Deliverable Phase 2 – Climate risk assessment

KÉZDI_Adapt

Romania/ Municipality of Târgu Secuiesc

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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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Document Information

Deliverable Title	Phase 2 – Climate risk assessment
Brief Description	The document presents a Hazard and Risk workflow for agricultural drought and rivel floods, on micro-regional level of Targu Secuiesc municipality and Covasna County. The CRA CLIMAAX unified methodology was applied using common and finetunned local context information's, this report analyses different crop yield and revenue losses, damage and vulnerability curves data due to drought and river flooding at different RCP scenario's. The Phase 2 results highlight the local aspects of hazard and risk with downscaled variables which can support to develop regional/local risk assessment strategies.
Project name	Developing climate and emergency risk management strategy using state of the art benchmark for Târgu Secuiesc municipality to increase regional climate resilience (KÉZDI_Adapt)
Country	Romania
Region/Municipality	Târgu Secuiesc, Covasna County
Leading Institution	Municipality of Târgu Secuiesc
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2.0	…	CLIMAAX's FSTP team	Review completed
5.0	…		Final version to be submitted

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5. Abbreviations and acronyms

Abbreviation / acronym	Description
APIA	Agricultural Payments and Intervention Agency
AWC	Soil Available Water Capacity
Bbox	Bounding box
CLIMAAX	CLIMate risk and vulnerability Assessment framework and toolboX
CRA	Climate Risk Assessment
CWB	Climatic Water Balance
ET_0	Reference Evapotranspiration
GCM	Global Climate Model
GIS	Geographic Information System
ISU	Inspectorate for Emergency Situations
IUDS	Integrated Urban Development Strategy
KPI	Key performance indicators
Ky	Yield response factor
LGP	Length period
MIP4Adapt	The Mission Implementation Platform (MIP4Adapt)
NRRP	National Plan for Recovery and Resilience
NUTS	Nomenclature of Territorial Units for Statistics
OER	Energy Cities Association
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
RMP	Risk assessment and management plan
SECAP	Sustainable Energy and Climate Action Plan
SGA	National Administration Romanian Waters

6. Executive summary

The KÉZDI_Adapt risk evaluation applied a structured and quantitative methodology to assess, compare, and prioritize climate risks affecting agriculture and settlements in Covasna County, with a specific focus on Târgu Secuiesc. The assessment followed the CLIMAAX Risk Evaluation protocol and combined climate modelling, agricultural and hydrological analysis, economic valuation, GIS-based spatial assessment, and stakeholder validation to ensure robust, transparent, and policy-relevant outcomes.

Agricultural drought emerged as the most severe and structurally embedded climate risk in the study area. Climate trend analysis shows a consistent increase in temperature and reference evapotranspiration (ET_0) across all analyzed scenarios, while precipitation displays high interannual variability without a compensating long-term increase. Consequently, Climatic Water Balance values remain negative across all time periods and RCP scenarios, confirming persistent and intensifying water stress even in a relatively cooler and wetter region such as Covasna County.

Crop yield loss assessments for near-future and mid-century periods under RCP 4.5 and RCP 8.5 demonstrate pronounced crop-specific sensitivity:

- Maize consistently exhibits the highest yield losses across all spatial scales and scenarios.
- Potato shows the second-highest vulnerability, particularly under near-future conditions with intensified growing-season water deficits.
- Wheat generally records lower losses at regional scale, but local farmland-scale analyses reveal increased sensitivity, highlighting the importance of downscaling.
- Rapeseed displays moderate but spatially heterogeneous responses.

Spatial resolution proved critical, large-scale domains (Bbox, NUTS) systematically amplified average yield-loss estimates due to spatial aggregation, whereas Covasna County farmland–scale analyses reduced extreme losses for maize and potato while highlighting some masked vulnerabilities for wheat and rapeseed, providing more actionable results on local scale.

Economic impact assessments confirm that biophysical drought impacts generate substantial financial losses in the absence of irrigation infrastructure:

- Near-future (2026-2030) revenue losses under RCP 4.5 exceed €1.38 million, with maize contributing the largest share:
- Mid-century (2046-2050) projections indicate stabilization or partial reduction of losses for some crops (most notably wheat) indicating limited adaptive potential under moderate warming, while maize remains the dominant economic risk;
- Revenue loss patterns closely mirror yield-loss dynamics, reinforcing the prioritization of studied crops (maize, wheat,, potato, rapeseed) in adaptation planning.

Stakeholder input and agricultural authority datasets corroborate these findings, emphasizing cumulative and often underreported impacts such as soil degradation, farm abandonment, reduced investment capacity, and increasing disparities between large and small farms. Agricultural drought is therefore confirmed as a structural, long-term risk rather than an episodic event.

River flooding risk was assessed using flood extent shapefiles for the Cașin and Râul Negru rivers, flood hazard raster maps, land-use data, vulnerability curves, and updated GDP-based economic values (Romania, World Bank, 2024), with scenario-based analyses for RCP 4.5 and RCP 8.5.

Key results indicate that:

- Flood risk in Târgu Secuiesc is currently moderate, but locally severe impacts occur during extreme rainfall events, particularly where flood extents overlap with built-up and high-value land uses;
- The availability of detailed spatial flood hazard data significantly improved exposure and damage assessments;
- Estimated flood damages reach several million euros when aggregated across affected land-use categories, with residential areas, infrastructure, and agricultural land representing the highest economic exposure.

Although technical assessments suggest that flood risk is manageable through structural protection measures, drainage improvements, early warning systems, and spatial planning, stakeholder consultations highlight constraints related to funding availability, institutional capacity, and competing municipal priorities. Repeated flood events substantially increase perceived severity and recovery challenges.

Risk prioritization was carried out using a dashboard-based evaluation of severity, urgency, and adaptive capacity, supported by quantitative CLIMAAX workflow results and refined through stakeholder engagement involving local authorities, farmers, and sectoral institutions.

- Agricultural drought was classified as a High Priority risk, reflecting substantional severity and more action needed urgency combined with medium adaptive capacity, particularly due to the absence of irrigation infrastructure.
- River flooding was also classified as a High Priority risk, driven by moderate severity and more action needed urgency, and low resilience capacity.

This transparent and participatory process ensures full alignment with the CLIMAAX methodology and provides a clear, evidence-based rationale for directing adaptation resources to the most critical climate risks.

Fine-tuned, local-scale workflows produce more realistic yield, revenue, and damage estimates and directly support targeted adaptation planning. Despite data and capacity constraints, the assessment strengthened institutional understanding, produced quantified evidence of current and future risks, and established a solid foundation for climate resilience planning in Covasna County.

In Phase 3, the project will work closely with relevant institutes and key local stakeholders to develop, on the basis of fine-tuned local data, a dedicated adaptation strategy and improved risk management plans. These will directly build on the findings and results of the current research and will support more precise identification and understanding of the specific local risk drivers affecting the most critical community systems in the area.

In parallel, the project aims to formally present the technical documentation and scientific results to national-level policymakers, ensuring that robust scientific evidence is explicitly considered in policy processes. By bridging the gap between research and policy, this approach will enable the uptake of scientifically grounded results at the political level and contribute to the development of well-founded, effective, and transparent public policies for climate risk management and adaptation.

1 Introduction

1.1 Background

Târgu Secuiesc Municipality is a micro-regional economic center (agriculture, textile industry, tourism) with a population of 18000, since 2021 the towns' important objective is to enhance adaptation aspects to climate consequences having a climate resilience urban area, providing sustainable economy growth and livelihood for citizens. The municipality already put effort on projects, initiatives focusing on climate effect and resilience such as: (i). developing the Integrated Urban Development Strategy (IUDS) in a teamwork with the World Bank and Ministry of Development experts; (ii). having the Sustainable Energy and Climate Action Plan (SECAP); (iii.) is charter signature of EU missions' adaptation to climate change. All our actions, experience prove that climate change adaptive capacity enhancement is important for the administration, therefore an inclusive and harmonized regional climate risk strategy without assumption will be the main pillar of climate resilient urban development.

The Integrated Urban Development Strategy (IUDS) points out some climate risk challenges affecting negatively forest and agricultural biomass, vulnerability to flooding, and the fact that there is a significant average temperature increase of 1.8°C (compared to 1960-2000 dataset) suggesting the need for a proactive climate risk management strategy implementation. In the Sustainable Energy and Climate Action Plan (SECAP) are identified the major climate risks for our town and extreme heatwaves, extreme cold, droughts events are classified into emergency scale regarding intensity and frequency. From the listed 19 climate adaptation actions highlighted in SECAP, 5 actions explicitly refer to the significance to have a multiple climate risk assessment tool and the other adaptations actions directly and indirectly could be implemented based on CRAs results.

Targu Secuiesc has a total area of 42.86 km^2 from which 8.7 km^2 (20%) is urban constructed area i.e. settlements, 27.55 km^2 farmland used in crop production (64%) and 6.61 km2 (15%) pasture utilized in livestock sector. Thus 79% of the total area of the administrative unit is accounted for the agriculture sector having a significant impact on our society in many ways i.e. supports livelihoods through food, habitat, and jobs; provides raw materials for food and other products; and builds strong economies through trade, all these aspects are heavily depended on climate risk management and adaptation measures.

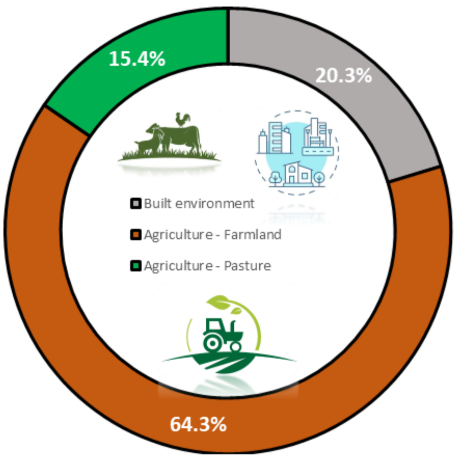

Figure 1- 1 Targu Secuiesc Municipality area division

The livelihood of the population is located on 20% of the total administrative area, which can be directly affected by the major climate risks and not only. Local scale scenarios are requiring urban-relevant climate projections where alongside environmental hazard the socioeconomic impact can be assessed.

Some of the major climate-related risks that are considered to carry out using different workflows are:

- Agricultura Drought – affecting agriculture, economic parameters i.e. 'lost opportunity cost" for crops grown under non-irrigated conditions;
- River floods – flood damages, flood inundation map, damage curves etc.

Local governments and communities, who are most affected by droughts and floods, should be empowered with CRA results to make decisions on irrigation systems, land use, and disaster preparedness based on localized conditions. Main stakeholders and beneficiaries who were involved in Phase 2 are: County Inspectorate for Emergency Situations, National Agency for Protected Natural Areas, Regional unit of the National Administration "Romanian Waters", Non-governmental Organizations (Energy Cities, AgroSic), Farmers, Local authorities, Scientific community (Academia) and other key community systems who are directly related to climate change (e.g. health and social care systems, critical infrastructure, water supply, landscape productivity and ecosystem health).

1.2 Main objectives of the project

Agricultural drought and river flood workflow results could play a crucial role in shaping effective policies and decision-making strategies in several areas, such as agriculture, water management, disaster preparedness, environmental conservation, and economic resilience on local and micro regional level i.e. Targu Secuiesc Municipality and Covasna County.

With agricultural drought Phase 2 results policymakers can use the outcomes to trigger early warning systems, informing/alerting farmers, and other stakeholders to take preventive actions like adjusting planting schedules, conserving water resources and implement sustainable irrigation system investment projects. Also, Agricultural Hazard Drought data can be used to predict crop losses, allowing for early interventions such as crop insurance payouts or subsidies to assist affected farmers.

Data generated in Phase 2 on river flow levels, and floodplain mapping can be used to predict when and where flooding is likely to occur. Policymakers can issue flood alerts, evacuations, and manage floodplain developments more effectively. Data on river flooding can guide regulatory frameworks on local level for floodplain zoning, land development in flood-prone areas, and the management of construction practices to minimize flood damage.

Climate risk assessments rely on accurate data about historical climate patterns, future climate projections, and sector-specific vulnerabilities (e.g., agriculture, water resources). However, limitations can be identified, data may be incomplete, outdated, inaccurate (e.g., irrigation system updated database, detailed cop planting strategy information on local level, microclimates), low spatial and temporal resolution as regional or local variations might not be fully captured by global models, affecting the precision of assessments for specific areas.

1.3 Project team

The head of team has a professional experience in environmental engineering, academia and consultancy reflecting his know-how in environmental protection and climate change topics (publications), as deputy mayor he initiated SECAP, the enrolment to MIP4ADAPT Charta etc. proves that climate risk adaptation and resilience is priority for the Municipality. All team members during

Phase 1 of the project are internal members of the Municipality, they are working in different departments (Civil protection, Urban planning, Project management, Communication) and their expertise and attributes helped to achieve the Milestones and Deliverable 1.

Table 1- 1 CLIMAAX KÉZDI_Adapt team

Bokor Tiberiu	City Mayor	Legal representant
Szilveszter Szabolcs (PhD)	Project leader, Head of the team Deputy Mayor	Agricultural drought, river flood workflow, dissemination of results, workshop presentations, local tv, radio and newspaper.
Paizs Gabor	Financial management	Maintaining and analyzing financial records
Bartha Zsuzsa, Rettegi Csenge	Project management	Monitoring spending, preparing reports
Miklos Arpad	Civil protection department	River flood workflow, dissemination of results
Olah Judit	Urban planning department	Data management, dissemination of results
Bartos Ménessy Kinga, Gajdó Szende	Communication department Disemination of results, communication	Writing press releases, manage social media and coordinate with media outlets, workshop organization, contracting

1.4 Outline of the document's structure

The Deliverable 2 document is organized in a logical, comprehensive, and structured format elaborated to clearly disseminate the finding of Phase2 CLIMAAX KÉZDI_adapt project. The **Executive Summary** presents the objectives, methods, and main findings of the deliverable, through **Introduction** part the reader will understand the background, goals and the project team working on the hazard and risk studies. The following chapter **Climate risk assessment - phase 2** details the scoping, objectives the main context, risk identification, hazard assessment, vulnerability all the main CRA building block of the project using local finetuned data. Key findings are presented in the **Conclusion** section of the document, where all the relevant obtained information is summarized from Phase 2 of CLIMAAX. The key performance indicators are presented in **Progress evaluation** chapter, in the **Supporting documentation** and **References** part all relevant outputs of Phase 2 are listed and citated document list respectively.

2 Climate risk assessment – phase 2

2.1 Scoping

2.1.1 Objectives

Agricultural drought and river flood workflow results could play a crucial role in shaping effective policies and decision-making strategies in several areas, such as agriculture, water management, disaster preparedness, environmental conservation, and economic resilience on local and micro regional level for Targu Secuiesc Municipality and Covasna County.

With agricultural Drought CRA results policymakers can use the outcomes to trigger early warning systems, informing/alerting farmers, and other stakeholders to take preventive actions like adjusting planting schedules, conserving water resources and implement sustainable irrigation system investment projects. Also, Agricultural Hazard Drought data calculates crop yield losses, allowing for early interventions such as crop rotation strategies, crop insurance payouts, or subsidies to assist affected farmers.

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Climate risk assessments rely on accurate data about historical climate patterns, future climate projections, and sector-specific vulnerabilities (e.g., agriculture, water resources). However limitations can be identified, data may be incomplete, outdated, inaccurate (e.g., irrigation system updated database, detailed cop planting strategy information on local level, microclimates), low spatial and temporal resolution as regional or local variations might not be fully captured by global models, affecting the precision of assessments for specific areas.

2.1.2 Context

Romania faces significant risks from natural hazards, including floods, droughts, and other extreme weather events. Between 1970 and 2021, the country experienced 90 disasters, resulting in $6.2 billion in damages and affecting over 2 million people. Projections indicate that extreme events could increase sixfold by 2080, to address these growing challenges, Romania with World Bank support (WorldBank, 2023) has committed to build resilience and strengthen its institutional, social and financial resilience through several instruments such as the recently approved Disaster Risk Management Loan with a Catastrophe Deferred Drawdown Option (CaTDDO) (GFDRR, 2024).

In 2024, Romania approved the National Strategy on Adaptation to Climate Change for 2024–2030, with a perspective towards 2050. This strategy aims to enhance the country's resilience to climate variability by improving adaptive capacity across sectors such as agriculture, water management, health, and infrastructure. It emphasizes the importance of forecasting, early warning systems, and integrating climate considerations into sectoral planning (Issuemonitoring, 2024).

The strategy outlines several key objectives aimed at enhancing Romania's resilience to climate change (Issuemonitoring, 2024).

- Strengthening Resilience: fortifying critical infrastructure, natural ecosystems, and socio-economic systems to better withstand and recover from climate-related risks. The strategy places particular emphasis on making these systems robust against extreme weather events, such as floods, droughts, and heatwaves;
- Reducing Vulnerability: the strategy focuses on key sectors—agriculture, water resources, energy, public health, and transport—that are particularly vulnerable to climate impacts. By implementing sector-specific measures, the strategy aims to reduce the risks associated with climate variability and extreme events, thus safeguarding livelihoods, food security, public health, and the continuity of essential services like transportation;
- Integrating Climate Adaptation: a crucial objective is to integrate climate adaptation measures into national and local policy frameworks. This integration ensures that all levels of governance, from municipalities to national agencies, work cohesively towards common climate goals.

Key National policies, regulations:

Emergency Ordinance No. 195/2005	Environmental Protection	This ordinance serves as the cornerstone of Romania's environmental legislation, outlining principles such as sustainable development, the "polluter pays" principle, and public participation in environmental decision-making. It addresses various aspects, including the management of hazardous substances, waste, biodiversity conservation, water and air quality, and soil protection. https://legislatie.just.ro/Public/DetaliiDocumentAfis/67634

Law No. 307/2006	Fire protection	Regulates fire prevention and extinguishing measures, relevant in the context of climate risks, such as drought and high temperatures. https://legislatie.just.ro/Public/DetaliiDocument/73657
Law No. 481/2004	Civil protection	Establishes the general framework for the prevention and management of emergency situations, including those generated by extreme climatic phenomena. https://legislatie.just.ro/Public/DetaliiDocument/56923
Law No. 101/2011	Prevention and Sanctioning of Environmental Degradation	This law establishes criminal measures to ensure effective environmental protection. It penalizes activities such as the improper collection, transport, recovery, or disposal of waste that may cause significant harm to individuals or the environment, with penalties ranging from fines to imprisonment https://legislatie.just.ro/Public/DetaliiDocument/129631
Law No. 104/2011	Air Quality	This law aims to protect human health and the environment by regulating measures to maintain and improve air quality. It sets out objectives for ambient air quality, methods for assessment, and provisions for public information and cooperation with other European Union member states to reduce air pollution. https://legislatie.just.ro/Public/DetaliiDocument/129642

Romania faces challenges in collecting detailed environmental data and developing sophisticated models to predict climate impacts accurately. Efforts are underway to build capacity within institutions like the National Bank of Romania to monitor environmental risks effectively. Efforts are underway to build capacity within institutions like the National Bank of Romania to monitor environmental risks effectively (EC, 2021).

Covasna County, located in central Romania, is known for several key economic sectors, including:

- Agriculture and Forestry: the region is rich in forests and agricultural land, with crops such as potatoes, cereals, and livestock farming playing a significant role. Rising temperatures and changing precipitation patterns may lead to droughts or excessive rainfall, impacting crop yields. Warmer conditions could also increase pest infestations and plant diseases;
- Tourism: Covasna is famous for its mineral waters, spas, and natural landscapes, attracting visitors for wellness tourism. While warmer weather could extend the summer tourism season, changes in precipitation patterns and potential water shortages might impact the spa and wellness industry, which relies on mineral water resources;
- Water Resource Management: Covasna County is known for its mineral water springs, which are bottled and exported. Water management is also crucial for agriculture and tourism. Drier conditions and increased demand could threaten groundwater levels and mineral water production. Flooding in some seasons might also affect negatively;
- Transport and Logistics: The county is a transit hub for goods moving between Transylvania and Moldova, relying on road and rail infrastructure. More frequent extreme weather events (floods, storms, landslides) could damage roads and railway networks, disrupting transport and trade.

The Risk assessment and management plan (RMP) developed in 2016 by the County Inspectorate for Emergency Situations details strictly risks associated with different meteorology and geological aspects neglecting comprehensive action plans derived from climate change risk analyses. We lack proper know-how on climate risk assessment tools/method, and insufficient datasets to develop climate mitigation strategy on local and microregional level.

Romania has initiated several projects and funding mechanisms to promote climate resilient that could help to meet project objectives:

- Romania Rural Pollution Prevention and Reduction Project. In April 2023, the World Bank and the Romanian government launched a €60 million project aimed at: enhancing monitoring of agricultural pollution, raising public awareness about environmental impacts, encouraging sustainable farming practices to reduce pollution (Worldbank, 2023).
- National Plan for Recovery and Resilience (NRRP): Supporting resilience and preparedness for future challenges. Implementing major reforms and investments aligned with the Recovery and Resilience Mechanism. This plan offers grants, financial instruments, and guarantees to support climate-resilient agriculture initiatives (ClimateAdapt, National Plan for Recovery and Resilience of Romania, 2024).
- The OrientGate project provides scientific support for Romania's climate adaptation policies, contributing to The National Climate Change Strategy and implementation of regional and local adaptation measures in agriculture. The pilot study, formulated within the OrientGate project, has as main objective the identification of measures to adapt crops to climate change in two different areas in Romania, Caracal in South of the country and Covasna in the centre (ClimateAdapt, 2014).
- Romania plans to invest €1.8 billion in a pilot project to develop 1,700 kilometres of irrigation canals, aiming to enhance water management and Support agribusiness resilience against climate variability (Trade, 2023).

2.1.3 Participation and risk ownership

During Phase 2, Municipality of Targu Secuiesc coordinated a structured and inclusive stakeholder engagement process to support the Climate Risk Assessment. Stakeholders were involved through round table discussion, personal meetings with the local farmers and the main local stakeholders, data-sharing sessions, and technical consultations.

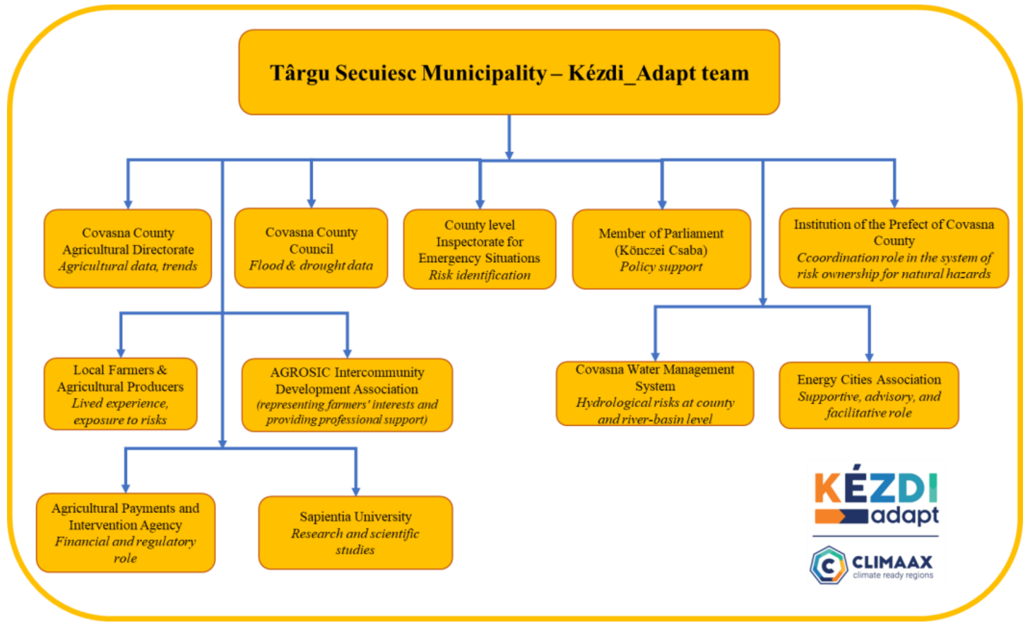


Figure 2- 1 Organigram mapping institutions and responsibilities

In Municipality of Targu Secuiesc and Covasna County the risk ownership follows a distributed model aligned with existing governance structures.

- County level Inspectorate for Emergency Situations (ISU Covasna): plays a central operational and coordinating role in the system of risk ownership for natural hazards in Covasna County, particularly for floods and drought-related emergencies. ISU Covasna contributes to risk identification through the preparation and periodic updating of the County Risk Analysis (Analiza de Risc la Nivel de Județ). This document identifies major hazards (including floods and droughts), exposed areas, and vulnerable populations, based on data provided by hydrological, meteorological, and environmental authorities. While ISU does not generate primary hazard data, it integrates sectoral assessments into an operational risk framework used for emergency planning.

- Institution of the Prefect of Covasna County plays a strategic governance and coordination role in the system of risk ownership for natural hazards, including agricultural droughts and river floods. Similar to ISU, the Prefect does not directly own the risks or the resulting damages, but acts as the representative of the central government responsible for ensuring that risk management responsibilities are properly exercised at the county and local levels.
- Covasna Water Management System (SGA) in risk ownership (Sistemul de Gospodărire a Apelor – SGA Covasna) plays a technical and operational role in risk ownership related to water-related hazards, particularly river floods, water scarcity, and drought impacts. SGA Covasna is a key institution responsible for the identification and assessment of hydrological risks at county and river-basin level.
- Covasna County Agriculture Directorate (Direcția pentru Agricultură a Județului Covasna) plays a sectoral governance and support role in the system of risk ownership related to agricultural drought, floods affecting farmland, and climate-related production risks. The Agriculture Directorate is responsible for monitoring agricultural conditions at county level, including crop status, soil moisture deficits, and damage caused by droughts, floods, or other extreme events. It participates in damage assessment commissions, collecting standardized data on affected crops and livestock. These assessments provide the formal basis for declaring agricultural disasters and for activating compensation or state aid schemes.
- Agricultural Payments and Intervention Agency (Agenția de Plăți și Intervenție pentru Agricultură – APIA) plays a financial and regulatory role in the system of risk ownership related to agricultural and climate-related hazards, including drought and floods affecting agricultural land. APIA maintains detailed records of agricultural land use, crop types, and beneficiaries of agricultural subsidies.
- Energy Cities Association (Asociația Orașelor Energiei din România - OER) is a non-governmental actor focused on promoting sustainable energy management, climate adaptation, and resilience in Romanian municipalities. In the context of risk ownership in Covasna County, particularly regarding climate-related hazards such as drought and flooding, OER plays a supportive, advisory, and facilitative role by supporting Kézdi_Adapt project in climate impact related planning and guidance for local vulnerability assessments.
- Könczei Csaba is the Member of Parliament, Vice-President for the Committee on Agriculture, Forestry, Food Industry and Specific Services
- Sapientia University plays a knowledge-generation and capacity-building role in the management of natural hazards such as agricultural drought and river floods. Sapientia University conducts research and scientific studies on climate hazards, hydrology, agriculture, and environmental change. The university can also collaborate in vulnerability assessments and in analysing socio-economic impacts of floods and droughts.

Vulnerable and priority groups in Covasna County are mainly represented by smallholder farmers, livestock keepers, and rural households whose livelihoods depend directly on climate-sensitive agricultural production. Additional vulnerable groups include residents and land users in flood-prone river valleys along the Raul Negru- river, Casin - river, Olt-river and its tributaries, as well as communities with limited financial and institutional capacity to recover from disasters. Representation of these groups occurs indirectly through local authorities, farmers' associations, and, to a lesser extent, civil society organizations, although formal mechanisms for their direct participation in risk governance remain limited.

2.1.4 Application of principles

In accordance with the CLIMAAX Framework Kézdi_adapt team integrated the principles of social justice, equity, and inclusivity with a specific focus on agricultural drought and river floods'. The municipality and its rural surroundings are marked by medium scale social and economic inequalities that significantly shape climate vulnerability. Small-scale and family farmers, together with low-income households, suffer disproportionately from agricultural drought due to very limited access to irrigation, credit, insurance, and modern technologies. This leads to higher risk of income instability, farm abandonment, and loss of intergenerational farming continuity. Flood risk also hits vulnerable groups hardest, especially the elderly, low-income residents, and people living in poorly serviced or flood-prone areas. Despite growing awareness of climate risks, inclusivity in planning remains limited: farmers, small producers, and marginalized groups are often underrepresented in decision-making processes due to barriers related to language, technical information, administrative complexity, and lack of time/capacity.

The assessment carried out for Târgu Secuiesc and Covasna County was designed to ensure quality through validated data, established methods, and reproducible workflows, using recognised climate models and official datasets. GIS-based analyses and progressive refinement to local scales improved accuracy and relevance for local planning.

Rigour was achieved by applying a systematic, multi-step risk assessment framework aligned with the CLIMAAX methodology. Multiple climate scenarios and time horizons were analysed. Quantitative outputs (yield loss, revenue loss, flood damages) were complemented by qualitative insights from stakeholders, ensuring that numerical results were interpreted within their real-world context.

Full transparency was ensured through detailed documentation of all assumptions, data sources, model choices, and analytical steps. Stakeholders were involved throughout the process to review, discuss, and improve early results, helping ensure accuracy and accountability. Final outputs, such as maps, dashboards, and summaries, were made easy to understand for both experts and non-experts. Together, these principles make the results reliable and easy to check, providing a strong basis for identifying risks, planning adaptation actions, and supporting informed decisions at local, county, and national levels.

The assessment follows a precautionary approach, meaning that even if climate predictions are uncertain, clear risks are taken seriously and action is not delayed. Instead of waiting for full certainty, the analysis looks at different climate scenarios and future time periods (RCP 4.5 and RCP 8.5). When results consistently show negative trends, such as more droughts or flood risks, this is considered enough reason to take early and proactive action. This helps ensure that decisions in Târgu Secuiesc and Covasna County are responsible, forward looking, and resilient, even when the future is uncertain.

2.1.5 Stakeholder engagement

The Phase 2 of the project shifts the focus from methodological development and initial testing of the CLIMAAX toolbox to practical, place-based implementation. This phase emphasizes close collaboration with local stakeholders, integration of sector-specific data, and translation of risk knowledge into actionable strategies. In Covasna County - Romania the Kézdi_Adapt team has prioritized the agricultural sector, one of the most climate-sensitive domains in the region, which faces increasing threats from agricultural droughts, heatwaves, and floods. A cornerstone of Phase

2 has been the establishment of a formal cooperation agreement with the Direcția pentru Agricultură Județeană Covasna (DAJ Covasna), the county-level agricultural directorate. This agreement creates a structured framework for ongoing data exchange, providing the project team with reliable, high-resolution statistics on land use and crop production trends. Key datasets include year-on-year changes in planted areas for major crops such as potatoes, wheat, maize, and rapeseed, all highly vulnerable to water stress and extreme temperatures. Parallel to this formal partnership, the team engaged in repeated consultations with the Covasna County Council, submitting targeted requests for geospatial and hydrological data relevant to both drought and flood risk analysis. Beyond institutional data collection, direct stakeholder interviews were conducted with farmers and local producers (Biofarm SRL., Agrico M SRL., Regina Cartofului Ag Co-op) to disseminate their experiences on how climate change affects farming activity. Selected interviews were professionally recorded and short educational videos were edited, serving as powerful tool for awareness-raising and knowledge transfer within the farming community

The Kézdi_Adapt team has developed a website where visitors can find clear and useful information in several sections, including Climaax and Kézdi_Adapt project objectives and results, press-related information, most notably a dedicated user friendly GIS based tab was developed where the users can investigate hazard and risk results for different scenarios by selecting distinct map layers covering the studied area (Targu Secuiesc and Covasna County) . The website is continuously updated with new results and outcomes as the project progresses. Kézdi_Adapt team also elaborated awareness campaign on social media platforms such as **TikTok, Facebook, and LinkedIn**, where updates and insights of the project are published.

At the strategic level, meetings were organized within the CLIMAAX framework, involving decision and policy makers. These included discussions with Könczei Csaba, Member of Parliament, and Kozma Béla, Director of DAJ Covasna. The common goal was to initiate and reinforce inter-institutional collaboration, understanding of drought, heatwave, and flood impacts, and deliver concrete support to stakeholders to enhance long-term resilience and sustainability of Covasna's agricultural economy.

2.2 Risk Exploration

2.2.1 Screen risks (selection of main hazards)

In Covasna County and broader central NUTS2 RO12 central region of Romania, several climate-related hazards were observed and are expected, based on historical data, recent events, and projections which are aligning with country scale Romania's vulnerability to intensifying extremes due to climate change, outlined in the national strategies (MMAP, 2024).

In case of Agricultural Drought:

- Romania has seen increased drought frequency since the 2000s, with notable impacts on yields in central regions: for example, maize production has shown regional disparities due to drought stress from 2003–2024 (Barna, 2025);
- The region already faces relatively high drought exposure, with projections showing increased risks on agriculture and water resource sectors;
- Climate trends show warmer/drier summers, increasing soil moisture deficits;
- Potential risks → Reduced crop production (potatoes, maize etc); →economic strain on farmers; soil erosion in dry periods followed by heavy rain.

In case of River Floods:

- Frequent overflows along rivers like the Olt, Raul Negru, and Casin, driven by heavy rainfall;
- Major flood event on May 26, 2025, affected Covasna and neighbouring Brașov counties, spreading across areas and leading to evacuations and infrastructure damage. Earlier events (e.g., 2018, 2021, 2022) have caused similar impacts, including inundated farmland and roads (Copernicus, Floods in Romania 2025).

In the risk assessment Agricultural Drought and River flooding are analyzed due to the abovementioned local importance of the hazard and risk.

Available Data/Knowledge and Further Needs

Available:

- Historical flood records (e.g., 2025 events via media/relief reports; past activations of Copernicus EMS for mapping)é
- Climate studies: OrientGate pilot on adaptation in Covasna, noting drought/flood extremes (ClimateAdapt, 2014);
- River monitoring (Olt and Negru rivers data from INHGA)é
- Agricultural impacts from national drought indices (Covasna County Agriculture Directorate).

Further data needed:

- Real-time/local monitoring (local updated flows, soil data);
- High-resolution Copernicus projections specific to county level: as smaller CORDEX grid or tools for qualitative interpolation i.e. downscaling;
- Socio-economic vulnerability data (farmer surveys on preparedness, interviews were made);
- Integration to local adaptation plans (Phase 3 Kézdi_Adapt can be the base).

2.2.2 Choose Scenario

In the Agricultural Drought workflow simulations were run for different start and end year periods, near future 2026-2030 and mid-century 2046-2050, also all the three RCP scenario of the defined periods were modelled to assess Hazard. Risk analysis was analysed for potential revenue losses from irrigation deficit for four crops (maize, wheat, potato, and rapeseed) under different emission scenario's (RCP2.6, 4.5 and 8.5) and period's (2026-2030 and 2046-2050) was investigated. Additionally for the workflow was updated in a such way that plots were generated for Covasna County considering only farmland areas; yield-loss values from the spreadsheet were linearly interpolated within the Covasna County bounding box; crop tables were updated with locally relevant start and end of season values; and the resulting yield and revenue loss outputs were merged and exported in NetCDF format (_4326_clip_Kézdi_Adapt), clipped to Covasna County farmland.

The river floods workflow was assessed by using common information already available such as high resolution JRD flood hazard maps, LUISA land cover dataset, and Damage Scanner tools. These datasets were completed by local flood maps generated by the Olt Basin Water Administration. Furthermore, Flood damage, inundation depth for different return periods, vulnerability damage curves, and economic losses (mln. €) was analyzed. Datasets were run for population and building damage risks too. In case of Workflow River flood two RCP scenarios 4.5 and 8.5, different return periods were applied (10, 20, 30, 40, 50, 75, 100, 200, 500) using Bbox coordinates [26.034535, 45.970344, 26.297783, 46.092297] for our municipality. In the Population and Building hazard and risk assessment [45.98122, 26.23853, 46.02972, 26.11275] coordinates were used.

2.3 Regionalized Risk Analysis

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

Table 2- 1 Data overview workflow #1

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
Crop yield reduction: Crop growing season lengths (maize, wheat, potato, rapeseed) Soil AWS, Elevetion, Climate zone GCM+RCM combinations	Irrigation availability and precipitation, ET0 values.	Linear interpolation yield loss to Covasna County farmland. Clipping from GAEZ to farmland surface. Total crop production and aggregated crops revenue	Map revenue and yield loss: Merging computed outputs (yield and revenue loss) and export in NetCDF format for Covasna County farmland Agricultural land level plotting of results Revenue losses for each main crop per grid cell based on the absence of irrigation system coverage on local scale (farm lands)

2.3.1.1 Hazard assessment

In Phase 2 two main branch of analyses were accomplished as follows:

1. **Part I.** Base workflow re-run analysis: due to the recent updates on initial Agricultural Drought workflow the main variables as RCP, ystart-yend, climate zone, the initial crop_table data was used as in Phase1 for discussion and comparison with Deliverable 1 results.
2. **Part II.** Finetuned workflow: includes personalized local context updates in the workflow

PART I. BASE WORKFLOW RE-RUN ANALYSIS

During phase 2 to significative number of runs were accomplished considering the workflow update timeline. In table 2-1 the re-run analysis scenarios are presented, and only data in thick blue colour cell border are used for result and discussion due to recent workflow update, additional all the yield, revenue loss data and plots can be found in Zenodo (10.5281/zenodo.18154423, Base workflow re-run analysis Deliverable 2_Phase1_vs_Phase2 / Base workflow re-run analysis Yield losses.docx

Table 2- 2 Investigated workflow runs in Part I.

NUTS2	RO12										
Scenario	Scale parameter	RCP	ystrat-yend	GCM+RCP combination	Climate Zone	Crops	Hazard & Risk	Crop table whole	Crop table clipped	Plots	Comments
1.1.	0.5	2.6	2026-2030	model_choice=1	5	maize','wheat','potato','rapeseed	OK	x	x	county level	NUTS Region june 25
1.2.	0.5	2.6	2026-2030	model_choice=1	5	maize','wheat','potato','rapeseed	OK	x	x	county level	NUTS Region september CODE update generates two crop sreadsheets
1.3.1	0.5	2.6	2026-2030	model_choice=1	5	maize','wheat','potato','rapeseed	OK	√	√	county level	ZOOM_COUNTY borders
1.3.2	0.5	2.6	2026-2030	model_choice=1	5	maize','wheat','potato','rapeseed	OK	√	√	county level	Fix which array is written to NetCDF output/
2.1.	0.5	4.5	2026-2030	model_choice=1	5	maize','wheat','potato','rapeseed	OK	√	√	county level	Fix which array is written to NetCDF output/
3.1	0.5	8.5	2026-2030	model_choice=1	5	maize','wheat','potato','rapeseed	OK	√	√	county level	Fix which array is written to NetCDF output/
4.1	0.5	2.6	2026-2030	model_choice=1	5	maize','wheat','potato','rapeseed	OK	√	√	agri land level	Agricultural level plot visualisation
5.1	0.5	2.6	2026-2030	model_choice=1	5	maize','wheat','potato','rapeseed	OK	√	√	agri land level	New workflow 17.12.2025
5.2	0.5	4.5	2026-2030	model_choice=1	5	maize','wheat','potato','rapeseed	OK	√	√	agri land level	New workflow 17.12.2025
5.3	0.5	8.5	2026-2030	model_choice=1	5	maize','wheat','potato','rapeseed	OK	√	√	agri land level	New workflow 17.12.2025
6.1	0.5	2.6	2046-2050	model_choice=1	5	maize','wheat','potato','rapeseed	OK	√	√	agri land level	New workflow 17.12.2025
6.2	0.5	4.5	2046-2050	model_choice=1	5	maize','wheat','potato','rapeseed	OK	√	√	agri land level	New workflow 17.12.2025
6.3	0.5	8.5	2046-2050	model_choice=1	5	maize','wheat','potato','rapeseed	OK	√	√	agri land level	New workflow 17.12.2025

Crop-specific vulnerability for the 2025 December updated Agricultural Drought Workflow using initial CLIMAAX variables

Generated precipitation and yield loss data plots are presented in tables 2-3 and 2-4

Table 2- 3 Cumulate precipitation and standard evapotranspiration plots for different RCP scenarios and time intervals finetuned for Covasna County farm land surfaces

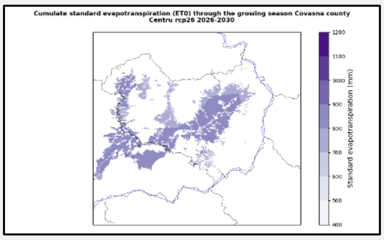
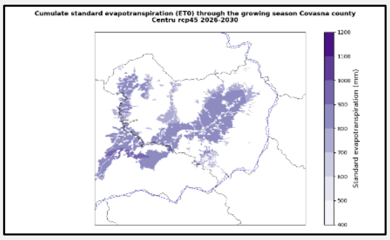
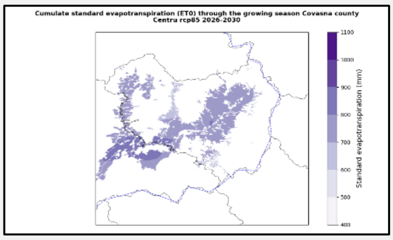
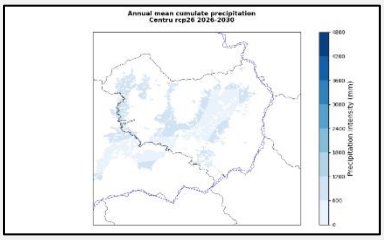
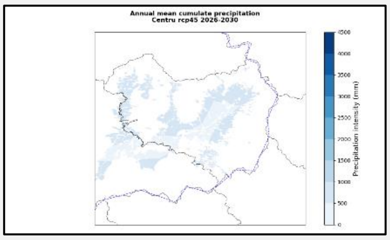
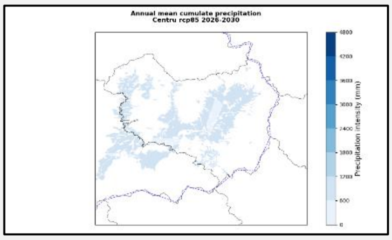
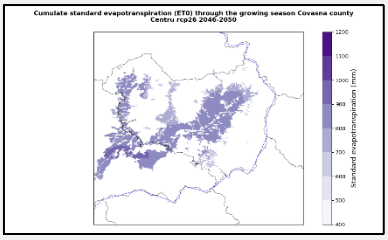
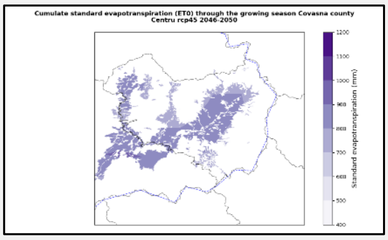
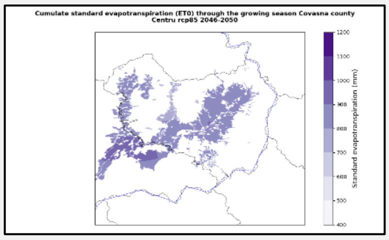
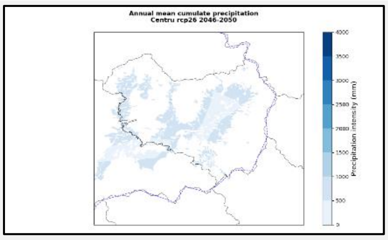
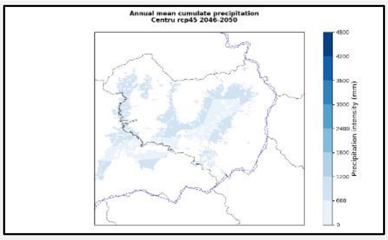
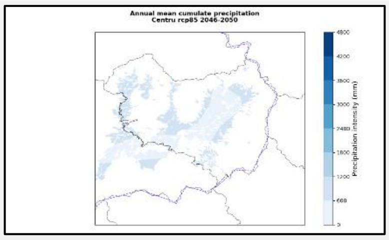
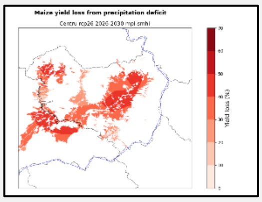
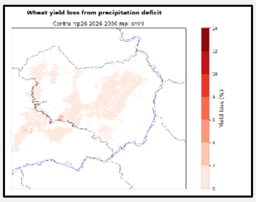
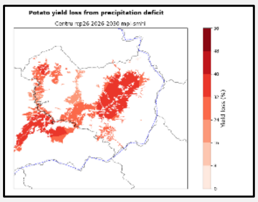
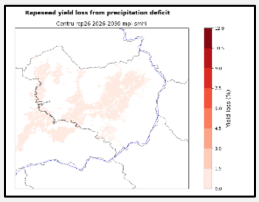
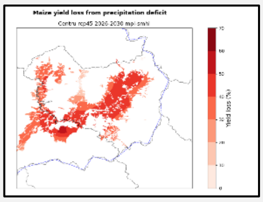
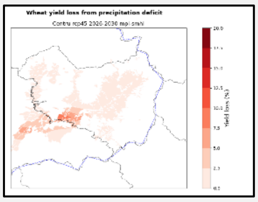
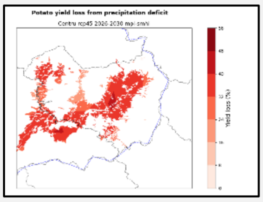
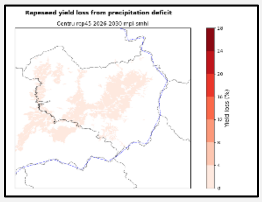
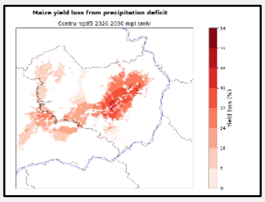
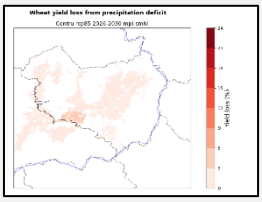
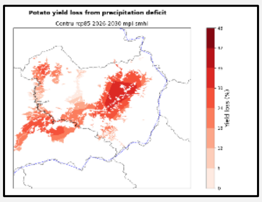
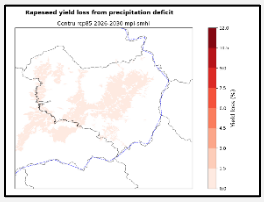
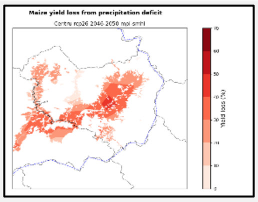
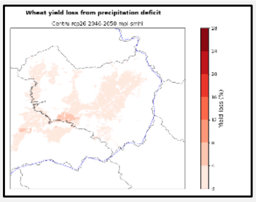
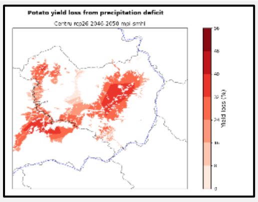
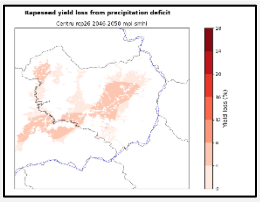
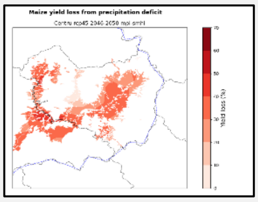
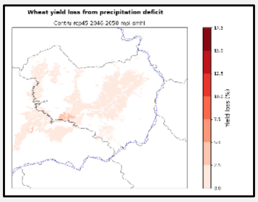
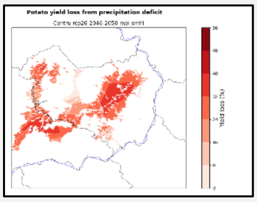
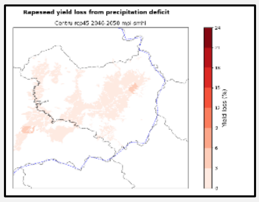
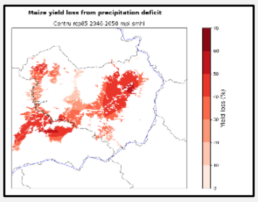
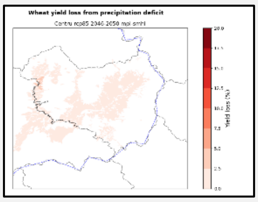
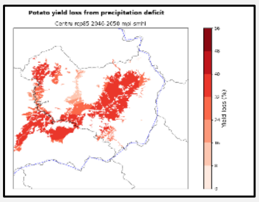
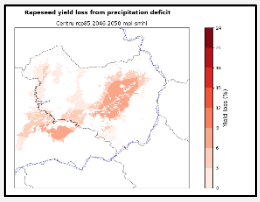
RCP2.6	RCP4.5	RCP8.5
	ystart - yend 2026-2030	
		
		
	ystart - yend 2046-2050	
		
		

Table 2- 4 Regions in dark red for different type of crops experiencing highest hydro-climatic stress under different RCP scenarios (2.6, 4.5, 8.5) near future time interval finetuned for Covasna County farm land surfaces

Maize	Wheat	Potato	Rapeseed
ystart - yend 2026-2030			
			
			
			
ystart - yend 2046-2050			
			
			
			

Generated hazard crop table and clipped crop table (NUTS2) level for near future and mid-century time intervals using different RCP scenarios are presented in tables 2-5, 2-6 (full data can be found on Zenodo (10.5281/zenodo.18154423, Deliverable 2_Base workflow re-run analysis Deliverable 2_Phase1_vs_Phase2.xlsx and Deliverable 2 Base workflow re-run analysis Yield losses.pdf)

CLIMAAX KÉZDI adapt

CROP TABLE

5.1 2026-2030								
Average yield loss					28.889	0.386	25.487	0.655
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp26	2026	2030	44.891	22.18	36.5857	0	25.54997	0
rcp26	2026	2030	44.885	22.334	51.14184	0	41.34115	1.457071
rcp26	2026	2030	44.878	22.488	42.34582	0	30.08355	0
rcp26	2026	2030	44.871	22.642	43.24496	0	27.66721	0.398974
rcp26	2026	2030	44.864	22.796	53.60872	2.136613	37.56978	5.986895

5.2. 2026-2030								
Average yield loss					29.503	0.601	27.659	0.768
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp45	2026	2030	44.891	22.18	25.01834	0	30.3697	0.000417
rcp45	2026	2030	44.885	22.334	60.55466	0	43.79853	2.633009
rcp45	2026	2030	44.878	22.488	41.28569	0	36.92477	0.181959
rcp45	2026	2030	44.871	22.642	39.79046	0	36.44681	0
rcp45	2026	2030	44.864	22.796	51.00787	0	41.32228	3.147889

5.3. 2026-2030								
Average yield loss					15.225	1.245	16.308	0.081
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp85	2026	2030	44.891	22.18	14.38678	0	12.46202	0
rcp85	2026	2030	44.885	22.334	27.74735	0	34.83699	0
rcp85	2026	2030	44.878	22.488	11.91167	0	19.30521	0
rcp85	2026	2030	44.871	22.642	26.82078	0	22.03074	0
rcp85	2026	2030	44.864	22.796	27.46947	0	30.94981	0

CROP TABLE

6.1 2046-2050								
Average yield loss					26.745	1.444	23.020	2.325
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp26	2046	2050	44.891	22.18	34.79986	0	27.71565	1.50003
rcp26	2046	2050	44.885	22.334	57.31741	3.285838	41.24988	5.671064
rcp26	2046	2050	44.878	22.488	44.96303	0	31.17441	3.556128
rcp26	2046	2050	44.871	22.642	37.32852	0	31.04078	3.48505
rcp26	2046	2050	44.864	22.796	55.63013	0	40.51785	5.422742

6.2 2046-2050								
Average yield loss					26.836	0.389	23.949	1.434
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp45	2046	2050	44.891	22.18	29.00163	0	29.90441	0.666563
rcp45	2046	2050	44.885	22.334	51.87124	0	44.54351	3.288346
rcp45	2046	2050	44.878	22.488	44.40775	0	34.44898	0.972813
rcp45	2046	2050	44.871	22.642	49.16805	0.001616	33.7334	2.132335
rcp45	2046	2050	44.864	22.796	55.44325	0	40.45439	5.792269

6.3 2046-2050								
Average yield loss					28.087	0.370	24.858	2.382
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp85	2046	2050	44.891	22.18	38.05422	0	25.21963	0.726517
rcp85	2046	2050	44.885	22.334	45.78737	0	42.64718	5.024636
rcp85	2046	2050	44.878	22.488	44.22092	0	33.32023	2.942529
rcp85	2046	2050	44.871	22.642	37.29134	0	33.57194	3.430717
rcp85	2046	2050	44.864	22.796	51.3749	0	38.91293	6.877344

CLIPPED CROP TABLE

5.1 2026-2030								
Average yield loss					27.823	0.656	24.642	0.274
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp26	2026	2030	45.484	23.637	23.70128	0	19.18075	0
rcp26	2026	2030	45.602	23.493	0.001016	0	0.710888	0
rcp26	2026	2030	45.594	23.649	8.246024	0	14.06799	0
rcp26	2026	2030	45.585	23.806	0	0	3.985639	0
rcp26	2026	2030	45.576	23.962	10.58993	0	8.700599	0

5.2. 2026-2030								
Average yield loss					27.504	1.108	26.093	0.340
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp45	2026	2030	45.484	23.637	1.59168	0	13.61812	0
rcp45	2026	2030	45.602	23.493	0	0	0.970811	0
rcp45	2026	2030	45.594	23.649	9.177136	0	9.668578	0
rcp45	2026	2030	45.585	23.806	0.146679	0	0.72603	0
rcp45	2026	2030	45.576	23.962	0	0	0.773994	0

5.3. 2026-2030								
Average yield loss					13.332	1.439	15.066	0.032
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp85	2026	2030	45.484	23.637	0	0	2.734788	0
rcp85	2026	2030	45.602	23.493	0	0	0	0
rcp85	2026	2030	45.594	23.649	0.567271	0	3.353862	0
rcp85	2026	2030	45.585	23.806	0.041234	0	0.045181	0
rcp85	2026	2030	45.576	23.962	0.481457	0	0.182146	0

CLIPPED CROP TABLE

6.1 2046-2050								
Average yield loss					24.708	1.629	21.859	1.730
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp26	2046	2050	45.484	23.637	0	0	13.39013	0
rcp26	2046	2050	45.602	23.493	0	0	0.047325	0.071035
rcp26	2046	2050	45.594	23.649	0	0	7.602062	0
rcp26	2046	2050	45.585	23.806	0	0	0	0
rcp26	2046	2050	45.576	23.962	0	0	0.111459	0

6.2 2046-2050								
Average yield loss					24.161	0.843	22.166	0.715
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp45	2046	2050	45.484	23.637	12.01774	0	16.17736	0
rcp45	2046	2050	45.602	23.493	0.34635	0	0	0
rcp45	2046	2050	45.594	23.649	3.39805	0	11.93119	0
rcp45	2046	2050	45.585	23.806	0	0	0	0.019629
rcp45	2046	2050	45.576	23.962	4.403846	0	0	0

6.3 2046-2050								
Average yield loss					26.768	0.610	24.673	1.328
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp85	2046	2050	45.484	23.637	22.10534	0	19.63837	0.281179
rcp85	2046	2050	45.602	23.493	0	0	0.098516	0
rcp85	2046	2050	45.594	23.649	15.20087	0	14.14156	0.017794
rcp85	2046	2050	45.585	23.806	0.000841	0	0.721527	0
rcp85	2046	2050	45.576	23.962	2.872301	0	4.522603	0

Figure 2- 2 Screen shots of total and clipped yield loss csv datasets for each RCP and near future, mid-century time scenarios.

Yield losses across crops, scenarios, and time periods.

Across all scenarios and periods, maize and potato exhibit the highest yield losses, whereas wheat and rapeseed show substantially smaller losses, generally below 2-3%. Yield losses calculated for clipped (NUTS-level) areas are consistently lower than those from the full crop tables, indicating a reduction in absolute values due to spatial aggregation. It worth of mention that the clipped CSV file(..._yield_loss_SPREADSHEET_clipped.csv) contains only data from points inside the provided Shape (by default a NUTS region. The full CSV (..._yield_loss_SPREADSHEET.csv) contains data from the entire Bbox, no data is interpolated to smooth the results, all data is in CORDEX resolution.

Table 2- 5 Yield loss (%) average values for crops, RCP scenarios, table types (whole/clipped) and time periodss

Yield loss ystart-yend 2026-2030 crop table					Yield loss ystart-yend 2026-2030 Clipped corp table				
RCP	maize	wheat	potato	rapeseed	RCP	maize	wheat	potato	rapeseed
2.6	28.889	0.386	25.487	0.655	2.6	27.823	0.656	24.642	0.274
4.5	29.503	0.601	27.659	0.768	4.5	27.504	1.108	26.093	0.340
8.5	15.225	1.245	16.308	0.081	8.5	13.332	1.439	15.066	0.032
Yield loss ystart-yend 2046-2050 crop table					**Yield loss ystart-yend 2046-2050 Clipped corp table**				
RCP	maize	wheat	potato	rapeseed	RCP	maize	wheat	potato	rapeseed
2.6	26.745	1.444	23.020	2.325	2.6	24.708	1.629	21.859	1.730
4.5	26.836	0.389	23.949	1.434	4.5	24.161	0.843	22.166	0.715
8.5	28.087	0.370	24.858	2.382	8.5	26.768	0.610	24.673	1.328

Near-future period (2026-2030)

In the full crop table part, maize and potato show high yield losses under RCP 2.6 and RCP 4.5, with markedly lower losses under RCP 8.5. Wheat and rapeseed losses remain low across all scenarios, with wheat showing a slight increase with increasing RCP. The clipped crop

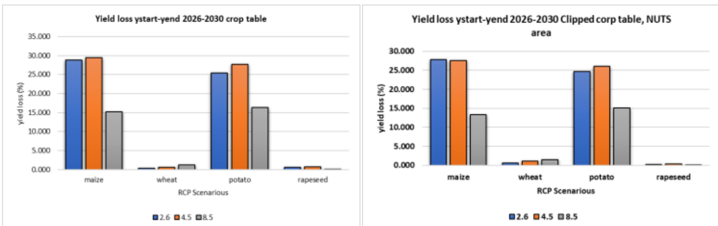


Figure 2- 3 Near-future 2026-2030 average yield loss results column representation

table section shows the same crop and scenario-specific patterns, but with yield losses approximately 3-10% lower, indicating that clipping affects magnitude rather than relative trends.

Mid-century period (2046-2050)

In the full crop table, yield losses for maize and potato increase with radiative forcing (increasing RCPs), reaching their highest values under RCP 8.5, while rapeseed losses also increase relative to the near-future period. Wheat remains comparatively stable, with losses below 1.5% across all scenarios. The clipped (NUTS-level) results reproduce the same patterns as the full crop table but with systematically lower yield loss estimates, particularly for maize and potato.

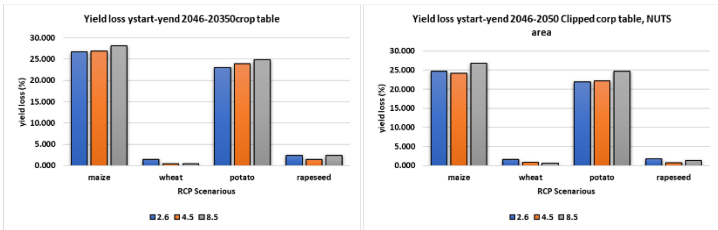


Figure 2- 4 Mid-century 2046-2050 average yield loss results column representation

The Phase 2 Initial updated workflow results clearly identify maize and potato as the most climate-vulnerable crops in both the near and mid-century periods. Their consistently large yield losses (Table 2-4) suggest strong sensitivity to temperature increases and associated water stress. Wheat, by contrast, appears relatively resilient, exhibiting only minor yield reductions even under high-emission scenarios. Rapeseed shows limited vulnerability in the near term but becomes increasingly affected by mid-century, indicating a delayed response to climate forcing.

The increase in yield losses from 2026–2030 to 2046- 2050 highlights the cumulative nature of climate impacts on agricultural systems. The shift from higher losses under lower RCPs in the near term to dominant losses under RCP 8.5 in the mid- century period suggests that short- term responses may be influenced by non-linear crop-climate interactions, while long-term outcomes are increasingly governed by the magnitude of warming.

Comparison of Deliverable 1 (Phase1) and Deliverable 2 (Phase2) initial Agricultural Drought workflow yield loss results

Phase 1 yield loss results were generated using the initial Agricultural Drought workflow, presented in Deliverable 1, while Phase 2 estimates were generated using an updated Agricultural Drought workflow (2025 mid-December version). The updated workflow incorporates a series of methodological corrections and refinements, including fixes to the agricultural drought hazard assessment, crop table structure, yield-loss calculation, and input–output handling. Key updates are documented (Table 2-6) through a sequence of commits addressing, among others, corrections to the yield loss percentage calculation, revised yield loss dependency on factor (Ky), clarification of growing length period (LGP) definitions and crop growth phases, and improvements to crop table export functionality.

Table 2- 6 Repository history, key commits driving Agricultural Drought workflow improvements, used in Phase 2 deliverable.

Agricultural drought	Commits	Date
CLIMAAX/ETa_fixes	Fixes for agricultural drought hazard assessment and crop table	Dec 17 2025
CLIMAAX/fix-lgp-description	Fix description of LGP and how phases are declared in the crop table	Dec 9 2025
CLIMAAX/fix-yield-loss-io	Correction of yield_loss_perc calculation and associated I/O	Dec 5 2025

Commit 34df76b	Propose fix for yield_loss_perc dependency on Ky	Nov 25 2025
Commit 855f9e7	Add clipped table export option	Jul 30 2025
https://github.com/CLIMAAX/DROUGHTS/commits/main/		

Impact of updated workflow on yield loss estimation

The updated workflow (Phase 2) systematically calculated lower projected yield losses compared to the initial workflow (Deliverable 1->Phase 1) across all crops for all RCPs and time periods.

Table 2- 7 Yield loss (%) comparison: Phase 1 vs Phase 2

Yield loss (%) comparison: Phase 1 vs Phase 2

Near-future period (2026–2030)				***Mid-century period (2046–2050)***			
RCP	***Crop***	***Phase 1***	***Phase 2***	***RCP***	***Crop***	***Phase 1***	***Phase 2***
2.6	*Maize*	*38.43*	*28.89*	***2.6***	*Maize*	*39.02*	*26.74*
	Wheat	*21.12*	*0.39*		*Wheat*	*25.91*	*1.44*
	Potato	*31.87*	*25.49*		*Potato*	*31.13*	*23.02*
	Rapeseed	*19.77*	*0.65*		*Rapeseed*	*27.3*	*2.33*
4.5	*Maize*	*44.51*	*29.5*	***4.5***	*Maize*	*37.56*	*26.84*
	Wheat	*22.57*	*0.6*		*Wheat*	*20.8*	*0.39*
	Potato	*35.07*	*27.66*		*Potato*	*31.03*	*23.95*
	Rapeseed	*21.75*	*0.77*		*Rapeseed*	*24.74*	*1.43*
8.5	*Maize*	*29.9*	*15.23*	*8.5*	*Maize*	*40.03*	*28.09*
	Wheat	*25.22*	*1.24*		*Wheat*	*20.62*	*0.37*
	Potato	*26.12*	*16.31*		*Potato*	*32.35*	*24.86*
	Rapeseed	*21.52*	*0.08*		*Rapeseed*	*22.38*	*2.38*

Difference intervals for all three RCP scenarios between the yield loss results:

- Wheat yield loss (%) intervals: Phase 1 ≈20-26%↔ Phase 2 ≈0.4-1.4%
- Rapeseed yield loss (%) intervals: Phase 1 ≈20-27% ↔ Phase 2 ≈0.1-2.3%
- Maize yield loss (%) intervals: Phase 1 ≈44.51-29.9% ↔ Phase 2 ≈29.5-15.23%.
- Potato yield loss (%) intervals: Phase 1 ≈35.07-26.12% ↔ Phase 2 ≈27.66-16.31%.

The largest reductions are observed for wheat and rapeseed yield loss values, for which Phase 1 yield losses typically ranged between approximately 20-27%, while Phase 2 the yield loss values are consistently below 3%, and in several cases close to zero. In contrast, maize and potato continue to exhibit notable vulnerability to agricultural drought under all RCPs, although projected losses are reduced by approximately 6-15 percentage points relative to Phase 1. The trends are consistent across both the near-future (2026-2030) and mid-century (2046-2050) periods, indicating that the effect of the workflow update is robust across time horizons and climate scenarios. The substantial moderation of yield loss estimates in the updated workflow suggests that the initial workflow likely overestimated drought-related yield impacts, particularly for crops with lower sensitivity under the revised crop tables and yield-loss formulation. The results highlight the strong sensitivity of agricultural drought impact assessments to workflow design choices, crop parameterization, and yield-loss calculation methods.

PART II. FINETUNED WORKFLOW: INCLUDES PERSONALIZED LOCAL CONTEXT UPDATES IN THE WORKFLOW

The workflow was updated (Hazard and Risk) to generate additional results, the main updates are as follows:

- ➢ Generating plots for Covasna County and only Farmlands;
- ➢ Linear interpolation of yield loss spreadsheet.csv values for Covasna County Bbox;
- ➢ Crop table update for local context Start and End season values;
- ➢ Merging computed outputs (yield and revenue loss) and export in NetCDF format …_4326_clip_Kézdi_Adapt , data clipped to Covasna County farmland.

Generated fine-tunned general data, spreadsheet results for near future and mid-century time intervals using different RCP scenarios can be found on Zenodo (10.5281/zenodo.18154423):

- Deliverable 2_Phase2_finetuning_local_context.xlsx
- Deliverable 2_Phase2_finetuning_local_context.pdf
- Deliverable 2 precipitation_ET0_Kézdi_Adapt .xlsx
- Deliverable 2_Phase2_finetuning_local_context.docx

Table 2- 8 Investigated workflow scenarios and variables in Part II.

NUTS2	RO12											
Scenario	Scale parameter	RCP	ystrat-yend	GCM+RCM combination	Climate Zone	Crops	Hazard & Risk	Crop table whole	Crop table clipped	Crop table interp CV	Plots	Comments
7.1	0.5	2.6	2026-2030	model_choice=1	5	['maize','wheat','potato','rapeseed']	OK	√	√	√	Covasna county agri land level	New workflow 17.12.2025, updated crop table
7.2.0	0.5	4.5	2026-2030	model_choice=0	5	['maize','wheat','potato','rapeseed']		√	√	√		
7.2.1	0.5	4.5	2026-2030	model_choice=1	5	['maize','wheat','potato','rapeseed']	OK	√	√	√		
7.2.2	0.5	4.5	2026-2030	model_choice=2	5	['maize','wheat','potato','rapeseed']	OK	√	√	√		
7.2.4	0.5	4.5	2026-2030	model_choice=4	5	['maize','wheat','potato','rapeseed']	OK	√	√	√		
7.3	0.5	8.5	2026-2030	model_choice=1	5	['maize','wheat','potato','rapeseed']	OK	√	√	√		
8.1	0.5	2.6	2046-2050	model_choice=1	5	['maize','wheat','potato','rapeseed']	OK	√	√	√		
8.2	0.5	4.5	2046-2050	model_choice=1	5	['maize','wheat','potato','rapeseed']	OK	√	√	√		
8.3	0.5	8.5	2046-2050	model_choice=1	5	['maize','wheat','potato','rapeseed']	OK	√	√	√		

Finetuning local context

Crop table was updated (Table 2-8) based on literature data and information from local agricultural partners reflecting Romania sowing and harvest DOY values for the investigated crops.

Table 2- 9 Identified sowing and harvest days for fine-tuning crop table local scale

Maize	Spring/summer crop	90–120 (late March to late April; optimal when soil >10°C)	270–300 (late September to late October)	EU MARS crop monitoring and USDA Foreign agricultural service	https://ipad.fas.usda.gov/rssiws/al/crop_calendar/europe.aspx
	Selected	105	285		https://agri4cast.jrc.ec.europa.eu/dataportal
Wheat	Mostly winter	270–300 (late September to late October, previous year)	180–220 (late June to late July)	EU MARS crop monitoring	https://agri4cast.jrc.ec.europa.eu/
	Selected	270	180		
Potato	Spring/summer crop	60–100 (early March to mid-April)	240–280 (late August to early October)	EU MARS crop monitoring	https://agri4cast.jrc.ec.europa.eu/
	Selected	60	280		
Rapeseed	Winter (oilseed rape)	230–270 (mid-August to late September	190–220 (early to late July)	EU MARS crop monitoring and USDA Foreign agricultural service	https://ipad.fas.usda.gov/cropexplorer/
	Selected	230	190		https://agri4cast.jrc.ec.europa.eu/dataportal

COMPARATIVE STUDY OF GCM+RCM MODELS UNDER RCP 4.5 SCENARIO

The objective of the comparative study was to analyze model predictions and to intestacy the best suitable GCM+RCM model combination for further analysis considering study area specific context. The yield loss from all investigated studied areas (Bbox, NUTs, CV farmland) and GCM+RCM combinations Maize consistently shows the highest yield losses, wheat is the least affected, potato ranks second, rapeseed third (Table 2-10).

Table 2- 10 GCM and RCM combination yield loss (%) results for RCP 4.5 scenario, model_choice 3 was omitted in this study due to miss use of grid by aladin63 RCM.

Yield loss (%) RCP 4.5 ystart-yend 2026-2030 Bbox crop table_fine_tuned						
model_choice	**Time**	**2026-2030**	**maize**	**wheat**	**potato**	**rapeseed**
0	GCM	ncc_noresm1_m	18.364	2.345	18.069	3.199
	RCM	geric_remo2015				
1	GCM	mpi_m_mpi_esm_lr	31.033	2.794	26.905	7.357
	RCM	smhi_rca4				
2	GCM	cnrm_cerfacs_cm5	12.560	1.413	14.310	2.363
	RCM	knmi_racmo22e				
4	GCM	ncc_noresm1_m	23.466	0.795	21.156	2.753
	RCM	smhi_rca4				
Yield loss (%) RCP 4.5 ystart-yend 2026-2030 Clipped NUTS region corp table fine_tuned						
model_choice	**Time**	**2026-2030**	**maize**	**wheat**	**potato**	**rapeseed**
0	GCM	ncc_noresm1_m	15.115	3.524	15.837	4.082
	RCM	geric_remo2015				
1	GCM	mpi_m_mpi_esm_lr	28.702	3.097	25.548	6.734
	RCM	smhi_rca4				
2	GCM	cnrm_cerfacs_cm5	11.216	1.734	13.458	2.221
	RCM	knmi_racmo22e				
4	GCM	ncc_noresm1_m	23.344	1.323	21.120	3.534
	RCM	smhi_rca4				
Yield loss (%) RCP 4.5 ystart-yend 2026-2030 Clipped Interp Covasna county corp table fine_tuned						
model_choice	**Time**	**2026-2030**	**maize**	**wheat**	**potato**	**rapeseed**
0	GCM	ncc_noresm1_m	11.200	2.749	13.275	3.364
	RCM	geric_remo2015				
1	GCM	mpi_m_mpi_esm_lr	27.122	2.023	24.188	5.321
	RCM	smhi_rca4				
2	GCM	cnrm_cerfacs_cm5	11.973	1.132	14.039	1.474
	RCM	knmi_racmo22e				
4	GCM	ncc_noresm1_m	20.961	0.856	18.927	2.855
	RCM	smhi_rca4				

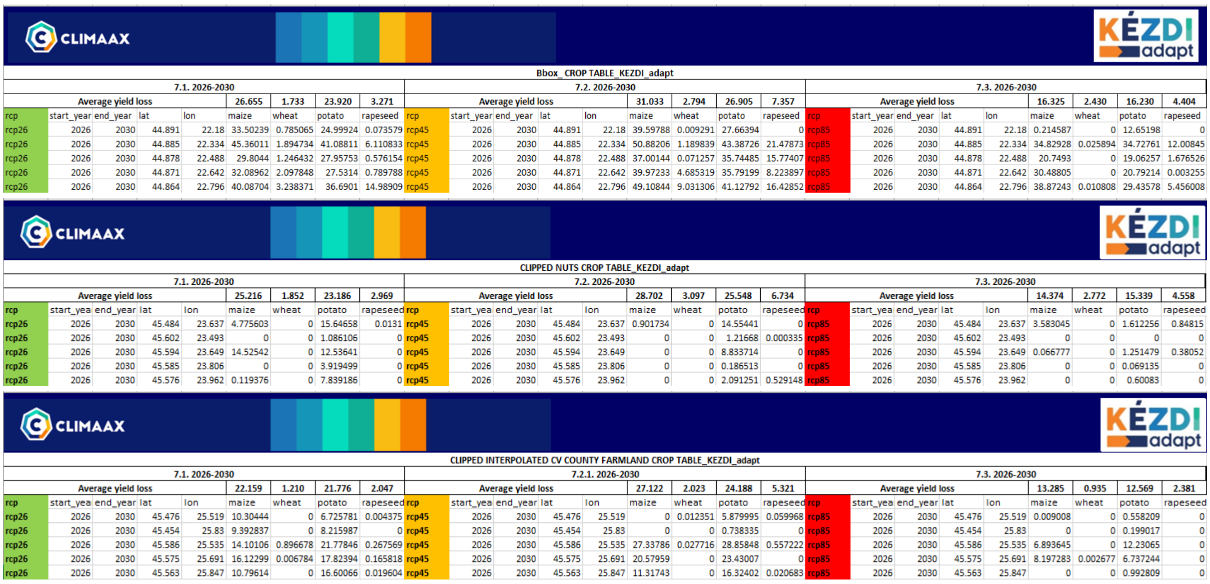
- Model choice 0 calculated moderate yield losses for all crops, with maize and potato being the most affected, while wheat and rapeseed experiences consistently lower losses. The magnitude of losses decreases from the Bbox scale to Covasna County farmland, suggesting a dampening effect of spatial clipping ➔ extremes on large scale are minimized on local scale.
- Model choice 1 generated the highest yield losses for all crops, regardless of spatial scale. Maize and potato are particularly vulnerable under this GCM+RCM combination, with losses remaining very high even at the county farmland level, indicating a strong and persistent climate stress signal i.e. hot summer and precipitation deficiency.
- Model choice 2 produced the lowest yield loss values among all GCM+RCM model combinations, indicating a milder climate impact compared to the other models.
- Model choice 4 generated intermediate to high yield losses, especially for maize and potato, with values closer to those of Model choice 1.

Overall, maize and potato showed the greatest sensitivity to climate change across all GCM+RCM model combinations, while wheat followed by rapeseed are the least affected crops. Significant differences between the yield loss results indicate substantial model uncertainty, highlighting that regional model selection plays a critical role in credible yield loss calculation.

Covasna county has ideal soil and climatic conditions for agriculture, the region is named as ''land of potato'', the agriculture is highly sensitive to summer extremes and precipitation deficits (multiplied by the low irrigation infrastructure). Dumitrecu et al. (Dumitrescu, 2023) and Bartok et al. (Bartok, 2021) investigated different climate models on Romania and concluded that mpi_m_mpi_esm_lr and smhi_rca4 GCM and RCM models (Model Choice 1 in our case) can be applied for climate change impact assessment (agriculture) on regional scale, having the suitability to model temperature and precipitation conditions for different crops. Therefore, Model Choice 1 GCM+RCM combination of GCM mpi_m_mpi_esm_lr (Max Planck Institute for Meteorology - European Space Agency Earth System Model - Low Resolution) and RCM smhi_rca4 (Swedish Meteorological and Hydrological Institute - Rossby Centre Regional Climate Model version 4) will be used for further investigations.

CROP-SPECIFIC VULNERABILITY FOR NEAR FUTURE (2026-2030) TIME INTERVAL FINE-TUNED CROP TABLE

In this part of the research the all the three RCPs with model choice 1 and the four crops were analyzed for near-future.



Bbox_ CROP TABLE_KEZDI_adapt

7.1. 2026-2030									7.2. 2026-2030									7.3. 2026-2030								
Average yield loss					26.655	1.733	23.920	3.271	Average yield loss					31.033	2.794	26.905	7.357	Average yield loss					16.325	2.430	16.230	4.404
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed	rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed	rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp26	2026	2030	44.891	22.18	33.50239	0.785065	24.99924	0.073579	rcp45	2026	2030	44.891	22.18	39.59788	0.009291	27.66394	0	rcp85	2026	2030	44.891	22.18	0.214587	0	12.65198	0
rcp26	2026	2030	44.885	22.334	45.36011	1.894734	41.08811	6.110833	rcp45	2026	2030	44.885	22.334	50.88206	1.189839	43.38726	21.47873	rcp85	2026	2030	44.885	22.334	34.82928	0.025894	34.72761	12.00845
rcp26	2026	2030	44.878	22.488	29.8044	1.246432	27.95753	0.576154	rcp45	2026	2030	44.878	22.488	37.00144	0.071257	35.74485	15.77407	rcp85	2026	2030	44.878	22.488	20.7493	0	19.06257	1.676526
rcp26	2026	2030	44.871	22.642	32.08962	2.097848	27.5314	0.789788	rcp45	2026	2030	44.871	22.642	39.97233	4.685319	35.79199	8.223897	rcp85	2026	2030	44.871	22.642	30.48805	0	20.79214	0.003255
rcp26	2026	2030	44.864	22.796	40.08704	3.238371	36.6901	14.98909	rcp45	2026	2030	44.864	22.796	49.10844	9.031306	41.12792	16.42852	rcp85	2026	2030	44.864	22.796	38.87243	0.010808	29.43578	5.456008

CLIPPED NUTS CROP TABLE_KEZDI_adapt

7.1. 2026-2030									7.2. 2026-2030									7.3. 2026-2030								
Average yield loss					25.216	1.852	23.186	2.969	Average yield loss					28.702	3.097	25.548	6.734	Average yield loss					14.374	2.772	15.339	4.558
rcp	start_yea	end_year	lat	lon	maize	wheat	potato	rapeseed	rcp	start_yea	end_year	lat	lon	maize	wheat	potato	rapeseed	rcp	start_yea	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp26	2026	2030	45.484	23.637	4.775603	0	15.64658	0.0131	rcp45	2026	2030	45.484	23.637	0.901734	0	14.55441	0	rcp85	2026	2030	45.484	23.637	3.583045	0	1.612256	0.84815
rcp26	2026	2030	45.602	23.493	0	0	1.086106	0	rcp45	2026	2030	45.602	23.493	0	0	1.21668	0.000335	rcp85	2026	2030	45.602	23.493	0	0	0	0
rcp26	2026	2030	45.594	23.649	14.52542	0	12.53641	0	rcp45	2026	2030	45.594	23.649	0	0	8.833714	0	rcp85	2026	2030	45.594	23.649	0.066777	0	1.251479	0.38052
rcp26	2026	2030	45.585	23.806	0	0	3.919499	0	rcp45	2026	2030	45.585	23.806	0	0	0.186513	0	rcp85	2026	2030	45.585	23.806	0	0	0.069135	0
rcp26	2026	2030	45.576	23.962	0.119376	0	7.839186	0	rcp45	2026	2030	45.576	23.962	0	0	2.091251	0.529148	rcp85	2026	2030	45.576	23.962	0	0	0.60083	0

CLIPPED INTERPOLATED CV COUNTY FARMLAND CROP TABLE_KEZDI_adapt

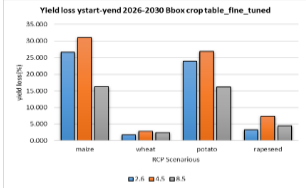
7.1. 2026-2030									7.2.1. 2026-2030									7.3. 2026-2030								
Average yield loss					22.159	1.210	21.776	2.047	Average yield loss					27.122	2.023	24.188	5.321	Average yield loss					13.285	0.935	12.569	2.381
rcp	start_yea	end_year	lat	lon	maize	wheat	potato	rapeseed	rcp	start_yea	end_year	lat	lon	maize	wheat	potato	rapeseed	rcp	start_yea	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp26	2026	2030	45.476	25.519	10.30444	0	6.725781	0.004375	rcp45	2026	2030	45.476	25.519	0	0.012351	5.879995	0.059968	rcp85	2026	2030	45.476	25.519	0.009008	0	0.558209	0
rcp26	2026	2030	45.454	25.83	9.392837	0	8.215987	0	rcp45	2026	2030	45.454	25.83	0	0	0.738335	0	rcp85	2026	2030	45.454	25.83	0	0	0.199017	0
rcp26	2026	2030	45.586	25.535	14.10106	0.896678	21.77846	0.267569	rcp45	2026	2030	45.586	25.535	27.33786	0.027716	28.85848	0.557222	rcp85	2026	2030	45.586	25.535	6.893645	0	12.23065	0
rcp26	2026	2030	45.575	25.691	16.12299	0.006784	17.82394	0.165818	rcp45	2026	2030	45.575	25.691	20.57959	0	23.43007	0	rcp85	2026	2030	45.575	25.691	8.197283	0.002677	6.737244	0
rcp26	2026	2030	45.563	25.847	10.79614	0	16.60066	0.019604	rcp45	2026	2030	45.563	25.847	11.31743	0	16.32402	0.020683	rcp85	2026	2030	45.563	25.847	0	0	0.992809	0

Figure 2- 5 Screen shots of yield loss results for initial Bbox, Clipped NUTs and Covasna County farmland in function of RCPs and near-future 2026-2030 time slice.

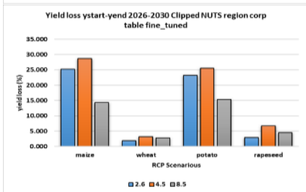
Table 2- 11 Near future (2026-2030) yield loss values downscaled from initial Bbox to NUTs and Covasna County farmland scale.

	RCP	2.6	4.5	8.5
Yield loss (%) ystart-yend 2026-2030 Bbox crop table_fine_tuned	maize	26.655	31.033	16.325
	wheat	1.733	2.794	2.430
	potato	23.920	26.905	16.230
	rapeseed	3.271	7.357	4.404
Yield loss (%) ystart-yend 2026-2030 Clipped NUTS region corp table fine_tuned	maize	25.216	28.702	14.374
	wheat	1.852	3.097	2.772
	potato	23.186	25.548	15.339
	rapeseed	2.969	6.734	4.558
Yield loss (%) ystart-yend 2026-2030 Clipped Interp Covasna county corp table fine_tuned	maize	22.159	27.122	13.285
	wheat	1.210	2.023	0.935
	potato	21.776	24.188	12.569
	rapeseed	2.047	5.321	2.381

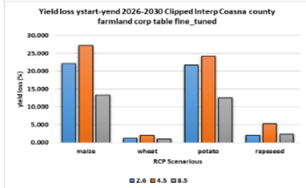
Comparison to downscaled regional linear interpolation, Covasna County farmland area



Bbox initial region: generated highest yield loss estimates, highest in RCP 4.5 scenario maize (31.03%), potato (26.905%) and rapeseed (7.357%). Larger Bbox dataset covers and could amplifies extreme yield loss values due to size of surface area i.e. spatial averaging of surface and yield loss data.



Clipped NUTS region: Yield losses are lower than Bbox, but higher than Covasna County farmland area, main differences, maize yield loss is lower with ≈ 5–10% and potato with ≈ 3–6% vs Bbox data.



Clipped Covasna County farmland area: Generated lowest yield losses for all crops and RCPs, indicating that local interpolation could smoothen extremes (if the base dataset is statistically processable).

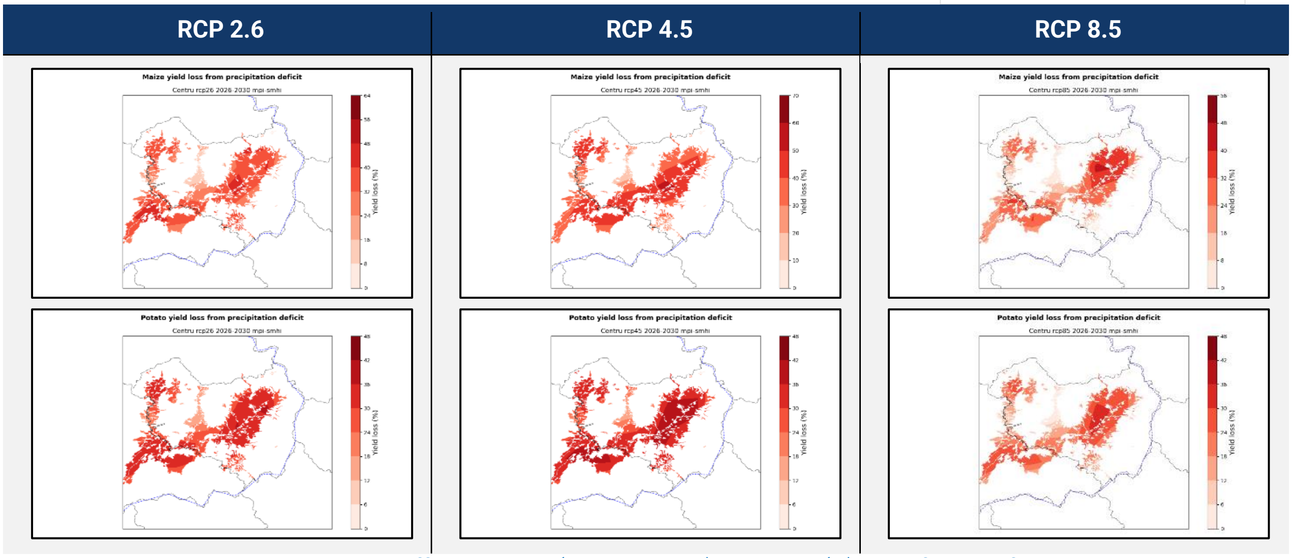


Figure 2- 6 Most effected crops (maize, potato) yield loss (%) plots for near-future

The Δ (%) Yield loss values compared to Bbox and Nuts region vs. Covasna County farmland area indicate that downscaling is crucial to reflect local yield loss values in local context.

Table 2- 12 The Δ (%) Yield loss values compared to Covasna County farmland values

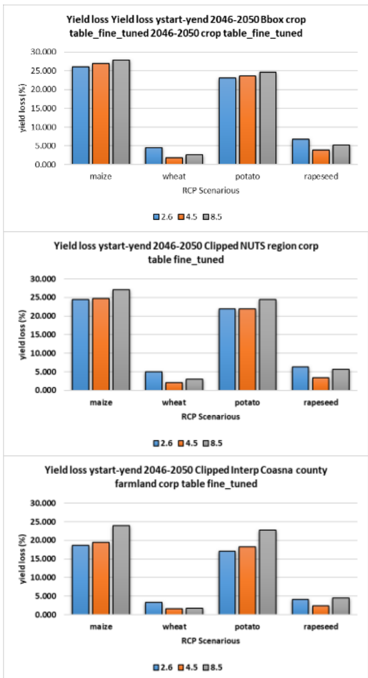
Δ (%) Yield loss ystart-yend 2026-2030 Clipped Bbox region vs Covasna County farmland corp table fine_tuned				
RCP	maize	wheat	potato	rapeseed
2.6	-16.869	-30.174	-8.966	-37.412
4.5	-12.602	-27.585	-10.097	-27.677
8.5	-18.620	-61.514	-22.560	-45.937
Δ (%) Yield loss ystart-yend 2026-2030 Clipped NUTS region vs Covasna County farmland corp table fine_tuned				
RCP	maize	wheat	potato	rapeseed
2.6	-12.126	-34.682	-6.083	-31.031
4.5	-5.505	-34.687	-5.325	-20.982
8.5	-7.571	-66.262	-18.061	-47.768

CROP-SPECIFIC VULNERABILITY FOR MID-CENTURY (2046-2050) TIME INTERVAL FINE-TUNED CROP TABLE

Table 2- 13 Mid-century (2046-2050) yield loss values downscaled from initial Bbox to NUTs and CV County farmland scale.

	RCP	2.6	4.5	8.5
Yield loss (%) ystart-yend 2046-2050 Bbox crop table_fine_tuned	maize	26.054	27.032	27.855
	wheat	4.576	1.844	2.613
	potato	23.094	23.557	24.678
	rapeseed	6.700	3.858	5.140
Yield loss (%) ystart-yend 2046-2050 Clipped NUTS region corp table fine_tuned	maize	24.471	24.776	27.060
	wheat	4.998	2.102	3.023
	potato	21.895	21.881	24.484
	rapeseed	6.327	3.466	5.618
Yield loss (%) ystart-yend 2046-2050 Clipped Interp Covasna County corp table fine_tuned	maize	2.600	4.500	8.500
	wheat	18.650	19.443	23.887
	potato	3.313	1.551	1.740
	rapeseed	17.070	18.264	22.724

Bbox initial region for mid-century (2046-2050) yield loss results show the highest estimates across all crops and RCPs, with particularly large losses for maize (26.054-27.855%) and potato (23.094-24.678%), moderate for rapeseed (3.858-6.700%), and comparatively low losses for wheat (1.844-4.576%), indicating as in case of near future period (2026-2030) that the large spatial extent amplifies adverse signals through spatial averaging over heterogeneous areas. Clipped NUTS region results closely follow the Bbox pattern but with slightly reduced magnitudes, with maize and potato losses typically lower by ≈1-2% points, suggesting that NUTS clipping dampens some extremes while preserving the dominant regional signal. Interpolated Covasna County farmland results diverge strongly from both regional approaches, producing substantially lower losses for maize (2.6-8.5%) and potato (1.551-3.313%) but significantly higher yield loss percentage for wheat (18.6-23.887%) and rapeseed (17.07-22.724%), demonstrating that local-scale interpolation smooths large-scale extremes while revealing crop-specific vulnerabilities that are hidden at coarser spatial resolutions.



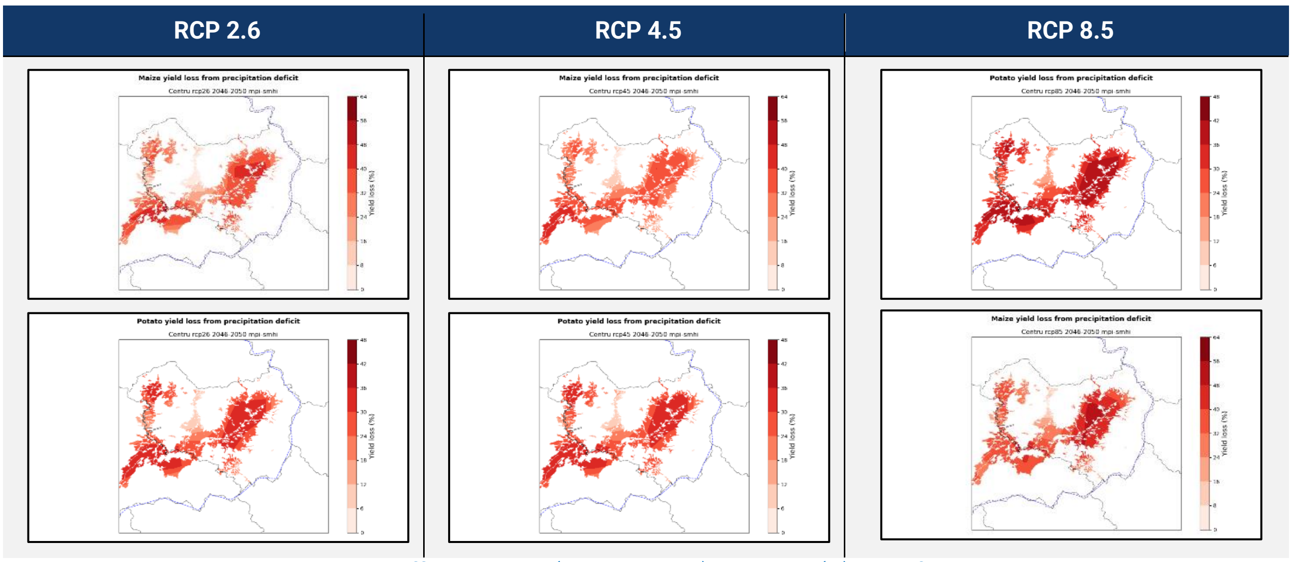


Figure 2- 7 Most effected crops (maize, potato) yield loss (%) plots for mid-century

Across all RCPs and crops, the negative Δ (%) Yield loss indicates (Table 2-14) also for Mid-Century time interval, that both Bbox and NUTS regional approaches overestimate yield losses relative to the interpolated Covasna County farmland results, with the largest discrepancies observed for rapeseed and wheat (around 40%), indicates that local-scale assessments substantially reduce estimated losses and alter crop-specific impact magnitude compared to larger spatial-scale analysis.

Table 2- 14 The Δ (%) Yield loss values compared to Covasna County farmland values

Δ (%) Yield loss ystart-yend 2046-2050 Clipped Bbox region vs Covasna county farmland corp table fine_tuned				
RCP	maize	wheat	potato	rapeseed
2.6	-28.420	-27.600	-26.085	-39.285
4.5	-28.075	-15.895	-22.467	-37.672
8.5	-14.245	-33.422	-7.918	-11.947
Δ (%) Yield loss ystart-yend 2046-2050 Clipped NUTS region vs Covasna county farmland corp table fine_tuned				
RCP	maize	wheat	potato	rapeseed
2.6	-23.789	-33.714	-22.037	-35.708
4.5	-21.526	-26.214	-16.532	-30.614
8.5	-11.728	-42.455	-7.189	-19.450

CLIMATIC WATER BALANCE ACROSS RCP SCENARIOS AND TIMELINE PERIODS

All scenarios show negative Climatic Water Balance (CWB) i.e. water deficit is caused when evapotranspiration exceeds precipitation. This indicates dry weather conditions, higher drought risk, and challenges for agriculture (e.g., maize, potato) and water resources management for irrigation in Covasna County.

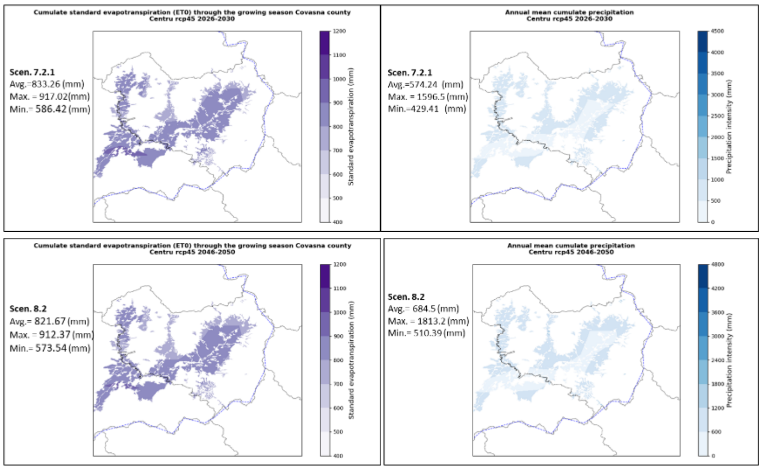


Figure 2- 8 Average ET0 and Precipitation RCP 4.5 for Near-future vs. Mid-century timescale

- **Near-future (2026-2030)**: RCP 2.6 projects the most severe deficit, while RCP 8.5 shows the least (near-neutral).
- **Mid-century (2046-2050)**: Deficits decreases in lower-emission scenarios (RCP 2.6 and 4.5) due to higher precipitation, but worsen slightly in RCP 8.5 due to rising ET0 (from warmer temperatures).

Table 2- 15 Average Precipitation, ET_0, and Climatic Water Balance across RCPs and periods

RCP	**ystrat-yend**	**Precipitaion (mm)**	**Cumulate standard evapotranspiration (ET0) (mm)**	**Climatic Water Balance (CWB)**
		Average	**Average**	**(P-ET0)**

2.6	**2026-2030**	269.6	820.646	-551.046
2.6	**2046-2050**	576.73	833.14	-256.41
4.5	**2026-2030**	574.24	833.26	-259.02
4.5	**2046-2050**	684.5	821.67	-137.17
8.5	**2026-2030**	716.01	760.529	-44.519
8.5	**2046-2050**	644.5	859.68	-215.18

Covasna County climate is cooler and wetter than southern Romania, but projections ET0, Precipitation and CWB values indicate increasing aridity risks, which align with national studies (MMAP, 2024) indicating also warmer temperatures, variable precipitation, and higher ET0 in future.

2.3.1.2 Risk assessment

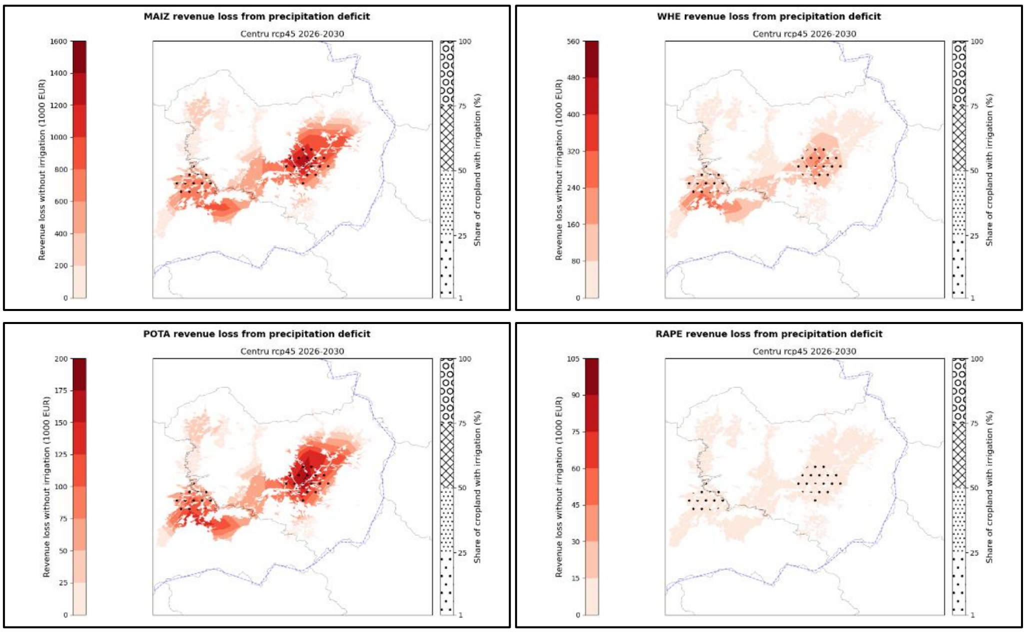


Figure 2- 9 Revenue loss without irrigation under RCP 4.5 for near-future timeline F

Table 2- 16 Revenue loss in EUR for near-future (2026-2030) timescale

Revenue loss ystart-yend 2026-2030 Clipped Interp Covasna county farmland corp table fine_tuned (EUR)								
	Maize		Wheat		Potato		Rapeseed	
RCP	Max.	Average	Max.	Average	Max.	Average	Max.	Average
2.6	1205122	432441	267288	44020	167871	64940	9031	2434
4.5	1381427	507574	319425	82495	179029	70979	14248	4661
8.5	939343	346407	163927	38563	152156	51351	9378	2520

Table 2-16 and Figure 2-8 indicate for near-future (2026–2030) revenue losses are the highest under RCP 4.5 for most crops (e.g., highest average for maize ≈€507k, wheat ≈€82k). RCP 8.5 indicates lower losses (possibly due to model variability or interpolation differences). Maize faces the largest revenue loss overall.

Table 2- 17 Revenue loss in EUR for near-future (2026-2030) timescale

Revenue loss ystart-yend 2046-2050 Clipped Interp Covasna county farmland corp table fine_tuned (EUR)								
	Maize		Wheat		Potato		Rapeseed	
RCP	Max.	Average	Max.	Average	Max.	Average	Max.	Average

2.6	938815	410615	318612	97325	162405	61276	14197	4199
4.5	917181	411760	223165	47828	152815	60372	9198	2702
8.5	1223910	479582	140251	36013	180798	70885	14355	3868

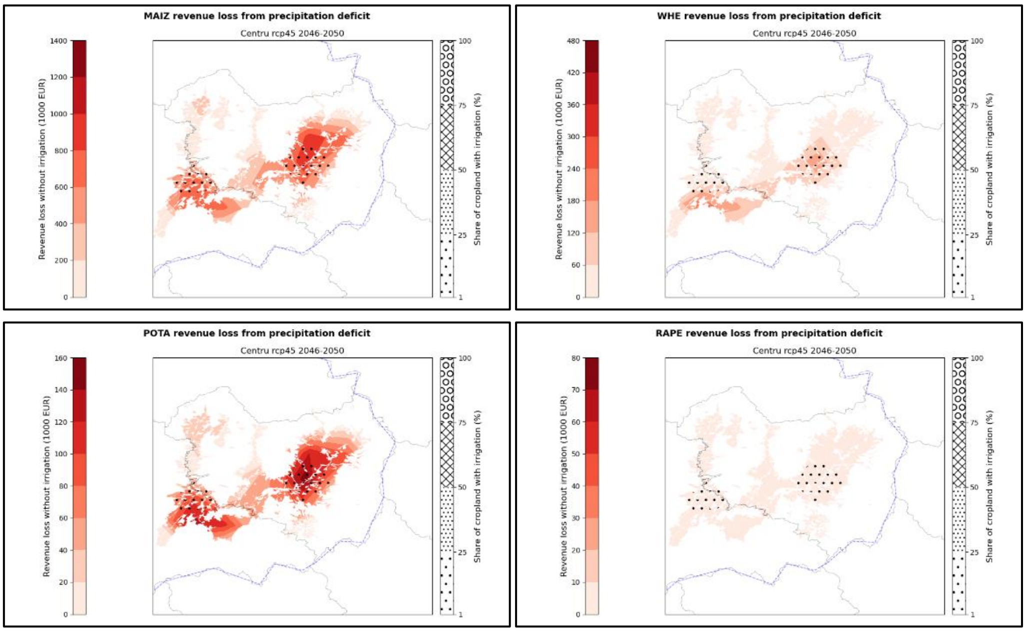


Figure 2- 10 Revenue loss without irrigation under RCP 4.5 for mid-century timeline

Table 2-17 and Figure 2-9 indicate for mid-century (2046-2050) that losses generally increase compared to near-future (2026-2030) period, especially under RCP 8.5 (highest average for maize ≈€480k, potato ≈€71k). RCP 2.6 and 4.5 show more moderate revenue loss impacts, but wheat and rapeseed averages rise in higher scenarios. Maize remains the most affected crop by far in absolute terms.

Revenue loss Impacts under moderate level RCP 4.5

Under the intermediate emissions pathway (RCP 4.5), projected climate impacts on agricultural revenue loss in Covasna County show moderate losses, with clear differences among crops and between time horizons. In the near future (2026-2030), RCP 4.5 produces the highest or near-highest revenue losses for most crops when compared with the other RCPs. Maize is the most affected crop, with maximum losses exceeding €1.38 million and average losses above €0.5 million, indicating high sensitivity to interannual climate variability even under moderate forcing. Wheat and potato experience substantially lower, but still relevant, losses, while rapeseed shows only minor impacts. Mid-century (2046-2050) timeline, revenue losses under RCP 4.5 decline consistently across all crops, both in maximum and average terms. Maximum maize revenue losses decrease to approximately €0.92 million, and average fall to about €0.41 million, although maize remains the dominant contributor to total economic risk. Wheat exhibits the strongest relative improvement, with average losses reduced by more than 40%, suggesting enhanced resilience under moderate warming conditions. Potato losses also decrease, though to a lesser extent, indicating persistent but manageable vulnerability. Rapeseed remains the least affected crop, with very low absolute losses throughout both periods.

2.3.2 Hazard #2 – River floods finetuning to local context

Table 2-17 Data overview workflow #2

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
River floods	Vulnerability damage curves	Land use, population, buildings	Map of flood depth and damage

2.3.2.1 Hazard assessment

In the second phase of the project we focus on analysing river flood risks based on more detailed, local datasets, considering the geographic properties of the city and the surrounding places. The analysed area is situated between 3 rivers, which have 2 merging points. These circumstances are significant concerns if there is a major rainfall on more than one of the water catchment basins simultaneously. Our analysis assesses the potential impacts and outcomes of the potential floods. In the process only the 2 bigger rivers (Casin and Raul Negru) were analysed because of the scare data. At first the different rivers were analysed separately, but after the right method was found to combine the different shape files, the analyses focused on the aggregate outputs. This vulnerability shows us the importance of understanding and managing the risks associated to river flood. Projections from the CLIMAAX toolbox highlight the flood risks and the potential damage zones in Targu Secuiesc.

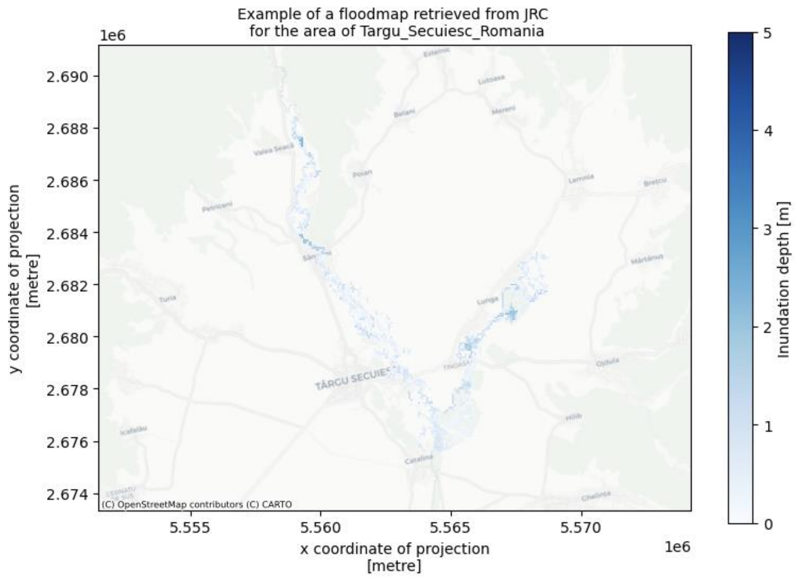


Figure 2- 11 Flood map from JRC for the studied region, Targu Secuiesc Municipality

The Europe-wide dataset of river floods provides a consistent overview of river flood hazard for all regions, but it has several important limitations. The dataset only includes large river basins (larger than 150 km^2) and does not include flood protections, which can lead to unrealistic flood maps in some regions. In addition, the underlying river model does not include any water management. This is why we could not get any valuable result on some maps. Here we can see the possible flooded territories of the Casin river at the left side and the Raul Negru at the right side.

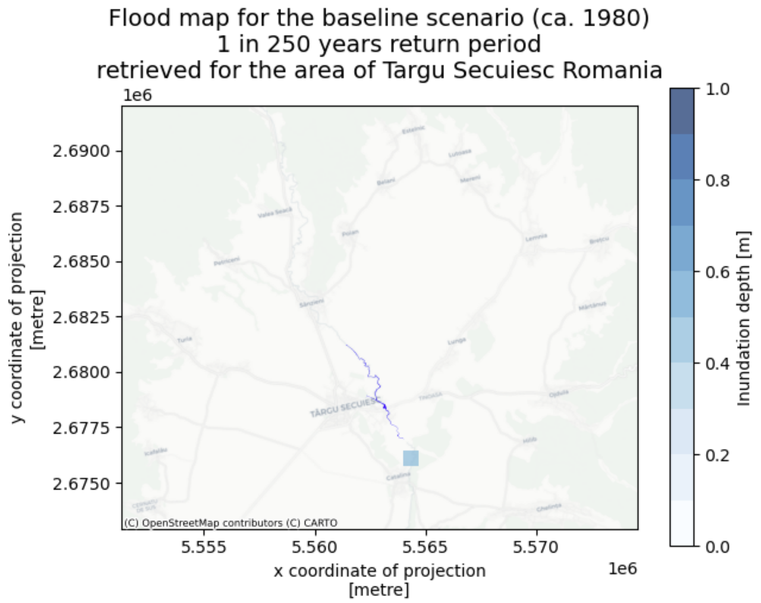


Figure 2- 12 Flood map for the baseline scenario 1 in 250 years return period

To improve the presentation of river flood maps we changed the colour of the two rivers, but probably the most important factor was to give a solution to zoom in and out form the map and to be able to move the map with the help of the mouse. This gives the user the ability to cut out part of a map with a much better resolution and to navigate through the map much easier than in the static maps provided before.

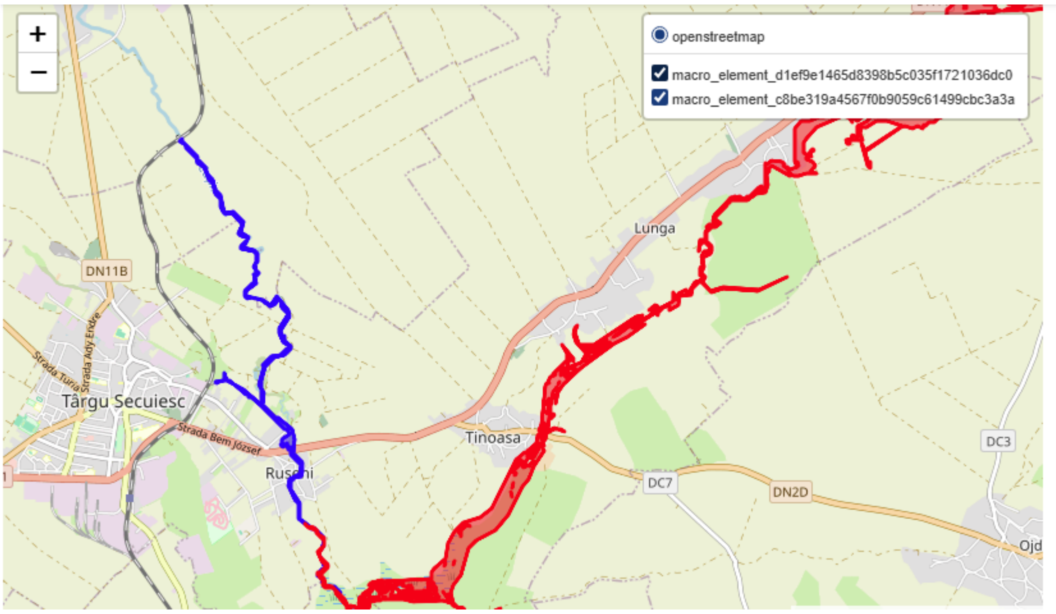


Figure 2- 13 Flood map for the Casin and Raul Negru rivers

You can also choose by a single click if you want to see only one of the rivers clicking in the top right corner on the desired option.

Trying to calculate the result for the 250-year return period we reach again the limitations of the available datasets. We have put the shape files sent by the Olt Basin Water Administration, but the blue square shows us only one pixel. This is because the shapefiles do not have water depth datasets, only this pixel has available data.

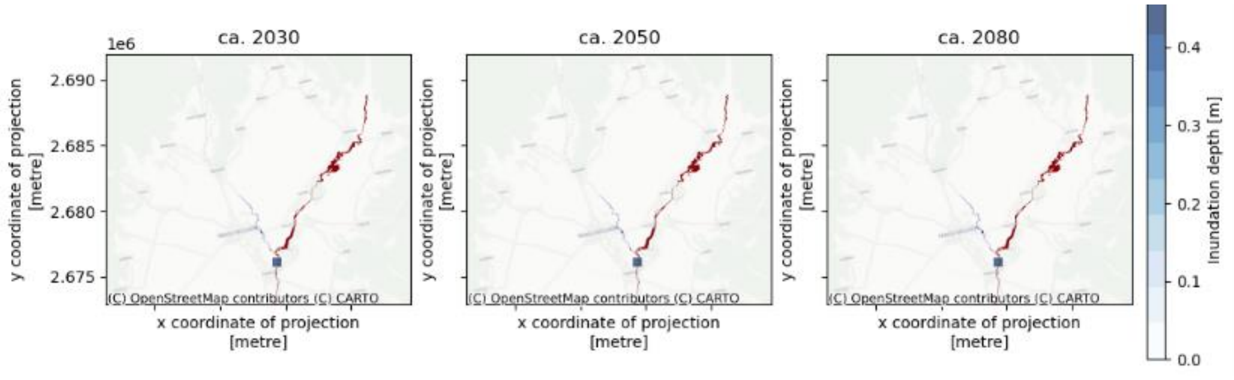


Figure 2- 14 Flood maps scenario 1 in 250-year return period RCP 4.5

RCP4.5 and RCP 8.5 scenarios give back the same result.

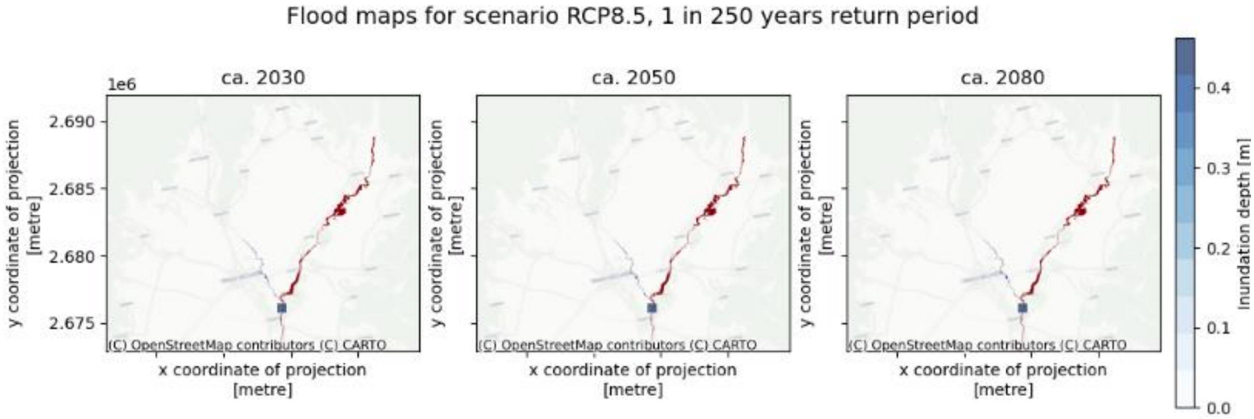


Figure 2- 15 Flood maps scenario 1 in 250-year return period RCP 8.5

2.3.2.2 Risk assessment

Flooding is a significant risk in Targu Secuiesc, although the last flood was in 2018, in 2025 was a near flood situation. The possibility exists every year when heavy rains fall in 2 or more river basins. The Casin and Raul Negru rivers are slow-flowing rivers, problems occur when the smaller rivers are also increased and the Raul Negru or the Olt river can barely/slowly take in the excess water. This results in a push back effect and the upper part of the rivers like Targu Secuiesc, when the accumulated water can't flow down and excess water keeps coming down. Usually, we have up to one month in April-May and one in June-July when rains are coming regularly.

In the first phase we conducted the analysis using global datasets, this caused in some cases to get flood maps with incomprehensible results.

In the second phase we obtained some shape files from the Olt Basin Water Administration regarding the Casin and Raul Negru rivers. These files contain flood maps but without water depth data. They only show the extent water can reach at a certain water level. These files were integrated in the hazard and risk assessment. Lack of data prohibited us to make a full analysis, sometimes the result showed only one pixel on the map, but we also managed to use simultaneously the two rivers’ maps showing the result of a double flood map.

Projections from the CLIMAAX toolbox highlight the flood risks and the potential damage zones in Targu Secuiesc. In this workflow we will visualize risks to build infrastructure presented by river flooding. Risk is expressed in this workflow in the form of economic damages.

We also used the combination of hazard and risk to create an overlay on a map where rivers are visible above hazard zones, providing a complete workflow visualization. What it does:

- hazard raster as background, with transparent blue shading;
- rivers as blue/red lines;
- buffer as transparent band;
- the map is interactive, zoomable, movable;
- it has a built in Layer Control so that the user can turn layers on and off.

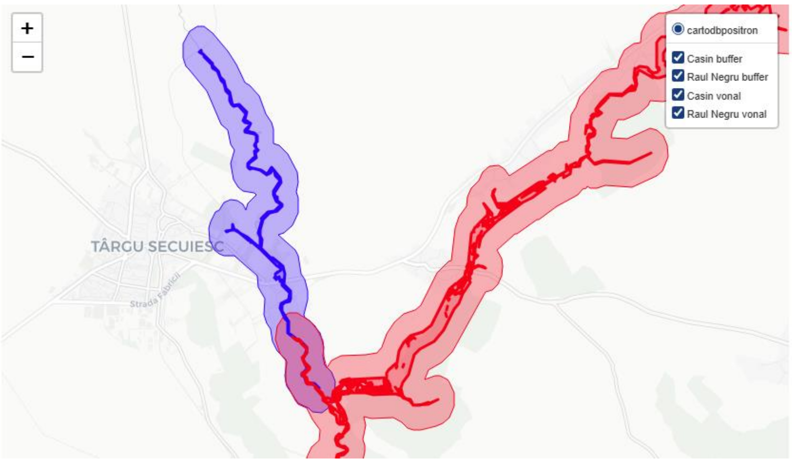


Figure 2- 16 Flood maps scenario 1 in 250-year return period RCP 4.5

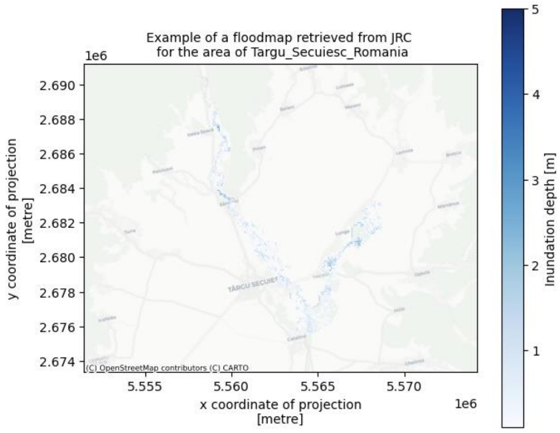


Figure 2- 17 Flood maps scenario 1 in 250-year return period RCP 4.5 without overlay and Layer control

We also used European-wide flood maps for river flooding to project economic damage to buildings using damage curves and building geometry, respectively exposed and displaced population using a population distribution map. We used pre-processed river flood maps and combined these with land use maps, as well as information on economic vulnerability (damage curves) to quantify the order of the damages in economic terms.

Analysing both (RCP 4.5 and 8.5) scenarios, even with the new shape files we observed that on the more distant periods the results become more insignificant. Lack of data prevents us from obtaining more valuable data, based on which we could give a more detailed estimate.

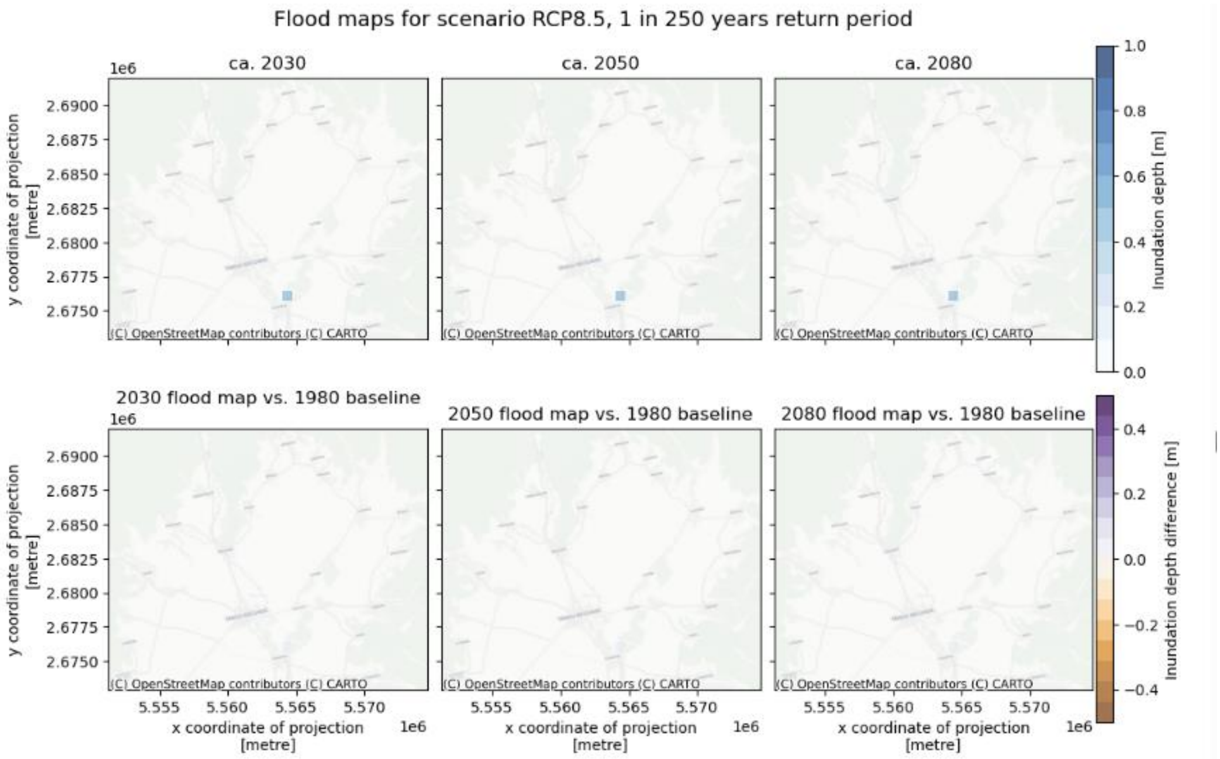


Figure 2- 18 Flood maps scenario 1 in 250-year return period RCP 8.5

In the following we show the results of the depth-damage curves for different types of damage classes. Depth–damage curves describe the relationship between flood water depth and the expected level of damage to exposed assets (such as buildings, infrastructure, or land use categories). They translate physical flood intensity (how deep the water is) into economic or relative damage. These curves are typically non-linear, reflecting the fact that damage increases rapidly once water enters buildings.

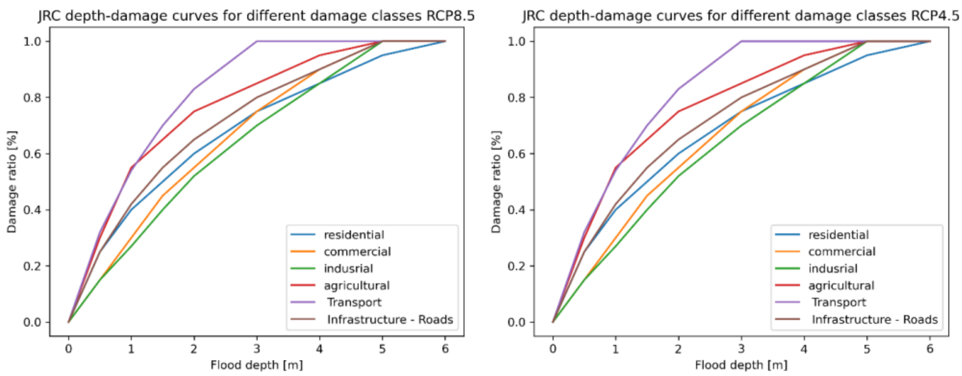


Figure 2- 19 Vulnerability flood damage curves RCP4.5 vs RCP8.5

How depth–damage curves work: a depth–damage curve assigns a damage ratio (usually between 0 and 1, or 0%–100%) to a given flood depth (0 → no damage, 1 → total damage). The biggest damage is caused at a lover level of water in transport facilities and the most resistant classes to water level is residential class. These curves are typically non-linear, reflecting the fact that damage increases rapidly once water enters buildings.

How to link land use types to economic damages

In order to assess the potential damage done by the flooding in a given scenario, we also need to assign a monetary value to the land use categories. We define this as the potential loss in

€/m². The plots below show us potential economic damage to infrastructure calculated by using Damage Scanner. It takes the following data:

- the clipped and resampled flood map;
- the clipped land use map;
- the vulnerability curves per land use category;
- a table of maximum damages per land use category.

We updated the GDP/capita data based on the 2024 dataset provided by the World Bank's Data Portal (20,080.20 USD). After we ran the RCP 4.5 and RCP 8.5 scenarios we didn't find any difference in the results.

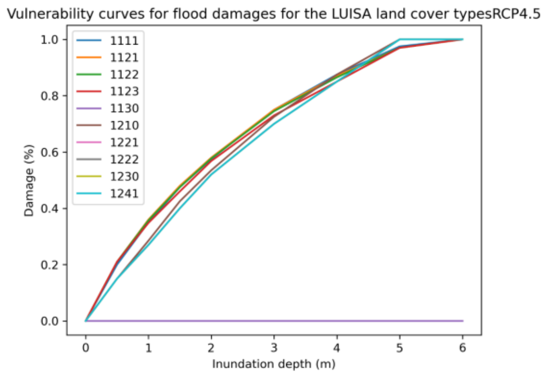


Figure 2- 20 Vulnerability flood damage curves for LUIS land cover types RCP 4.5

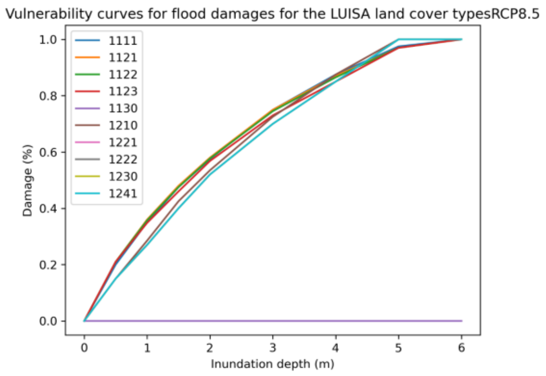


Figure 2- 21 Vulnerability flood damage curves for LUIS land cover types RCP 8.5

The values presented in the following comparison represent total economic damages expressed in million euros (M€) for each land-use category. These figures correspond to aggregated damage estimates at land-use class level, rather than unit-area or per-square-meter values. All values therefore quantify absolute monetary losses, already integrated over the spatial extent of the corresponding land-use class.

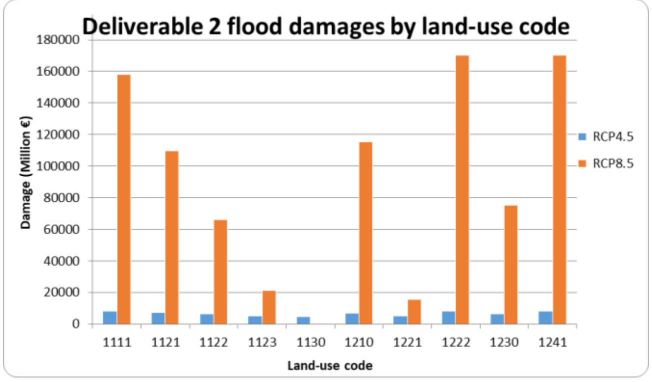


Figure 2- 22 Vulnerability flood damage by LUISA land cover types RCP 4.5 vs. 8.5

Three datasets are compared:

Deliverable 1 (D1): A baseline damage estimate, identical for both RCP4.5 and RCP8.5 scenarios. This indicates that climate scenarios were not differentiated in Deliverable 1, and damages are driven by a single methodological assumption.

Deliverable 2 – RCP4.5 (D2_45): An updated damage estimate reflecting climate change impacts under a moderate emissions pathway.

Deliverable 2 – RCP8.5 (D2_85): A damage estimate corresponding to a high-emissions scenario, representing more severe climate change conditions.

Across all land-use types, Deliverable 2 shows substantially higher damages than Deliverable 1. Since all values are expressed in million euros, this difference represents large absolute increases in expected losses, not marginal changes. This systematic increase indicates that the discrepancy is primarily methodological, rather than purely climate-driven. Deliverable 2 incorporates a more detailed representation of exposure, asset values, and damage potential, whereas Deliverable 1 reflects a simplified or conservative approach.

The comparison between D2_45 and D2_85 highlights the climate signal:

RCP8.5 consistently results in higher damages than RCP4.5, expressed as additional losses in million euros. The relative increase varies by land-use type, with urban, commercial, and high-density areas exhibiting the strongest sensitivity to the high-emissions scenario. This reflects the combined effect of: increased flood hazard intensity, higher exposure of valuable assets, and land-use-specific vulnerability. Because the results are expressed in absolute monetary terms, land-use classes with larger spatial extent or higher economic value naturally dominate total damages: high-density urban and commercial land uses account for the largest losses (in M€), due to concentrated and high-value assets. Medium- and low-density residential areas show lower but still substantial damages. Urban vegetation, transport, and special-use areas contribute comparatively smaller damage totals, reflecting lower asset intensity.

The results represent aggregated economic losses, not normalized values. Differences of several million euros between scenarios are highly significant from a risk management and policy perspective.

In summary, the reported values quantify total flood-related economic damages in million euros, aggregated by land-use category. Deliverable 2 consistently indicates higher damages than Deliverable 1, while the comparison between RCP4.5 and RCP8.5 within Deliverable 2 reveals a clear climate-change signal, with substantially higher losses under the high-emissions scenario. These results provide a robust basis for scenario comparison, risk prioritization, and climate adaptation planning.

RCP4.5	Phase 1	Phase2	Absolute difference	Realitve change %
1111	600,26	8.192,72	7.592	1365%
1121	414,49	7.228,87	6.814	1744%
1122	245,02	6.265,02	6.020	2557%
1123	69,91	5.252,98	5.183	7514%
1130	0,00	4.819,24	4.819	#DIV/0!
1210	405,23	6.987,90	6.583	1724%
1221	40,41	5.060,21	5.020	12522%
1222	565,84	8.192,72	7.627	1448%
1230	242,50	6.265,02	6.023	2584%
1241	565,84	8.192,72	7.627	1448%

Figure 2- 23 Vulnerability flood damage for LUISA land cover types RCP 4.5 Phase 1 vs Phase 2

This table presents a land-use–based comparison between Phase 1 and Phase 2 under the RCP4.5 scenario, with all values expressed in million euros (M€). The comparison is performed at the level of individual land-use codes, allowing a detailed assessment of how damage estimates change between the two deliverables. Overall, Deliverable 2 (RCP4.5) consistently reports higher flood damage values than Deliverable 1 across all land-use categories. The resulting positive absolute differences indicate an increase in estimated damages when moving from Deliverable 1 to Deliverable 2. Since the same climate scenario (RCP4.5) is considered, these differences cannot be attributed to climate forcing alone. Instead, the observed increases primarily reflect methodological improvements introduced in Deliverable 2, including a more detailed representation of exposed assets, updated economic valuation, and refined damage modelling assumptions. In particular, land-use classes associated with dense urban fabric and commercial activities show the largest absolute increases in damages, expressed in million euros, due to their higher concentration of valuable assets.

The relative change (%) further highlights the magnitude of these methodological differences by normalizing the absolute change with respect to Deliverable 1. High relative increases indicate land-use categories where Deliverable 1 likely underestimated potential flood damages compared to the more comprehensive approach applied in Deliverable 2.

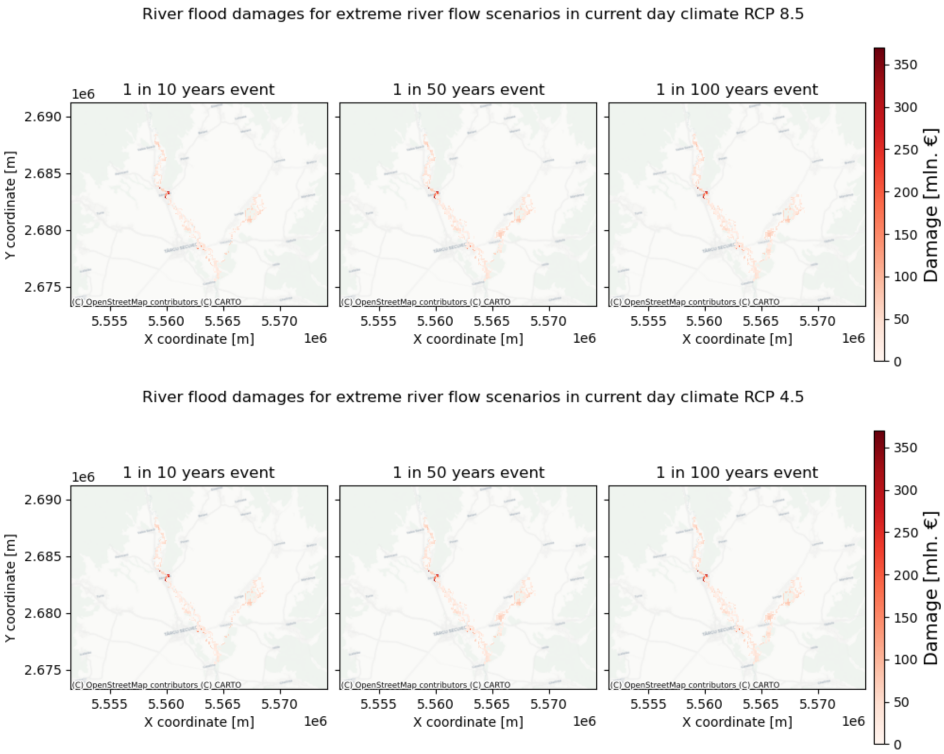


Figure 2- 24 River flood damage for extreme river flow scenarios RCP 4.5, RCP 8.5

Combining the maps and curves discussed earlier we can plot the damages to get a spatial view of what places can potentially be most affected economically. As we can see in the plots above, in the case of a longer return period we have a higher rate of flooded area in both examined scenarios.

To get a better indication of why certain areas are damaged more than others, we can also plot the flood map and land use maps in one figure for a given return period.

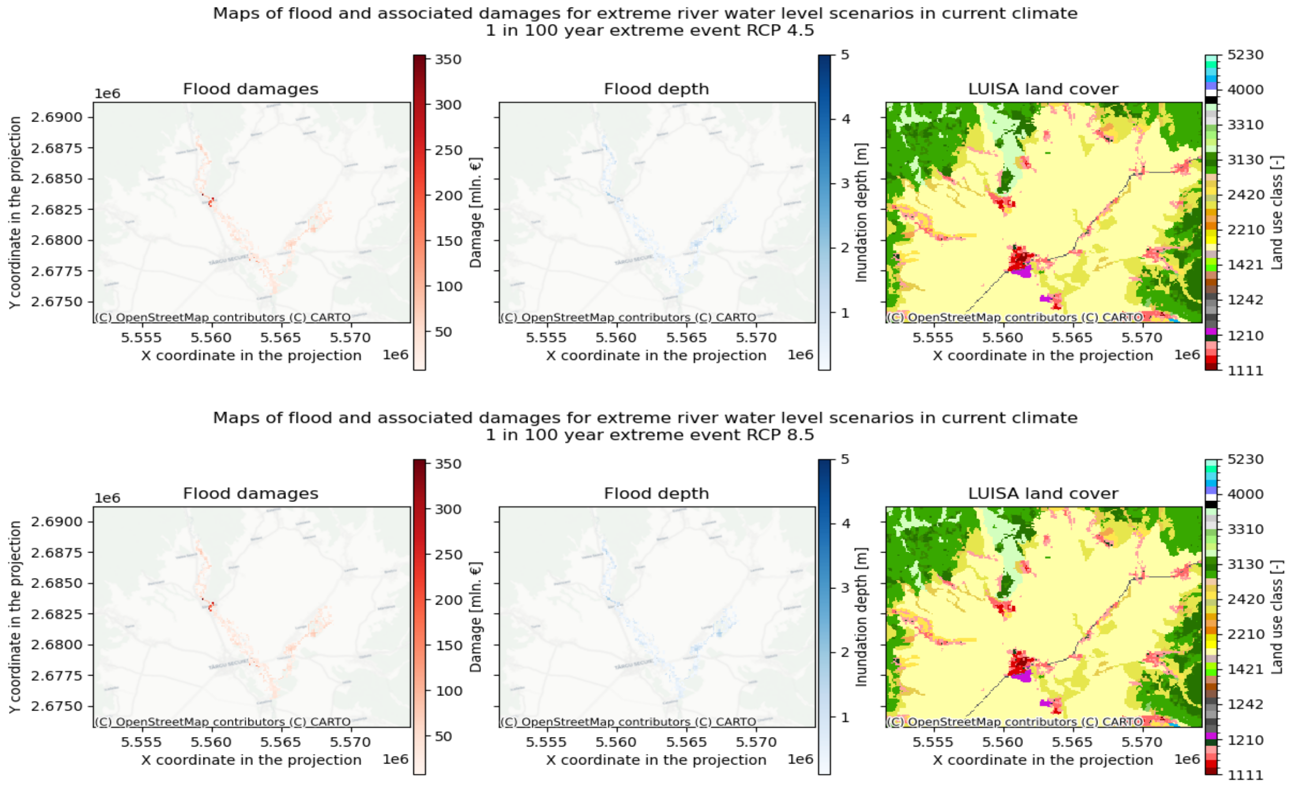


Figure 2- 25 River flood map RCP 4.5 and 8.5

Here we see both the potential flood depths and the associated economic damages. This overview helps to see which areas carry the most economic risk under the flooding scenarios.

2.3.3 Additional assessments based on local models and data

2.3.3.1 Hazard assessment

Agricultural drought hazard workflow:

- The workflow generates specific maps and plots that zoom in on Covasna County and even more precisely on areas identified as farmlands, this gives a much clearer, localized picture of calculated agricultural drought hazard;
- Yield loss values from the yield loss.csv were linearly interpolated for Bbox that covers Covasna County, creating a spatially realistic projections of yield loss;
- The crop table was updated with Covasna County specific start and end dates for the growing season;
- The workflow merges the computed yield losses with the corresponding revenue loss estimates into a single dataset. The final output is exported as a NetCDF file, clipped to Covasna County boundaries, and masked to include only farmland areas in EPSG:4326 coordinate system.

River floods hazard workflow:

- Local river flood hazard workflow was developed for the Târgu Secuiesc area by clipping and reprojecting European (JRC EFAS) and global (Aqueduct) flood datasets to a precise local bounding box;
- Official flood hazard shapefiles were obtained from the Olt River Basin Water Administration, covering recognised flood-prone areas along the main river courses affecting Târgu Secuiesc;

- The flood hazard workflow was complemented by consultations with the Covasna County Council, providing contextual information on flood-affected zones and infrastructure exposure;
- All locally sourced shapefiles were harmonised with the modelling framework by transformation into the common European coordinate reference system (EPSG:3035);
- Local flood hazard datasets were overlaid with modelled flood hazard maps to support spatial validation and interpretation of flood extents.

2.3.3.2 Risk assessment

Agricultural drought risk workflow:

- Analysis of precipitation and reference evapotranspiration (ET_0) trends for three RCP scenarios, covering near-future and mid-century time horizons;
- Derivation of Climatic Water Balance indicators to quantify water deficit conditions across scenarios and periods;
- Detailed crop yield loss analysis by crop type, time horizon, and RCP scenario, using fine-tuned crop growing-season calendars;
- Optimization of GAEZ data to reflect the specific surface area and agricultural characteristics of Covasna County farmland;
- Application of local spatial interpolation techniques to improve representation of drought impacts at county-scale farmland resolution;
- Generation of comparative plots across multiple spatial scales (Bbox, NUTS, and Covasna County farmland) to assess scale effects on results;
- GIS-based visualization of NetCDF outputs, converting model results into spatially explicit maps and plots;
- Estimation of crop-specific and total revenue losses under drought conditions, assuming the absence of irrigation infrastructure.

River floods risk workflow:

- Integration of flood extent shapefiles for the Cașin and Râul Negru rivers into the analytical framework;
- Use of flood hazard raster maps to identify and spatially delineate exposed areas;
- Generation of scenario-based flood hazard outputs for RCP 4.5 and RCP 8.5;
- Combination of flood hazard data with land-use datasets to support exposure and damage assessment;
- Application of land-use–specific economic values (€/m²) and corresponding vulnerability curves to estimate potential damages;
- Incorporation of updated Romania GDP-based economic inputs (World Bank, 2024) to ensure consistency with current economic conditions;
- Estimation of flood damages by land-use category, expressed in million euros, to support risk comparison and prioritization.

2.4 Key Risk Assessment Findings

2.4.1 Mode of engagement for participation

In Phase 2, we assessed the risks of agricultural drought and river flooding through focused discussions with institutional experts and key stakeholder groups. These meetings built on the general stakeholder engagement process described in Section 2.1.5. Our main purpose was to interpret the CLIMAAX Kézdi_Adapt risk results and check how relevant and representative they are for the local context of Târgu Secuiesc and Covasna County.

Both the Covasna County Agriculture Directorate and local farmers clearly identified drought as their most serious climate-related concern. They also reported growing conflicts over water allocation. While decision-makers recognize the problem, they feel they lack adequate tools and information for effective long-term planning. This contributes to the perception that the drought risk is becoming increasingly severe.

In case of River flood Workflow, a key element of stakeholder engagement was the provision of flood hazard spatial data. Flood extent shapefiles were obtained from the Olt River Basin Water Administration, which provided authoritative and locally relevant information on flood-prone areas. These datasets were essential for refining the exposure analysis and ensuring that the spatial representation of flood risk reflects local hydrological conditions and historical flood behaviour. In addition, consultations were held with the County Council.

2.4.2 Gather output from Risk Analysis step

KÉZDI_Adapt risk evaluation step quantifies risk information and data for the selected hazard, different Hazard base Risk outputs were elaborated to increase better understanding and interpretation of the step.

Agricultural drought risk assessment outputs:

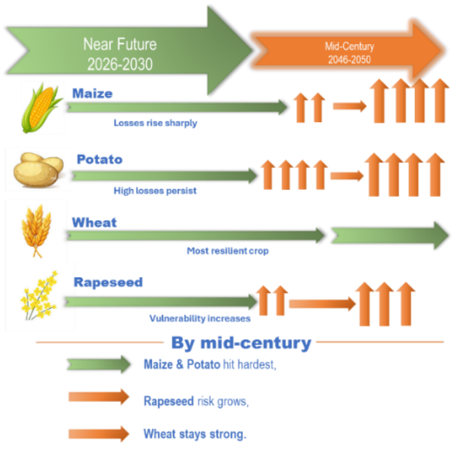
- Precipitation, ET0 trends for three RCP scenarios and for near-future and mid-century time scale, additionally Climate Water Balance data was determined;
- Yield loss was intensively analyzed for different time scale, RCPs using fine tined crop growing season data;
- Local spatial interpolation for county scale farmland;
- Plots for different spatial areas: Bbox, Nuts, Covasna county ->farmland;
- GIS based plotting of generated NetCDF -> visual plots;
- Revenue loss for all the studied crops in case of absent irrigation infrastructure;
- GAEZ data optimization for specific surface area of Covasna County farmland.

River flooding risk assessment output:

- Flood extent shapefiles for Cașin and Râul Negru rivers integrated into the analysis;
- Flood hazard raster maps identifying exposed areas;
- Scenario-based outputs for RCP 4.5 and RCP 8.5;
- Flood and land-use datasets for damage assessment;
- Land-use–based economic valuation (€/m²) and vulnerability curves applied;
- Updated Romania GDP-based economic input (World Bank 2024);
- Estimated flood damages by land-use category (million €).

2.4.3 Assess Severity

Agricultura drought risk is substantial severe, considering both historic and current trends. In Covasna County, agricultural drought has shifted from an occasional climate anomaly to a frequent and persistent stressor, driven by rising temperatures, longer dry spells, and declining soil moisture during critical growing seasons. These trends have already resulted in repeated yield



losses, increasing production costs, and reduced land productivity across large agricultural areas. Current observations and stakeholder evidence indicate that impacts are cumulative and long-lasting, with drought increasingly undermining soil quality and the economic viability of farming, suggesting that without intervention, future impacts will intensify and may become partially irreversible. Agricultural drought in Targu Secuiesc and Covasna County is a high-risk priority that affects large farmland areas, particularly those with potatoes, maize. The climate hazard can generate substantial financial losses through reduced yields, crop failures, and rising irrigation and input costs, placing significant strain on agriculture, a cornerstone of the county's economy and employment. Beyond direct production losses, drought also could trigger indirect effects such as supply-chain disruptions, low capacity for farm investment, and increased pressure on public budgets. Although it causes limited immediate human losses, its economic and territorial footprint is extensive, having an impact on entire micro-regions.

Flood risk in Târgu Secuiesc can be characterized as moderate in severity when assessed against historical experience, current conditions, and future climate projections. Historically, flood events have occurred intermittently rather than frequently, typically linked to intense precipitation and river overflow, and their impacts have been localized and sector-specific, mainly affecting residential buildings, local transport infrastructure, small commercial activities, and agricultural land in flood-prone areas. While financial damages can be locally significant, particularly in urban and commercial zones, impacts have generally been temporary, with limited disruption to essential services and no evidence of high human losses, widespread displacement, long-term economic paralysis, or failure of critical infrastructure. Looking ahead, climate change is expected to increase the magnitude of potential damages due to more intense rainfall events and growing exposure of assets, however, current assessments indicate that these impacts are unlikely to undermine the city's overall functioning or long-term viability, suggesting that flood risk remains manageable but justifies sustained investment in prevention, preparedness, and adaptation to limit cumulative stress on infrastructure and vulnerable households.

2.4.4 Assess Urgency

Agricultural drought in Târgu Secuiesc, Covasna County has a substantial severity, based on both historical trends and current conditions. Increasing temperatures, prolonged dry periods, and declining soil water content, lack of irrigation infrastructure have made agricultural drought more frequent and persistent, causing substantial negative impacts on agriculture which is one of the county's most climate-sensitive and economically important sector. Large areas of farmland are affected, leading to reduced crop yields, financial losses, and growing uncertainty for farmers, while drought-degraded soils also amplify flood damage during intense rainfall events. Stakeholder perspectives, particularly from farmers and small producers, highlight cumulative and often underreported impacts such as soil degradation, farm abandonment, and rising inequality between large and small farms, reinforcing the perception of drought as a structural rather than episodic risk. Datasets from agricultural authorities confirms these trends, while engagement with decision-makers shows improving awareness but uneven technical and know-how capacity to fully address cascading and long-term consequences.

In Târgu Secuiesc, flood risk severity is generally considered moderate, but with the potential to become locally severe during extreme rainfall events. The municipality's exposure is mainly linked to river and pluvial flooding driven by intense precipitation, which can cause short-notice disruption, property damage, and challenging recovery, particularly if events occur repeatedly. While technical assessments suggest that flood risk can be managed through flood safety construction measures, drainage improvements, early warning systems, and spatial planning, effective risk reduction depends on long-term planning and early investment. In practice, adaptation efforts may be constrained by funding limitations, institutional capacity, and competing municipal priorities, meaning that waiting for clearer or more severe flood impacts would likely reduce the effectiveness of future adaptation in Târgu Secuiesc.

Feedback and cooperation from stakeholders increased climate mitigation perspective on local level, the following takeaways can be listed:

- Agricultural drought is perceived as a real risk *with and negative tendency,* affecting planting decisions, yields, and farm viability year after year;
- Limited access to irrigation, environmental, technological, legal and economic constrains makes drought impacts disproportionately severe;
- River floods, are seen as *high-impact events*, for build and agricultural environment;
- Crop yield and revenue loss results confirmed structural shifts need in land use, with water-sensitive crops (potatoes, maize) becoming increasingly exposed;
- Drought and flood are challenging the traditional perception that these hazards are spatially or temporally separate;
- Flood risk is perceived as urgent due to immediate disruption, property damage, and difficult recovery, particularly with repeated events;
- Direct experience of flooding increases the perceived severity of impacts;
- Flood risk is considered manageable if addressed through structural protection, early warning systems, and spatial planning;
- Awareness of flood risk is increasing, but response capacity is limited by funding, institutional constraints, and competing priorities;
- Stakeholder evidence reinforced the need to move from awareness to implementation-ready adaptation measures, aligned with the goals of the CLIMAAX framework.

2.4.5 Understand Resilience Capacity

In Târgu Secuiesc and Covasna County, a range of climate risk management measures are already in place mainly under development to address agricultural drought, spanning financial, social, and natural dimensions, although their effectiveness and territorial coverage remain uneven. Financially, farmers benefit from national and EU agricultural subsidies, compensation schemes for climate-related crop losses, and a limited uptake of crop insurance, which help buffer economic shocks but often fall short for small and medium-sized producers. Social resilience is supported through farmer cooperatives and producer associations that enable information exchange, joint input purchasing, and mutual support during adverse seasons. Human capacity is strengthened through advisory services and training provided by Direcția pentru Agricultură Județeană Covasna, focusing on farming practices, crop diversification, and compliance with agri-environmental schemes. Physical measures include localized irrigation systems, gradual adoption of drought-tolerant crop varieties, although irrigation infrastructure remains limited and unevenly distributed across the county. Natural measures such as crop rotation, reduced tillage, maintenance of grasslands, and buffer zones could contribute to improved soil water retention and ecosystem resilience. Local and county authorities are planning or piloting targeted interventions, including small-scale irrigation implementation, water retention measures, and enhanced hydrological monitoring in areas exposed to both drought and floods (Climaax Kézdi_Adapt, Urbact-Sponge measures). The successful implementation of the projects/actions could provide a solid foundation for drought risk management, stakeholders consistently emphasize the need for stronger coordination, scaled-up investment, and more equitable access to measures to effectively respond to the increasing severity of climate impacts.

Climate risk management measures to address river flood risk are already in place and are complemented by several implemented and planned interventions at local and regional levels. Financially, municipal budgets support the routine maintenance of drainage infrastructure and emergency response, while national and EU funding mechanisms are accessed for larger flood protection and infrastructure projects when available. Socially, local emergency response systems and some sort of community awareness activities try to enhance preparedness through communication during flood events and coordination with residents, particularly in the most affected areas. From a human capacity perspective, municipal staff and emergency services play a central role in flood response and recovery, supported by technical expertise from regional water authorities, although capacity may be stretched during severe events. Existing measures include river channel maintenance, drainage networks, small-scale flood defences, and emergency response infrastructure. Early warning and emergency response systems operate at county and national levels, with continued efforts to improve forecasting, communication, and coordination during extreme weather events (https://inundatii.ro/). Access to national and EU funding programs supports planned investments in flood risk reduction, climate adaptation, and resilience, although implementation may be phased due to financial and administrative constraints. Overall, these combined measures provide a solid foundation for managing current flood risk in Târgu Secuiesc, but their long-term effectiveness depends on sustained investment, capacity building, timely implementation, and the integration of future climate risk projections into long-term planning.

2.4.6 Decide on Risk Priority

The assignment of risk priority was carried out through a structured evaluation process based on the Key Risk Assessment protocol, using the evaluation dashboard as the main analytical and decision-support tool. For each identified climate hazard, the dashboard guided the systematic scoring of three core dimensions: severity, urgency, and capacity (resilience/CRM). Severity scores were derived from climate trends, spatial extent of impacts, and potential economic, environmental, and social consequences. Urgency captured the frequency of events, immediacy of observed impacts, and the time sensitivity for effective intervention. Capacity assessed the existing ability to manage and reduce risks, considering institutional frameworks, financial resources, infrastructure, knowledge, and adaptive practices already in place.

Initial scores were informed by quantitative analyses (climate data, agricultural and hydrological statistics) and then reviewed and adjusted through stakeholder meetings, expert discussions, and feedback sessions involving local authorities, farmers, and sectoral experts, including representatives of Direcția pentru Agricultură Județeană Covasna. This participatory step was essential to validate dashboard results, incorporate local knowledge, and reflect real-world constraints and vulnerabilities that are not always captured by data alone.

The finalized values are presented in the Risk Workflow table (Table 2-18), where the combined interpretation of severity, urgency, and capacity leads to the determination of the overall risk priority. Risks characterized by high severity and urgency but only moderate or low adaptive capacity such as agricultural drought were classified as High priority. This transparent and replicable process ensures that prioritization is evidence based, locally grounded, and fully aligned with the methodology of the CLIMAAX, providing a clear rationale for focusing adaptation efforts and resources on the most critical risks.

Table 2- 18 Matrix of Key Risk Assessment

Risk Workflow	Severity		Urgency	Capacity	Risk Priority
	C	F		Resilience/ CRM	
River flooding	2	2	3	1	High
Coastal flooding	n.a	n.a	n.a	n.a	n.a
Heavy rainfall	n.a	n.a	n.a	n.a	n.a
Heatwaves	n.a	n.a	n.a	n.a	n.a
Drought	3	3	3	2	High
Fire	n.a	n.a	n.a	n.a	n.a
Snow	n.a	n.a	n.a	n.a	n.a
Wind	n.a	n.a	n.a	n.a	n.a

Risk priority was carried out through a structured evaluation process in line with the CLIMAAX Risk Evaluation protocol (Table 2-18), through the evaluation dashboard as analytical and decision-support tool. The process focused on two key climate risks relevant to Covasna County and Târgu Secuiesc: agricultural drought and river flooding. For each risk, the dashboard guided the systematic scoring of three core dimensions: severity, urgency, and capacity (resilience/climate risk management). Severity scores were derived from historical and current climate trends, the spatial extent of impacts, and the potential economic, environmental, and social consequences associated with drought impacts on agriculture and flood impacts on settlements and infrastructure. Urgency reflected the frequency of events, the immediacy of observed impacts, and the time sensitivity for effective intervention, while capacity assessed the existing ability to manage and reduce risks by considering institutional frameworks, financial resources, infrastructure, knowledge, and adaptive practices already in place.

Initial scores were determined by hazard and risk workflow results data, covering climate agricultural and hydrological data, and were subsequently reviewed and refined through stakeholder engagement. Meetings, expert discussions involved local authorities, farmers, sectoral experts, and institutional representatives, including the Direcția pentru Agricultură Județeană Covasna, Olt River Basin Water Administration, County Council who also supported the alignment between local risk understanding, regional planning objectives, and institutional capacities. This participatory step was essential to validate the dashboard results, incorporate local knowledge, and reflect real-world constraints and vulnerabilities that are not always captured by data alone, particularly in relation to on-the-ground agricultural conditions and flood response capacities.

A key element of the river flooding assessment was the use of flood hazard spatial data, including flood extent shapefiles, which enabled a refined exposure analysis and ensured that the spatial representation of flood risk accurately reflected local hydrological conditions and historical flood behaviour.

The risk prioritization in the Risk Workflow table represents, the combined interpretation of severity, urgency, and capacity. Both agricultural drought and river flooding were classified as High priority risks, reflecting their high severity and urgency in combination with low and medium adaptive capacity. This transparent, participatory ensures that prioritization is evidence-based, locally grounded, providing a clear rationale for focusing adaptation efforts and resources on the most critical climate risks.

2.5 Monitoring and Evaluation

Key Lessons Learned:

- Workflow Methodological design strongly controls impact magnitude: The transition from the Phase 1 to the Phase 2 workflow demonstrates that agricultural drought impacts can be substantially over- or underestimated depending on model formulation, confirming that transparent, well-documented, and tested workflows are essential for credible drought risk assessments.
- Crop vulnerability is highly differentiated and persistent: Maize consistently emerges as the most drought-sensitive crop, followed by potato, while wheat is generally the least affected at regional scales.
- Spatial scale fundamentally shapes results and interpretation: Large spatial domains (Bbox, NUTS) can systematically amplify yield-loss estimates due to spatial averaging over heterogeneous climatic and agronomic conditions. Local-scale analyses (Covasna County farmland) reduce extreme losses for maize and potato but can reveal increased vulnerability for crops such as wheat and rapeseed. This highlights that regional-scale results are not directly transferable to local decision-making without downscaling and local calibration.
- Local context integration adds analytical value: Incorporating local crop calendars, season start/end dates, and spatial interpolation significantly improves the relevance of results. The finetuned workflow demonstrates that local data can smooth unrealistic extremes while uncovering crop-specific risks that are hidden at coarser resolutions, supporting more targeted and actionable adaptation planning.
- Model choice matters as much as scenario choice: The comparative GCM–RCM analysis shows that model selection has a decisive influence on projected drought severity. The MPI-ESM-LR + RCA4 combination consistently produces stronger drought signals and higher yield losses, aligning with literature data. This underlines the importance of model evaluation and justification, rather than relying on a single or arbitrary climate model.
- Water deficit is a persistent and growing constraint: Negative Climatic Water Balance values across all scenarios and periods indicate structural water stress, driven by increasing evapotranspiration and variable precipitation. Even in relatively cooler and wetter regions such as Covasna County, drought risk remains significant, particularly for water-demanding crops, emphasizing the need for improved water management and irrigation strategies.
- Economic impacts mirror biophysical vulnerability but show adaptive potential: Revenue loss assessments confirm maize as the dominant source of economic risk, with near-future losses under RCP 4.5 exceeding €1.38 million. However, declining mid-century losses for most crops especially wheat suggest that moderate warming, combined with adaptive capacity or changing climatic balances, may partially offset impacts. This demonstrates the value of coupling hazard metrics with economic analysis to support prioritization.

- Localized, fine-tuned assessments are essential for adaptation planning: The overall lesson is that robust agricultural drought risk assessment requires updated methodologies, validated climate models, and local-scale implementation. Fine-tuned workflows provide more realistic estimates, improve confidence in results, and enable evidence-based decisions on crop selection, irrigation investment, and climate adaptation strategies at county and farm levels.
- Integrated approaches substantially improve flood risk understanding: The combination of quantitative damage estimates, spatial flood hazard data, and scenario-based analysis proved effective in capturing flood risk dynamics and revealing both current and future impacts, particularly in urban and high-value land-use areas.
- Flood risk already has tangible and growing economic consequences: The assessment confirmed that flooding is not only a future concern but already causes measurable economic damage, with projected increases over time due to exposure patterns and evolving risk conditions.
- Data limitations are a critical bottleneck: Limited availability of harmonised local data and the effort required to align datasets and assumptions significantly constrained the depth and precision of the analysis, highlighting the need for improved local databases.
- Spatial river flood hazard data are essential for meaningful analysis: The availability of new spatial flood hazard data during the process significantly enhanced exposure and risk assessments, demonstrating the high added value of detailed and up-to-date geospatial information.
- Stakeholder contributions are vital but underutilised: Stakeholders played an important supportive role in Monitoring and Evaluation by providing data, yet limited staff capacity and time reduced opportunities for broader engagement and deeper co-production of results.
- Iterative analysis supports learning and transparency: Learning was effectively ensured through iterative analysis, clear documentation of assumptions, and systematic comparison of scenarios and deliverables, strengthening transparency and methodological robustness.
- Capacity and resource constraints limit analytical ambition: Further improvements in flood risk assessment would require more detailed exposure data, stronger technical expertise, and dedicated human and financial resources.
- Lack of integrated monitoring systems limits long-term tracking: The absence of a fully integrated local monitoring system prevents systematic tracking of flood risks over time and limits the ability to assess trends and effectiveness of future interventions.
- Efficient use of resources can still deliver strong outcomes: Despite constraints, resources were used efficiently, and the analytical framework and stakeholder collaboration functioned well within existing limits.
- Institutional decision-making capacity was strengthened: Overall, the second phase significantly enhanced institutional understanding of flood risk in Târgu Secuiesc, providing a stronger evidence base for informed decision-making and future investment planning.

The final outcomes will be communicated through a multi-channel, stakeholder-oriented approach to ensure accessibility, transparency, and practical uptake in Covasna County. Core results are disseminated via the Kézdi_Adapt /CLIMAAX project website, including interactive GIS-based hazard and risk maps, which allow users to explore scenarios relevant to agriculture and climate risks. These technical outputs are complemented by clear explanatory texts, summaries, and visual materials tailored for non-technical audiences. Targeted communication with decision-makers and institutions is ensured through workshops, meetings, and policy-oriented briefs, supporting evidence-based planning and coordination. For broader outreach and awareness raising, results and key messages are shared through social media platforms (Facebook, TikTok, LinkedIn), short educational videos, and press materials, helping to reach farmers, local communities, and the wider public. This combined communication strategy ensures that final outcomes are not only reported, but actively used to support climate resilience, capacity building, and informed decision-making.

2.6 Work plan Phase 3

In Phase 3, we will work closely together with the relevant institutes and key local stakeholders to develop based on local fine-tuned data, a dedicated strategy and improved risk management plans. These will be based on the findings and results of our research and will help us better identify and understand the specific local risk drivers that affect the most important community systems in the area.

Our main goal is to present the technical documentation of our research to policy makers on national level, ensuring that scientific evidence is formally considered. We aim to bridge the gap between research and policy, allowing our findings to be considered, and used at the political level. This approach ensures that political decision-making is informed by reliable scientific results, contributing to the development of well-founded, effective, and transparent public policies.

Table 2- 19 Deliverable list

Nº	Phase	Name	Due by
D1	Multi-risk climate assessment	Implementation of the CLIMAAX common methodology for multi-risk assessment and analysis of the results.	Month 6 *31/03/2025*
D2	Refined regional/local multi-risk assessment	Refined regional/local risk assessment including local data and comparison of results.	Month 16 *30/01/2026*
D3	Adaptation strategies and improved Risk Management Plans	Contribution to local adaptation strategies and improved risk management plans based on the previous studies.	Month 22 *30/07/2026*

Milestones Phase 3:

- M12. Definition of feasible adaptation strategy on local level (Month 19);
- M13. Scientific publication or conference attendance (Month 20)
- M14. Technical document to support local risk management elaboration (Month 20);
- M15. Draft document of improved local risk management plan project closer (Month 21);
- M16. Workshop for result dissemination (Month 21);
- M17. Attend CLIMAAX workshop held in Brussels (Month 22).

3 Conclusions Phase 2- Climate risk assessment

The fine-tuned agricultural drought workflow generated a more accurate and policy-relevant hazard and risk analysis of agricultural drought due to workflow methodological corrections with local-scale customization, thought explicit quantification of yield and revenue loss and climatic water balance. The re-run of the base workflow demonstrated that Phase 1 results substantially overestimated drought-induced yield losses. For example, wheat and rapeseed yield losses, which previously ranged from approximately 20-27% in Phase 1, are reduced in Phase 2 to below 3%, and in several cases approach near-zero values across all RCPs and both time intervals (2026-2030 and

2046–2050). In contrast, maize and potato remain the most vulnerable crops, although their projected losses are reduced by approximately 6–15 percentage points compared with Phase 1, confirming that while impacts were overestimated previously, drought risk for these crops remains high, the trends were similar.

The finetuned workflow highlights strong spatial-scale effects, in the near-future (2026–2030), the Bbox-level analysis under RCP 4.5 produces the highest yield-loss estimates, with maize losses reaching 31.0%, potato 26.9%, and rapeseed 7.4%, while wheat remains the least affected. When the analysis is spatially constrained to the NUTS region, maize losses decrease by approximately 5-10%, and potato by 3-6% relative to the Bbox results. The most localized assessment, focusing on Covasna County farmland, generates the lowest yield losses for all crops and RCPs in the near-future, highlighting that linear interpolation to local scale and cropping calendars can smooth regional extremes. In the mid-century period (204662050), the same scale-dependent pattern persists. Bbox-level results show maize losses of 26.1-27.9% and potato losses of 23.1-24.7%, rapeseed losses of 3.9-6.7%, and wheat losses of 1.8–4.6%. NUTS-level clipping reduces maize and potato losses by around 1–2 percentage points while preserving the regional signal. However, at the Covasna County farmland scale, yield losses diverge markedly: maize losses fall to 2.6–8.5% and potato to 1.663.3%, whereas wheat and rapeseed show substantially higher losses of 18.7-23.9% and 17.1-22.7%, respectively. This shift illustrates the fine-tuning on local level can uncover crop-specific vulnerabilities that are masked in regional averages.

Climatic Water Balance (CWB) analysis further supports these findings, all scenarios and periods exhibit negative CWB values, indicating persistent water deficits driven by evapotranspiration exceeding precipitation. In the near-future, RCP 2.6 produces the most severe deficits, while RCP 8.5 remains close to neutral. By mid-century, water deficits decrease under RCP 2.6 and RCP 4.5 due to increased precipitation, but intensify slightly under RCP 8.5 as higher temperatures increase reference evapotranspiration (ET_0). Despite Covasna County's relatively cooler and wetter baseline climate, projected increases in ET_0 and precipitation variability point toward growing aridity risks consistent with national climate assessments.

Economic impacts under the moderate-emission RCP 4.5 scenario mirror the biophysical results in the near-future, maize experiences the largest revenue losses, with maximum losses exceeding €1.38 million and average losses above €0.5 million, reflecting high sensitivity to interannual climate variability. Wheat and potato incur lower but still meaningful losses, while rapeseed remains marginally affected. By mid-century, revenue losses decline across all crops: maximum maize losses decrease to approximately €0.92 million, and average losses to around €0.41 million. Wheat shows the strongest relative improvement, with average losses reduced by more than 40%, while potato losses decline more modestly and rapeseed continues to exhibit minimal economic risk.

Overall, the combined agricultural drought hazard and economic analyses highlight the necessity of using updated, locally fine-tuned workflows to support evidence-based agricultural adaptation strategies, prioritizing crop selection, water management, and regional planning to mitigate future climate-related risks.

In case of River flooding workflow Phase 2 of the project successfully advanced the understanding of flood risk in Târgu Secuiesc by integrating quantitative damage estimates, spatial flood hazard data, and scenario-based analysis. A key conclusion is that flood risk already causes measurable economic impacts and is projected to increase over time, particularly in urban and economically valuable land-use areas.

The assessment addressed key challenges related to risk quantification and spatial validation, notably through the use of flood extent shapefiles provided by the Olt River Basin Water Administration and through stakeholder consultation at the regional level. These efforts strengthened the robustness and credibility of the risk evaluation and supported evidence-based prioritisation. However, several challenges remain unaddressed or only partially addressed, these include limited availability of detailed local exposure data, gaps in long-term monitoring systems, and constraints in financial and institutional capacity to fully assess cascading impacts and social vulnerability.

Key findings indicate that flood risk in Târgu Secuiesc is characterised by moderate severity, increasing urgency, and low resilience capacity, which together justify a high overall risk priority. The analysis also highlights that early action is critical, as adaptation measures require long lead times and current capacities are insufficient to manage future risk escalation.

Overall, this project phase significantly improved institutional understanding of flood risk and provides a solid foundation for subsequent phases focusing on adaptation planning, capacity building, and implementation of targeted risk reduction measures.

4 Progress evaluation

Table 4- 1 Overview key performance indicators

Key performance indicators	*Progress*
3 local workshops for stakeholders' involvement during project activities for each Deliverable (1,2,3);	Completed
2 of workflows successfully applied with refined local data on Deliverable 2;	Completed Agricultural Drought and River Flood Workflows used.

Table 4- 2 Overview milestones

Milestones	*Progress*
M6. Attend Climaax workshop held in Barcelona;	Completed https://climaax.kezdi.ro/press/workshop-in-barcelona-presenting-the-results-of-the-first-phase/
M7. Updating raster orthophoto map with additional data collected;	Completed
M8. Test of workflow Droughts using refined local data;	Completed
M9. Test of workflow Precipitation using refined local data;	Completed

5 Supporting documentation

https://doi.org/10.5281/zenodo.18154423

- Deliverable 2 GIS Agricultural drought hazar&risk_KEZDI_Adapt.zip
- Deliverable 2 PicMess - phase 2 + campaign.zip
- *Deliverable 2 precipitation_ET0_KEZDI_adapt.xlsx*
- Deliverable 2 key_risks_dashboard_KEZDI_Adapt_simple.xlsx
- *Deliverable2_Revenue_loss_NetCDF_KEZDI_adapt.xlsx*
- Deliverable 2 Plots Base workflow re-run analysis Yield losses.pdf
- Deliverable 2_Phase2_finetuning_local_context.xlsx
- Deliverable 2_Base workflow re-run analysis Deliverable 2_Phase1_vs_Phase2.xlsx
- Deliverable 2_Shapefiles SGA_River flooding.zip
- Deliverable 2_Data files excel_River flooding.zip
- Deliverable 2_Hazard Maps and curves_River flooding.zip
- Deliverable 2_Maps and excel files for only Casin river_River flooding.zip
- Deliverable 2_Workflow files_River flooding.zip
- Deliverable 2_Barcelone_Workshop CLIMAAX - A0 poster_KEZDI_adapt.pdf
- Deliverable 2_Phase2_Plots finetuning_local_context.pdf
- Deliverable 2 Agricultural Drought worflow.zip
- CLIMAAX M16 Deliverable template FSTP V01_KEZDI_adapt.pdf

COMMUNICATION OUTPUTS • KÉZDI_ADAPT GROUP

After delivering PHASE 1 of the Climaax programme, and stepping into PHASE 2, our aim was to draw media and public attention to our research. On this basis, we created a Facebook page and a TikTok channel operated by the Kézdi_adapt group to promote the Climaax project, where we launched an awareness-raising campaign, and our official website was also established. At the same time, we reported on the results of the first phase in the local media, as well as on the launch of our social media platforms and the importance of the awareness-raising campaign.

Our official page: https://climaax.kezdi.ro/

Our Facebook page: https://www.facebook.com/climaax.kezdi/

Our TikTok channel: https://www.tiktok.com/@climaax.kezdi?_r=1&_t=ZN-930jpgHBuQo

Links to media coverage:

- https://www.youtube.com/watch?v=s9iKNAmVqUI

Release date: December 11, 2025

- https://www.youtube.com/watch?v=62SpOwo-EYM

Release date: December 11, 2025

- https://www.youtube.com/watch?v=muFAmJnpoak

Release date: December 11, 2025

- https://covasna45.ro/index.php/lumea-noastra/proiectul-climaax-targu-secuiesc-cauta-solutii-la-schimbarile-climatice/

Release date: January 6, 2026

- https://bioeconomia.ro/politici-publice/proiectul-climaax-viitorul-gestionarii-riscurilor-climatice/

Release date: January 6, 2026

OFFICIAL WEBSITE LAUNCH

The Kézdi_adapt group launched the project's official website on December 2nd, 2025 in three languages: English, Romanian and Hungarian. The website features six main menus:

- About Climaax
- About Us
- Media
- Our Research
- Hazard & Risk Maps
- Gallery

Link to the website: https://climaax.kezdi.ro/

SOCIAL MEDIA PLATFORMS LAUNCH

After creating our official website, our aim was to be present actively on social media platforms as well, and considering the content we had on the project, we decided to launch the project's own Facebook page and TikTok channel.

The Facebook page was launched on December 9th, 2025 at the same time with our TikTok channel. Our Facebook page features content already available on other platforms, such as the interviews held in local radios.

Following the research completed in the first phase, we launched an awareness-raising campaign on our social media platforms, Facebook and TikTok. The campaign running on Facebook was built using information received from the Covasna County Directorate for Agriculture, while the TikTok videos feature local farmers who are directly affected by climate change.

The Facebook campaign began on December 11th, 2025, with content on the following dates:

- December 11, 12, 15, 17, 19, 22, 23, 29, 30
- January 5, 6, 8, 9, 12, 13, 14, 16 and 19

Total 18 posts.

Link to all content: https://www.facebook.com/climaax.kezdi/

For the TikTok channel we recorded the videos between December 5th and 12th, 2025, altogether 12 videos have been shot with six local farmers. The launch of the first video was on January 9th, 2026, and we keep posting videos until February 6th, on the following dates:

- January 9, 14, 15, 19, 21, 23, 26, 28, 30
- February 2, 4, 6

Total 12 videos.

Link to all videos: https://www.tiktok.com/@climaax.kezdi?_r=1&_t=ZN-930jpgHBuQo

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