Deliverable Phase 1 – 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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1. Document Information

Deliverable Title	Phase 1 – 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 information's available, this report analyses different crop yield and revenue losses, damage and vulnerability curves data due to drought and river flooding at different RCP scenarios. The Phase 1 results indicate the applicability potential and further activities to downscale projected climate indicator using local high-resolution data and approaches this way regional/local risk assessment strategies can be developed.
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
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5.0	…		Final version to be submitted

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5. Abbreviations and acronyms

Abbreviation / acronym	Description
CLIMAAX	CLIMate risk and vulnerability Assessment framework and toolboX
CRA	Climate Risk Assessment
IUDS	Integrated Urban Development Strategy
KPI	Key performance indicators
MIP4Adapt	The Mission Implementation Platform (MIP4Adapt)
RCP	Representative Concentration Pathway
SECAP	Sustainable Energy and Climate Action Plan

6. Executive summary

Targu Secuiesc total area of 42.86 km^2 and 79% 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. The main goal of KÉZDI_adapt project is to evaluate climate change on agricultural drought and river floods in local level, this way awareness on climate change impact on key community systems cand be achieved, and supporting local business, authorities and other stakeholders on climate hazard, risk types, expected exposer, vulnerability and resilience support.

Agricultural Drought and river flood hazard and risk assessment workflow were investigated, for four types of crops regarding revenue loss and river flood damage data results highlight the vulnerability of the studied region.

In case of agricultural drought analysis maize revenue loss remained stable at 0.56 under RCP 2.6 and 4.5 but increased to 0.64 under RCP 8.5 in both periods, indicating greater sensitivity to extreme climate scenarios. Wheat experienced a higher loss of 320,000 EUR in 2046-2050 across all RCPs, whereas in 2026-2030, the loss was lower at 280,000 EUR under RCP 4.5 and 8.5. Potato remained the most resilient crop, with a consistent revenue loss of 48,000 EUR across all RCPs and timeframes, making it the least financially impacted. Rapeseed, however, sees its lowest loss in 2026-2030 under RCP 4.5 at 560,000 EUR, while under RCP 2.6 and 8.5, the loss rose to 640,000 EUR. By 2046-2050, revenue loss under RCP 8.5 increased to 640,000 EUR, whereas it stabilized at 560,000 EUR for RCP 2.6 and 4.5.

River flood hazard and risk modelling results indicate that the Europe-wide River flood dataset offer a comprehensive overview of flood hazards across regions but has significant limitations, as it only includes large river basins and does not account for flood protection measures, leading to potentially unrealistic flood maps in some areas. For the 250-year return period, the dataset reached its limitations, with results generated only a blue square, indicating incomplete data representation. Over longer timeframes, the significance of the results diminishes due to data scarcity, resulting in gaps in the current analysis. Under RCP 8.5, damage curves show a steeper rise, meaning major damage occurs even with lower floodwater depths, leading to a faster rate of damage increase. Like the depth-damage patterns in the RCP 8.5 scenario, residential areas are generally less vulnerable to lower floodwater levels compared to agricultural lands, which face higher exposure and risk.

The CLIMAAX methodology for hazard and risk assessment proved to be effective, user-friendly, and highly useful. The main challenges during the modelling phase were understanding and accessing specific local variables needed to run the workflows.

For agricultural drought, the primary difficulty was quantifying economic losses from climate impacts due to incomplete or missing climate and irrigation datasets. In the case of river floods, there was limited access to high-resolution models tailored to our region.

1 Introduction

1.1 Background

Târgu Secuiesc Municipality is a micro-regional economic centre (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.

1.2 Main objectives of the project

The main objective of the project is to develop a climate adaptation, mitigation strategy and improved risk management plan for Târgu Secuiesc Municipality with downscaled realistic data in CLIMAAX framework and CRA toolbox.

Specific objectives of KÉZDI_adapt project are as follow:

- Evaluation of impact regarding agricultural drought and river floods on agricultural and other land cover types and built environment;
- Increasing awareness of the importance of climate change impact on key community systems on micro-region level;
- Support SME's, local and national authorities on climate hazard types, expected damages, exposer, vulnerability.

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 TIBOR	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
MÉNESSY KINGA KITTY, 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 document is organized in a logical, comprehensive, and structured format elaborated to clearly disseminate the finding of Phase1 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 CRA studies. The following chapter **Climate risk assessment - phase 1** details the scoping, objectives the main context, risk identification, hazard assessment, vulnerability all the main CRA building block of the project. Key findings are presented in the **Conclusion** section of the document, where all the relevant obtained information is summarized from Phase 1 of CLIMAAX. The key performance indicators are presented in **Progress evaluation and contribution to future phases** chapter, in the **Reporting documentation** and **References** part all relevant outputs of Phase 1 are listed and citated document list respectively.

2 Climate risk assessment – phase

2.1 Scoping

Targu Secuiesc micro-region 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 utilised 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.

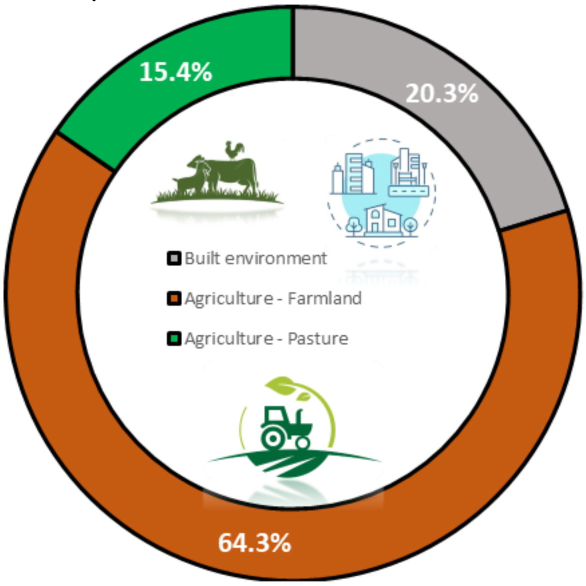


Figure 2- 1 Targu Secuiesc Municipality are division

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 must be assessed.

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

- 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 1 are: County Inspectorate for Emergency Situations, National Agency for Protected Natural Areas, Regional unit of the National Administration "Romanian Waters", Non-governmental Organizations (Green Sun Association, Energy Cities, AgroSic), Civil society, Farmers, Local authorities, Scientific community (Academia), Students, Tourism industry, 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).

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 i.e. 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 can be used to predict crop losses, allowing for early interventions such as crop insurance payouts or subsidies to assist affected farmers.

Data 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.

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.

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).

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

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 kilometers of irrigation canals, aiming to enhance water management and Support agribusiness resilience against climate variability (Trade, 2023).

2.1.3 Participation and risk ownership

Târgu Secuiesc municipality holds formal responsibility for risk ownership, as it is legally accountable for civil protection and public safety. KÉZDI_adapt project offers continuous technical support, enhancing the municipality's ability to adopt, execute, and oversee CLIMAAX CRA findings related to agricultural drought and rivel flood hazard, risk assessment. Risk levels can be established through municipal policies and public consultations, based on CRA results in a such way to ensure balance between practicality and key community systems and social expectations. The results will be primarily communicated to local decision-makers, civil society representatives, and relevant stakeholders that can provide additional expertise or resources.

Stakeholders are central to the adaptation process, analysing the capacity of stakeholders to cope with and adapt to climatic events is fundamental to develop a comprehensive climate adaptation and resilience strategy on regional level. We need to understand the role of stakeholders in the decision-making process which undoubtedly will assist in the implementation of adaptation policies on local level. Main stakeholders and beneficiaries that we can list will be: County Inspectorate for Emergency Situations, Regional unit of the National Administration "Romanian Waters", Non-governmental Organizations (Green Sun Association, Energy Cities NGO), Civil society, children's and youth, Farmers, Local authorities, Scientific community (Academia),Students, Tourism industry, 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).

To ensure the Climaax project impact maximisation different activities are needed and has been some already accomplished, such as:

- Communication: includes informing activities to raise awareness about Climaax project and engage targeted audience with publication, articles, press release, local radio and television interview, publications on social media platforms and advertisement, campaigns (Facebook, Instagram, X).
- Dissemination: Different workshops were and will be organized during the project implementation where stakeholders will be informed about the project and how they can

benefit from the results. Technical documents and all results obtained will be open source, open to public.

- Exploitation: The technical documents generated through the project will help decision makers to use it in forming new risk management strategies on local and regional scale. The overall scientific output will be a package with technical, workshop documents, article, and CRA toolbox results that can be utilized by decision makers and scientific community to implemented the Climaax framework and CRA toolbox in other micro-regions.

2.2 Risk Exploration

2.2.1 Screen risks (selection of main hazards)

The following climate-related hazards and potential risk are most relevant for our community: Agricultural drought, Rivel floods.

Significant climate change related concern in Romania is agricultural drought, which can be characterized by insufficient soil moisture negatively affecting crop growth, approximately 30% of the country's land is susceptible to desertification, leading to detrimental impacts on agriculture, food supply and economy (Copernicus, 2020). In Târgu Secuiesc, studies have indicated that adjusting sowing dates can enhance water use efficiency. For instance, sowing maize earlier, between March 20 and April 1, has been shown to improve water utilization compared to later sowing dates. Similarly, for winter wheat, later sowing dates, such as September 10 and October 5, have demonstrated better water efficiency than earlier dates (ClimateAdapt, 2014).

In September 2024, Romania, along with other Central European countries, experienced some of the worst floods in at least two decades. The floods resulted in significant destruction, with at least 23 fatalities reported across the region. In Romania, rainfall and subsequent flash floods affected numerous villages and towns across eight counties, particularly in the eastern regions of Galati and Vaslui (ECMWF, 2024).

2.2.2 Workflow selection

Two CLIMAAX workflows were analysed in KÉZDI_adapt project, agricultural drought and river floods were selected which are one of the most significant climate hazards, each workflow was applied using predefined specific methodology and datasets.

2.2.2.1 Workflow #1: Agricultural Drought

In the Agricultural Drought workflow different type of scenario's were analysed, simulations were run for different start and end year periods, near future 2026-2030 and mid-century 2046-2050, also three RCP scenario of the defined periods were modelled to assess Hazard. Risk analysis was analysed for potential revenue losses from irrigation deficit on NUTS2 Centru region, Romania level applying a bbox zooming function to highlight the east part of the studied area. Risk analysis 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.

2.2.2.2 Workflow #2: River floods

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. Flood damage, inundation depth for different return periods, vulnerability damage curves and economic losses (mln. €) was analyzed.

2.2.3 Choose Scenario

For Workflow #1 Agricultural drought short term (2026-2030) and mid-term (2046-2050) time intervals were analysed using three RCP scenario's namely 2.6, 4.5 and 8.5.

In case of Workflow #2 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.

2.3 Risk Analysis

2.3.1 Agricultural Drought Workflow #1

Table 2- 1 Data overview workflow #1

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
Agricultural drought	Aggregated crops revenue loss	Total crop production, crop yield loss	Map revenue loss

2.3.1.1 Hazard assessment

During Phase 1 of the project in the Agricultural Drought workflow we focused on analysing yield loss percentage reduction in case of maize, wheat, potato, and rapeseed plants which are intensively cultivated on agricultural land in Targu Secuiesc and Covasna County.

Crop specific parameters needed for hazard assessment were imported form the crop table preselected for sub continental climate zone no. 5.

Table 2- 2 Crop growth parameters used in Hazard calculations

FAO_Code	***111***	***113***	***121***	***270***
Crop	wheat	maize	potato	rapeseed
Clim	5	5	5	5
Kc_in	0.7	0.3	0.5	0.35
Kc_mid	1.15	1.2	1.15	1.15
Kc_end	0.3	0.5	0.75	0.35
lgp_f1	0.11	0.2	0.19	0.2
lgp_f2	0.33	0.2	0.23	0.4
lgp_f3	0.39	0.27	0.35	0.2
lgp_f4	0.17	0.33	0.23	0.2
Season Start	336	136	122	259
Season End	151	286	252	74
RD1	0.2	0.2	0.2	0.2
RD2	1.25	1	0.4	1
DF	0.55	0.55	0.35	0.6
Type	1	1	1	1
Ky	1	1.5	1.1	1

Different type of scenario's were analysed, simulations were run for different start and end year periods, near future 2026-2030 and mid-century 2046-2050, also three different RCP scenario of the defined periods were modelled.

Table 2- 3 Agricultural drought workflow scenarios.

NUTS2	**RO12**				
Scenario	**Scale parameter**	**RCP**	**ystrat-yend**	**GCM+RCP selection**	**Climate Zone**
1.1	0.5	2.6	**2046-2050**	model_choice=1	5
1.2	0.5	2.6	**2046-2050**	model_choice=1	5
1.3	0.5	2.6	**2046-2050**	model_choice=1	5
1.4	0.5	2.6	**2046-2050**	model_choice=1	5
1.5	0.5	2.6	**2046-2050**	model_choice=1	5
1.6	0.5	2.6	**2046-2050**	model_choice=1	5

2.1	0.5	2.6	**2026-2050**	model_choice=1	5
3.1.	0.5	2.6	**2026-2030**	model_choice=1	5
4.1.	0.5	4.5	**2026-2030**	model_choice=1	5
4.2.	0.5	4.5	**2026-2030**	model_choice=1	5
5.1.	0.5	4.5	**2046-2050**	model_choice=1	5
5.2.	0.5	4.5	**2046-2050**	model_choice=1	5
6.1	0.5	**8.5**	**2026-2030**	model_choice=1	5
6.2	0.5	**8.5**	**2026-2030**	model_choice=1	5
7.1	0.5	**8.5**	**2046-2050**	model_choice=1	5
7.2	0.5	**8.5**	**2046-2050**	model_choice=1	5

In the Hazard assessment workflow python code changes were applied to visualise in more detail our interested region and some additional code generating layers was add for a clearer and more understandable visualisation of the hazard and risk results plots.
Below is presented the additional rules introduced in the code and the generated plots:

ZOOM NUTS2 region EAST

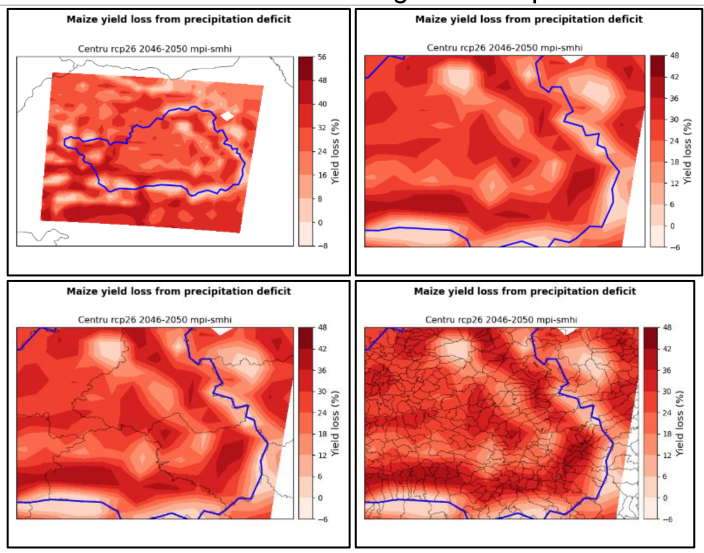
```
map_yield =Basemap(
        resolution='i',
        #llcrnrlat=bbox[1]-zoom,
urcrnrlat=bbox[3]+zoom,
        #llcrnrlon=bbox[0]-zoom,
urcrnrlon=bbox[2]+zoom,
llcrnrlat=45.4529, # lower left corner latitude
llcrnrlon=24.4107, # lower left corner longitude
urcrnrlat=46.9432, # upper right corner latitude
urcrnrlon=26.6431,# upper right corner longitude
```

NUTS2_COUNTYborders:

```
shapes =
gpd.read_file('https://github.com/wmgeolab/geoBoundaries/raw/9469f09/releaseData/gbOpen/ROU/ADM1/geoBoundaries-ROU-ADM1_simplified.geojson')
   shapes.plot(ax=plt.gca(), aspect=None,
facecolor="none", linewidth=0.5, alpha=0.5)
```

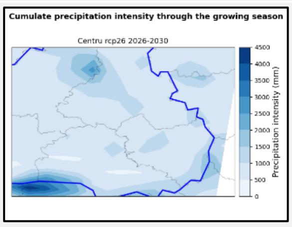
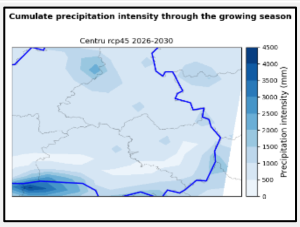
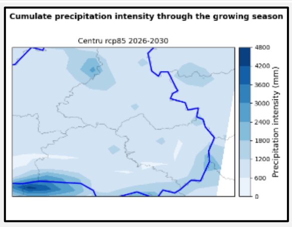
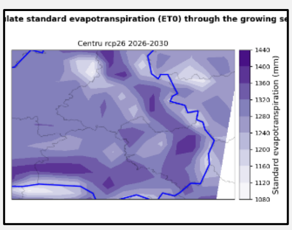
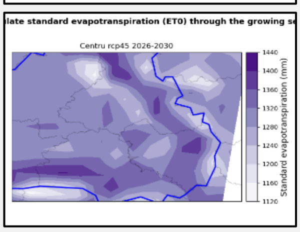
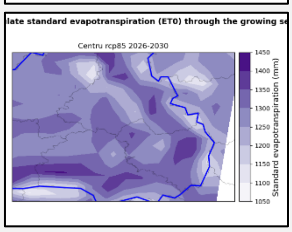
NUTS2_UAT borders:

```
shapes =
gpd.read_file('https://github.com/wmgeolab/geoBoundaries/raw/9469f09/releaseData/gbOpen/ROU/ADM2/geoBoundaries-ROU-ADM2_simplified.geojson')
   shapes.plot(ax=plt.gca(), aspect=None,
facecolor="none", linewidth=0.5, alpha=0.5)
```



Generated precipitation and yield loss data plots are presented in tables 2-4 and 2-5.

Table 2- 4 Cumulate precipitation and standard evapotranspiration plots for different RCP scenarios and time intervals

RCP 2.6	RCO 4.5	RCP 8.5
	ystart - yend 2026-2030	
		
		
	ystart - yend 2046-2050	

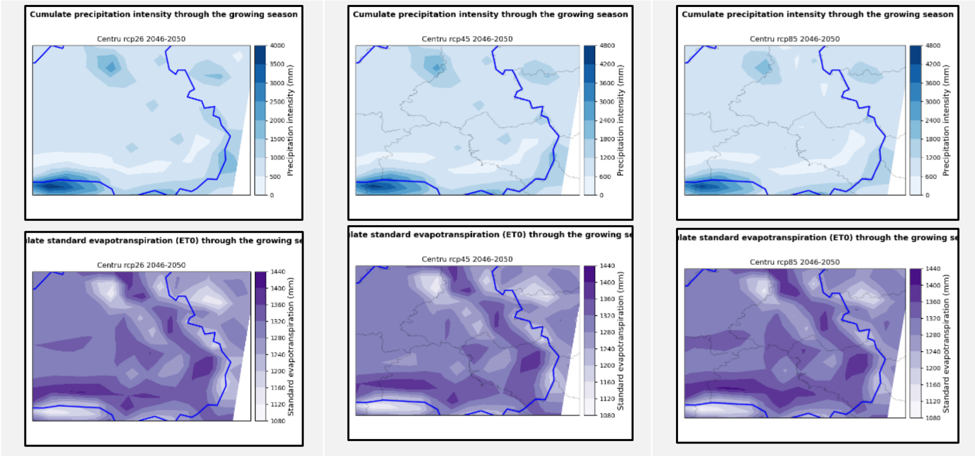
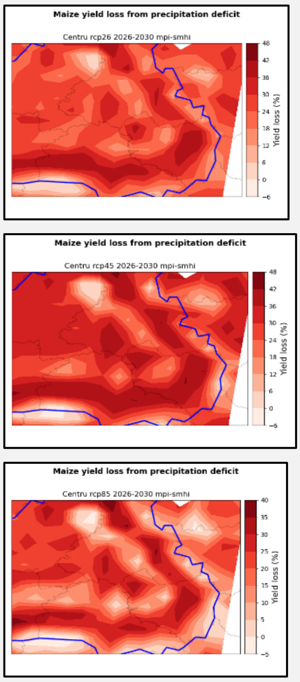
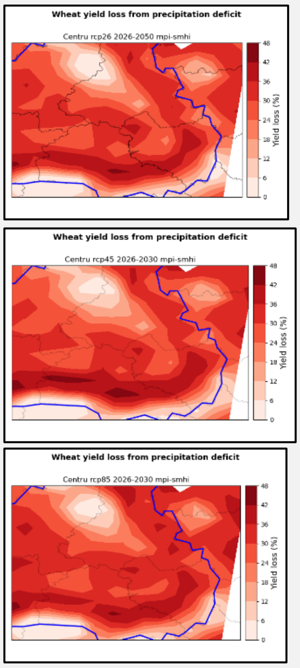
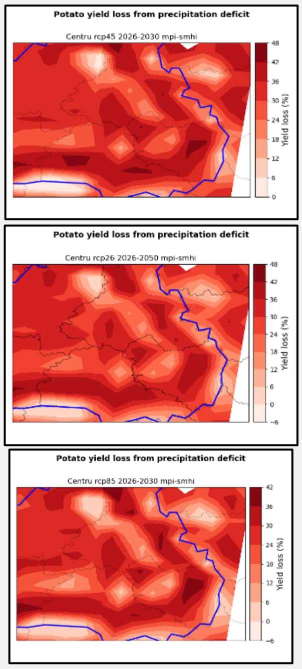
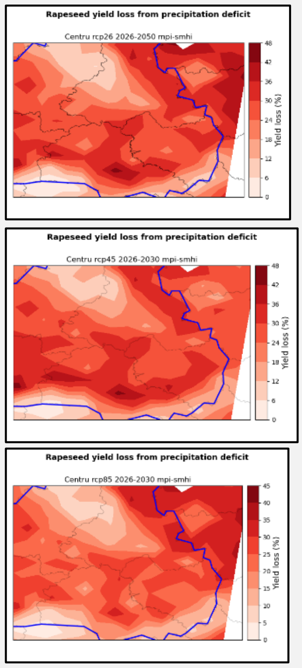
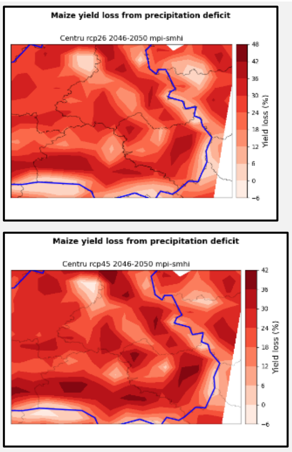
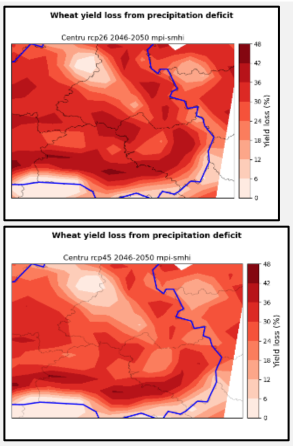
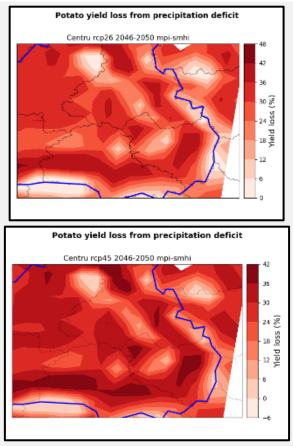
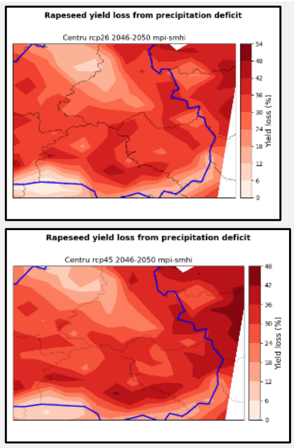
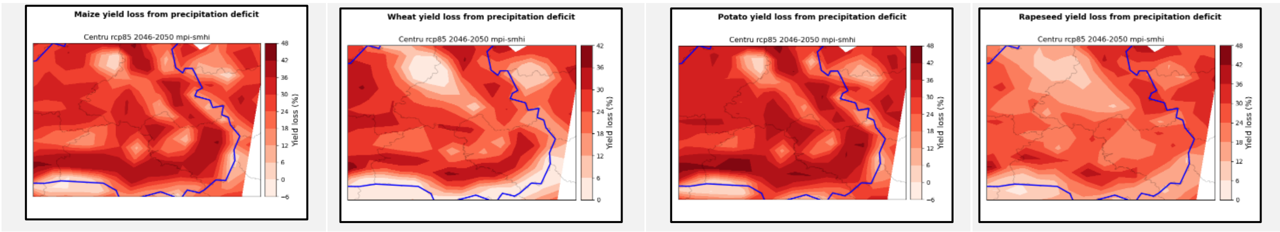


Table 2- 5 Regions in dark red for different type of crops experiencing highest hydro-climatic stress under different RCP scenarios (2.6, 4.5, 8.5) near future time interval.

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



Generated hazard crop yield loss values on NUTS2 level for near future and mid-century time intervals using different RCP scenarios are presented in tables 2-5, 2-6.

3.X. 2026-2030								
Average yield loss					38.433	21.122	31.866	19.766
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp26	2026	2030	44.891	22.180	25.810	15.309	32.312	20.870
rcp26	2026	2030	44.885	22.334	62.121	13.922	47.617	13.172
rcp26	2026	2030	44.878	22.488	33.598	11.880	32.730	16.401
rcp26	2026	2030	44.871	22.642	43.916	7.995	30.276	11.956
rcp26	2026	2030	44.864	22.796	54.231	22.974	40.690	21.626
rcp26	2026	2030	44.857	22.951	51.294	27.006	39.070	30.163
rcp26	2026	2030	44.850	23.105	40.838	17.863	35.141	19.000
rcp26	2026	2030	44.842	23.259	51.778	20.878	39.203	16.213
rcp26	2026	2030	44.834	23.412	43.926	25.173	34.884	26.808
rcp26	2026	2030	44.826	23.566	51.741	26.476	39.222	24.493
rcp26	2026	2030	44.817	23.720	46.740	28.113	36.779	28.239
rcp26	2026	2030	44.809	23.874	46.401	24.826	37.400	19.890

4.X. 2026-2030								
Average yield loss					44.507	22.567	35.068	21.751
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp45	2026	2030	44.891	22.180	49.543	9.422	37.018	18.112
rcp45	2026	2030	44.885	22.334	66.662	9.997	49.728	13.252
rcp45	2026	2030	44.878	22.488	54.758	7.665	39.215	15.441
rcp45	2026	2030	44.871	22.642	52.178	3.293	38.879	10.810
rcp45	2026	2030	44.864	22.796	62.157	16.934	45.661	16.697
rcp45	2026	2030	44.857	22.951	59.329	21.854	43.859	21.810
rcp45	2026	2030	44.850	23.105	54.222	13.846	40.151	14.180
rcp45	2026	2030	44.842	23.259	58.820	16.257	43.545	13.486
rcp45	2026	2030	44.834	23.412	55.553	19.947	41.060	22.504
rcp45	2026	2030	44.826	23.566	58.276	21.662	43.252	20.131
rcp45	2026	2030	44.817	23.720	56.026	23.407	41.490	22.800
rcp45	2026	2030	44.809	23.874	58.523	22.018	43.284	17.149

6.X. 2026-2030								
Average yield loss					29.899	25.218	26.124	21.524
rcp	start_year	end_year	lat	lon	maize	wheat	potato	rapeseed
rcp85	2026	2030	44.891	22.180	23.349	21.435	22.477	23.348
rcp85	2026	2030	44.885	22.334	54.511	21.317	41.779	16.381
rcp85	2026	2030	44.878	22.488	29.248	19.818	28.382	22.935
rcp85	2026	2030	44.871	22.642	35.233	14.240	27.511	15.855
rcp85	2026	2030	44.864	22.796	46.830	26.398	36.834	24.451
rcp85	2026	2030	44.857	22.951	44.834	31.033	35.546	30.708
rcp85	2026	2030	44.850	23.105	31.603	23.510	30.569	22.169
rcp85	2026	2030	44.842	23.259	45.300	27.861	36.148	19.708
rcp85	2026	2030	44.834	23.412	35.695	31.538	30.616	27.346
rcp85	2026	2030	44.826	23.566	43.158	31.830	35.139	24.465
rcp85	2026	2030	44.817	23.720	36.382	32.214	31.513	27.232
rcp85	2026	2030	44.809	23.874	40.790	30.263	34.156	22.114

Figure 2- 2 Screen shot of yield loss data analysis

Table 2- 6 Yield loss average values for different RCP climate change scenarios

Crop	RCP 2.6 (2026-2030)	RCP 4.5 (2026-2030)	RCP 8.5 (2026-2030)	RCP 2.6 (2046-2050)	RCP 4.5 (2046-2050)	RCP 8.5 (2046-2050)	Δ RCP 2.6 (%)	Δ RCP 4.5 (%)	Δ RCP 8.5 (%)
Maize	38.433	44.507	29.899	39.015	37.561	40.032	0.582	-6.946	10.133
Wheat	21.122	22.567	25.218	25.908	20.799	20.622	4.786	-1.768	-4.596
Potato	31.866	35.068	26.124	31.131	31.032	32.355	-0.735	-4.036	6.231
Rapeseed	19.766	21.751	21.524	27.303	24.742	22.382	7.537	2.991	0.858

The yield loss in **near future** time interval **(2026-2030)** for maize is highest under the RCP 4.5 scenario, wheat yield loss increases with RCP levels, rising from 21.122% at RCP 2.6 to 25.218% at RCP 8.5, similar to wheat, potato yield loss increases slightly from 31.866% at RCP 2.6 to 35.068% at RCP 4.5, but decreases to 26.124% at RCP 8.5 and Rapeseed yield loss shows a slight increase from 19.766% at RCP 2.6 to 21.751% at RCP 4.5, followed by a slight decrease to 21.524% at RCP 8.5. Interestingly the RCP 8.5 with the highest radiative forcing value e.g. very high emission scenario generated the low yield percentage results, even significantly lower than RCP 2.6 the 'very stringent pathway" (CarbonBreef, 2018).

The **mid-century (2046-2050)** yield loss values percentage compared to **near future** time interval **(2026-2030)** for each RCP scenarios as follows:

- Maize: Under RCP 2.6, yield loss slightly increases (+0.582%), under RCP 4.5, yield loss drops significantly (-6.946%), in case of RCP 8.5, yield loss increases dramatically (+10.133%), showing maize is highly vulnerable to extreme climate change;
- Wheat: Yield loss increases significantly under RCP 2.6 (+4.786%), yield loss reduces slightly under RCP 4.5 (-1.768%) and under RCP 8.5, wheat yield loss decreases (-4.596%);
- Potato: Under RCP 2.6 and 4.5, yield loss decreases slightly (-0.735% and -4.036%) and under RCP 8.5, yield loss increases by +6.231%, indicating more sensitivity to RCP 8.5 extreme warming;
- Rapeseed: Shows the biggest increase for mid-century in yield loss under RCP 2.6 (+7.537%), under RCP 4.5 and 8.5 show small increases (+2.991% and +0.858%).

2.3.1.2 Risk assessment

The figures presented in Table 2-7 show the potential revenue losses from irrigation deficit in NUTS2 Centru region, Romania with a bbox zooming on the east part of the region, for the selected crops (maize, wheat, potato and rapeseed), emission scenario’s (RCP2.6, 4.5 and 8.5) and period’s (2026-2030 and 2046-2050). Losses are expressed by the red shading and represent the ‘lost opportunity cost’ in thousands of euros if crops are grown under non-irrigated conditions. The hatches show the share of cropland in each grid-point with irrigation systems already implemented in 2010 and serves as an indicator of vulnerability to rainfall scarcity.

Table 2- 7 Risk assessment results for different RCP scenario’s and reference periods

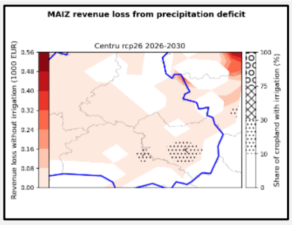
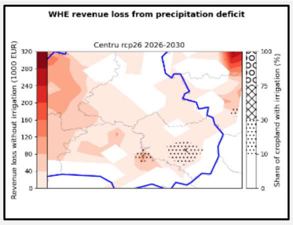
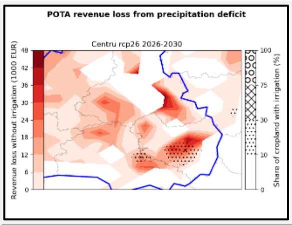
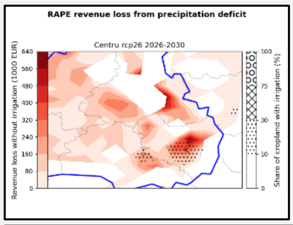
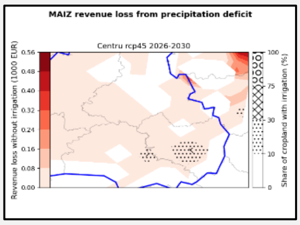
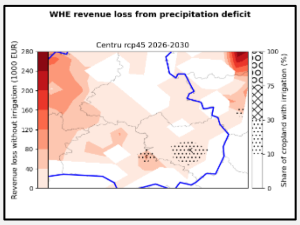
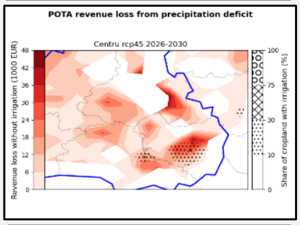
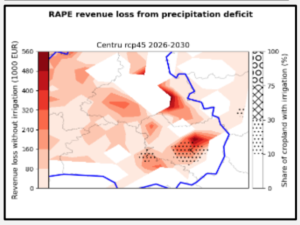
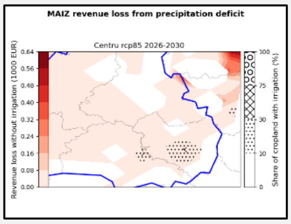
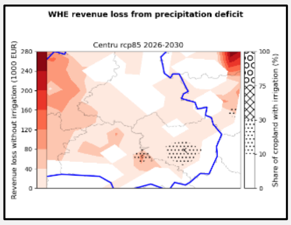
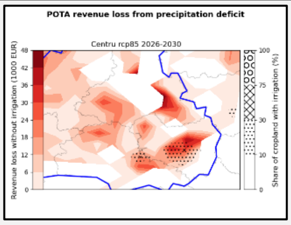
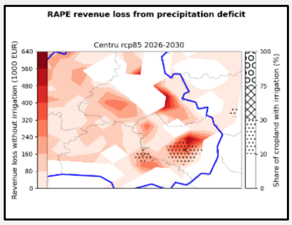
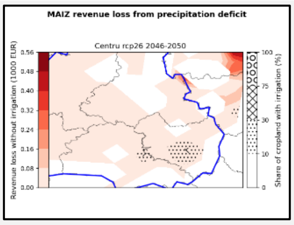
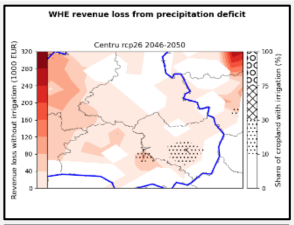
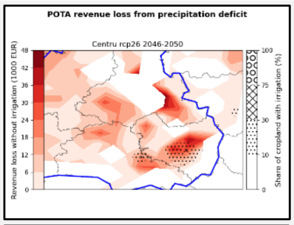
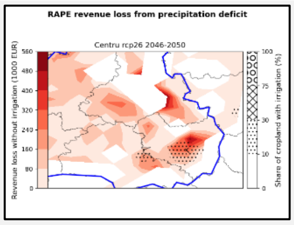
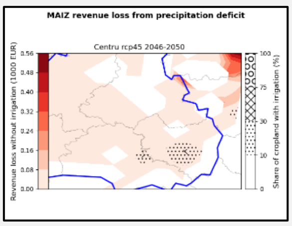
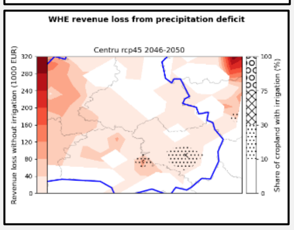
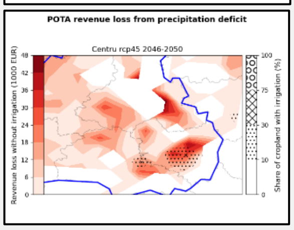
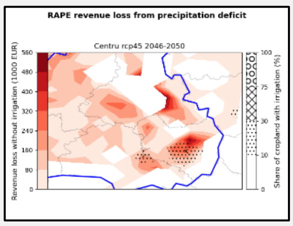
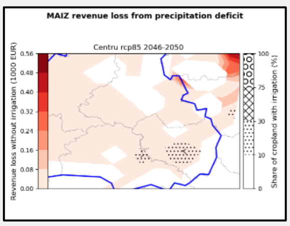
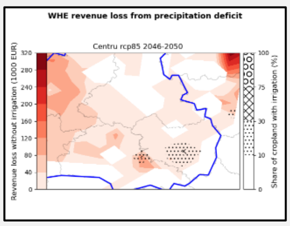
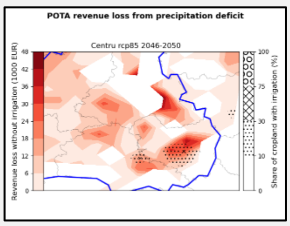
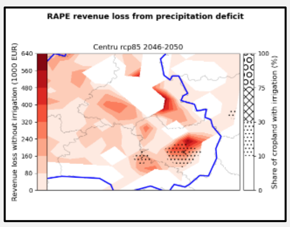
Maize	Wheat	Potato	Rapeseed
ystart - yend 2026-2030			
			
			
			
ystart - yend 2046-2050			
			
			
			

Table 2- 8 Maximum revenue loss (in 1000 EUR) without irrigation for two periods: 2026-2030 and 2046-2050, across different RCP scenarios (2.6, 4.5, and 8.5).

Revenue loss without irrigation (1000 EUR) 2026-2030				
RCP	Maize	Wheat	Potato	Rapeseed
2.6	0.56	320.00	48.00	640.00
4.5	0.56	280.00	48.00	560.00
8.5	0.64	280.00	48.00	640.00
Revenue loss without irrigation (1000 EUR) 2046-2050				
RCP	Maize	Wheat	Potato	Rapeseed
2.6	0.56	320.00	48.00	560.00
4.5	0.56	320.00	48.00	560.00
8.5	0.64	320.00	48.00	640.00

The maps and table (2-6, 2-7) highlight interesting trends, for each selected crop:

- Maize: Revenue loss remains constant at 0.56 (RCP 2.6 & 4.5) but increases to 0.64 under RCP 8.5 in both periods it shows sensitivity higher representative concentration pathways
- Wheat: Loss is higher (320,000 EUR) in 2046-2050 across all RCPs, whereas in 2026-2030, it was lower (280,000 EUR) under RCP 4.5 and 8.5;
- Potato: Loss remains unchanged at 48,000 EUR across all RCPs and both time intervals, indicating resilience making it the least financially impacted crop;
- Rapeseed: In 2026-2030, loss is lowest under RCP 4.5 (560,000 EUR) but increases under RCP 2.6 and 8.5 (640,000 EUR). In 2046-2050, loss increases to 640,000 EUR under RCP 8.5 and stabilizes at 560,000 EUR for RCP 2.6 and 4.5.

2.3.2 River floods #2

Table 2- 9 Data overview workflow #2

Hazard data	*Vulnerability data*	*Exposure data*	*Risk output*
River floods	vulnerability damage curves	Land use	Map of flood depth and damage

2.3.2.1 Hazard assessment

In the first phase of the project we focus on analysing river flood risks, considering the geographic properties of the city and the surrounding places. The city of Targu Secuiesc lies between 3 rivers which have 2 merging points, one at the north border and the other on the south border of the city. These circumstances are significant concerns for us if there is a major rainfall on the water catchment basins. Our analysis assesses the potential impacts and outcomes of the potential floods. 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.

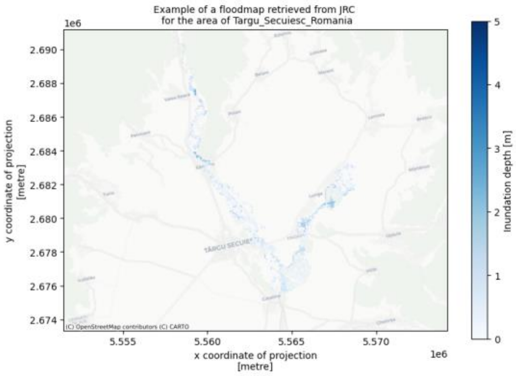


Figure 2- 3 Flood map from JRC for the studied region, Targu Secuiesc Municipality

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 150km2) 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.

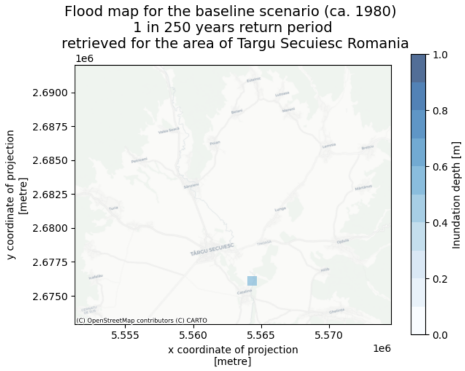


Figure 2- 4 Flood map for the baseline scenario 1 in 250 years return period

As we try to calculate the result for the 250 year return period we reach the limitations of the currently available datasets, and we get as a result a map with invaluable plot data, only a blue square.

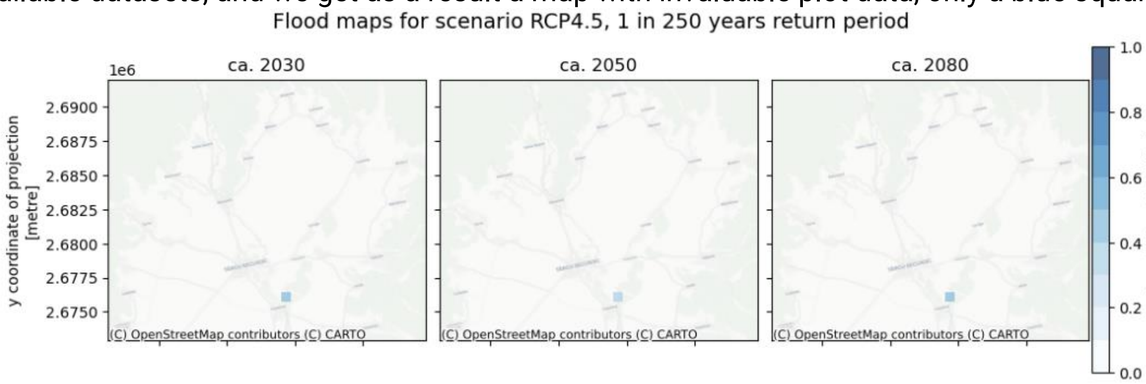


Figure 2- 5 Flood maps scenario 1 in 250 year return period RCP 4.5

We have also run the RCP4.5 and RCP 8.5 scenarios with the same result.

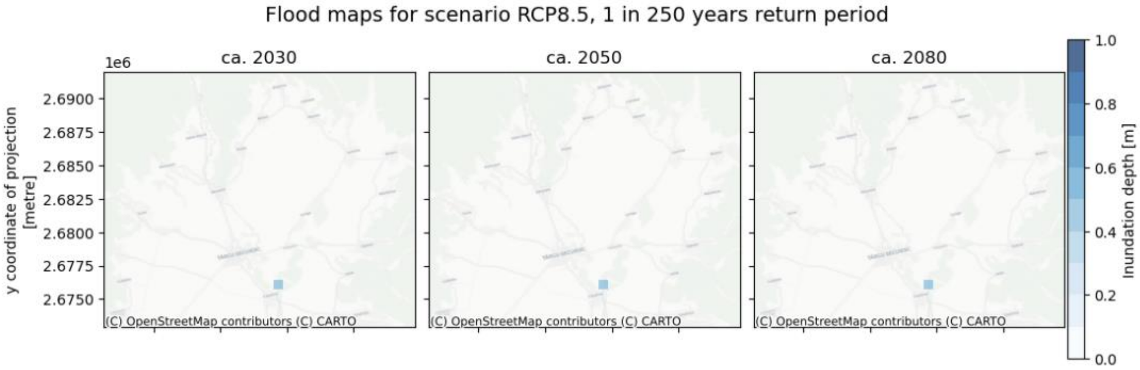


Figure 2- 6 Flood maps scenario 1 in 250 year return period RCP 8.5

2.3.2.2 Risk assessment

Flooding is a significant risk in Targu Secuiesc, although the last flood was in 2018, the possibility exists every year when the rain season comes. Usually, we have up to one month in the spring and one in the summer when rains are coming regularly. In 2018 the Ruseni part of the city was affected, although the water retracted after 6-8 hours, the damage was done. The damage include farmland, basements of houses, roads, and gardens.

In the first phase we conducted the analysis using global datasets, this caused in some cases to get flood maps with incomprehensible results. Hopefully in the next phases we can implement local databases to get proper results.

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 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.

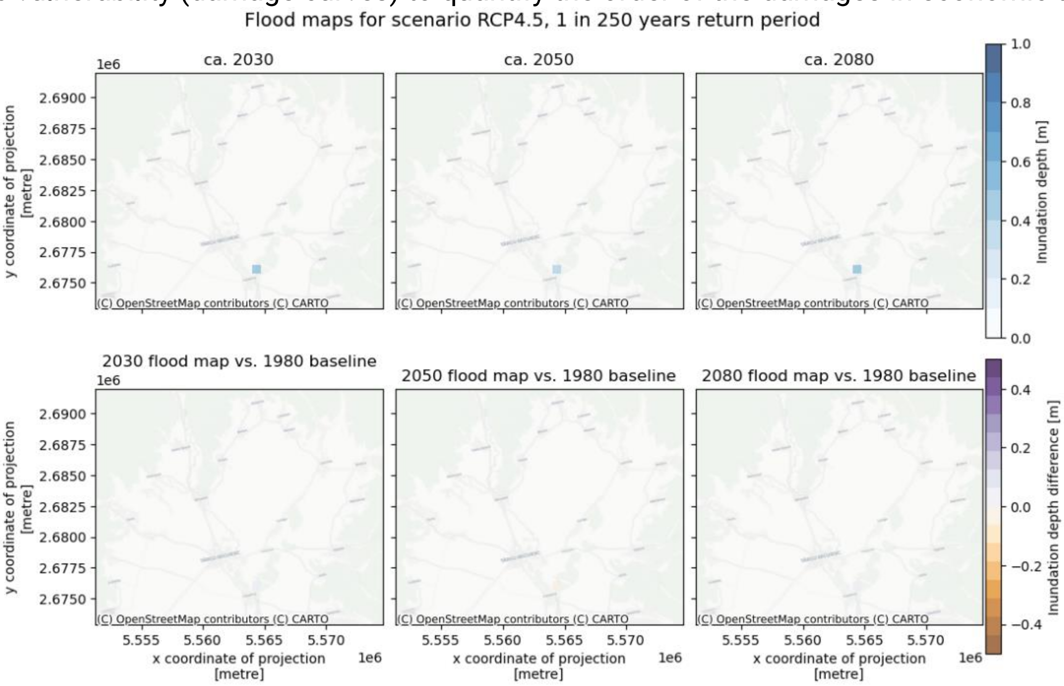


Figure 2- 7 Flood maps scenario 1 in 250 year return period RCP 4.5

Although we looked for both (RCP 4.5 and 8.5) scenarios we observed that on the more distant periods the results become more insignificant. Scarce data prevents us to deliver results which can be evaluated at the present moment.

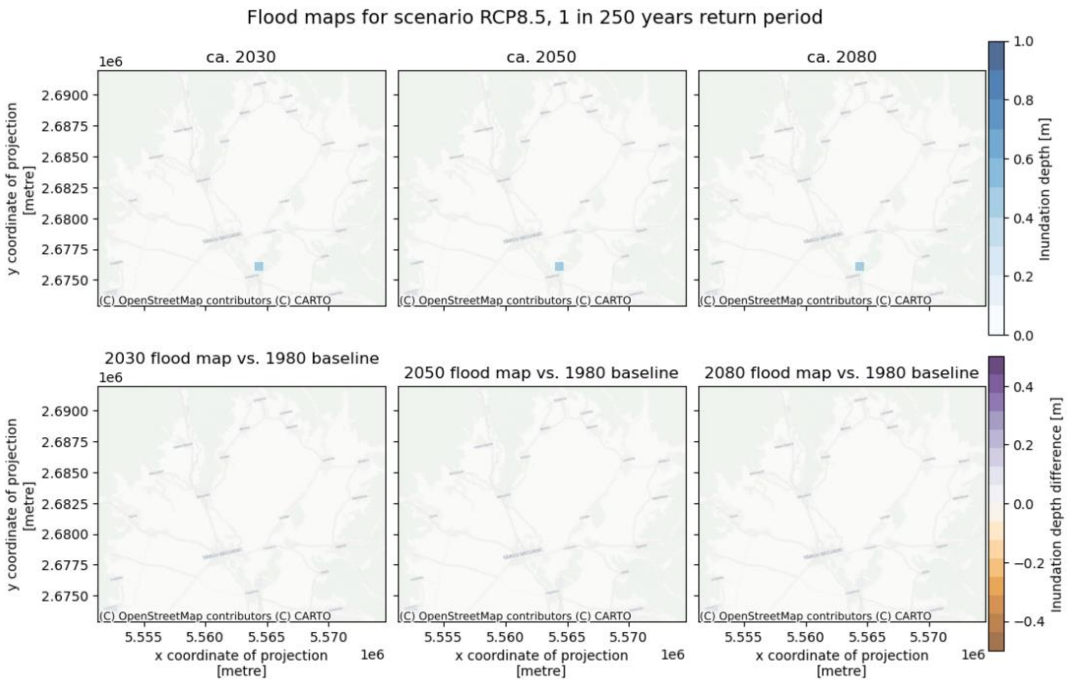


Figure 2- 8 Flood maps scenario 1 in 250 year return period RCP 8.5

In the following you can see the depth-damage curves for different damage classes. The plot shows the likely % of damage suffered by the different type of land regarding the depth of the water levels. We can see that in the case of RCP8.5 damage curves have a steeper rising section, which means that major damage levels are obtained even with a lover depth of floodwater, higher damage is resulted at a faster rate.

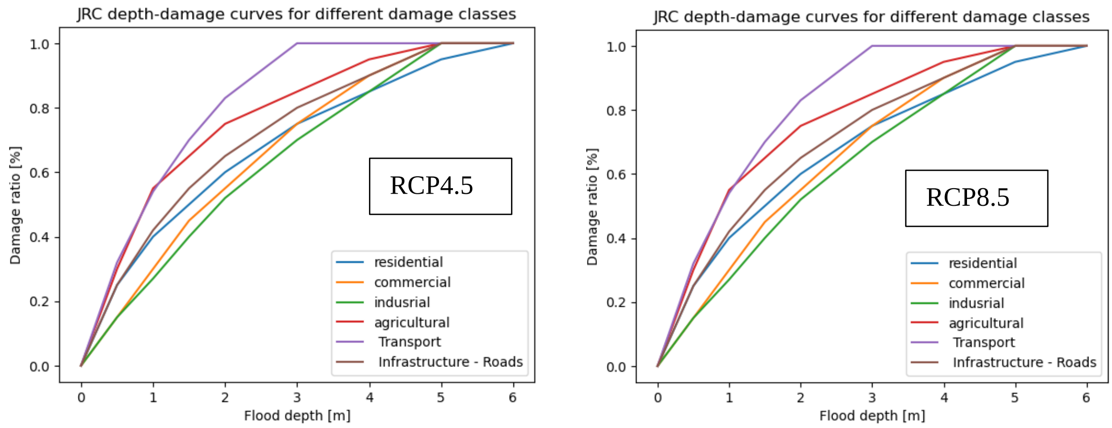


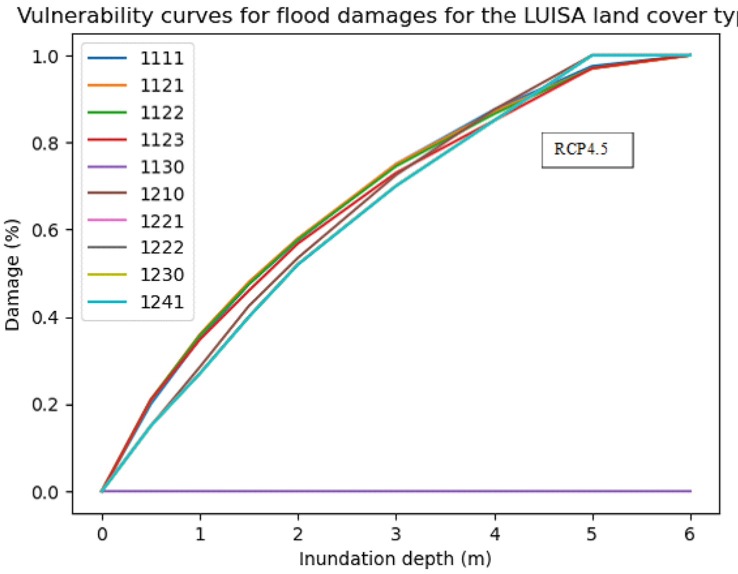
Figure 2- 9 Vulnerability flood damage curves RCP 4.5 vs RCP 8.5

Linking 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 calculate by using DamageScanner. 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

Similar to the depth-damage curves we get worse results by the RCP8.5 scenario. Residential areas are less vulnerable at lower levels of flood water, but are more vulnerable at higher levels of water than for example agricultural land. This also means that by lower water levels the damages are relatively lower than in the case of agricultural lands.



Land use code	total €/m²
1111	600.269784
1121	414.499401
1122	245.022999
1123	69.919184
1130	0.000000
1210	405.238393
1221	40.417363
1222	565.843080
1230	242.504177
1241	565.843080

Figure 2- 10 Vulnerability flood damage curves for LUIS land cover types RCP 4.5

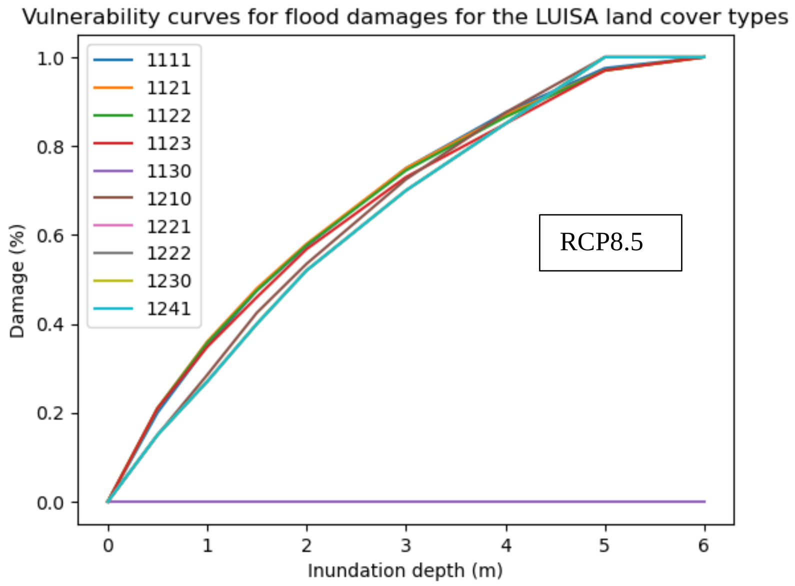
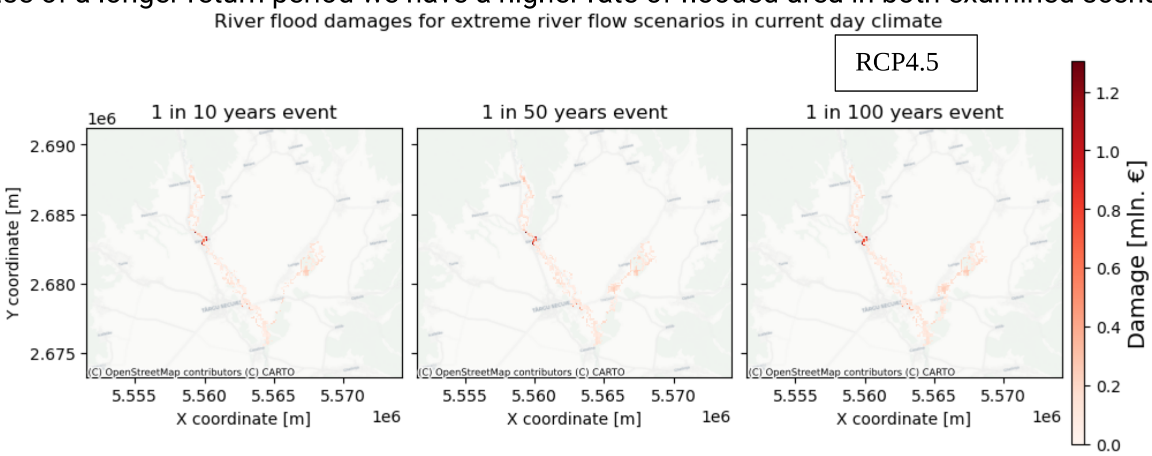


Figure 2- 11 Vulnerability flood damage curves for LUIS land cover types RCP 8.5

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 below in the case of a longer return period we have a higher rate of flooded area in both examined scenarios.



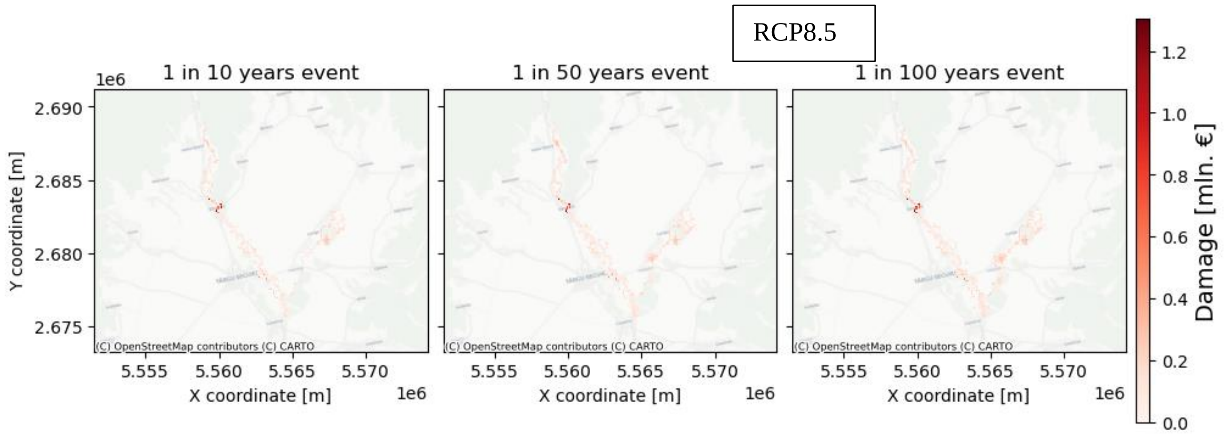


Figure 2- 12 River flood damage for extrem river flow scenarious RCP 4.5, RCP 8.5

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.

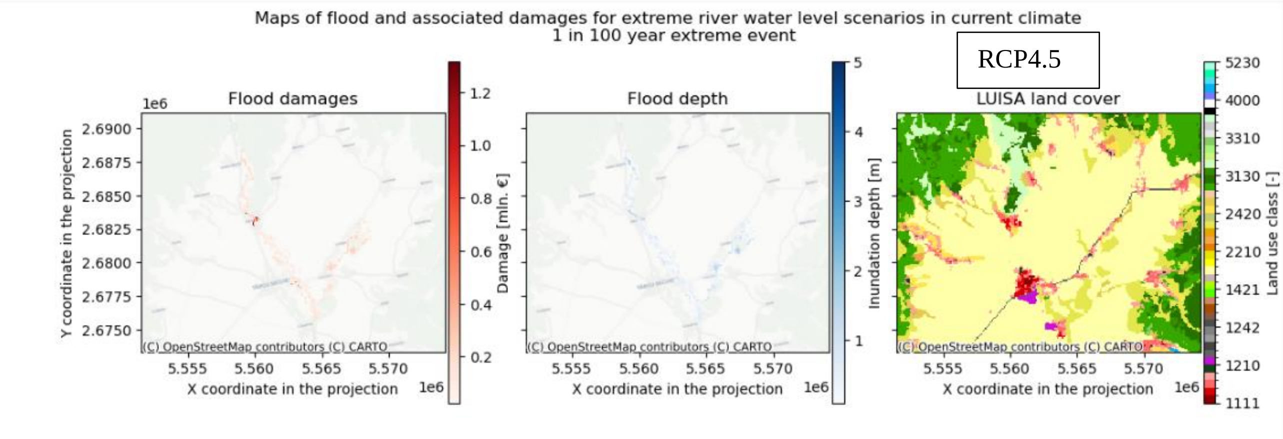


Figure 2- 13 River flood map RCP 4.5

In this way we can understand and represent more easily the effects of the floods on different types of land.

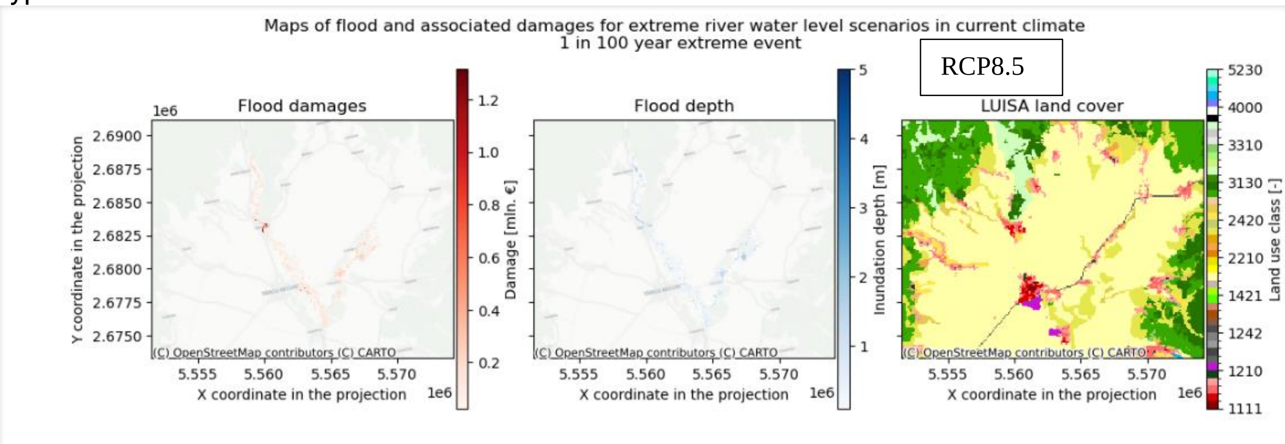


Figure 2- 14 River flood map RCP 8.5

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.

2.4 Preliminary Key Risk Assessment Findings

2.4.1 Severity

Agricultural drought Workflow #1:

- Maize: Under RCP 2.6, yield loss slightly increases (+0.582%), under RCP 4.5, yield loss drops significantly (-6.946%), in case of RCP 8.5, yield loss increases dramatically (+10.133%), showing maize is highly vulnerable to extreme climate change;
- Wheat: Yield loss increases significantly under RCP 2.6 (+4.786%), yield loss reduces slightly under RCP 4.5 (-1.768%) and under RCP 8.5, wheat yield loss decreases (-4.596%);
- Potato: Under RCP 2.6 and 4.5, yield loss decreases slightly (-0.735% and -4.036%) and under RCP 8.5, yield loss increases by +6.231%, indicating more sensitivity to RCP 8.5 extreme warming;
- Rapeseed: Shows the biggest increase for mid-century in yield loss under RCP 2.6 (+7.537%), under RCP 4.5 and 8.5 show small increases (+2.991% and +0.858%);
- Maize: Revenue loss remains constant at 0.56 (RCP 2.6 & 4.5) but increases to 0.64 under RCP 8.5 in both periods it shows sensitivity higher representative concentration pathways
- Wheat: Loss is higher (320,000 EUR) in 2046-2050 across all RCPs, whereas in 2026-2030, it was lower (280,000 EUR) under RCP 4.5 and 8.5;
- Potato: Loss remains unchanged at 48,000 EUR across all RCPs and both time intervals, indicating resilience making it the least financially impacted crop;
- Rapeseed: In 2026-2030, loss is lowest under RCP 4.5 (560,000 EUR) but increases under RCP 2.6 and 8.5 (640,000 EUR). In 2046-2050, loss increases to 640,000 EUR under RCP 8.5 and stabilizes at 560,000 EUR for RCP 2.6 and 4.5.

River flood Workflow #2:

- 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 150km^2) and does not include flood protections, which can lead to unrealistic flood maps in some regions;
- the result for the 250-year return period we reach the limitations of the currently available datasets, the plots generated only a blue square result;
- we observed that on the more distant periods the results become more insignificant, due to scarce data there were some lacks of results now;
- in the case of RCP8.5 damage curves have a steeper rising section, indicating major damage levels even with a lover depth of floodwater, higher damage is resulted at a faster rate;
- Like the depth-damage curves for RCP8.5 scenario, residential areas are less vulnerable at lower levels of flood water compared to agricultural lands;
- in the case of a longer return period we have a higher rate of flooded area in both examined scenarios.

2.4.2 Urgency

In case of Agricultural Drought, immediate actions have to be made, highlighting the importance of implementing irrigation systems but applying sustainable water management principles this case productive and financial sustainable agriculture sector can be maintained.

The urgency of River Flood hazard and risks heavily dependent on extreme climate events, however there is some inconsistency in the results (i.e. downscaled data is needed) they indicate negative impact on agricultural land and build environment, prioritizing the generation of more realistic flood maps is essential.

2.4.3 Capacity

Targu Secuiesc municipality climate risk management should be multilevel, involving policy support, financial support, education, infrastructure, and natural conservation. There were already measures taken to highlight institutional commitment in Integrated Urban Development Strategy (IUDS) 2021-2030, Sustainable Energy and Climate Action Plan (SECAP) and by accession as Signature of EU missions’ adaptation to climate change.

Different opportunities can be already identified to deal with agricultural drought and river flood risks, such as:

- Financial measures: subsidies via Common Agricultural Policy (CAP) and National Rural Development Program to support sustainable farming practices, agricultural Insurance Schemes to help farmers recover from climate-induced losses and grants for irrigation implementation and modernization to improve water use efficiency.
- Social measures: climate change education programs for farmers and rural communities, strengthening farmer cooperatives to increase resilience, meteorological and hydrological alerts for floods, droughts, and storms, local-level initiatives promoting sustainable land and water management.
- Human aspects: teaching, informing campaigns for drought-resistant crops, water-saving techniques, and precision agriculture (sensors, AI, remote sensing to optimize farming).
- Physical aspects: expansion, renovation of piers, reservoirs, and drainage systems to prevent floods, investments in smart irrigation to optimize water use.
- Natural aspects: encouraging crop rotation, organic farming, and no-till agriculture, protecting wetlands and restoring natural floodplains.

2.5 Preliminary Monitoring and Evaluation

Lesson learned, from both workflows:

- The CLIMAAX methodology for hazard and risk assessment proved to be effective, learnable i.e. user friendly and very use fool;
- Most difficulties in the whole modelling phase were to understand and access specific local variables to run the code;
- Main challenge in case of agricultural drought was to quantifying economic losses from climate impacts due to incomplete or missing climate and mostly irrigation datasets. In case of River flood there is limited access to high resolution models tailored to our region;
- Stakeholder engagement was successful due to the actuality of the selected climate related hazards, the workshop attracted more than 30 participants, including stakeholders from Romanian General Inspectorate for Emergency Situations (Inspectoratul General pentru Situații de Urgență) National Environmental Guard (Garda Națională de Mediu) Energy Cities Association in Romania (Asociația Orașe Energie în România); representatives of civil organizations and institutions: Green Sun, university professors (Sapientia University), as well as students specializing in agriculture and related fields.

3 Conclusions Phase 1- Climate risk assessment

The CLIMAAX Phase 1 the KÉZDI_adapt team members became competent in using CLIMAAX common methodology, additional theoretical knowledge regarding climate risk, resilience and adaptation was acquired giving the ability to increase understanding of local risk drivers using European datasets. As results the team achieved to implement and use fully customized regional hazard and risk assessment workflows regarding agricultural drought and river flood.

Main Findings:

Agricultural Drought (Workflow #1):

- Maize: Slight yield loss under RCP 2.6 (+0.582%), but a significant drop under RCP 4.5 (-6.946%). However, RCP 8.5 leads to a sharp increase (+10.133%), indicating high vulnerability to extreme climate change.
- Wheat: Yield loss increases under RCP 2.6 (+4.786%) but decreases under RCP 4.5 (-1.768%) and RCP 8.5 (-4.596%).
- Potato: Shows resilience, with slight yield loss reductions under RCP 2.6 and 4.5 (-0.735%, -4.036%), but an increase under RCP 8.5 (+6.231%).
- Rapeseed: The highest mid-century yield loss occurs under RCP 2.6 (+7.537%), with smaller increases under RCP 4.5 (+2.991%) and RCP 8.5 (+0.858%).

- Maize: Stable revenue loss (5600) under RCP 2.6 & 4.5 but increases to 6400 under RCP 8.5.
- Wheat: Higher losses in 2046-2050 (320,000 EUR) across all RCPs compared to 2026-2030 (280,000 EUR under RCP 4.5 & 8.5).
- Potato: Remains financially stable with a constant loss (48,000 EUR).
- Rapeseed: Loss increases in 2046-2050 under RCP 8.5 (640,000 EUR) but stabilizes at 560,000 EUR for RCP 2.6 & 4.5.

River Flood (Workflow #2):
- Flood Hazard Data Limitations: The dataset covers only large river basins (>150 km²) and lacks flood protection data, causing inaccuracies.
- 250-Year Return Period: Data limitations cause unreliable flood maps, especially for distant projections.
- Flood Damage Trends: Under RCP 8.5, flood damage escalates rapidly, with agricultural lands more vulnerable than residential areas.
- Longer Return Periods: Result in a larger flooded area in both examined scenarios.

Agriculture faces significant risks under extreme climate scenarios, particularly for maize and rapeseed, while potato remains the most resilient. River flood risks worsen under RCP 8.5, with higher and faster damage rates. Data limitations affect long-term flood risk assessments, requiring improved modelling and flood protection integration.

4 Progress evaluation and contribution to future phases

During Phase 1 our team became competent in Climaax common methodology, two workflows ere successful applied (Agricultural drought and River Flood), the stated Key Performance Indicators and Milestones were achieved.

Further in phase 2 the team scan and collect already available data and information to improve the local representativity of the results obtained in Phase 1, results from agricultural drought, river flood analysis in a such way to be able to visualize climate indicators on municipal, micro-region level. The Municipality raster orthophoto data (already available) will be merged with other layers containing agricultural land, river basin information, vegetation/green infrastructure which are available in different databases, collection and GIS handling methods will be used.

In Phase 3 RAST adaptation strategy benchmark applicability on local level will be investigated based on results from previous phases, giving the opportunity to identify and understand local risk drivers affecting Key Community Systems. Drafting a realistic local climate adaptation, mitigation strategy is emphasised resulting in an improved risk management plant for Targu Secuiesc Municipality in a strong collaboration with County Inspectorate for Emergency Situations and other relevant stakeholders, key community systems who are most affected by climate change (e.g. critical infrastructure, water supply, landscape productivity, local farmers).

Table 4- 1 Overview key performance indicators

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

Key performance indicators	*Progress*
1 scientific publication or conference attendance on Deliverable 3;	-
1 technical document for support of local risk management elaboration on Deliverable 3;	-
1 draft document of improved local risk management plan project closer on Deliverable 3.	-
3 local workshops for stakeholders' involvement during project activities for each Deliverable (1,2,3);	-

Table 4- 2 Overview milestones

Milestones	*Progress*
M1. Competences for using CLIMAAX framework and CRA toolbox;	Completed 31.01.2025
M2. Stakeholders meeting, local workshop;	Completed 25.03.2025
M3. Test of workflow Droughts using common information already available;	Completed 31.01.2025
M4. Test of workflow River flooding using common information already available completed	Completed 31.01.2025
M5. Test of workflow Heatwaves using common information already available;	In best case scenariou was introduced as milestone the 3rd worklfow package, if there will be enough capacity we would like to investigate, in the KPIs was indiated: "2 of workflows successfully applied on Deliverable 1"
M6. Attend Climaax workshop held in Barcelona;	-
M7. Updating raster orthophoto map with additional data's collected;	-
M8. Test of workflow Droughts using refined local data;	-
M9. Test of workflow Precipitation using refined local data;	-
M10. Test of workflow Heatwaves using refined local data;	-
M11. Stakeholder workshops presentation of downscaled results;	-
M12. Definition of feasible adaptation strategy on local level;	-
M13. Scientific publication or conference attendance;	-
M14. Technical document to support local risk management elaboration;	-
M15. Draft document of improved local risk management plan project closer;	-
M16. Workshop for result dissemination;	-
M17. Attend Climaax workshop held in Brussels.	-

5 Supporting documentation

1. Main Report

2. Visual Outputs:
    a. Agricultural drought hazard and risk plots, data
    b. River flood hazard and riks plots, data
3. Communication outputs
    a. Branding material
    b. Press release, TV interview

Szilveszter, S., Miklos, A., Bartos-Ménessy, K., & Rettegi, C. (2025). CLIMAAX M6 deliverable KÉZDI_adapt. Zenodo. https://doi.org/10.5281/zenodo.15115366

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