in villages where very little green spaces are present as well as in agricultural fields where farmers may be exposed to very hot temperatures.

2.4.2 Gather output from Risk Analysis step

The main output used for the risk evaluation step was the estimated economic damage resulting from extreme climate events (drought, flooding, landslide) under different hazard scenarios. Damage data was generated and presented to local actors both at the asset level (i.e., building, agricultural field) through the WebGIS platforms to improve information sharing and validation, and at the municipal scale to inform planning across the Valcerrina UoM. Figure 2-10 compares, in a qualitative way, the magnitude of the damage resulting from different risks in each municipality. It gives a first level overview of how risk differs spatially across the UoM and how different risks compare to each other in economic terms. The data shown in Figure 2-10 were presented to local actors during the stakeholder meetings and through the Technical Briefs prepared at the end of Phase II (SI-4).

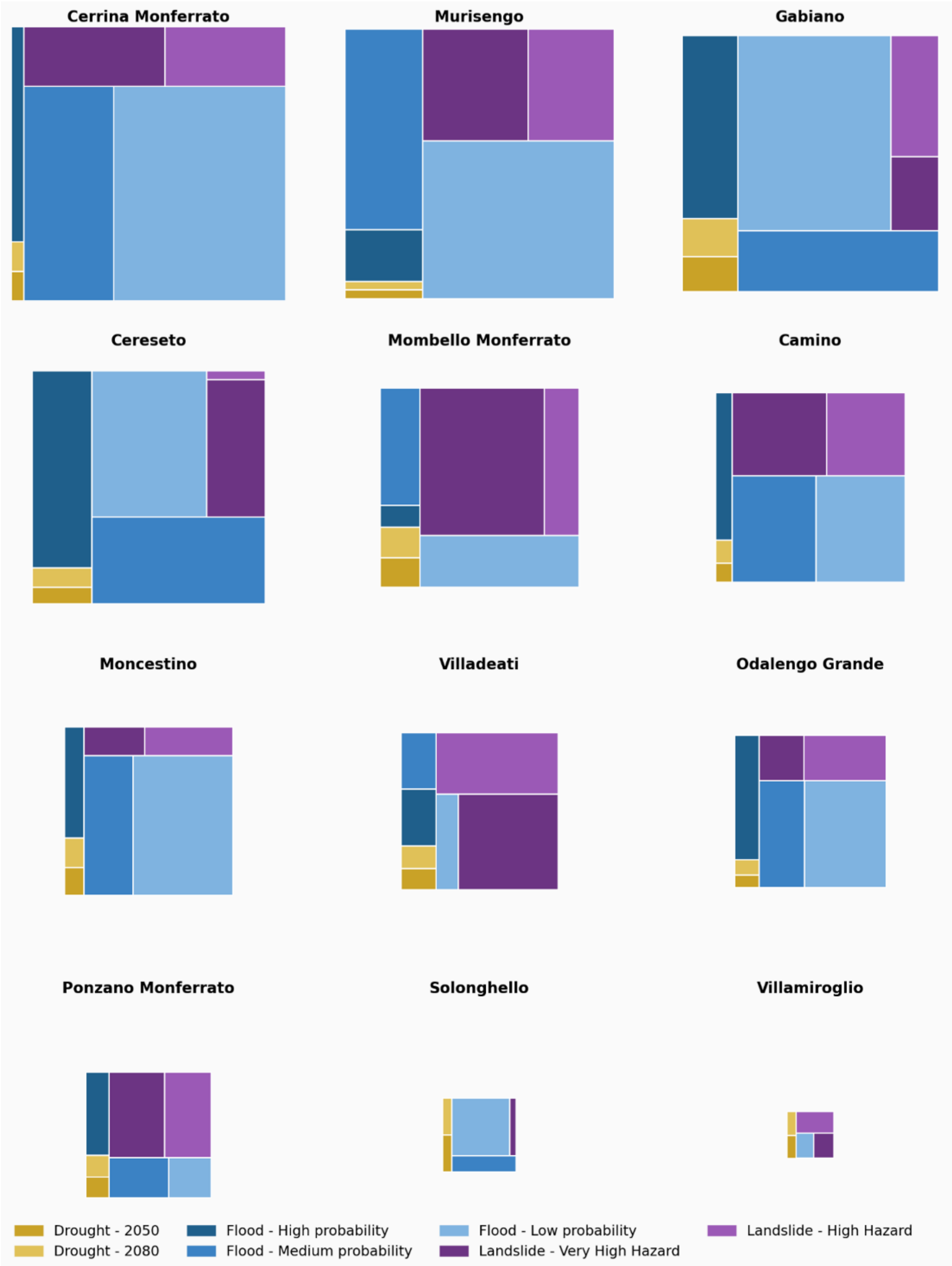


Figure 2-10: Comparison of economic damage across risks and municipalities in Valcerrina UoM. The size of the rectangles are proportional to the value of the economic damage. The economic damage from drought is an annual value, whereas the economic damage from flooding and landslide is event-based.

2.4.3 Assess Severity

The assessed climate risks in Valcerrina — river floods, drought, landslides and wildfire — vary in spatial extent and sectors of impact.

- **Flood risk.** The extension of the risk assessment to the secondary hydrographic network and the integration of local economic data provide new insights into flood risk in the Valcerrina UoM. While the municipalities along the northern boundary, Moncestino and Gabiano, have a large portion of the territory exposed to flooding along the river Po, the impact is mostly limited to the agricultural sector. The resulting economic damage is thus lower than the one experienced in municipalities affected by flooding from smaller watercourses, such as Cerrina Monferrato and Murisengo, where several industrial, commercial and residential assets are exposed. Results show that in high and medium probability events the impact to the agriculture sector is higher than the damage to buildings, emphasising the need to develop adaptation measures specific to the agri-food sector. The total estimated damage in Valcerrina for high, medium and low probability events is 4.54 mln €, 10.27 mln €, and 17.88 mln € respectively. **Moderate Severity**.

- **Drought risk.** Maize, soybeans and alfalfa are driving drought risk in Valcerrina, with an annual estimated revenue loss by 2050 of 237000€, 190000€, and 153000€ over the UoM. Permanent crops, such as hazelnut and grapes, are expected to experience lower production loss due to water scarcity but the risk will become substantial, especially towards 2080, because of their high economic value. The total revenue loss from the impact of drought in Valcerrina is expected to reach 900000€ by 2050. Furthermore, local experts emphasize that beyond drought-driven yield losses there are other processes through which a changing climate is already affecting crop production, including spread of diseases, damage from hail, heavy rainfall, late frost, hot temperatures, potentially resulting in higher revenue loss and uncertain income for farmers. **Substantial Severity**
- **Landslide risk.** It represents a significant risk in Valcerrina that can lead to substantial and irreversible damages to buildings and to the agriculture sector. An economic value of approx. 8.9 mln€ is exposed to a very high level of hazard because of the territory susceptibility to landslides. **Substantial Severity**.
- **Wildfire risk.** Wildfire currently poses a low hazard and is expected to intensify only moderately in the near future through a lengthening of the fire season. **Limited severity**

2.4.4 Assess Urgency

The urgency of each risk was evaluated considering the anticipated changes for the future, the timeliness of risk mitigation measures needed, and the time required to adapt to the risk.

- The climate change analysis undertaken in Phase I suggests that the magnitude of **flooding** along the Po River is not expected to change significantly in the future. However, the Po River Basin Authority emphasize in the latest Flood Risk Management Plan (2021) that there is a knowledge gap on the impact that climate change might have on the frequency and magnitude of extreme events. In parallel, several flood risk mitigation measures have been implemented in the last two decades throughout the basin, ultimately reducing exposure and risk. It is thus uncertain whether an increase in the flood river flows or in floods frequency would translate in a higher risk for population, buildings and agricultural fields in Valcerrina. From the analysis undertaken in Phase II it is clear that a large portion of the total economic damage originates from flooding of smaller watercourses affecting several residential, industrial and commercial buildings. In these areas more time and resources will be required for implementing flood risk mitigation measures (e.g., levee) or for relocating economic activities. In addition, the local civil protection team stated during the stakeholder workshop in June 2026 that the frequency of very short, very heavy rainfall events have increased over the last two decades, with more incidents of damage to infrastructure and properties. Along the secondary hydrographic network, heavy rainfall events can quickly lead to overtopping of watercourses and cause localised flooding. Overall**, more action is needed** in developing knowledge on the impact of climate change on the Po River flooding and on better assessing risk in relation to localised heavy-rainfall driven flooding along the secondary hydrographic network.
- Phase II confirms that **agricultural drought** is a substantial hazard requiring near-term but not urgent planning and adaptation, given its slow-onset nature and projected intensification over the next two / three decades. Local actors from the agri-food sector emphasize that drought conditions are already affecting crop production, but these are still limited to sporadic events (such as summer 2021, 2022). **More action is** therefore **needed** to increase preparedness of the local agricultural sector to more frequent and persistent water deficit conditions, requiring thus long-term adaptation measures rather than short-term emergency responses.
- The urgency of **wildfire risk** and **landslide risk** is set to **watching brief**. As reported by the local civil protection team, the frequency of wildfire has remained stable, if not decreased, over the recent past, and the analysis shows only a moderate increase by mid-century. Similarly, the susceptibility of the territory to landslides is not expected to change from the current scenario, but there remains a knowledge gap in understanding the impact of climate change on the meteorological and hydrogeological conditions that trigger land movements.

2.4.5 Understand Resilience Capacity

Valcerrina's ability to address climate risks is uneven across hazards:

- Flooding from the Po River is a well-studied hazard and risk management plans are updated regularly at the regional and River Po Basin Authority levels. The alert system and the activation of the civil protection services is also considered well established and functional. However, the robustness of the risk and disaster management system is limited when it comes to the flooding from smaller watercourses and the secondary hydrographic network. No detailed pluvial and fluvial flood modelling of the secondary network has been carried out recently and the civil protection team of the UoM points to the limited accuracy of the alert system to capture localised, very intense heavy rainfall that have a larger impact on small catchments than on the large Po River basin. Furthermore, the resilience of the agricultural sector, which is the most impacted sector, is limited due to low investments, profitability, low adoption of flood insurance mechanisms and lack of recovery plans. **Medium**

- The community is largely unprepared for droughts, an emerging risk for which no long-term regional or national plans have already been developed. The lack of water resources readily available in Valcerrina partly hinders the uptake of irrigation, which however may be increasingly needed in the future. **Low.**
- **Substantial** capacity to deal with wildfire risk is present at the regional and local level. The Regional Wildfire Risk Plan updated in 2024 generated strong knowledge on wildfire risks and it outlined a plan of adaptation measures to be implemented across the whole region. In Valcerrina, the civil protection team reports that interventions for wildfires have decreased over the recent past (10-15 years) thanks also to the preventive measures put in place locally.
- Valcerrina has long-standing experience with landslides, and as such it has developed capacity to recover from such events. However, the effectiveness of the alert system is limited due to the lack of detailed knowledge on landslide susceptibility and on the triggering meteorological conditions.

2.4.6 Decide on Risk Priority

Based on the integration of severity, urgency and capacity, the assessed climate risks were prioritized as presented in Figure 2-11. Drought is the risk with the highest priority considering that the local economy is heavily dependent on agriculture, the expected near-future impact of climate change on crop production is substantial and the lack of water and financial resources hinders the development of irrigation infrastructure. River flooding and landslides follow as moderate risk driven on one hand by the flooding hazard along the secondary hydrographic network and the limited alert capacity for short, localized heavy rainfall events, and on the other hand, by the high exposure to landslide-prone areas. Finally, wildfire has the lowest priority given the limited current and future severity and the resilience capacity already in place to prevent and mitigate it.

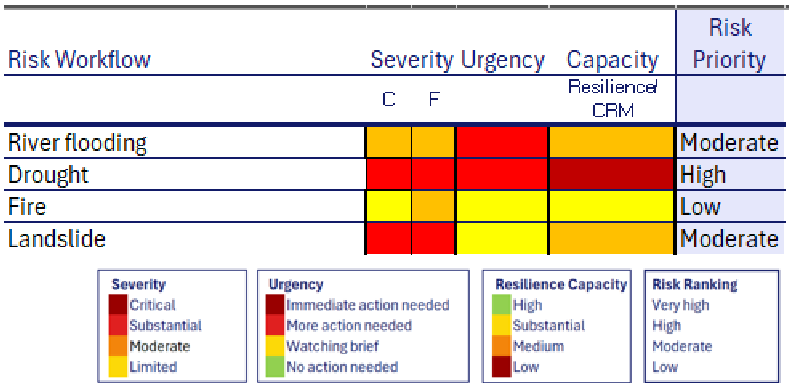


Figure 2-11: Phase II risk prioritization for Valcerrina UoM.

2.5 Monitoring and Evaluation

Added value and limitations of local data integration. Phase II highlighted both the strengths and the limitations of integrating local data and models into the CLIMAAX workflows. Overall, the experience confirms the added value of using local data, particularly in relation to the estimation of economic damage. The economic losses estimated for drought and flooding differ substantially from those obtained in Phase I and appear better aligned with the expectations of experts and decision makers in Valcerrina. These improvements provide local decision makers with more realistic estimates of the costs associated with climate change impacts, supporting more informed evaluation, prioritisation and investment planning.

At the same time, access to relevant local data was not always possible, which limited the extent to which some workflows could be fine-tuned. For example, the exposure and vulnerability data underpinning the wildfire risk assessment developed by the regional authority are not publicly available. This prevented their integration with the hazard data derived from the CLIMAAX workflow. However, the overall effect of this limitation on the project is considered limited, as wildfire is regarded by local actors as a low-priority risk. In other cases, available local data required additional processing before they could be integrated into the workflows. This was the case for flood depths along smaller watercourses and the secondary hydrographic network, which had to be derived from flood extent data before being used in the damage assessment workflow.

Strategic uptake of CRA results. Phase II also clarified the strategic outcomes that the CRA should support and opened a discussion on how the project results and tools can be used by the UoM. This topic was addressed during the stakeholder meeting in June 2026, where local actors provided initial ideas that will guide the implementation of Phase III. Two main pathways for local uptake emerged:

- **Training, education and awareness raising.** CRA results and the WebGIS platforms can be used to strengthen knowledge of local climate risks. For example, the head of the UoM civil protection team proposed sharing the platform with volunteers to improve their understanding of local risk hotspots. The three environmental organisations involved in the Climate Fresk workshop also expressed interest in using both the workshop methodology and the CRA results to further develop climate awareness in Valcerrina.
- **Advocacy and mobilisation of investment.** The evidence generated by the project can support dialogue with higher governance levels, including the regional authority, and help advocate for investment in adaptation measures. Through the CIVAL project, the Valcerrina UoM demonstrates how a bottom-up approach to climate risk assessment can generate locally relevant evidence on the costs of climate change impacts. This is particularly important for drought, where local capacity to manage the risk remains limited.

By contrast, integrating the CRA results into local civil protection plans is currently considered a less immediate priority. The plans were updated and formally approved in 2025, before the results of the fine-tuned CRA were available. This option may therefore be revisited in future planning cycles, once the results have been further validated and discussed with local authorities.

Remaining knowledge gaps. Local actors highlighted several knowledge gaps that should be addressed in future work. The most important relate to the potential impact of climate change on the frequency of flood events and to the interaction between pluvial and river flooding in compound-risk situations affecting the secondary hydrographic network. Further research is needed to understand the meteorological and hydrological mechanisms that drive these compound flood events and to develop warning systems for short-duration, high-intensity rainfall. In addition, further analysis of landslide susceptibility and triggering conditions could improve the evidence base for urban planning and risk reduction.

2.6 Work plan Phase 3

Phase III (July 2026 – December 2027) will consolidate the results of the fine-tuned CRA and work towards their strategic uptake in local decision-making processes. Table 2-6 lists the activities to be conducted in Phase III across the main dimensions of the project.

Table 2-6: Planned activities in Phase III

Topic	Planned Activities in Phase III
Flood risk	The focus in Phase III will be on the dissemination and validation of the fine-tuned CRA results. This process has been already started at the end of Phase II by the mayors and technical officers of the 12 municipalities. They are using the WebGIS platforms to explore the estimated economic damage and compare it against the information already available in local urban development and civil protection plans. The integration of the CRA in future updates of these plans will be further explored through dedicated meetings with the mayors. The river floods workflow (discharges) will be tested to evaluate the impact of climate change on the frequency and magnitude of flood events along the Po River. This knowledge gap became evident during Phase II. However, two limitations have already been identified when attempting to implement the workflow in Phase II: the lack of local river flow data over the period 1995–2005 for validation and the fact that the workflow is limited to low return periods of up to 50 years, while flood risk in Valcerrina is mostly associated with lower-probability events. Building on the discussion held with the UoM civil protection team during the workshop in June 2026, an attempt will be made to gather additional local data on the occurrence and impact of compound pluvial/fluvial flood events along the secondary hydrographic network. This will stimulate discussion on possible adaptation measures and may prompt the implementation of the CLIMAAX heavy rainfall workflow if sufficient data are available for local validation. Lastly, the webGIS platform will be used jointly with the technical officers of the UoM to identify key areas of risks and develop possible risk mitigation measures.
Drought risk	The agricultural drought risk analysis is considered complete. Effort in Phase III will thus focus on developing adaptation measures and testing their impact on the assessed risk. As a first step, the drought risk workflow will be modified to calculate the seasonal irrigation requirement (mm) and combined with the local cropping pattern to estimate irrigation volumes. Secondly, a water availability assessment for the Valcerrina UoM will be conducted to identify which water resources could potentially be mobilised for irrigation. This may include a high-level site suitability analysis for the development of small hill reservoirs, which are deemed one of the few options available locally to enable irrigation. Finally, a quick cost-benefit analysis will be performed to compare revenue loss due to drought against the investment cost for irrigation. Other agricultural adaptation measures, such as changing cropping patterns and anticipating sowing dates, will be explored.
Wildfire and landslide risk	No further risk analysis is expected to be undertaken in Phase III unless new local data on hazard, exposure and vulnerability become available. To create further knowledge on landslide risk, the landslide susceptibility map used in the hazard assessment will be compared with the ground motion dataset made available by the European Copernicus Land Monitoring Service European Ground Motion Service — Copernicus Land Monitoring Service and with local records of landslides. Even

	though such analysis will not feed into the risk assessment outputs, it may help generate a better understanding of landslide hazard in Valcerrina.
Integrated climate risks solution	A multi-risk index will be developed at the municipality scale integrating the results of the CRA with socio-economic characteristics derived from the ISTAT social and material vulnerability index. The index will then be included in the WebGIS platform. Further development of the platform is planned to enable the visualisation of the impact of adaptation measures, such as irrigation, on the risks. The interface and functionalities of the WebGIS dashboards will be validated with target users and enriched with additional layers as required to meet local information needs.
Stakeholder involvement	Engagement of local experts and decision makers will be continued through tailored meetings to validate the results of the fine-tuned CRA, collect additional data and develop adaptation measures. Furthermore, the results of Phase II will be used to start the consultation with provincial and regional authorities aimed at presenting the outcomes of the CIVAL project and fostering synergies with their ongoing climate adaptation initiatives.

3 Conclusions Phase 2- Climate risk assessment

Phase II of the CIVAL project set out to generate climate risk information more closely aligned with local needs and priorities, to raise awareness of climate change impacts and initiate discussion on adaptation, and to explore how the fine-tuned climate risk assessment (CRA) could feed into local decision-making. This phase delivered on the first two objectives and laid the groundwork for the third, which will be pursued in Phase III. By integrating local hazard, exposure and vulnerability data into the standard CLIMAAX workflows, Phase II produced an economically grounded, multi-hazard assessment for the Valcerrina UoM and demonstrated how a bottom-up approach can complement the top-down planning instruments operating at regional and national level.

Key findings. The assessment confirmed and quantified four hazards and supported their prioritisation:

- **Drought** is the highest-priority risk for Valcerrina. The local economy depends heavily on agriculture, near-future impacts on crop production are substantial, and the capacity to respond is low given the scarcity of water and financial resources for irrigation. Estimated annual revenue loss reaches approximately €900,000 by 2050, driven mainly by maize, soybeans and alfalfa, with high-value permanent crops such as hazelnut and grape becoming substantial contributors towards 2080.
- **River flooding** is a moderate-priority risk. Extending the assessment to the secondary hydrographic network revealed that most economic damage arises not from the Po River — where impacts are largely agricultural — but from smaller watercourses affecting residential, industrial and commercial assets in municipalities such as Cerrina Monferrato and Murisengo. Estimated total damage is €4.54m, €10.27m and €17.88m for high-, medium- and low-probability events.
- **Landslides** are a moderate-priority risk, with about €8.9m of economic value exposed to very high hazard, predominantly affecting agriculture.
- **Wildfire** is the lowest-priority risk; the CLIMAAX results and the Regional Wildfire Risk Plan converge on a currently low hazard expected to increase only moderately by mid-century.

Challenges addressed. Phase II resolved several gaps identified in Phase I. The integration of local economic data produced realistic, asset-level estimates of expected damage that were previously unavailable at municipal level, with flood damage estimates roughly an order of magnitude lower than in Phase I and far better aligned with stakeholder expectations. The drought assessment gained spatial detail and local crop relevance, a dedicated landslide damage workflow was created, and the comparison of CLIMAAX and regional approaches to wildfire added confidence through methodological redundancy. The results were made explorable and verifiable through an interactive WebGIS platform — a novelty for the UoM — and were evaluated with more than 40 local actors, experts and technical officers, strengthening both awareness and the legitimacy of the outputs.

Challenges not fully addressed. The integration of the CRA results into formal policy and planning processes remains the principal open challenge. The Inter-Municipal Civil Protection Plan was approved in 2025, before the fine-tuned results were available, and local planning follows well-established regional timelines and standards; embedding the results therefore requires not only technical rigour but also political coordination and further validation of the assessment's authority. Data access also constrained the work: the exposure and vulnerability datasets underpinning the regional wildfire assessment are not public, and flood data for the secondary network required processing before use. Finally, several knowledge gaps remain open, notably the influence of climate change on the frequency of flood events, compound pluvial–fluvial flooding along the secondary network, the susceptibility and meteorological triggers of landslides, and the emerging concern of heatwaves in rural areas, which was raised by stakeholders but not assessed.

Overall conclusion. Phase II confirms the added value of combining state-of-the-art CLIMAAX workflows with local data to generate locally relevant, economically meaningful risk evidence, while also exposing the practical limits of data availability and institutional uptake. Beyond Valcerrina, the experience offers a transferable model for small, rural local authorities seeking to complement regional adaptation and civil protection strategies with bottom-up evidence. Phase III will build on these foundations by consolidating and validating the results, co-developing and testing adaptation measures — particularly irrigation options for drought — developing an integrated multi-risk index, and advancing the dialogue with local, provincial and regional authorities needed to translate the evidence into action.

4 Progress evaluation

Table 4-1: Overview key performance indicators

Key performance indicators	*Progress*
2 Policy Briefs produced for Local, Regional, and National decision-makers	**Achieved** 1 brief on Drought Risk in Valcerrina + 1 brief on Flood Risk in Valcerrina. See Annex SI-4: Briefs for stakeholders in the Zenodo folder Rather than Policy Briefs two briefs on the results of the fine-tuned CRA were prepared. Policy-relevant outcomes will be developed in Phase III as adaptation measures are developed.
1 WebGIS operational platform	**Achieved** CIVAL — Piattaforme Climatiche Val Cerrina integrating 4 dashboard
20 Communication actions	**Exceeded** 30+ communication actions in Phase I and II. Refer to SI-4 in Deliverable I and II for a list of communication outputs.
4 Workshops & Training Sessions	**Achieved** 1 workshop already implemented at the end of Phase I – See Deliverable Phase I 1 interactive scientific workshop on climate change with three local environmental organizations (Legambiente, Madre Selva, Parco del Po Piemontese)

Key performance indicators	*Progress*
	1 technical meeting with Valcerrina UoM on 29/04/2026 for presentation of results and WebGIS platforms 1 workshop with experts, citizens and mayors of Valcerrina UoM on 16/06/2026 for presentation of results and risk evaluation

Table 4-2: Overview milestones

Milestones	*Progress*
M2.1 Local datasets ready	**Achieved**
M2.2 Floods, Droughts, Fires workflow implemented for Phase 2	**Achieved** Drought risk workflow fine-tuned with local datasets on hazard, exposure and vulnerability. Flood risk workflow fine-tuned with local datasets on hazard and economic exposure. New landslide risk workflow developed, integrating local data on landslide susceptibility and economic exposure. Forest fire workflow not further developed, but its results compared against the wildfire risk assessment undertaken by the regional authority.
M2.3 Solution tested ready for scenario exploitation	**Achieved** WebGIS platform implemented: CIVAL – Piattaforme Climatiche Val Cerrina, integrating 4 dashboards

5 Supporting documentation

The following outputs have been produced during Phase II of the CIVAL project:

- CIVAL Project - Main Report – Deliverable Phase II (pdf)
- SI-1: Annexes to the Main Report (pdf)
- SI-2: Stakeholders workshops (pdf)
- SI-3: List of communication outputs (pdf)
- SI-4: Briefs for stakeholders (pdf)
- SI-5: Demonstration video of the WebGIS platform (mp4)
- SI-6: Handbook workflow codes and outputs (zip folder)
    - Flood Risk
    - Drought Risk
    - Landslide Risk

6 References

Zellner, P., & Castelli, M. (2022). Vegetation Health Index - 231 m 8 days (Version 1.0) [Data set]. Eurac Research. https://doi.org/10.48784/161b3496-534a-11ec-b78a-02000a08f41d