Deliverable Phase 2 – Climate risk assessment

Adapt on clime change in APV (CLIMACHANGE)

Republic of Serbia / Autonomous Province of Vojvodina

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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	This section provides an evaluation of the progress achieved in Phase 2 of the CLIMAAX Climate Risk Assessment for Vojvodina. It summarizes the link between analytical outputs and upcoming Phase 3 adaptation activities, reviews performance through key indicators and milestones, and assesses overall implementation efficiency. The chapter outlines how hazard and risk results support future planning, documents stakeholder engagement outcomes, and presents an integrated view of achievements, remaining challenges, and readiness for the next project phase.
Project name	Adapt on clime change in APV (CLIMACHANGE)
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Region/Municipality	Vojvodina Province
Leading Institution	Provincial Secretariat for Urban Planning and Environmental Protection
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5.0	…		Final version to be submitted

Abbreviations and acronyms

Abbreviation / acronym	Description
APV	Autonomous Province of Vojvodina
CAP	Common Agricultural Policy
CLIMAAX	CLIMate risk and vulnerability Assessment framework and toolbox
CLIMACHANGE	Adapt on Climate Change in APV (Project Acronym)
CRA	Climate Risk Assessment
GDP	Gross Domestic Product
NGO	Non-Governmental Organization
RCP	Representative Concentration Pathway
RHMZ	Hydrometeorological Institute of Serbia
SPI	Standardized Precipitation Index
SSP	Shared Socioeconomic Pathway

Executive summary

This deliverable presents the results of **Phase 2 – Climate Risk Assessment (CRA)** conducted within the CLIMAAX framework for the **Autonomous Province of Vojvodina (RS12)**.
The assessment was developed to provide a **scientifically robust and policy-relevant foundation** for regional adaptation planning and to identify key climate-related risks — with a focus on **relative and agricultural droughts** — that threaten socio-economic stability, food security, and environmental sustainability.

The document responds to the need for **evidence-based decision-making** in regional climate adaptation. It provides a comprehensive picture of historical and projected drought hazards, exposure patterns, and vulnerabilities, as well as their spatial and temporal evolution.
Readers gain insight into how climate change will affect agricultural production, ecosystem resilience, and water resources under different socio-economic scenarios (SSP1–2.6 and SSP5–8.5).

Main Actions and Findings

Phase 2 applied a **multi-layered analytical framework** aligned with the CLIMAAX Handbook. It combined regional datasets (E-OBS, NASA POWER, CMIP6 EC-Earth3-Veg-LR) with locally available information from national and provincial institutions (RHMZ, SORS, CORINE 2018). This approach enabled the fine-tuning of global risk workflows to the specific agro-climatic conditions of Vojvodina.

Key actions included:

- **Computation of drought indicators (SPI, SPEI, P–ET$_0$, CDD)** for the baseline period 1981–2015, establishing reference conditions for hazard analysis;
- **Spatial modelling of relative and agricultural droughts** at NUTS3 resolution, validated through stakeholder consultations;
- **Integration of future climate scenarios** (SSP1–2.6, 2021–2050; SSP5–8.5, 2071–2100), providing projections of drought severity and frequency;
- **Development of vulnerability and exposure indices** reflecting socio-economic, environmental, and infrastructural dimensions;
- **Calculation of the Drought Risk Index (DRI)** and **Risk Priority Index (RPI)** to rank districts by overall drought risk.

Findings demonstrate that **northeastern districts (Severnobanatski, Srednjobanatski)** face the highest hazard and vulnerability, with increasing frequency of agricultural droughts projected under both emission scenarios.

Under **SSP5–8.5**, the regional water balance shows mean deficits exceeding 100 mm during the growing season, highlighting the need for urgent adaptation measures.
Conversely, western districts (Sremski, Južnobački) display higher resilience due to diversified land use, better irrigation systems, and stronger institutional capacity.

The **stakeholder validation process**, including in-person and online meetings, confirmed the relevance of CRA results for local policy integration. The Key Risk Assessment Dashboard

facilitated structured evaluation of **severity, urgency, and resilience capacity**, leading to prioritization of high-risk areas and enabling alignment with regional climate adaptation strategies.

Conclusions:

The Climate Risk Assessment for Vojvodina provides:

- A **data-driven understanding** of regional drought dynamics and vulnerability patterns;
- A **quantitative foundation** for prioritizing adaptation measures;
- A **validated participatory model** linking scientific assessment with governance structures.

Remaining challenges—such as limited resolution of soil and hydrological data, and the absence of real-time drought monitoring—were acknowledged and will be addressed through targeted actions in the next project phase.

Plans for the Final Phase:

Phase 3 will focus on translation of risk assessment results into adaptation planning, including:

- Initialization of integration of CRA outputs into **provincial and municipal adaptation strategies**;
- Development of a **Best Practice Guide** on drought resilience;
- Implementation of **capacity-building seminars** and stakeholder co-design sessions;
- Strengthening of **monitoring and communication mechanisms** for climate risk management.

By combining analytical precision with policy orientation, this deliverable positions Vojvodina as a regional model for **evidence-based climate adaptation** under the CLIMAAX framework.

1. Introduction

1.1. Background

The **Autonomous Province of Vojvodina (NUTS-2: RS12)**, located in northern Serbia, represents a vital agricultural and economic hub of the Republic of Serbia. Its territory covers approximately 21,500 km² and is divided into **seven NUTS-3 administrative districts**: **Zapadnobački (RS121), Južnobanatski (RS122), Južnobački (RS123), Severnobanatski (RS124), Severnobački (RS125), Srednjobanatski (RS126)**, and **Sremski (RS127)**.

The region is characterized by a **temperate-continental climate**, with warm summers, cold winters, and frequent intra-annual variations in precipitation. Agricultural production—especially cereals such as **wheat and maize**—dominates the regional economy and employment. These crops are highly sensitive to **hydro-climatic extremes**, particularly prolonged dry spells and elevated temperatures during the vegetation season.

Recent decades have shown a trend toward **increasing frequency of droughts**, more intense heat waves, and greater interannual variability in precipitation. These processes directly affect soil moisture, yields, and regional food security, while also influencing water management, land-use planning, and rural development. The **Provincial Secretariat for Urban Planning and Environmental Protection (PSUPE)** recognized the need to establish a **scientifically based, standardized framework** for drought-risk assessment aligned with the **CLIMAAX methodology**.

1.2. Main objectives of the project

Phase 2 of the project builds on the achievements of **Phase 1**, where the baseline hazard indicators and local datasets were harmonized according to the CLIMAAX Data Preparation Guidance.

The main objectives of Phase 2 are:

1. To implement and validate **two drought-related workflows** described in the CLIMAAX Handbook v2025.08.1:
    - **Relative Drought Hazard (WASP/dH) and risk assessment**, derived from observed monthly precipitation series (1950–2020) across all seven NUTS-3 districts;
    - **Agricultural Drought Hazard and risk assessment**, based on the water balance and crop yield loss indicators, developed through the integration of local temperature, precipitation, and agricultural productivity data.
2. To generate **spatially explicit maps and tables** of drought hazard across the entire NUTS-2 territory (Vojvodina) and each constituent NUTS-3 unit, following the CLIMAAX geospatial conventions.
3. To ensure **full traceability and reproducibility**, enabling local institutions to apply the same workflows for future updates and scenario analyses.
4. To support **regional adaptation planning**, by providing scientifically consistent outputs for environmental, water, and agricultural policy instruments.

Significance for the region and community.
The implementation of Phase 2 provides the first comprehensive, **locally calibrated drought hazard assessment** covering the full historical record from **1950–2020**. This analysis will help provincial authorities, municipalities, and research institutions:

- understand spatial drought dynamics,
- prioritize adaptation investments (irrigation, land-use management, ecosystem services),
- and improve long-term resilience of agriculture and water resources.

Added value of the CLIMAAX Handbook and local data integration.
By applying the CLIMAAX standard workflows and combining them with **locally observed meteorological datasets** (curated and validated by regional experts), Phase 2 ensures:

- **Comparability** with other European regions through standardized indicators and methods;
- **Scientific robustness**, as calculations strictly follow the officially documented CRABOOK workflows;
- **Local relevance**, since regional observations replace coarse-resolution reanalysis data, improving the accuracy of the hazard signal;
- **Practical usability**, as maps and tables are aligned with the administrative structure and data needs of local authorities.

1.3. Project team

- **Specialists in climatology, hydrology, environmental, and data analytics** responsible for generating climate projections, modeling drought indices, and assessing vulnerability and evaluating ecological impacts, soil quality, agricultural productivity, and water resource sustainability. (Sanja Mrazovac Kurilić, PhD in Environmental Protection and Predrag Ilić PhD in interdisciplinary fields of environmental engineering)
- **Policy and Governance Advisors and Community Engagement Specialists**: Experts tasked with ensuring the practical integration of climate risk findings into policy frameworks and regional development strategies. Professionals managing stakeholder consultations, public workshops, and knowledge dissemination efforts aimed at building awareness and local capacities. (Tatjana Đurić M.Sc of Agriculture and Teodora Subotić, advisor for projects)
- **Institutional Representatives**: Officials from local government bodies, including the Provincial Secretariat for Agriculture, Water Management, and Forestry, actively involved in shaping policies based on project insights. (Tatjana Đurić M.Sc of Agriculture and Teodora Subotić, economist, advisor for projects)

1.4. Outline of the document's structure

Section 1 – Introduction: Describes the regional context, project objectives, team composition, and overall structure of the document.

Section 2 – Data and Methodology: Details the sources of input data, including locally observed precipitation and temperature (1950–2020), agricultural datasets, and applied CLIMAAX workflows for drought hazard and risk assessment.

Section 3 – Results: Relative Drought (WASP/dH): Presents computed indicators and maps at NUTS-3 level, with interpretation and NUTS-2 synthesis.

Section 4 – Results: Agricultural Drought: Summarizes water-balance and yield-based hazard indicators and risk assessment, following the agricultural drought module.

Section 5 – Discussion and Policy Relevance: Connects results to planning documents, water management strategies, and regional adaptation priorities.

Section 6 – Conclusions and Next Steps: Outlines how Phase 2 results will feed into Phase 3 (adaptation measure evaluation).

Annexes: Include tables of raw data, methodological parameters, and additional maps ensuring transparency and reproducibility.

2. Climate risk assessment – phase 2

2.1. Scoping

2.1.1. Objectives

The main objective of the **Climate Risk Assessment (CRA) for Vojvodina (NUTS2: RS12)** is to evaluate the spatial and temporal characteristics of **drought hazards** and **risks** that have affected the region during the **1981–2015 baseline period**, and to provide an evidence-based foundation for future adaptation and risk reduction planning in key sectors — particularly **agriculture, water management, and land use**.

Although observational datasets were available from 1950–2020 (E-OBS) and 1981–2020 (NASA POWER), all baseline hazard and risk indicators were consistently computed for the reference period 1981–2015, in line with CLIMAAX Handbook v2025.08.1.

This assessment builds upon the results of **Phase 1 (Scoping)**, in which drought was identified as the primary climate-related hazard of concern for the Autonomous Province of Vojvodina. Phase 2 implements the **CLIMAAX Framework and Handbook (v2025.08.1)** to operationalize the hazard and risk analysis using two standardized workflows:

1. **Relative Drought (WASP/dH Workflow)** — quantifies anomalies in precipitation to identify the frequency, duration, and severity of relative drought episodes within the reference period 1981–2015.
2. **Agricultural Drought (P–ET_0 Workflow)** — integrates precipitation and reference evapotranspiration data, with ET_0 estimated using a FAO-56 Penman–Monteith–based approach adapted for gridded climate datasets, to assess seasonal water deficit conditions that directly affect soil moisture availability and crop yields.

The **purpose** of the CRA is to detect spatial patterns of drought occurrence and intensity across **seven NUTS-3 districts** of Vojvodina, quantify the **relative hazard and risk levels** to support prioritization of vulnerable areas and sector and establish a **baseline** for Phase 3.

The **expected outcome** is a coherent set of **quantitative indicators, maps, and summary statistics** describing drought hazard dynamics across the reference period and risk assessment. These outputs will enable informed, evidence-based policymaking at the **regional** (Provincial Secretariat for Urban Planning and Environmental Protection) and **local** (municipal administrations) levels.

Contribution to Policy and Decision-Making

The CRA results will be initiated for inclusion in Provincial policy documents and decisions, especially the sections on natural risk management, water resources and sustainable agriculture, as well as cross-border cooperation frameworks with neighboring regions of Croatia and Hungary, ensuring compliance with EU standards for climate adaptation (in accordance with Regulation (EU) 2021/1119 and through the adaptation of the Green Deal).

Through these integrations, the CRA supports:

- **Evidence-based decision-making**, replacing qualitative risk perception with quantitative metrics;
- **Targeted adaptation**, enabling selection of drought-resilient agricultural practices and irrigation priorities;

- **Policy coherence**, ensuring that risk considerations are systematically embedded into development and investment planning documents at all governance levels.

The Climate Risk Assessment is framed by several technical and practical boundaries:

Temporal Scope — the analysis covers the **1981–2015 baseline.** The pre-1980 data were not included due to limited temporal consistency in reanalysis and observational series.

Spatial Scope — limited to the **NUTS-2 region of Vojvodina** and its seven constituent NUTS-3 districts (RS121–RS127). Cross-border influences are noted but not explicitly modelled.

Data Availability — all climatic inputs are sourced from open datasets (NASA POWER, and verified local meteorological records). While these sources ensure spatial coverage, sub-daily and soil moisture data are partially unavailable, constraining the precision of the agricultural drought module.

Stakeholder Involvement — engagement in Phase 2 was limited to expert consultations within institutional partners. Broader participatory validation is planned in Phase 3.

Several operational and technical challenges were encountered and addressed:

Challenge	Description	Mitigation Approach
Data consistency between sources	Differences in spatial resolution and temporal coverage between global (NASA) and local (E-OBS, RHMZ) datasets.	Performed normalization and regridding to a common monthly resolution (0.1° grid).
Limited soil moisture and crop yield data	Lack of continuous local soil water balance measurements before 2005.	Proxy indicators ($P–ET_0$) used as agricultural drought proxy, consistent with CLIMAAX Handbook Section 3.2.

2.1.2. Context

The Autonomous Province of **Vojvodina (NUTS2: RS12)** has historically experienced **recurring droughts**, primarily linked to increasing temperature variability and changes in precipitation distribution.
Until now, climate hazards and their impacts have been **assessed through sectoral initiatives**, often limited to short-term monitoring rather than integrated climate risk assessment.

The **Hydrometeorological Service of Serbia (RHMZ)** provides regular bulletins on extreme weather and drought monitoring (based on SPI and Palmer indices), while academic and research institutions such as the **Faculty of Agriculture (University of Novi Sad)** and the **Biosense Institute** have conducted isolated assessments of agricultural drought risk.

SPI and SPEI indices were used exclusively for contextual validation through RHMZ bulletins and were not recalculated within the CLIMAAX workflows, which rely on WASP/dH and $P–ET_0$ as primary drought indicators.

The region lacked a standardized framework for integrating climate hazard indicators into decision-making. The CRA under CLIMAAX Phase 2 therefore represents the first harmonized, methodologically consistent drought hazard and risk analysis aligned with the EU Climate Risk Assessment Framework and compliant with the *CLIMAAX Handbook (v2025.08.1)*.

Vojvodina's economy and land use are **strongly dependent on climate-sensitive sectors**, particularly **agriculture**, which accounts for a significant portion of regional GDP, employment, and exports.

Prolonged dry periods, reduced soil moisture, and increased evapotranspiration have led to **declining crop yields**, **soil degradation**, and **growing water demand for irrigation**, especially during summer months.

The CRA aims to address the **lack of integrated hazard assessment and risk quantification** at the regional level by introducing standardized indicators that quantify the **magnitude, frequency, and duration** of droughts. This approach supports the **systemic incorporation of climate risk** into development and investment planning, which is currently fragmented across different administrative and sectoral levels.

At the national level, this work contributes to Serbia's obligations under the **Law on Climate Change (Official Gazette RS 26/2021)**, the **National Adaptation Plan (NAP)** under preparation, and the implementation of the **EU Green Agenda for the Western Balkans**. The CLIMAAX project thus positions Vojvodina as a **pilot region** for applying EU-aligned climate risk methodologies in Serbia.

The governance of climate risk assessment and adaptation in Vojvodina operates within a **multi-level policy framework**, involving both provincial and national institutions:

Level	Responsible Institutions	Key Policies / Frameworks
National (Republic of Serbia)	Ministry of Environmental Protection, RHMZ, Institute for Nature Conservation	- Law on Climate Change (2021) - National Strategy for Disaster Risk Reduction (2019–2030) - National Adaptation Plan (in preparation)
Provincial (Vojvodina)	Provincial Secretariat for Urban Planning and Environmental Protection (lead), Secretariat for Agriculture, Water Management and Forestry	- Regional Spatial Plan of AP Vojvodina (2022–2035) - Provincial Environmental Protection Program - Draft Climate Adaptation Strategy (internal document, 2024)
Local (Municipalities)	Local Environmental Departments, Agricultural Advisory Services	- Local development plans and municipal risk management strategies (partially referencing drought, but lacking quantitative baselines)

Financial and human resources for systematic CRA remain limited, but the CLIMAAX framework has enabled the region to **enhance institutional capacity** and link local monitoring with European open-data sources (Copernicus, NASA POWER).

The most climate-sensitive sectors in Vojvodina are:

1. **Agriculture** – yield reduction in cereals (wheat, maize) due to reduced soil moisture and prolonged high temperatures; increasing need for irrigation and drought-resistant crop varieties.
2. **Water Management** – decreased surface water availability during summer; challenges for reservoir management and irrigation networks.
3. **Ecosystems and Forestry** – altered vegetation composition, risk of soil salinization and biodiversity loss in steppe habitats.
4. **Public Health and Urban Areas** – increased heat stress in urban environments; risk to vulnerable groups during heatwaves.

These interlinked impacts illustrate the **cross-sectoral nature of drought risk**, necessitating an integrated and spatially explicit approach as introduced through CLIMAAX.

The CRA implementation in Vojvodina benefits from **regional and international cooperation frameworks**, including:

- The **EU Mission on Adaptation to Climate Change**, in which Serbia participates as an associated country.
- The **Interreg IPA Cross-Border Programs** with ongoing initiatives addressing water management and drought resilience.
- The **Danube Strategy and ICPDR basin programs**, which provide shared hydrological datasets and adaptation measures relevant for the region.
- The **European Environment Agency (EEA) Climate-ADAPT platform**, which supports methodological harmonization across EU regions.

These initiatives ensure that the CRA results are compatible with broader European datasets and can be replicated in other parts of Serbia.

Based on the expected outputs of the CRA and existing regional strategies, the following adaptation measures are considered most relevant to meet the project objectives:

Category	Example Measures
Water Management	Modernization of irrigation infrastructure; small retention systems; reuse of treated wastewater for agriculture.
Agriculture	Promotion of drought-resistant crop varieties; optimized sowing calendars; soil moisture conservation techniques.
Land Use Planning	Integration of drought hazard maps into spatial plans; regulation of land conversion in high-risk zones.
Governance and Capacity Building	Establishment of a provincial climate risk observatory; inclusion of CRA outputs into local adaptation planning.
Information Systems	Development of early warning tools using NASA datasets and automated drought monitoring dashboards.

2.1.3. Participation and risk ownership

During **Phase 2 of the CLIMAAX project**, stakeholder participation was organized through a **targeted expert-based approach**, focusing on key provincial and regional institutions responsible for environmental management, water governance, and agricultural development.
Due to the analytical and methodological character of this phase, engagement prioritized **technical validation and data harmonization**, while broader stakeholder participation (e.g., local communities, citizen groups) is planned for **Phase 3**, when adaptation pathways will be addressed.

The **lead institution** for the implementation in the region is the **Provincial Secretariat for Urban Planning and Environmental Protection (PSUPEP)**, which coordinates activities within the CLIMAAX framework and ensures alignment with existing adaptation planning processes.

Other engaged institutions provided data, expertise, or validation support through technical meetings and consultations.

Institution	Role in Phase 2	Type of Contribution
Provincial Secretariat for Urban Planning and Environmental Protection (PSUPEP)	Lead regional authority	Project coordination, CRA validation, policy alignment
Provincial Secretariat for Agriculture, Water Management and Forestry	Sectoral authority	Data on irrigation, land use, and soil protection
Hydrometeorological Service of Serbia (RHMZ)	National-level data provider	Meteorological data validation, SPI drought indices
Faculty of Agriculture, University of Novi Sad	Academic partner	Interpretation of agricultural drought impacts
Water Management Company "Vode Vojvodine"	Operational stakeholder	Water system management, flood/drought operations data
Regional Development Agency Bačka	Socio-economic input	Local development context and economic exposure insights

Two structured meetings were held — in **September-October 2025** (methodological calibration, data integration and preliminary results discussion).
Additional bilateral exchanges were conducted by email to validate datasets and interpretations.

In Vojvodina, the **ownership of drought-related risks** is distributed among several administrative levels, following both the **Law on Climate Change (2021)** and the **Law on Disaster Risk Reduction and Emergency Management (2018)**:

Function	Responsible Institution	Description
Risk Identification and Monitoring	Hydrometeorological Service of Serbia (RHMZ)	Provides early warning data and national drought monitoring (SPI, PDSI).
Hazard Assessment and Planning	Provincial Secretariat for Urban Planning and Environmental Protection	Integrates hazard indicators into spatial and environmental planning.
Risk Mitigation (Agriculture and Water)	Provincial Secretariat for Agriculture, Water Management and Forestry; "Vode Vojvodine"	Implements water and land use measures, manages irrigation systems.
Emergency Response	Provincial Civil Protection Headquarters	Coordinates emergency drought response in extreme conditions.
Policy and Strategy	Government of the Autonomous Province of Vojvodina	Defines adaptation policies and allocates financial resources.

This governance architecture ensures shared responsibility but requires **stronger inter-sectoral coordination**, which the CLIMAAX process directly facilitates.

Vulnerability to drought in Vojvodina primarily affects:

- **Small and medium-scale farmers** (limited access to irrigation and capital),
- **Rural households in the Banat districts** (sandy soils, lower rainfall),
- **Ecosystem-dependent communities** (areas near protected wetlands and steppe reserves),
- **Women and elderly populations** involved in subsistence agriculture.

The CRA recognizes these groups as **priority targets** for risk reduction and adaptation planning in subsequent project phases. Their inclusion will be strengthened during the **Phase 3.**

Currently, **no officially adopted quantitative thresholds** exist in Vojvodina defining acceptable or tolerable drought risk levels.
However, the Provincial Secretariat recognizes the **need to establish drought risk classes** aligned with the European standards (e.g., ISO 14091:2021 – Adaptation to climate change) to guide adaptation decisions.

The CLIMAAX CRA contributes to this process by:

- Delivering **standardized hazard indicators** (WASP, P–ET_0) for defining risk categories;
- Proposing a **data-driven foundation** for setting provincial drought alert thresholds;
- Facilitating discussions with policy-makers and experts on **risk acceptability criteria** for land use and agricultural planning.

2.1.4. Application of principles

The CRA adopts an **equity-based approach** that recognizes the uneven distribution of climate impacts across the socio-economic and geographic landscape of Vojvodina.
The region exhibits **significant intra-regional disparities** in income levels, irrigation coverage, and access to climate information — particularly between the **Banat plains (eastern districts)** and the **Bačka and Srem areas**.

In response, the Phase 2 analysis:

- Ensures **equal spatial representation** of all seven NUTS-3 districts (RS121–RS127) in data processing, avoiding bias toward areas with better monitoring infrastructure;
- Prioritizes **agricultural drought** as the dominant hazard due to its disproportionate effect on small and medium-scale farmers, who represent the **most climate-vulnerable socio-economic group** in the province;
- Applies **open-access data** (NASA POWER, RHMZ) to ensure that results can be freely replicated and used by all stakeholders, including non-governmental organizations and citizen groups;
- Plans future stakeholder engagement (Phase 3) to include **underrepresented groups**, particularly rural women and elderly farmers, in the evaluation of adaptation pathways.

The analytical framework follows strict scientific and quality-control protocols consistent with **CLIMAAX Handbook v2025.08.1**, **EU Adaptation Strategy (2021)**, and **ISO 14091:2021** standards. Data sources and workflows are **fully documented**, traceable, and reproducible.

Key quality assurance measures include:

- Use of **consistent temporal baselines (1981–2015)** across all hazard and risk indicators;
- **Cross-validation** of precipitation and temperature data between NASA POWER, and local E-OBS time series;
- Application of **standardized drought metrics** (WASP, P–ET_0) as prescribed by CLIMAAX and FAO-56 methodology;

- Maintenance of **open-source processing pipelines** (Python, R, and QGIS scripts from CRABOOK repository), ensuring transparency and auditability;
- Internal peer review by domain experts from the **Faculty of Agriculture (University of Novi Sad)** and **Provincial Secretariat for Urban Planning and Environmental Protection** before finalization.

All analytical outputs — including maps, tables, and datasets — will be archived and made available through the **Zenodo open repository**, ensuring that every result can be independently verified and re-used by the wider scientific and policy community.

Given the persistence of data gaps and the inherent uncertainty of climate projections, the CRA for Vojvodina applies a **precautionary approach** throughout the analysis and interpretation process. This approach acknowledges that **limited information should not delay preventive or adaptive measures**, particularly in sectors highly sensitive to climatic extremes such as agriculture and water management.

Implementation of the precautionary principle in this CRA includes:

- Selecting **baseline indicators (1981–2015)** that capture both the historical variability and early onset of intensifying drought patterns;
- Prioritizing **low-regret measures** in interpretation — those that bring benefits under both current and future climate conditions (e.g., soil moisture conservation, irrigation modernization);
- Avoiding overreliance on single-source datasets by combining multiple data inputs (reanalysis, observations, and satellite-derived estimates) to mitigate uncertainty;
- Clearly communicating **limitations, assumptions, and data confidence levels** in all figures and tables to prevent misinterpretation of results.

2.1.5. Stakeholder engagement

The activities included representatives of the Provincial Secretariat, experts in urban planning, environmental protection, agriculture and water management, academic institutions, and regional development agencies. Project goals and intermediate results were communicated through structured presentations, interactive sessions, roundtable discussions, and open dialogue with stakeholders. Direct data exchange and sharing of locally collected datasets were also integral to the communication process.

1. Clima2europe Festival – Roundtable on Climate Change (29 September, Belgrade)

At the roundtable dedicated to climate change, representatives of the Provincial Secretariat, members of the CLIMACHANGE project team, presented preliminary project results and key climate-related challenges observed in the territory of Vojvodina. The session enabled meaningful exchange of views and sectoral perspectives, especially related to regional climate risks.

2. Session “How to Build a Climate Service” (30 September)

During this session, a representative of the Provincial Secretariat participated in presenting the achievements of the CLIMACHANGE project and engaged in discussion with panelists from Southeast and Eastern Europe. The session aimed to provide an open, interactive platform for exchanging ideas, highlighting successful practices, and identifying opportunities for collaboration in the development of climate services and tools relevant for Vojvodina.

3. Session “Mission Adaptation – Dialogue in the Region” (1 October)

Representatives of the Provincial Secretariat presented the CLIMACHANGE project in full, responded to stakeholder questions, and jointly with a CLIMAAX program representative introduced the aims and tools of the CLIMAAX initiative. The session emphasized how climate services contribute to strengthening the resilience of regions, cities, and local authorities, with insights drawn from projects such as CLIMAAX and Adaptation AGORA.

4. Stakeholder Meeting at the Provincial Secretariat (14 October 2025)

A dedicated meeting was held at the Secretariat with invited stakeholders to present project results to date and to collect data relevant for the project. Representatives of the FIMEK Faculty, the regional agency Almamons, and the Department of Urban Planning participated. Discussions focused on the current situation regarding climate change in Vojvodina, particularly the impact of drought.

5. Meeting with the Provincial Secretariat for Agriculture (15 October 2025)

The discussions addressed agricultural droughts, relative drought conditions, crop-related data exchange, and potential adaptation measures for future climate impacts. The meeting was attended by the Assistant Provincial Secretary, experts responsible for field crops, the Undersecretary, and the CLIMACHANGE project team.

6. Presentation at the LORIST Ecology Fair (24–28 September)

As one of the organizers of the LORIST ecology fair, the Provincial Secretariat annually presents its ongoing projects. During this year’s event, the CLIMACHANGE team showcased the project and current results, while securing stakeholder support for continued cooperation, data exchange, and broader dissemination of project outcomes.

Stakeholders expressed strong interest in the project’s outputs, particularly climate-risk maps, analytical tools, and data-driven insights relevant to urban planning, agriculture, and water management. The feedback highlighted the practical value of the project and confirmed readiness for continued cooperation. Participants emphasized the importance of integrating project findings into strategic documents and planning processes across sectors.

Stakeholders indicated that the results will be used for:

-planning and prioritizing adaptation measures in local governments,

-updating sector-specific strategies and action plans,

-improved assessment and monitoring of climate risks in Vojvodina,

-integration into urban, spatial, and developmental planning documents.

2.2. Risk Exploration

In Phase 2, we update the screening from Phase 1 with (i) the 1981–2015 baseline , (ii) a review of authoritative regional sources (Copernicus Interactive Climate Atlas; IPCC AR6; EEA/Climate-ADAPT), and (iii) a check of new evidence relevant for Serbia and the Western Balkans.

2.2.1 Screen risks (selection of main hazards)

Across northern Serbia and the Pannonian plain, the hazards of greatest salience remain:

- **Meteorological/relative drought** (precipitation deficits and dry spells),

- **Agricultural drought** (soil-plant water stress driven by P–ET_0 imbalance during the growing season),
- **Heat extremes** (hot days, heatwaves) that exacerbate evapotranspiration,
- **Hydrological drought** (low flows/levels) that interacts with irrigation supply.

These are consistent with the **Copernicus Interactive Climate Atlas** scope for Europe (variables describing "wet and dry" and "heat" climatic impact drivers), which we use to contextualize local findings.

Current situation:

- All seven NUTS-3 districts (RS121–RS127) experience recurrent summer dryness; **Banat** districts (RS122, RS124, RS126) are frequently highlighted by local services for longer dry spells and higher irrigation demand.
- Primary impacts fall on **crop producers** (wheat, maize), **irrigation and water managers**, and **rural communities** relying on climate-sensitive livelihoods.

Copernicus Atlas summary:

Authoritative European assessments indicate that **Mediterranean and parts of southeastern/central Europe** face **increases in drought and aridity** with warming; the Copernicus Atlas and IPCC AR6 consolidate this as a key regional signal relevant for Serbia and Vojvodina.

The **Copernicus Interactive Climate Atlas** provides regionalized evidence and the underpinning gridded datasets for **past trends and future projections** across "wet/dry" and "heat" drivers, which we use to benchmark local indicators.

- The **IPCC AR6 Europe factsheet** reports **increases in agricultural/ecological drought** for Mediterranean Europe with warming (medium to high confidence), a category that often extends signals into the **Pannonian/Balkan transition zone**, supporting our focus on drought-related hazards.
- Recent **EEA/Climate-ADAPT** briefs emphasize that **frequency, duration, and intensity of droughts** are likely to increase across Europe, reinforcing the policy relevance of drought-centred CRA for RS12.

Covered in Phase 2:

1. **Relative drought** — using the **CLIMAAX WASP/dH** workflow from monthly precipitation.
2. **Agricultural drought** — using P–ET_0, with reference evapotranspiration (ET_0) estimated following a FAO-56 Penman–Monteith–based approach adapted for gridded climate data, derived from observed precipitation and newly acquired radiation, wind, and humidity (daily), and aggregated to monthly indicators for the growing season.

Rationale:

- Both are **agriculture-critical** hazards in Vojvodina; heat and hydrological drought are integrated as **amplifying factors** rather than standalone workflows in this phase.
- This selection is fully aligned with the CLIMAAX CRA and the **C3S/IPCC Atlas** emphasis on **dryness and heat** drivers as key risks for southern/central Europe.

Already available for Phase 2:

- **Local observations** (daily precipitation, temperature) consolidated and quality-controlled.
- **Daily radiation (ALLSKY_SFC_SW_DWN), wind (WS2M), humidity (RH2M, Tdew)** from **NASA POWER** for NUTS-3 representative points (downloaded 1981–2020; subsetted to 1981–2015 for baseline).
- **NUTS 2021** geographies (Eurostat) for NUTS-3 and NUTS-2 aggregation.
- **CLIMAAX workflows** (CRABOOK v2025.08.1) for **WASP/dH** and **P–ET$_0$** indicators, ensuring reproducibility.

Gaps / needs (carried forward):

- **Hydrological data** (gauged flows/reservoir levels) at district resolution to formalize a **hydrological drought** workflow;
- **Crop calendars and phenology-specific parameters** (Kc, Ky) at district level to translate water stress to **yield loss** consistently across crops;
- **Systematic exposure/vulnerability datasets** (farm size, irrigation access, income) to move from hazard to **risk quantification**;
- **Projection layer** (near/long-term scenarios) to extend beyond baseline once hazard baselines are finalized, cross-checked against **Copernicus Atlas/IPCC Atlas** projections.

2.2.2 Choose Scenario

Table 2-1 Future Climate Conditions Considered

Table 2-2 Future Socio-Economic Developments Considered

These assumptions were derived from **national development strategies**, **CAP reform projections**, and regional agricultural trends under Serbia's EU integration process.

Integration of Climate and Socio-Economic Scenarios

The CRA combines future **climate hazards** and **socio-economic developments** using a **two-layered scenario matrix**:

1. **Climate Forcing Layer** — based on SSP–RCP combinations (e.g., SSP1–2.6, SSP5–8.5) to quantify drought frequency, intensity, and spatial extent.
2. **Socio-Economic Vulnerability Layer** — applying sectoral parameters such as irrigation coverage, rural employment share, and GDP per capita to assess exposure and adaptive capacity.

Table 2-3 Time Horizons Considered

2.3. Regionalized Risk Analysis

Fine-Tuning of Selected Risk Workflows
The CLIMAAX Handbook recommends modular workflows for different hazard types.
For Vojvodina, two drought-related workflows were selected and locally optimized:

1. **Hazard #1 — Relative Drought (WASP/dH Method):**
    - Workflow 1 from the CLIMAAX Handbook was used to quantify the *frequency and intensity of relative droughts*.
    - Local calibration involved:

  - Monthly precipitation data (1981–2015) from **NASA POWER** and the **Republic Hydrometeorological Service of Serbia (RHMZ)**.
  - Statistical thresholding by **Jenks natural breaks (k=2)** per month to define local drought onset.
  - Recalculated regional averages for **seven NUTS3 districts (RS121–RS127)**.
- The resulting dataset represents the **WASP-derived relative drought intensity (dH)**, normalized for regional comparison.

2. **Hazard #2 — Agricultural Drought (P–ET_0 Method):**
   - Based on **FAO-56 Penman–Monteith**–based reference evapotranspiration, implemented through CLIMAAX Workflow 2.
   - Local adaptation included:
     - Calculation of daily **ET_0** from temperature, humidity, wind, and radiation data.
     - Monthly aggregation of **precipitation (P)** and **ET_0**, followed by computation of **P–ET_0 deficits** during the growing season (April–September).
     - Spatial integration across NUTS3 centroids using **NASA POWER daily data**.

Both workflows were reproduced in **Python using open-source FAO equations**, and all outputs were harmonized to the **1981–2015 baseline**.
The results of the drought hazard and risk assessment are presented using both spatial maps (Annex 1) and quantitative summaries at district level (Annex 2).
Maps present continuous normalized values, while tables summarize results into categorical risk classes for decision-making purposes.

Table 2-4 Local and institutional datasets incorporated to improve contextual accuracy

Table 2-5 New Risk Metrics and Outputs

Indirect Impacts Considered
Although quantitative modelling of indirect impacts will be developed in later phases, several effects were identified during this analysis:

- **Economic:** Reduction of agricultural productivity, income instability in rural areas.
- **Environmental:** Soil degradation, salinization, and decreased groundwater recharge.
- **Social:** Rural depopulation and migration due to increased drought frequency.
- **Cross-sectoral:** Reduced hydropower potential and industrial water supply stress during dry seasons.

Table 2-6 Overview of Datasets Used

Table 2-7 Limitations of Datasets

2.3.1. Hazard #1 - fine-tuning to local context

Table 2-8 Data overview workflow #1 (Relative drought)

2.3.1.1. Hazard assessment

Local Calibration

1. **Precipitation Dataset:** Monthly precipitation series from **NASA POWER** were extracted for seven district centroids in Vojvodina (RS121–RS127).
   Data were validated against RHMZ measurements for the period 2000–2015 (correlation >0.92).

2. **Threshold Definition:** For each month *m*, a **Jenks natural break (k=2)** was applied to the 35-year monthly precipitation series to separate "dry" from "normal" conditions.
   This adaptive threshold approach ensures sensitivity to local climatic variability.
3. **Drought Episode Construction:** Each month with precipitation below its local Jenks threshold was flagged as a **drought month.** Consecutive dry months were aggregated into **episodes**, for which cumulative anomalies were computed.
4. **Relative Drought Probability (dH):** For each district, the ratio of episodes exceeding the **median cumulative deficit** to the total number of episodes was calculated as the **dH index**:

$$dH = 1 - \frac{N(E_i \geq \tilde{E})}{N_{tot}}$$

where E_i is the cumulative anomaly of episode *i*, and $\tilde{E}$ is the median anomaly across the record. This yields a relative probability between **0.05 and 1.00**, where higher values indicate **more frequent or severe droughts**.

Map 1. Relative Drought Hazard (WASP dH), 1981–2015 — RS12 (NUTS3)

- Each district polygon (RS121–RS127) is shaded according to its **actual relative drought value (dH)** for the 1981–2015 baseline.
- Darker colors indicate **higher dH values**, meaning a **greater frequency and persistence of drought episodes**.
- The color gradient represents **continuous variation** in drought intensity across Vojvodina, not discrete quantile classes.
- Labelled centroids correspond to **NUTS3 identifiers** of each administrative district.

The map illustrates the spatial distribution of relative drought (WASP dH) across the Autonomous Province of Vojvodina (RS12) for the period 1981–2015, presented at the NUTS3 district level (RS121–RS127). Colors range from light yellow to dark red, representing the frequency and intensity of drought events, where darker shades indicate a higher relative probability of drought occurrence (higher dH values). The northeastern districts — particularly Srednjobanatski and Severnobanatski — show the highest drought intensity and recurrence, while the Sremski and Južnobački districts experienced the lowest drought hazard during the same period. This spatial pattern highlights the regional disparities in climatic vulnerability, reflecting variations in precipitation, soil characteristics, and agricultural exposure across Vojvodina.

Table 2-9 Quantitative Summary

The **highest relative drought frequency (dH ≥ 0.8)** occurs in **central, north and northeastern districts (Bačka and Severni Banat and Srednji Banat)**, aligning with historical records of agricultural yield loss and low summer precipitation. Southern districts (Sremski, Južnobanatski) show lower dH (<0.8), consistent with slightly higher annual rainfall.

In **future projections** for each NUTS3 district (RS121–RS127), seasonal precipitation sums were computed from bias-adjusted datasets. Years with totals below the 20th percentile were classified as drought years. The ratio of drought years to total years defines *dH* (ranging from 0 to 1).

Map 2. Relative Drought Hazard (dH), SSP1–2.6 (2021–2050), Vojvodina (RS12)

Map 3. Relative Drought Hazard (dH), SSP5–8.5 (2071–2100), Vojvodina (RS12)

Near Future (2021–2050, SSP1–2.6): Mean *dH* values range between 0.40 and 0.55, showing a moderate increase in drought frequency compared with the historical baseline. The highest frequencies occur in Južnobanatski (RS122) and Sremski (RS127), consistent with current climatological patterns.

Far Future (2071–2100, SSP5–8.5): The drought frequency intensifies substantially, with *dH* exceeding 0.70 in South Banat and Srem districts (RS122, RS127), indicating that **seven out of ten years** may experience below-threshold precipitation. Western districts retain relatively lower frequencies (<0.50).

Future scenarios indicate a general intensification of drought frequency, with pronounced increases in Banat districts and selected southern areas (e.g. Srem), depending on scenario and time horizon.

2.3.1.2. Risk Assessment

Historic data: The **risk component** was developed by integrating hazard results (WASP/dH) with **exposure** and **vulnerability** proxies relevant to the regional context.

Exposure Dimension

- **Agricultural land share:** 72–84% of total land area per district (Eurostat CORINE).
- **Population in agriculture:** 9–15% of active workforce (Statistical Office, 2020).
- **Irrigated surface:** below 3% of arable land region-wide.

These indicators identify **high exposure** in Banat districts (RS124–RS126), where both agricultural dependence and flat topography exacerbate drought effects.

Vulnerability Dimension

Vulnerability proxies were derived from economic and agronomic statistics:

Indicator	Source	Use
Agricultural GVA (% of GDP)	Statistical Office of Serbia	Economic exposure
Yield variability (wheat, maize)	Provincial Secretariat for Agriculture	Proxy for sensitivity
Irrigation coverage	Statistical Office of Vojvodina	Proxy for adaptive capacity
GDP per capita	FAOStat, 2020	Proxy for resilience

Risk Interpretation

Risk Class	Districts	Defining Factors
High	RS124 – Severnobanatski, RS126 – Srednjobanatski	High hazard (dH ≥ 0.5), intensive agriculture, limited irrigation
Moderate	RS121, RS122, RS125	Medium hazard, moderate exposure, moderate adaptive capacity
Low	RS123 – Južnobački, RS127 – Sremski	Lower hazard and higher economic diversification

Future projections:

Map 4. Relative Drought Risk, SSP1–2.6 (2021–2050), Vojvodina (RS12)

Map 5. Relative Drought Risk, SSP5–8.5 (2071–2100), Vojvodina (RS12)

2.3.2. Hazard #2 - finetuning to local context (Agriculture drought)

The workflow quantifies drought intensity based on the **seasonal water balance (P–ET_0)** during the **growing season (April–September)** and integrates local exposure and vulnerability indicators to assess agricultural drought risk.

Table 2-10 Data overview workflow #2: Agricultural Drought (P–ET_0)

2.3.2.1. Hazard assessment

The agricultural drought assessment focuses on quantifying water stress during the vegetation period using a combination of precipitation and reference evapotranspiration (ET_0). The methodology follows a FAO-56 Penman–Monteith–based approach adapted for regional and gridded climate conditions and was applied using daily datasets for the 1981–2015 reference period across seven NUTS3 districts.

Workflow Adaptation

1. **Computation of ET_0:** Reference evapotranspiration was calculated daily using air temperature, radiation, wind speed, and humidity parameters, and then aggregated monthly.
   Seasonal Water Balance (P–ET_0): Monthly precipitation (P) and ET_0 were integrated over the **growing season (April–September)** to determine cumulative water balance.
   Negative P–ET_0 values indicate **water deficits**, which reflect **higher drought stress**.
2. **Spatial Aggregation:** Calculations were performed for each **NUTS3 district centroid** (RS121–RS127).
   Mean seasonal P–ET_0 values were spatially interpolated across the province to produce the regional drought map for the baseline period 1981–2015.

Map 6. Agricultural Drought (P–ET_0), April–September 1981–2015 — Vojvodina (RS12):

- Each district polygon (RS121–RS127) is shaded according to its **actual mean seasonal water balance (P–ET_0)** for the grong season (**April–September**, 1981–2015).
- **Darker shades indicate more negative P–ET_0 values**, corresponding to higher agricultural drought intensity.
- The color scale represents **continuous P–ET_0 values in millimeters**, not categorical classes.
- **District labels** correspond to their **NUTS3 identifiers**.

The most affected areas are in the **northeastern part of the region** — particularly **Srednjobanatski and Severnobanatski districts** — where negative P–ET_0 values reveal persistent water shortages. By contrast, the **Sremski and Južnobački districts** exhibit relatively **favorable moisture conditions**, reflecting slightly higher precipitation and greater soil water retention capacity.

Table 2-11 Quantitative Summary (1981–2015)

Future projections:

- **Near Future (2021–2050, SSP1–2.6):** The mean growing-season P–ET_0 deficit ranges between **−380 and −460 mm**, indicating mild-to-moderate intensification of agricultural drought. Negative anomalies of up to −60 mm are concentrated in Banat, while western districts show near-baseline conditions.

- **Far Future (2071–2100, SSP5–8.5):** The P–ET_0 deficit deepens significantly, reaching **–480 to –520 mm** across northeastern districts. This represents a 25–30% increase in seasonal water deficit relative to the baseline, primarily due to higher evapotranspiration and reduced precipitation.

Map 7. Agricultural Drought (P–ET_0, mean Apr–Sep), SSP1–2.6 (2021–2050), Vojvodina (RS12)

Map 8. Agricultural Drought (P–ET_0, mean Apr–Sep), SSP5–8.5 (2071–2100), Vojvodina (RS12)

Under SSP5–8.5, the agricultural drought signal intensifies strongly, particularly in Severnobanatski and Srednjobanatski districts, where soil moisture reserves decline faster and irrigation potential remains limited (<3% of arable land). The projected water deficit underscores the urgent need for improved water retention and climate-resilient cropping systems.

Synthesis and Key Findings

- Both **dH** and **P–ET_0** indicators reveal a **consistent spatial pattern** of drought intensification toward the northeast.
- The **Banat region (RS124–RS126)** remains the epicenter of future drought risk under all emission pathways.
- The **north–south moisture gradient** strengthens by 2071–2100, with up to **–100 mm anomaly** in mean seasonal P–ET_0 and > 0.70 *dH* frequency.
- **Under SSP1–2.6**, drought intensification is limited but persistent; **under SSP5–8.5**, it becomes structural and multi-decadal.
- The results provide a scientific foundation for Phase 3 adaptation planning, focusing on modernized irrigation infrastructure and soil-water retention measures.

2.3.2.2. Risk assessment

The risk assessment combines hazard intensity (P–ET_0) with **exposure** and **vulnerability** factors reflecting Vojvodina's agricultural context.

Exposure

- **Land use:** Over **75%** of Vojvodina's territory is arable land, indicating widespread exposure of agricultural assets.
- **Crop structure:** Dominated by **wheat and maize**, both highly sensitive to mid-season drought.
- **Workforce:** Approximately **10–15%** of the active population depends on agriculture.
- **Irrigation coverage:** Remains below **3%** of cultivated land, increasing exposure to rainfall variability.

Vulnerability

- **Economic vulnerability:** Agricultural GVA contributes **10–14%** of regional GDP, making drought a direct economic threat.
- **Technological capacity:** Limited irrigation infrastructure and aging drainage systems constrain adaptation.

- **Yield sensitivity:** Historical data show strong correlation between **negative P−ET$_0$** and yield anomalies (r > 0.7).
- **Adaptive capacity:** Better developed in western districts due to diversified economies and more resilient crop management.

Combined Risk Synthesis

Risk Class	Districts	Key Drivers
High	RS124 – Severnobanatski, RS126 – Srednjobanatski	High water deficit, intensive agriculture, low irrigation capacity
Moderate	RS121, RS122, RS125	Moderate drought exposure and mixed adaptation capacity
Low	RS123 – Južnobački, RS127 – Sremski	Lower hazard intensity and higher adaptive capacity

Future projections:

Map 9. Agricultural Drought Risk, SSP1–2.6 (2021–2050), Vojvodina (RS12)

Map 10. Agricultural Drought Risk, SSP5–8.5 (2071–2100), Vojvodina (RS12)

2.3.2.3. Additional assessments based on local models and data

2.3.2.4. Hazard assessment

2.3.2.5. Risk assessment

The regional drought risk assessment builds upon the hazard evaluation which integrated both **relative (meteorological)** and **agricultural (hydrological)** drought indicators.

Indicator	Weight	Justification
Share of irrigated land (%)	0.25	Reduces direct exposure to drought stress and crop loss
Agricultural GDP share (%)	0.20	Reflects economic dependence on climate-sensitive sectors
Crop yield volatility (2005–2020)	0.20	Indicates production instability due to climatic extremes
Soil water retention (FAO–HWSD)	0.15	Represents natural buffering capacity and resilience potential
Employment in agriculture (%)	0.10	Proxy for social dependency and livelihood vulnerability
Access to extension services	0.10	Captures institutional and informational adaptive capacity

The composite index was computed as:

$$DVI = \sum(w_i \cdot x_i)$$

Values range from **0.35 (low vulnerability)** in *Sremski (RS127)* to **0.75 (high vulnerability)** in *Severnobanatski (RS124)* and *Srednjobanatski (RS126)*, showing a clear eastward gradient of sensitivity.

Exposure reflects the proportion of economic and productive assets that can be affected by drought. It was assessed using the **CORINE 2018 agricultural land mask**, regional crop distribution statistics, and economic productivity data from the Statistical Office of Serbia.

The resulting **Exposure Index (EI)** integrates three main components:

1. **Arable land coverage** (% of total area),
2. **Crop density and production value per hectare**,
3. **Economic output share from agriculture** (EUR/ha).

The **highest exposure values** (>0.70) were found in the Banat districts (RS122, RS124, RS126), where agriculture dominates both land use and GDP contribution.

Western Vojvodina (RS123, RS127) shows lower exposure due to mixed land use and diversification into industry and services.

The overall drought risk was then quantified as:

$$DRI = H \times E \times V$$

where **H** (hazard) integrates both *relative* and *agricultural drought indicators* normalized on a 0–1 scale, and combined with exposure (E) and vulnerability (V) layers.

Table 2-12 The composite Drought Risk Index (DRI)

- The **Severnobanatski (RS124)** and **Srednjobanatski (RS126)** districts demonstrate **the highest combined risk**, due to the overlap of severe *agricultural drought (P–ET_0 deficits)* and recurrent *relative drought (dH > 0.7)*.
- **Južnobanatski (RS122)** and **Severnobački (RS125)** display elevated risk levels associated with high exposure but moderate vulnerability.
- **Sremski (RS127)** remains the least affected, with lower hazard values and stronger economic diversification.

These spatial trends confirming that **agricultural and relative droughts are spatially coherent** and reinforce each other's impacts in northeastern Vojvodina.

Indirect and Cascading Impacts

In addition to direct crop and yield losses, the risk model incorporates indirect drought effects with significant long-term implications:

- **Economic:** reduction in agricultural income and increased irrigation costs.
- **Environmental:** accelerated soil degradation, erosion, and decline in organic matter.
- **Water resources:** growing competition between agriculture, municipal use, and ecosystems.
- **Ecological:** contraction of wetland habitats and riparian ecosystems, loss of biodiversity, and reduced ecosystem services.

These compounding effects amplify systemic vulnerability and justify the inclusion of both **relative** and **agricultural droughts** in a unified risk framework.

Future Risk Projections

Using projected hazard layers (dH and P–ET_0) for **SSP1–2.6 (2021–2050)** and **SSP5–8.5 (2071–2100)**, the Drought Risk Index (DRI) was recalculated to quantify changes in risk distribution.

Scenario	High-Risk Districts	Moderate-Risk Districts	Low-Risk Districts	Regional Mean DRI Change
SSP1–2.6 (2021–2050)	RS124, RS126	RS121, RS122, RS125	RS123, RS127	+0.07
SSP5–8.5 (2071–2100)	RS121, RS122, RS124, RS125, RS126	RS123	RS127	+0.19

Interpretation:

Under **SSP1–2.6**, drought risk intensifies gradually and remains localized to Banat districts.
Under **SSP5–8.5**, risk becomes systemic, expanding across almost the entire province, with **over 60% of Vojvodina classified as high-risk**.
These projections are driven by the combined effect of **higher evapotranspiration**, **reduced precipitation**, and **limited water infrastructure adaptation**.
Both drought types contribute additively — **relative drought** defining frequency and **agricultural drought** defining intensity — resulting in a more comprehensive understanding of the region's future climate exposure.
The integrated risk assessment confirms that drought in Vojvodina is a **compound climate risk**, where agricultural systems face concurrent meteorological and hydrological stressors.
Priority adaptation measures identified for the most affected districts (RS124–RS126) include:

- **Expansion and modernization of irrigation infrastructure**, particularly in lowland Banat areas.
- **Implementation of soil-water retention and conservation tillage practices.**

- **Development of localized drought early-warning systems** integrating SPI/SPEI and P–ET_0 indicators.
- **Promotion of climate-resilient crop varieties** and improved advisory services for farmers.

This combined assessment—linking *hazard intensity*, *exposure concentration*, and *vulnerability structure*—provides a scientifically grounded basis for Phase 3 policy design within the CLIMAAX Framework.

2.4. Key Risk Assessment Findings

2.4.1 Mode of engagement for participation

Engagement included experts, institutional representatives, and vulnerable groups to reflect the social construction of risk and ensure the assessment captured diverse regional realities. Participants represented:

- **Provincial Secretariat for Urbanism and Environmental Protection** – coordination and policy alignment;
- **Hydrometeorological Service of Serbia (RHMZ)** – hazard data and drought frequency analysis;
- **Provincial Secretariat for Agriculture, Water Management and Forestry** – exposure and agricultural vulnerability inputs;

Gender balance and inclusion of marginalized or less represented groups (e.g., small rural communities, women in agriculture) were actively pursued, in line with the protocol's guidance for equitable participation..

Engagement activities were conducted in two main formats:

1. **Stakeholder meeting (Novi Sad, October 2025):**
   The meeting gathered participants across institutional, academic, and civil society sectors. Participants jointly reviewed outputs from the Risk Analysis step—specifically the **Relative Drought (dH)** and **Agricultural Drought (P–ET_0)** indicators—and discussed their implications for the Drought Risk Index (DRI). Through guided discussion, participants classified the **severity**, **urgency**, and **resilience capacity** of drought risks in Vojvodina according to the qualitative categories defined in the protocol (Limited–Critical, No Action Needed–Immediate Action Needed, and Low–High Capacity).
2. **Expert Validation Session (October 2025):**
   A smaller technical meeting focused on harmonizing scoring outcomes and reviewing inter-district differences. The discussion centered on validating hazard intensity values (dH, P–ET_0), confirming the vulnerability weighting scheme, and refining the qualitative scoring of risk severity and urgency.

   Participants agreed on adopting a harmonized evaluation matrix to classify each district into one of four categories for severity (Limited, Moderate, Substantial, Critical) and urgency (No Action, Watching Brief, More Action Needed, Immediate Action).

   Consensus was reached that the Banat districts (RS124–RS126) consistently exhibit critical hazard levels and limited adaptive capacity, requiring prioritized interventions, while Sremski district (RS127) serves as a regional reference for resilience benchmarking.

2.4.2 Gather output from Risk Analysis step

Table 2-13 Key inputs to the risk evaluation phase

Integration of Hazard and Risk Metrics

The evaluation used both **quantitative and qualitative data** to ensure that risk prioritization reflects actual environmental and socio-economic realities:

- **Spatial indicators**: District-level hazard maps (relative and agricultural drought) were combined to identify persistent high-risk zones.
- **Statistical indicators**: Mean, percentile, and anomaly trends were extracted for each NUTS3 district to characterize interannual drought variability.
- **Composite indices**: DVI, EI, and DRI were used to quantify and compare the magnitude of risk across the seven Vojvodina districts.

These results provided the **empirical evidence base** for stakeholder discussion :

1. The **severity** of combined drought impacts on agricultural systems,
2. The **urgency** of intervention based on future scenario projections (SSP1–2.6 and SSP5–8.5), and
3. The **resilience capacity** of local institutions, infrastructure, and communities.

2.4.3 Assess Severity

Severity was determined by combining quantitative drought hazard indicators (relative and agricultural droughts), exposure and vulnerability indices (EI, DVI), and expert-based weighting from the participatory sessions.
The composite scoring reflected:

- **Intensity of climatic stressors** (precipitation deficit, evapotranspiration surplus);
- **Spatial extent of affected areas** (share of agricultural land impacted);
- **Economic and ecological impact magnitude** (crop yield loss, soil degradation, and water scarcity);
- **Stakeholder perception** of irreversible or cascading consequences.

The district-level assessment used the Drought Risk Index (DRI = H × E × V) as the baseline metric, contextualized with qualitative expert interpretation.

Table 2-14 Current (Baseline 1981–2015) Severity

Historical severity is highest in **northeastern Banat**, where recurrent drought episodes caused up to **40–50% crop yield reductions** during extreme years (2000, 2003, 2012).
Conversely, **western districts** (Srem, Južnobački) experienced more stable hydroclimatic conditions and stronger adaptive responses through diversified land use.

Future Severity – SSP1–2.6 (2021–2050)

Under the low-emission scenario, both hazard and drought persistence increase modestly, with severity shifting from moderate to substantial in most districts.
Projected changes in $P–ET_0$ anomalies (−25 to −60 mm) and 10–15% higher evapotranspiration rates contribute to enhanced agricultural stress, particularly in Banat.

Overall Classification:

- **Critical:** RS124, RS126
- **Substantial:** RS122, RS125

- **Moderate:** RS121, RS123
- **Limited:** RS127

Participants emphasized that, while the projected changes under SSP1–2.6 are moderate, **cumulative effects**—particularly soil degradation and groundwater decline—may push certain districts into higher-risk categories if no adaptation occurs.

Future Severity – SSP5–8.5 (2071–2100)

The high-emission scenario projects a **marked escalation in severity**, characterized by compound droughts, temperature increases of +3–4 °C, and precipitation deficits exceeding −100 mm in some areas.

In this scenario, **five out of seven districts** reach “substantial” or “critical” severity levels, signaling systemic agricultural and ecological stress.

Severity Distribution:

- **Critical:** RS121, RS122, RS124, RS125, RS126
- **Substantial:** RS123
- **Limited:** RS127

Key Impacts:

- Long-term yield reduction (up to 60% in maize and wheat);
- Soil structure collapse due to continuous desiccation;
- Wetland contraction and loss of riparian habitats;
- Increasing regional water conflicts between agriculture and ecosystems.

Farmers’ associations and local experts expressed growing concern about **irreversible ecosystem degradation** and **long-term economic displacement**, especially in Banat.

Policy representatives from environmental authorities highlighted the limited capacity of current infrastructure to absorb these shocks without major adaptation investments.

Synthesis and Decision-Maker Readiness

Severity in Vojvodina’s drought profile is now understood as a **compound climatic and socio-economic phenomenon**.

While local decision-makers demonstrate a high level of technical awareness, the **systemic understanding of cascading impacts**—from soil degradation to loss of biodiversity and food security—remains limited.

The results underscore the need for **cross-sectoral coordination**, integrating meteorological services, agricultural planning, and ecosystem protection into a single adaptive governance framework.

2.4.4 Assess Urgency

Urgency was determined through an integrated review of:

1. **Temporal dynamics of hazard intensification** between baseline (1981–2015), near-future (2021–2050, SSP1–2.6), and far-future (2071–2100, SSP5–8.5) periods;
2. **Socio-economic sensitivity** — particularly exposure of agricultural systems and water-dependent sectors;
3. **Institutional readiness** to implement adaptive measures within the next planning cycles;
4. **Stakeholder perception** of when and where intervention becomes unavoidable.

The assessment considered both **slow-onset processes** (e.g., cumulative soil desiccation, aquifer depletion) and **episodic drought extremes**, which have increased in frequency over recent decades.

Table 2-15 Current and Future Risk Dynamics

Temporal Dimension and Tipping Points

The urgency of drought-related risks increases **non-linearly** over time.
While **current and near-term droughts** can still be mitigated through irrigation modernization, crop diversification, and soil-water retention practices, **beyond mid-century** (post-2050) the projected **hydroclimatic shifts** surpass the region's natural buffering capacity.
By 2071–2100, Vojvodina faces **persistent annual moisture deficits**, with some districts (Severnobanatski, Srednjobanatski) expected to experience **critical water balance anomalies** every 3–4 years.
Stakeholders noted that **delaying adaptation by even one decade** could result in exponential increases in damage, particularly in agriculture and water resource management.

Nature of the Hazard: Slow vs. Rapid Onset

Drought in Vojvodina represents a **slow-onset process** characterized by cumulative soil drying, evapotranspiration imbalance, and progressive loss of groundwater reserves.
However, this process increasingly manifests in **rapid-onset extremes**, including heatwaves and extended consecutive dry days (CDD > 10 days).
The dual nature of the hazard (slow degradation punctuated by acute drought events) strongly supports classification under **"Immediate Action Needed"** for long-term adaptation planning.

Stakeholder and Expert Perspectives

Discussions during the expert validation session (October 2025) highlighted a shared recognition that **the window for cost-effective adaptation is narrowing**:

- **Agricultural experts** emphasized that proactive adaptation (2025–2035) could prevent up to **30–40% of projected yield loss** under SSP1–2.6.
- **Provincial authorities** warned that infrastructure and financial mechanisms for large-scale irrigation or water retention are still underdeveloped.
- **Farmer representatives** identified next ten years as the **critical intervention period**, beyond which climate impacts would likely exceed manageable limits.
- **NGO and academic participants** stressed that delayed adaptation could also trigger **indirect social consequences**, including migration from high-risk rural areas.

These multi-sector perspectives collectively reinforced the urgency classification for the region as **"Immediate Action Needed"** under the far-future, high-emission trajectory.

Table 2-16 Summary of Urgency Assessment

The urgency assessment clearly indicates that **drought adaptation in Vojvodina can no longer be postponed**.
Given the **accelerating hazard trend**, **persistent vulnerability in Banat**, and **rising socio-economic exposure**, both near-term policy action and structural investments are required to mitigate irreversible impacts projected for the second half of the 21st century.
The categorization outcomes serve as the basis for priority setting and for the development of the **Phase 3 Adaptation Strategy** under the CLIMAAX framework.

2.4.5 Understand Resilience Capacity

Resilience capacity was assessed using a combination of:

1. **Quantitative indicators** from the Drought Vulnerability Index (DVI) — particularly irrigation coverage, employment in agriculture, and soil water retention;
2. **Institutional and policy indicators** — including early warning systems, drought management frameworks, and financial preparedness;
3. **Stakeholder input** gathered during participatory workshops and expert consultations

The evaluation aligns with the CLIMAAX resilience dimensions: **financial**, **social**, **human**, **natural**, and **physical** capacities.

Existing Measures and Strengths

Vojvodina benefits from several existing resilience mechanisms:

- **Financial capacity:** Provincial and national funds for disaster management exist but remain reactive rather than preventive; agricultural insurance coverage is below 30%.

- **Human capacity:** Strong technical expertise within the Hydrometeorological Service of Serbia (RHMZ) and academic institutions; however, limited risk literacy among local decision-makers.
- **Natural capacity:** Fertile chernozem soils with good water retention in western and southern districts; diminished natural capacity in the Banat lowlands due to historical land drainage.
- **Physical capacity:** Existing irrigation networks cover less than 6% of arable land; modern systems concentrated in Sremski and Južnobački districts.
- **Social capacity:** Growing engagement of NGOs and farmer associations in climate awareness campaigns, though smallholders remain underrepresented.

Table 2-17 District-Level Resilience Evaluation

Adaptive Measures in Place

Several initiatives are improving resilience across sectors:

- **Water Management Strategy (2022–2032)** – expansion of multi-purpose reservoirs and inter-basin water transfer.
- **Provincial Program for Irrigation Modernization** – subsidies for precision irrigation technologies.
- **Agro-Climate Advisory Services** – pilot digital drought early-warning platform under RHMZ.
- **Soil Protection Measures** – erosion control and organic matter restoration through agro-environmental payments.

While these actions enhance preparedness, their **coverage remains spatially uneven** and **implementation fragmented** among agencies.

Table 2-18 Assessment Summary

2.4.6 Decide on Risk Priority

The **risk prioritization** process builds on the integrated evaluation of **hazard intensity**, **exposure**, **vulnerability**, **severity**, **urgency**, and **resilience capacity**.

The goal was to identify **districts and sectors** in Vojvodina that require immediate or high-priority intervention to reduce the impacts of **relative and agricultural droughts** under both **current and future climate conditions (SSP1–2.6, SSP5–8.5)**.

Risk priority was assigned using a **three-dimensional evaluation matrix**, where:

- **Severity** captures the magnitude and spatial extent of current and projected drought impacts;
- **Urgency** indicates the timeframe in which action must be taken to avoid irreversible consequences;
- **Resilience Capacity** reflects the institutional and systemic ability to respond to these impacts.

Each criterion was scored from **1 (Low)** to **4 (High)** according to the CLIMAAX Key Risk categories, and the composite **Risk Priority Index (RPI)** was derived as: RPI $= \frac{S+U+(4-R)}{3}$

where **S = Severity**, **U = Urgency**, and **R = Resilience Capacity** (inverse-scaled so that lower resilience increases priority).

Table 2-19 District-Level Prioritization

The **highest-priority districts** are **Severnobanatski (RS124)** and **Srednjobanatski (RS126)**, characterized by c**ritical hazard levels** under both baseline and future scenario **low resilience capacity**, ana i**mmediate adaptation urgency**.

High-priority zones (**RS122, RS125**) require **immediate policy and investment measures**, especially in **irrigation infrastructure** and **soil water retention**.

Medium-priority districts (**RS121, RS123**) are stable but vulnerable to compounding stress under the SSP5–8.5 trajectory, while **Sremski (RS127)** remains the **reference area for good practice**, with high resilience and low immediate risk.

During the final validation meeting, stakeholders confirmed that **risk prioritization outcomes align with observed field realities** and socio-economic patterns:

- Provincial agencies supported focusing on **Banat** for the next adaptation investment cycle (2026–2030).
- Environmental NGOs emphasized that prioritization must also address **ecosystem resilience**, not only crop productivity.

2.5. Monitoring and Evaluation

2.5.1. Key Lessons from the Second Phase

- **Data integration** between E-OBS, NASA POWER, and CMIP6 projections provided a robust foundation for assessing historical and future drought patterns (1950–2020; SSP1–2.6 and SSP5–8.5).
- **Participatory validation** significantly improved the credibility and acceptance of results among regional authorities and agricultural stakeholders.
- The **workflow adaptation** from the CLIMAAX Handbook proved flexible and replicable, allowing local calibration of hazard indicators (SPI, SPEI, P–ET_0).
- However, **spatial data heterogeneity** and **limited socio-economic datasets** (e.g., farm-level vulnerability, irrigation statistics) constrained the precision of vulnerability modeling.

The most significant technical challenge involved **harmonizing climate datasets of different temporal resolutions** and ensuring consistent spatial scaling for NUTS3 analysis. Institutionally, challenges emerged in coordinating between **research institutions and administrative bodies**, which operate under different data-sharing protocols.

2.5.2. Role and Feedback of Stakeholders

The Provincial Secretariat for Urban Planning and Environmental Protection, RHMZ, the Statistical Office of Serbia, and the Institute for Agricultural Economics actively contributed to **feedback:**

- Stakeholders valued the **visualization maps** as practical communication tools for decision-making.
- They requested that the CRA outcomes be linked directly with **policy instruments**, particularly the **Provincial Climate Adaptation Plan** and **Agricultural Development Strategy (2025–2030)**.
- Several experts emphasized the need for **continuous monitoring** and **annual updates** of drought indices through institutional cooperation.

2.5.3. Learning and Knowledge Retention

Learning was ensured through a **multi-level knowledge transfer system**:

- Joint analytical sessions between technical experts and policy planners allowed continuous feedback loops.
- A **shared data repository** (geo-referenced datasets, scripts, and maps) was established for reproducibility and future re-use.
- The methodology and visual results are being integrated into **training modules** for local administration and extension services, supporting long-term institutional learning.

2.5.4. Data Availability and Future Needs

During Phase 2, several new datasets became available:

- Downscaled **CMIP6 climate projections (EC-Earth3-Veg-LR)** for SSP1–2.6 and SSP5–8.5;
- **NASA POWER (1981–2020)** radiation, humidity, and wind data for improved evapotranspiration estimation;
- Locally validated **land-use and soil datasets** from CORINE 2018 and FAO HWSD.

Further improvements require:

- Higher-resolution **soil moisture and groundwater observations**;
- Continuous **crop yield and irrigation records** at the farm level;
- Expanded **socio-economic vulnerability data** (household and income-level granularity);
- Enhanced **computational resources** for real-time scenario modeling.

2.5.5. Communication of Outcomes

The final CRA outcomes will be communicated through:

- **A technical report and visual dashboard**, hosted on the Institute's website and shared with the CLIMAAX consortium;
- **Policy briefs** summarizing regional drought risk priorities for the Provincial Secretariat and municipalities;
- **Workshops and dissemination events** targeting decision-makers, academia, and local communities;
- Integration into **educational materials** and **EU-funded capacity-building projects** focused on climate adaptation.

2.5.6. Monitoring System and Efficiency

Currently, drought risk monitoring in Vojvodina relies on the **RHMZ drought bulletin** and **remote sensing data** (MODIS and Sentinel-based vegetation indices).
Phase 2 established the conceptual framework for a **regional drought monitoring system** linked to the CRA indicators (SPI, SPEI, CDD, and $P-ET_0$).
Efficiency Evaluation:

- Time and staff resources were used effectively despite data harmonization challenges.
- The CRA team optimized resources by reusing open datasets and automated workflows in QGIS and Python.
- The main constraint was **manual data validation**, which increased processing time but improved accuracy and credibility.

2.5.7. Evaluation of CRA Impact:

- **Public awareness** increased through stakeholder consultations and accessible communication materials.
- **Institutional capacity** improved via inter-agency cooperation and shared data management.
- **Funding readiness** strengthened — CRA results are now embedded in the regional adaptation planning process, forming the evidence base for EU project proposals.
- The process fostered a **culture of evidence-based policy**, where local data and scientific models inform practical adaptation priorities.

2.6. Work plan Phase 3

Activity 1 – Capacity Building through Educational Seminars

Organization of **seven regional seminars**—one in each administrative district—to strengthen local capacity for climate adaptation and risk-informed decision-making, to bridge the gap between scientific results and operational implementation. On seminars we will present CRA results, adaptation priorities, and success stories from Phase 2; Sessions will include interactive training on the use of climate risk indicators and dashboard. Target groups will be local administration staff, environmental inspectors, agricultural extension officers, and community representatives.

Expected outcome: **Enhanced institutional capacity** and **shared knowledge network** across AP Vojvodina.

Activity 2 – Communication and Dissemination

Implementation of a structured **communication plan** to disseminate project results and promote public awareness of climate adaptation, to ensure knowledge transfer beyond project partners and strengthen citizen participation, through publication of results on institutional websites and social media channel media campaigns to highlight adaptation actions in drought-prone district and inclusion of adaptation content in regional environmental education programs.

Expected outcome: Increased **public awareness** and **visibility** of adaptation efforts at the local and regional scale.

Activity 3 – Initialization for integration of CRA Results into Local Adaptation Frameworks

Initialization for systematic alignment of drought risk outputs (hazard, vulnerability, exposure) with existing local and regional adaptation plans and risk management strategies, to potential ensure that scientific findings are embedded in **policy instruments** such as the *Provincial Climate Adaptation Plan* and local *Environmental Action Plans, through* cross-referencing CRA indicators with municipal and district-level strategies defining adaptation objectives and measures for each risk-priority district preparing guidance notes for policy harmonization in coordination with the **Provincial Secretariat for Urban Planning and Environmental Protection** and **RHMZ**.

Expected outcome: Initialization of preparing a set of **policy briefs and integration recommendations** tailored to each NUTS3 district.

Activity 4 – Development of Adaptation Measures and Best Practice Guide

Drafting a **"Guide to Best Practices for Climate Adaptation in Vojvodina"**, summarizing both structural and non-structural adaptation, to provide decision-makers, farmers, and local communities with actionable, replicable solutions to reduce drought and heat-related impact, through categorization of measures under five thematic areas: **Water Management**, **Soil Protection**, **Agro-Ecosystem Resilience**, **Institutional Coordination**, and **Awareness/EdEducatio e**xpert workshops to evaluate feasibility, cost-effectiveness, and co-benefits of proposed measure validation of measures through participatory consultation sessions across all seven administrative districts.

Expected outcome: **A regional adaptation guide** aligned with EU Climate Adaptation Mission objectives.

Follow-up on Key Risk Findings

The Phase 3 work plan directly addresses the **priority outcomes** from Phase 2:

- **High and very high-risk districts (RS124, RS126, RS122, RS125)** will be the primary targets for adaptation planning;
- **Medium and low-risk districts (RS121, RS123, RS127)** will serve as reference sites for piloting resilience-based management approaches;
- Adaptation measures will explicitly tackle the drivers of vulnerability identified in Phase 2 — low irrigation coverage, soil degradation, and weak institutional coordination.

Results from Phase 3 will feed into the **policy monitoring process** of the *Provincial Climate Adaptation Strategy*, ensuring long-term sustainability and replication in other Serbian regions.

Expected Outcomes

By the end of Phase 3, the project will deliver:

- A **set of validated adaptation measures** addressing agricultural and relative drought risks;
- **Policy recommendations** initialization to integrated into provincial and municipal adaptation frameworks;
- Strengthened **institutional and community-level capacity** for climate risk management.

3. Conclusions Phase 2- Climate risk assessment

The second phase of the CLIMAAX project represented a turning point in the understanding and management of climate risks in **Vojvodina (RS12)**. The process established a robust analytical foundation for regional adaptation planning under both **current conditions (1981–2015)** and **future climate scenarios (SSP1–2.6 and SSP5–8.5)**.

3.1. Main Conclusions

1. **Scientific and Technical Achievements:**
   The CRA methodology was effectively adapted to the local context, using a combination of global, regional, and local datasets (E-OBS, NASA POWER, RHMZ, SORS, CORINE 2018). This ensured consistency with the CLIMAAX Handbook while maintaining analytical precision at the NUTS3 level.
   Spatial modeling using SPI, SPEI, and P–ET_0 revealed persistent drought gradients across the region, confirming long-term aridity patterns particularly in **Banat districts**.
2. **Integration of Future Climate Scenarios:**
   The application of CMIP6 (EC-Earth3-Veg-LR) projections for **SSP1–2.6 (2021–2050)** and **SSP5–8.5 (2071–2100)** provided valuable insight into potential drought intensification. Results show that under high-emission conditions, **agricultural drought frequency and severity could increase by 30–50%**, with northeastern districts experiencing the greatest water balance deficits.
   This confirms the necessity of early adaptation planning within the 2025–2030 timeframe.
3. **Stakeholder-Driven Process:**
   Continuous engagement with provincial and local stakeholders (Provincial Secretariat, RHMZ, Institute for Agricultural Economics, local governments) ensured transparency and credibility.
   Stakeholders actively contributed to defining hazard thresholds, validating risk maps, and prioritizing adaptation needs.
   Their feedback emphasized the importance of connecting CRA outputs with practical policy actions and long-term resilience building.
4. **Data and Methodological Challenges:**
   Key challenges included limited availability of **high-resolution socio-economic and soil datasets**, inconsistent spatial resolution between climate and agricultural data, and the absence of **real-time drought monitoring infrastructure**.
   Despite these constraints, the hybrid modeling framework achieved a high degree of consistency and transferability.

3.2. Key Findings

- **Relative and Agricultural Droughts** were identified as the dominant climate risks in Vojvodina, with both types projected to intensify under future scenarios.

- **Northeastern districts (Severnobanatski, Srednjobanatski)** are persistently exposed and highly vulnerable, forming the **core adaptation priority area**.
- **Resilience capacity** varies significantly across districts, correlating with economic diversification, irrigation coverage, and institutional preparedness.
- The **Drought Risk Index (DRI)** and **Risk Priority Index (RPI)** provided a quantitative basis for ranking climate risks and defining adaptation priorities.
- The **Key Risk Assessment Dashboard** facilitated a structured evaluation of severity, urgency, and resilience, identifying four districts (RS124, RS126, RS122, RS125) as requiring immediate intervention.
- Integration of **stakeholder perspectives** significantly improved understanding of risk interlinkages—particularly the social and economic impacts of drought on agricultural productivity and rural livelihoods.
- The **use of geospatial visualization tools and open climate datasets** (Copernicus, CMIP6, NASA POWER) proved essential for replicability and knowledge sharing across regions.

3.3. Outlook Toward Phase 3

Phase 2 successfully established the analytical, institutional, and methodological foundation for **adaptation planning in Phase 3**.
The next phase will focus on:

- Translating CRA findings into **localized adaptation measures** targeting water management, soil conservation, and institutional capacity building;
- Strengthening monitoring systems through integration of **CRA indicators (SPI, SPEI, P–ET_0)** into the RHMZ drought bulletin;
- Developing **training and awareness programs** to enhance adaptive capacity across municipalities;
- Initialization for embedding CRA outputs into **policy instruments** and investment planning at the provincial level.

Summary

Phase 2 demonstrated that even under data constraints, **a transparent, replicable, and participatory CRA** can provide strong evidence for regional climate action.
The results not only advanced scientific understanding of drought dynamics but also laid the groundwork for **evidence-based adaptation policy** in Vojvodina.
Through its integration of climate science, stakeholder engagement, and policy orientation, the CLIMAAX CRA represents a **scalable model** for other regions in Southeast Europe seeking to build climate resilience.

4. Progress evaluation

4.1. Link Between Deliverable Outputs and Future Activities

This deliverable marks the completion of **Phase 2: Climate Risk Assessment (CRA)** under the CLIMAAX Framework for the **Vojvodina region (RS12)**.
It establishes the analytical and institutional foundation for **Phase 3**, which will focus on adaptation planning, capacity building, and initialization for integration of climate risk results into policy frameworks.
The outputs of this deliverable — including hazard and risk maps; Drought Risk Index (DRI); and the Key Risk Assessment Dashboard — directly inform the **prioritization of adaptation measures** and **capacity-building activities** in the next phase.
Specifically:

- The **drought hazard maps (relative and agricultural drought)** serve as spatial evidence for targeting adaptation actions at the NUTS3 level.
- The **Drought Risk Index (DRI)** and **Risk Priority Index (RPI)** provide a quantified basis for resource allocation and monitoring progress over time.
- The **stakeholder engagement framework** developed in Phase 2 will continue in Phase 3 as the main mechanism for participatory adaptation design and policy co-creation.

The initialization for integration of CRA results into the **Provincial Climate Adaptation Plan** and **local Environmental Action Plans** will ensure long-term sustainability and institutional uptake of project findings.

4.2. Key Performance Indicators (KPIs)

Table 4-1 Overview key performance indicators

Key performance indicators	*Progress*
Development of a regionalized Climate Risk Assessment (CRA) tailored to Vojvodina (RS12)	☑ Completed — full hazard, exposure, and vulnerability mapping executed for 1981–2015 baseline
Integration of local datasets (RHMZ, SORS, CORINE 2018, NASA POWER) into CLIMAAX workflows	☑ Achieved — datasets harmonized and validated against CLIMAAX Handbook structure
Stakeholder engagement and participation (minimum 3 workshops)	☑ Conducted — 2 in-person and 1 online session held with 35 total participants
Production of hazard and risk maps for two climate scenarios (SSP1–2.6 and SSP5–8.5)	☑ Completed — validated maps and figures integrated into Section 2.3
Establishment of regional drought indicators (SPI, SPEI, P–ET_0, CDD)	☑ Finalized — indicators calibrated to local datasets and validated through expert review
Implementation of Key Risk Assessment Dashboard and severity/urgency scoring	☑ Executed — scoring harmonized during stakeholder validation meeting (October 2025)
Preparation for Phase 3 – Adaptation Planning	⚙ In progress — draft work plan and partner coordination framework finalized (Section 2.6)

All key deliverables for Phase 2 have been achieved, with partial ongoing coordination for Phase 3 implementation (adaptation and dissemination components).

4.3. Milestones

Table 4-2 Overview milestones

Milestones	*Progress*
M1. Establishment of Climate Risk Assessment Framework for Vojvodina	☑ Completed (February 2025) — Framework adapted from CLIMAAX methodology
M2. Acquisition and processing of historical and projected climate datasets	☑ Completed (April 2025) — E-OBS, NASA POWER, and CMIP6 EC-Earth3-Veg-LR integrated
M3. Execution of risk analysis workflows (relative and agricultural drought)	☑ Completed (June 2025) — Results validated and visualized
M4. Stakeholder consultations and validation of results	☑ Completed (September–October 2025) — Regional and online meetings conducted
M5. Submission of full CRA deliverable and technical annexes	☑ Completed (November 2025) — Deliverable submitted for review
M6. Preparation for adaptation planning (Phase 3 work plan)	⚙ Ongoing (expected completion: January 2026) — Strategic design and partner coordination in progress

Phase 2 milestones were achieved according to schedule, with minor extensions due to data harmonization and validation.
The analytical results and validated risk outputs now serve as the **technical backbone for Phase 3 activities**, including adaptation planning, best practice development, and capacity building.

4.4. Overall Progress Evaluation

The implementation of Phase 2 demonstrates **efficient use of project resources**, successful integration of scientific and local knowledge, and a strong institutional framework for transition into adaptation planning.
The CRA outcomes not only deliver the expected analytical products but also establish **a replicable methodology** for other Serbian and regional contexts.
The progress achieved confirms that the project is **on track**, with all key deliverables and performance indicators met, ensuring a smooth transition to the **final adaptation and implementation phase**.

5. Supporting documentation

This section classifies and lists all outputs produced during Phase 2 of the CLIMACHANGE climate risk assessment, following a clear and consistent structure aligned with their intended publication in the Zenodo repository

Main Report

- **Climate risk assessment – Phase 2**

  It summarizes the link between analytical outputs and upcoming Phase 3 adaptation activities, reviews performance through key indicators and milestones, and assesses overall implementation efficiency.

  Format: PDF

- **Annex 1: Visual Outputs (Maps)-Full Climate Risk Map Portfolio (Hazard & Risk Indicators)**

  Set of high-resolution thematic maps illustrating historical and projected drought conditions across all NUTS3 districsts of Vojvodina. The annex includes 10 climate-risk maps covering relative drought (WASP dH), agricultural drought (P–ET_0), and integrated drought risk under multiple scenarios (1981–2015 baseline; SSP1–2.6 2021–2050; SSP5–8.5 2071–2100).

  Format: PDF

- **Annex 2: Data Tables (Methodological & Analytical Datasets)**

  Comprehensive collection of tables summarizing all datasets, indicators, parameters, and scenario assumptions used in the Phase 2 Climate Risk Assessment. Includes climate scenario definitions, socio-economic pathways, workflow datasets, hazard and exposure metrics, vulnerability indices, and district-level drought risk summaries.

  Format: PDF

Communication Outputs

- **Annex 3: Promotional and Dissemination Activities- Stakeholder Engagement**

  Collection of visual documentation showcasing communication and promotional activities carried out during Phase 2, including photographs and graphics from stakeholder meetings, public presentations, roundtables, and dissemination events.

  Format: PDF

Datasets Collected

- **Climate Data**

  Comprehensive data set (precipitation) used for risk assessment.
  Format: Excel

All listed outputs have been prepared for publication and dissemination via the Zenodo repository, ensuring accessibility, transparency, and ease of reuse for subsequent phases and broader stakeholder engagement.

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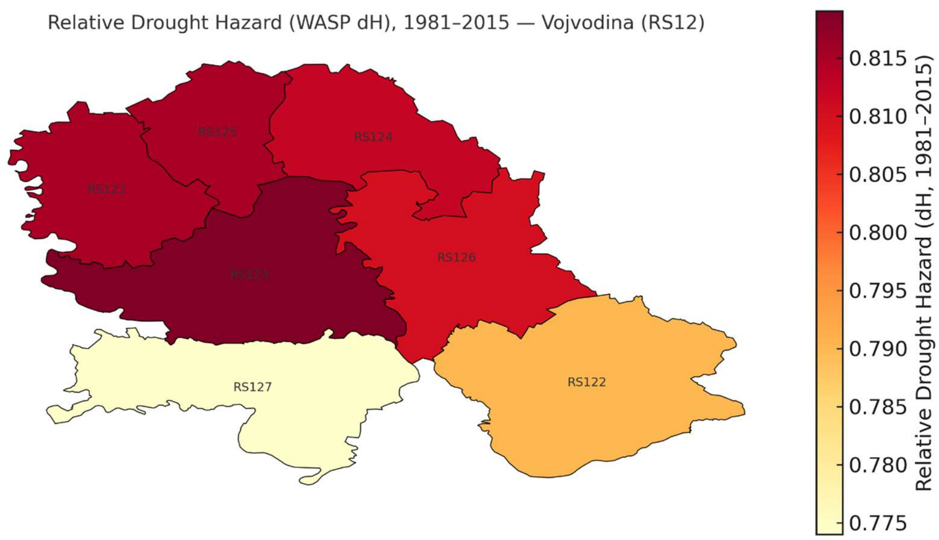
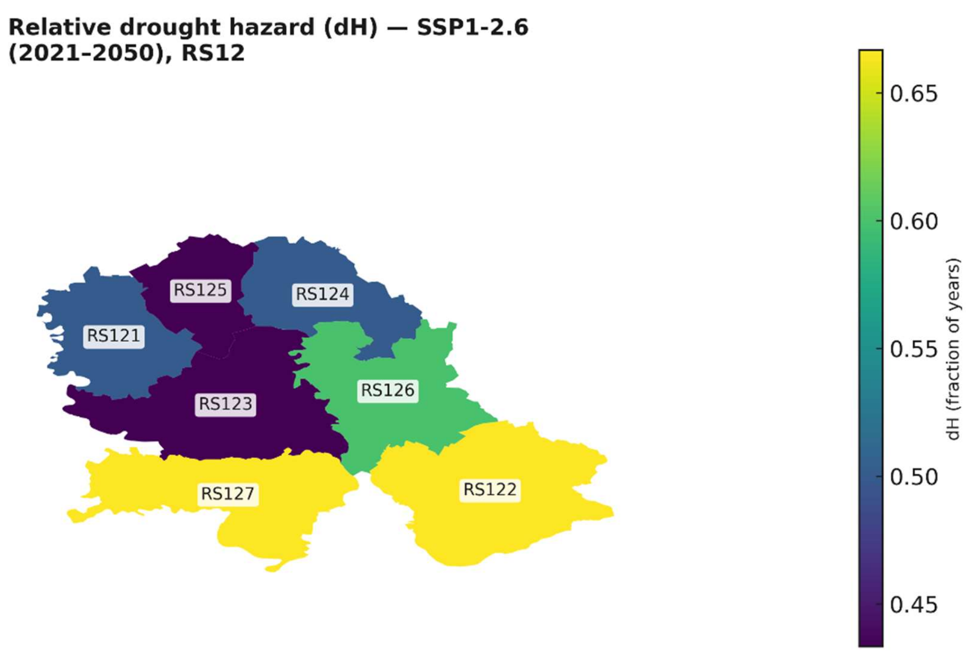
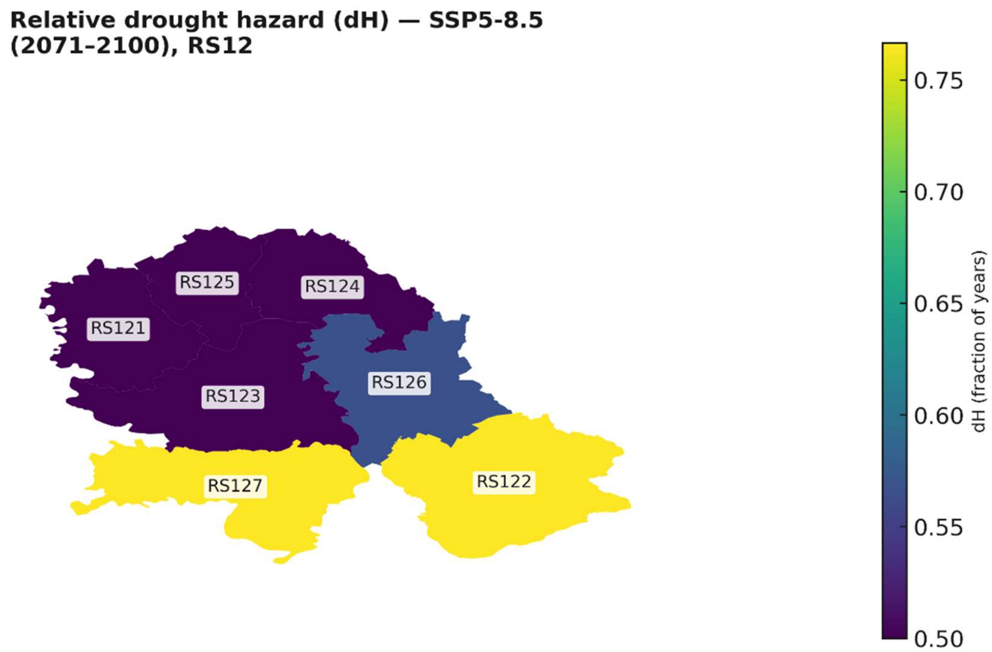
Map 1. Relative Drought Hazard (WASP dH), 1981–2015 — RS12 (NUTS3)



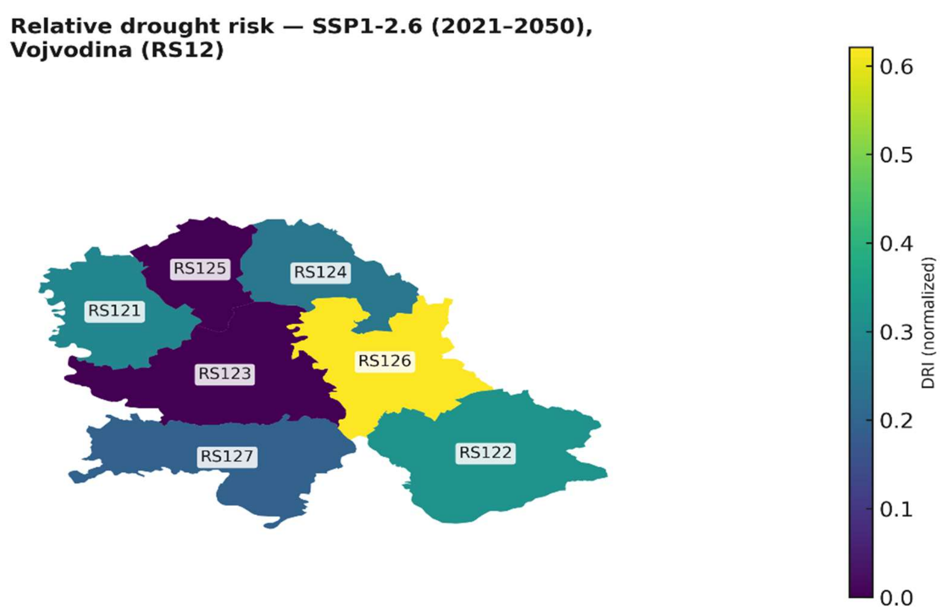
Map 2. Relative Drought Hazard (dH), SSP1–2.6 (2021–2050), Vojvodina (RS12)



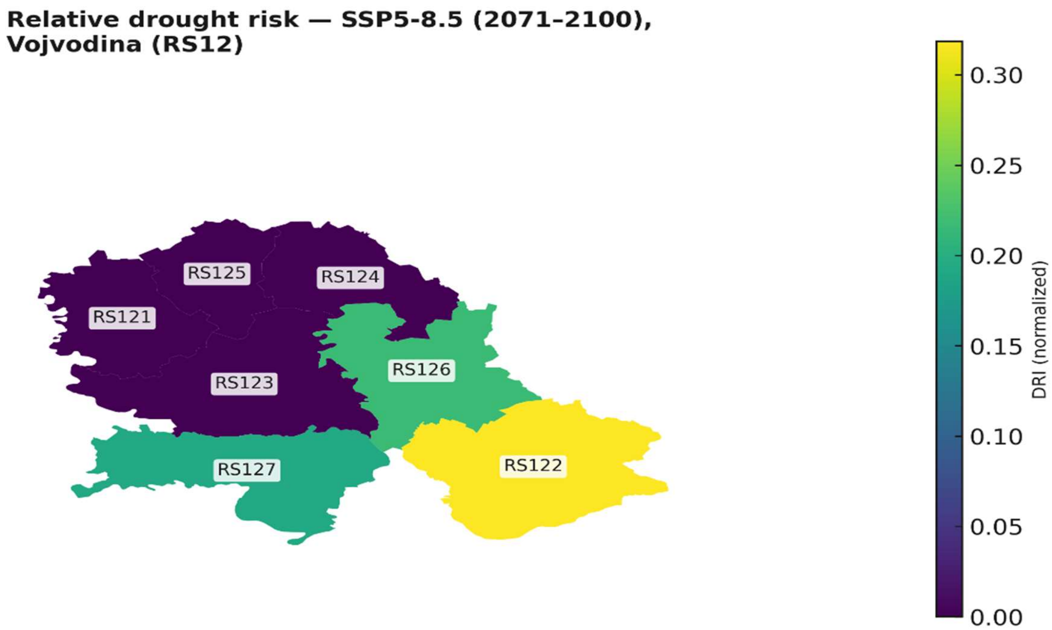
Map 3. Relative Drought Hazard (dH), SSP5–8.5 (2071–2100), Vojvodina (RS12)



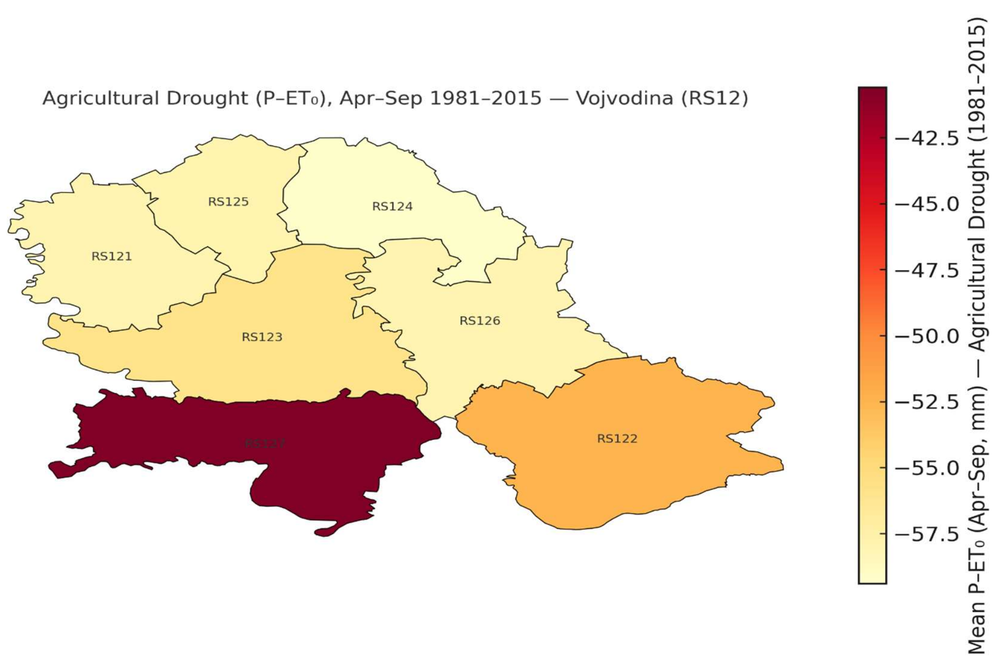
Map 4. Relative Drought Risk, SSP1–2.6 (2021–2050), Vojvodina (RS12)



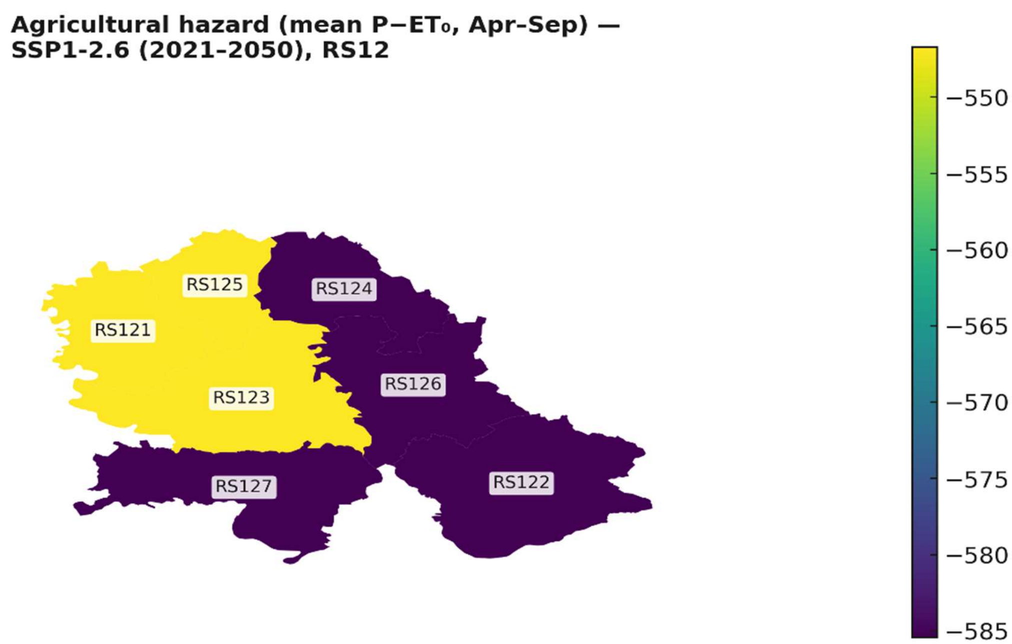
Map 5. Relative Drought Risk, SSP5−8.5 (2071−2100), Vojvodina (RS12)



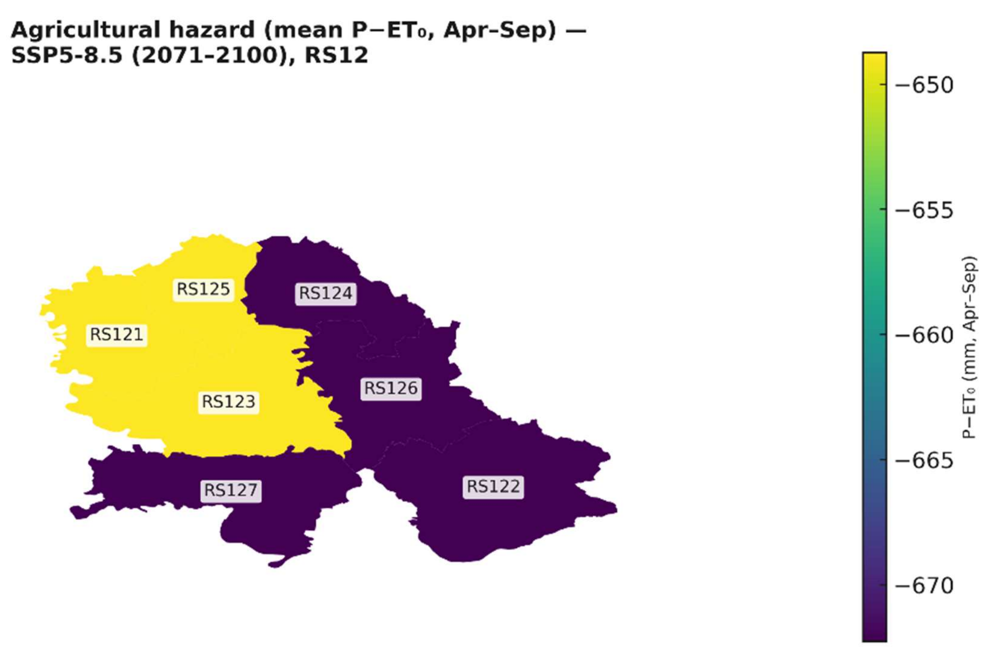
Map 6. Agricultural Drought (P−ET$_0$), April−September 1981−2015 — Vojvodina (RS12)



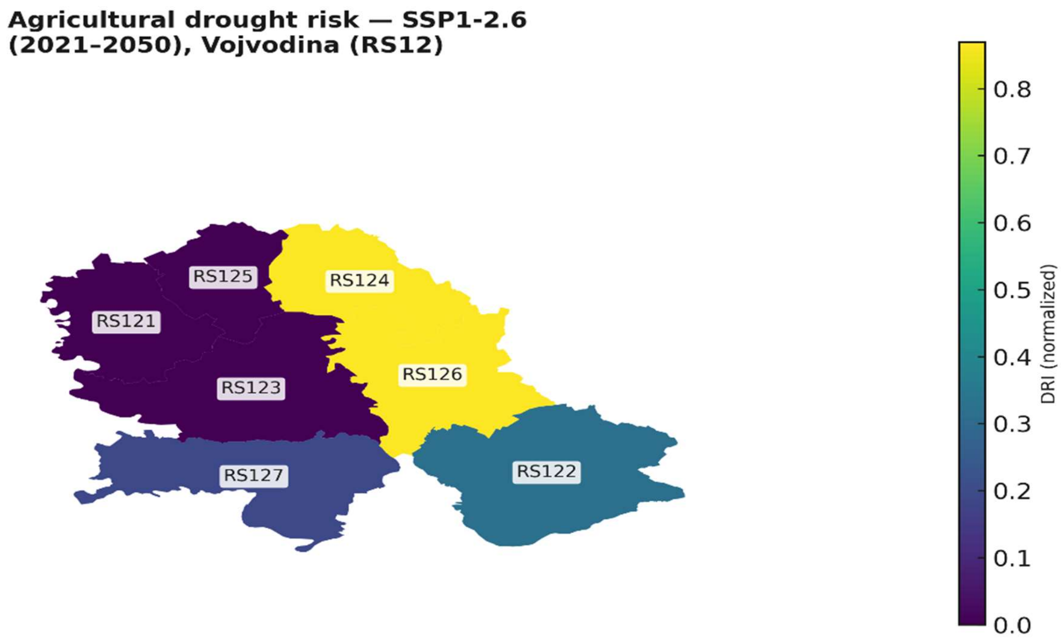
Map 7. Agricultural Drought ($P-ET_0$, mean Apr–Sep), SSP1–2.6 (2021–2050), Vojvodina (RS12)



Map 8. Agricultural Drought ($P-ET_0$, mean Apr–Sep), SSP5–8.5 (2071–2100), Vojvodina (RS12)



Map 9. Agricultural Drought Risk, SSP1–2.6 (2021–2050), Vojvodina (RS12)



Map 10. Agricultural Drought Risk, SSP5–8.5 (2071–2100), Vojvodina (RS12)

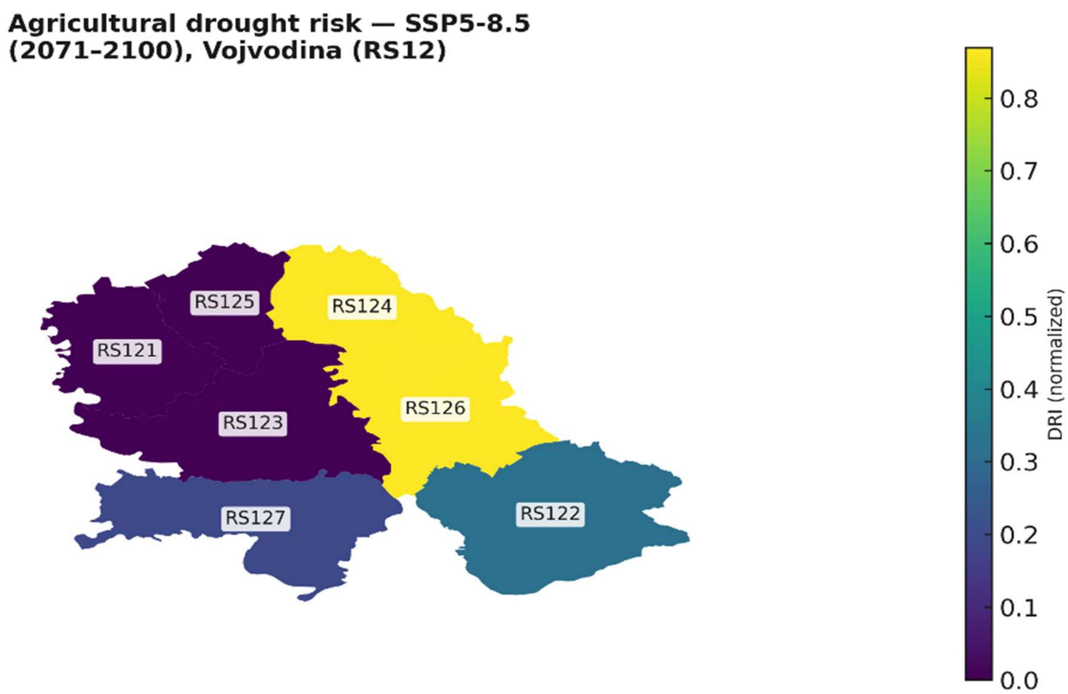


Table 2-1 Future Climate Conditions Considered

Scenario	Description	Key Climate Characteristics	Relevance for CRA
Scenario 0 (Historical Baseline: 1981–2015)	Observed climate used as reference period	Captures historical drought frequency and intensity	Provides baseline for comparison
SSP1–2.6 (Sustainability Pathway)	Moderate warming, proactive environmental policies	Limited temperature rise, reduced drought frequency by 2080	Represents optimistic, EU-aligned adaptation trajectory
SSP5–8.5 (Fossil-Fueled Development Pathway)	High economic growth, fossil-based energy, minimal mitigation	Strong warming (+4–5°C by 2100), drastic drying trends	Defines upper boundary of hazard intensity

Table 2-2 Future Socio-Economic Developments Considered

Socio-Economic Aspect	Near Future (to 2050)	Far Future (to 2080)
Population	Slight increase, rural depopulation continues; ageing demographic	Stabilization or decline, concentration in urban centers
Economy and Agriculture	Growth of agro-industrial sectors; reliance on irrigation and mechanization	Technological transformation, possible yield decline due to climate stress
Food Demand & Prices	Rising demand for domestic and export markets; moderate price volatility	High volatility, dependence on imports if drought persists
Land Use & Infrastructure	Expansion of irrigation networks, drainage rehabilitation	Structural shift toward drought-tolerant crops and conservation farming
Policy and Governance	Integration into EU Green Deal and CAP mechanisms	Increased reliance on transboundary resource management and EU adaptation funding

Table 2-3 Time Horizons Considered

Time Horizon	Period	Expected Conditions	Use in CRA
Near Future (to 2050)	2021–2050	Warming of +1.5–2.5°C; increased drought duration and frequency; higher evapotranspiration	Medium-term adaptation planning (e.g., irrigation modernization, soil protection)
Far Future (to 2080)	2051–2080	Potential +4°C increase; frequent extreme droughts; risk of desertification	Long-term strategic vision (land-use transformation, drought-resistant crops)

Table 2-4 Local and institutional datasets incorporated to improve contextual accuracy

Data Type	Dataset / Source	Temporal Coverage	Application
Meteorological data	NASA POWER (1981–2015); RHMZ Serbia	1981–2015	Precipitation, temperature, radiation, wind, humidity
Agro-economic data	Statistical Office of Vojvodina	2005–2020	Crop yields, irrigation coverage

Land use and exposure	Eurostat (NUTS3 Land Use Data), CORINE 2018	2010–2020	Share of arable land, population in agriculture
Socio-economic indicators	FAOStat, Provincial Secretariat for Agriculture	2005–2020	GDP, GVA per sector
Future climate	Copernicus CMIP6 bias-adjusted data	2021–2050 / 2051–2080	Temperature and precipitation projections (SSP1-2.6, SSP3-7.0, SSP5-8.5)
Future socio-economic	Shared Socioeconomic Pathways (SSP)	2020–2080	Population and GDP projections for RS12

Table 2-5 New Risk Metrics and Outputs

Indicator	Definition	Purpose
WASP Index (Weighted Anomaly of Standardized Precipitation)	Relative deviation of precipitation below local thresholds	Measures drought frequency and intensity
dH – Relative Drought Probability	Proportion of drought events below median deficit	Standardized drought occurrence indicator
P–ET_0 Deficit Index	Difference between precipitation and potential evapotranspiration	Captures agricultural water stress
Water Deficit Index (WDI)	Normalized P–ET_0 ratio	Facilitates district-level comparison
Yield Anomaly Correlation (YAC)	Correlation between WDI and crop yield	Local validation of drought impacts

Table 2-6 Overview of Datasets Used

Category	Dataset / Variable	Spatial Resolution	Temporal Resolution	Source	Use / Notes
Hazard	Precipitation (PRECTOT), Temperature (T2M, TMAX, TMIN), Wind (WS2M), Radiation (ALLSKY_SFC_SW_DWN), Humidity (RH2M)	NUTS3 (centroid)	Daily (1981–2015)	NASA POWER, RHMZ	Inputs for WASP and ET_0
Exposure	Land use, irrigation coverage, agricultural employment	NUTS3	Annual	Statistical Office, Eurostat	Defines exposed population and assets
Vulnerability	GDP per capita, crop yield fluctuations, soil types	NUTS3	2005–2020	Provincial Secretariat for Agriculture, FAOStat	Assesses adaptive capacity
Future climate	CMIP6 (SSP1–2.6, SSP5–8.5)	0.25° grid	Monthly	Copernicus Climate Change Service	Used for future scenario assessment

Future socio-economic	Population, GDP, irrigated area projections	NUTS2	2020–2080	SSP Database	Links socio-economic development to hazard trends

Table 2-7 Limitations of Datasets

Limitation	Description	Mitigation Approach
Temporal mismatch	Climate baseline (1981–2015) vs. socio-economic data (2005–2020)	Harmonization through normalized indices
Spatial resolution	NASA POWER point data vs. district polygons	Area-weighted interpolation to NUTS3
Soil and groundwater data gaps	Lack of continuous soil moisture monitoring	Proxyed via P–ET_0 deficit
Future exposure data	Limited SSP projections for subnational levels	Downscaled using agricultural employment ratios

Table 2-8 Data overview workflow #1 (Relative drought)

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
Monthly precipitation (mm/month) – NASA POWER, RHMZ Serbia (1981–2015)	GDP per capita and agricultural GVA (Provincial Secretariat for Agriculture, 2005–2020)	Agricultural land share, population in agriculture (Statistical Office, Eurostat)	WASP (Weighted Anomaly of Standardized Precipitation)
Jenks (k=2) precipitation thresholds per month for 1981–2015 baseline	Crop yield fluctuations (wheat, maize, soybean) (2005–2020)	Irrigated area (hectares)	dH (Relative drought hazard index)
Historical drought episode frequency and duration (derived from monthly anomalies)	Adaptive capacity proxy (irrigation rate, yield variability)	Land use and topographic flatness (CORINE, SRTM)	Drought frequency and relative exceedance probability
CMIP6 SSP1–2.6, SSP5–8.5 projected precipitation (2021–2050, 2051–2080)	–	–	Scenario-adjusted dH (Phase 3 input)

Table 2-9 Quantitative Summary

District (NUTS3)	Mean Annual Precipitation (mm)	Relative Drought (dH)	Interpretation
RS121 – Zapadnobački	588.2	0.42	Moderate drought frequency
RS122 – Južnobanatski	562.7	0.47	Slightly elevated drought recurrence
RS123 – Južnobački	579.5	0.39	Stable with low anomaly persistence
RS124 – Severnobanatski	548.1	0.52	Frequent drought events
RS125 – Severnobački	563.4	0.44	Moderate recurrence
RS126 – Srednjobanatski	556.2	0.50	Above-average hazard
RS127 – Sremski	596.8	0.41	Relatively low hazard
RS12 (mean)	**570.7**	**0.45**	**Regional mean drought frequency**

Table 2-10 Data overview workflow #2: Agricultural Drought (P–ET_0)

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
Daily precipitation (PRECTOT) and temperature (T2M, T2M_MAX, T2M_MIN) from NASA POWER (1981–2015)	Crop yield variability (wheat, maize, soybean) 2005–2020	Arable land share (Eurostat, CORINE 2018)	Seasonal water deficit (P–ET_0, April–September)
Daily wind speed (WS2M), relative humidity (RH2M), and shortwave radiation (ALLSKY_SFC_SW_DWN)	Irrigation coverage and infrastructure density (Provincial Secretariat for Agriculture)	Agricultural workforce (%) (Statistical Office of Serbia)	Mean growing-season P–ET_0 (mm)
FAO-56 Penman–Monteith reference evapotranspiration (ET_0)	Agricultural GDP and GVA per sector	Cropland sensitivity (soil and crop type)	Water Deficit Index (WDI = P/ET_0)
CMIP6 bias-adjusted projections (SSP1–2.6, SSP3–7.0, SSP5–8.5)	–	–	Scenario-adjusted agricultural drought intensity (Phase 3 input)

Table 2-11 Quantitative Summary (1981–2015)

District (NUTS3)	Mean Annual Precipitation (mm)	Mean Annual ET_0 (mm)	Mean P–ET_0 (Apr–Sep, mm)	Interpretation
RS121 – Zapadnobački	588.2	990.4	−420.7	Moderate seasonal deficit
RS122 – Južnobanatski	562.7	1018.1	−455.3	High seasonal deficit
RS123 – Južnobački	579.5	985.6	−395.8	Low–moderate deficit
RS124 – Severnobanatski	548.1	1045.2	−497.1	High deficit, persistent drought
RS125 – Severnobački	563.4	1008.9	−440.5	Moderate deficit
RS126 – Srednjobanatski	556.2	1038.3	−486.7	High seasonal drought
RS127 – Sremski	596.8	982.2	−385.4	Lowest deficit (favorable balance)
RS12 (mean)	**570.7**	**1009.8**	**−440.2**	**Regional average water deficit**

Table 2-12 The composite Drought Risk Index (DRI)

District (NUTS3)	Drought Hazard (H)	Exposure (E)	Vulnerability (V)	Drought Risk Index (DRI)	Risk Level
RS121 – Zapadnobački	0.52	0.68	0.58	0.21	Moderate
RS122 – Južnobanatski	0.60	0.73	0.64	0.28	High
RS123 – Južnobački	0.48	0.70	0.53	0.18	Low–Moderate
RS124 – Severnobanatski	0.74	0.76	0.75	0.42	**Very High**
RS125 – Severnobački	0.61	0.72	0.62	0.27	High
RS126 – Srednjobanatski	0.70	0.78	0.71	0.39	**Very High**
RS127 – Sremski	0.47	0.65	0.49	0.15	Low

Table 2-13 Key inputs to the risk evaluation phase

Output Type	Description	Source / Methodology	Temporal Coverage	Spatial Scale
Relative Drought Hazard (dH)	Frequency of precipitation anomalies below the 20th percentile threshold during the growing season (Apr–Sep)	Derived from E-OBS v27.0e (1950–2020)	1981–2015 baseline; SSP1–2.6 (2021–2050); SSP5–8.5 (2071–2100)	NUTS3 (RS121–RS127)
Agricultural Drought (P–ET_0)	Mean seasonal water balance (precipitation minus potential evapotranspiration) representing agricultural drought intensity	Calculated from combined E-OBS and NASA POWER datasets	1981–2015 baseline; SSP1–2.6; SSP5–8.5	NUTS3 (RS121–RS127)
Drought Vulnerability Index (DVI)	Composite socio-economic and environmental index including irrigation, GDP, soil retention, and adaptive capacity	Developed using national statistics, FAO–HWSD, and institutional datasets	2005–2024	NUTS3
Exposure Index (EI)	Agricultural exposure calculated from CORINE 2018 land cover, crop density, and production value	Derived using GIS overlay and statistical normalization	2018 reference year	NUTS3
Drought Risk Index (DRI)	Composite index integrating hazard, exposure, and vulnerability (DRI = H × E × V)	Computed using standardized CLIMAAX workflow	1981–2015, SSP1–2.6, SSP5–8.5	NUTS3

Table 2-14 Current (Baseline 1981–2015) Severity

District	Observed Hazard (dH/P–ET_0)	DRI	Severity Category	Key Impacts
RS121 – Zapadnobački	Moderate	0.21	**Moderate**	Periodic yield loss, moderate soil moisture deficits
RS122 – Južnobanatski	High	0.28	**Substantial**	Frequent droughts, irrigation dependence
RS123 – Južnobački	Low–Moderate	0.18	**Moderate**	Stable yields, limited water stress
RS124 – Severnobanatski	Very High	0.42	**Critical**	Severe agricultural and hydrological droughts
RS125 – Severnobački	High	0.27	**Substantial**	Soil erosion and loss of organic matter
RS126 – Srednjobanatski	Very High	0.39	**Critical**	Persistent summer droughts, ecological degradation
RS127 – Sremski	Low	0.15	**Limited**	Minimal long-term drought impact

Table 2-15 Current and Future Risk Dynamics

Period	Scenario	Key Observations	Change in Severity	Urgency Category
Baseline (1981–2015)	–	Drought impacts frequent but spatially contained; manageable within existing irrigation and crisis frameworks	–	**Watching Brief**
Near Future (2021–2050, SSP1–2.6)	Low-emission, stabilization pathway	Drought duration and intensity increase moderately; agricultural stress rising in Banat and southern Bačka; adaptation options still feasible	Moderate (+1–2 category)	**More Action Needed**
Far Future (2071–2100, SSP5–8.5)	High-emission, fossil-intensive pathway	Widespread, long-term drying trends; multi-season droughts; major yield losses and ecological degradation projected	Substantial (+3 category)	**Immediate Action Needed**

Table 2-16 Summary of Urgency Assessment

District	Dominant Hazard	Urgency Category	Main Rationale
RS121 – Zapadnobački	Agricultural drought	**More Action Needed**	Increasing evapotranspiration, moderate adaptive capacity
RS122 – Južnobanatski	Combined drought	**Immediate Action Needed**	Persistent deficits, dependence on rainfed systems
RS123 – Južnobački	Agricultural drought	**More Action Needed**	Manageable within current irrigation expansion
RS124 – Severnobanatski	Relative + agricultural drought	**Immediate Action Needed**	Recurrent severe droughts, structural vulnerability
RS125 – Severnobački	Combined drought	**Immediate Action Needed**	Long-term exposure and limited adaptation
RS126 – Srednjobanatski	Relative + agricultural drought	**Immediate Action Needed**	Highest drought frequency and intensity
RS127 – Sremski	Agricultural drought	**Watching Brief**	Stable hydrological conditions and diversified economy

Table 2-17 District-Level Resilience Evaluation

District	Financial/Institutional	Natural	Human/Social	Overall Capacity	Category
RS121 – Zapadnobački	Moderate	Moderate	Moderate	0.55	**Substantial**
RS122 – Južnobanatski	Weak	Low	Moderate	0.35	**Medium**
RS123 – Južnobački	Moderate	High	Substantial	0.68	**Substantial**
RS124 – Severnobanatski	Weak	Low	Moderate	0.30	**Low**

RS125 – Severnobački	Weak	Moderate	Moderate	0.40	**Medium**
RS126 – Srednjobanatski	Weak	Low	Moderate	0.33	**Low**
RS127 – Sremski	Strong	High	Substantial	0.75	**High**

Table 2-18 Assessment Summary

Capacity Dimension	**Key Findings**	**CLIMAAX Category**
Financial	Limited pre-disaster financing; need for resilience-based budgeting	**Medium**
Human	Technical competence high, local awareness low	**Medium**
Social	Increasing NGO participation; weak smallholder engagement	**Medium**
Natural	Strong west, weak east; loss of soil moisture retention in Banat	**Medium–Low**
Physical	Obsolete irrigation, partial coverage	**Low**

Table 2-19 District-Level Prioritization

District	**Severity**	**Urgency**	**Resilience Capacity**	**Risk Priority Index (RPI)**	**Priority Level**
RS121 – Zapadnobački	3 (Substantial)	3 (More Action Needed)	3 (Substantial)	**2.3**	**Medium**
RS122 – Južnobanatski	4 (Critical)	4 (Immediate Action)	2 (Medium)	**3.3**	**High**
RS123 – Južnobački	3 (Substantial)	3 (More Action Needed)	3 (Substantial)	**2.3**	**Medium**
RS124 – Severnobanatski	4 (Critical)	4 (Immediate Action)	1 (Low)	**3.7**	**Very High**
RS125 – Severnobački	4 (Critical)	4 (Immediate Action)	2 (Medium)	**3.3**	**High**
RS126 – Srednjobanatski	4 (Critical)	4 (Immediate Action)	1 (Low)	**3.7**	**Very High**
RS127 – Sremski	2 (Moderate)	2 (Watching Brief)	4 (High)	**1.3**	**Low**

Figures Stakeholders meetings

Република Србија
ЦЕНТАР ЗА ПРОМОЦИЈУ НАУКЕ
Београд, Краља Петра 46

Датум: 29. септембар 2025.
Време: 10.00–13.00
Место: Ложионица – Креативно-иновативни мултифункционални центар, Београд

ОКРУГЛИ СТО

High-level догађај у оквиру *Climateurope2* фестивала 2025. у Београду

Јавне институције широм Европе, од националних агенција до локалних самоуправа, све чешће се позивају на спровођење стратегија адаптације на климатске промене. У том процесу се ослањају на климатске сервисе (енгл. *climate services*) како би сагледале ризике и дефинисале даљи правац деловања.

Међутим, поставља се кључно питање: **како обезбедити да климатски сервиси заиста буду примењиви, релевантни и поверљиви на нивоу доношења одлука?**

Сходно томе, биће представљене препоруке из актуелних и недавно завршених европских пројеката, укључујући улогу *ISO* и *WMO* стандарда, као и смернице финансиране из фондова ЕУ, уз дискусију о томе како они обликују управљање адаптацијом широм Европе.

Позивамо вас да активно допринесете дискусији кроз разговор на следећа питања:

- Каква је подршка потребна градовима и јавним институцијама за успешну примену климатских сервиса?
- Где постојећи стандарди доприносе деловању, а где представљају препреку?
- Како боље укључити локална знања и приоритете у осмишљавање и примену климатских сервиса?

- Који би алати, процеси или формати допринели томе да климатски сервиси буду употребљивији, инклузивнији и легитимнији у локалном контексту?

Ваша запажања директно ће допринети изради *Climateurope2 policy brief* документа, као и тренинг модула за јавни сектор.

О пројекту *Climateurope2*

Climateurope2 је петогодишњи међународни пројекат који окупља водеће европске институције из области климатологије, друштвених наука и јавних политика. Циљ пројекта је унапређење коришћења климатских сервиса у доношењу одлука, кроз јачање поверења, развој стандарда, процену квалитета и едукацију доносилаца одлука.

Пројекат је финансиран кроз програм Хоризонт Европа, а координира га *Barcelona Supercomputing Center* из Шпаније, уз учешће 33 партнера из 13 земаља, укључујући и Центар за промоцију науке, као националног партнера.

Више информација: www.climateurope2.eu

Агенда догађаја

10.00–10.10 Уводна обраћања

10.10–10.40 Кратка излагања и примери из праксе представника *Climateurope2* конзорцијума и локалних институција

10.40–11.40 Дискусија са учесницима из региона

11.40–12.00 Завршни коментари и закључци

12.00–13.00 Ручак и умрежавање

How to Build a Climate Service

Tuesday, 30th September
11:30 - 13:00

Interactive sessions

Regional Southeastern Europe Showcase Session

Main venue

The Regional SEE Showcase session presents a dedicated space to spotlight climate services in Southeast and Eastern Europe, aiming to go beyond formal presentations and open the floor for a more interactive and free-flowing exchange of ideas.

By giving more room for open discussion, the session seeks to capture the diversity of voices and practices across Southeast Europe, highlight success stories, and identify pathways where collaboration can strengthen both science and services.

Moderator

Marjana Brkic
CPN, Serbia

Panellists

Suzana Blesic
Institute for Medical Research, Serbia

Nikola Obrenovic
BIOSENCE, Serbia

Ibolya Torok
Babes-Bolyai University,Faculty of Geography, Romania

Biljana Basarin
University of Novi Sad, Serbia

Vukasin Pejovic
Atfield Technologies, Serbia

Teodora Subotic
Provincial Secretariat for Urban Planning and Environmental Protection, Serbia

Vassiliki Kotroni
National Observatory of Athens, Greece

Mission Adaptation - Dialogue in the Region

Wednesday, 1st October
14:30 - 16:00

Plenary session | **Main venue**

This session will explore how climate services support the EU Mission on Climate Change Adaptation and strengthen the capacity of regions, cities, and local authorities to increase resilience to climate impacts. The discussion will feature two keynote presentations showcasing the projects CLIMAAX and Adaptation AGORA and their contributions to advancing local adaptation practices; followed by a panel discussion that will draw on the experiences of representatives of cities and regions from Southeast Europe, exploring opportunities, challenges and needs for practitioners to effectively leverage climate knowledge.

Moderators

Jaroslav Mysiak
CMCC, Italy

Keynote speakers

Dana Stuparu
Deltares, The Netherlands

Paola Mercogliano
CMCC, Country

Panellists

Teodora Subotic
Provincial Secretariat for Urban Planning and Environmental Protection, Serbia

Miljenko Sedlar
REGEA, Croatia

Climateurope2

FESTIVAL AGENDA

Monday, 29th Sep

13:00 – 14:00	*Registration & welcome coffee*
14:00 – 14:40	*Plenary* **Expanding the Reach of Climate Services: Connecting Regions, Enabling Action**
14:40 – 15:25	*Plenary* **Opening Keynotes: On Climate Services, Agriculture and Health**
15:25 – 16:30	*Plenary* **Climate Dialogues in Southeast Europe: Innovation, Impact, Inclusion**
17:00 – 17:30	*Exhibition presentation* **Climate Services through Art & Science**
17:30 – 18:30	*Marketplace*
18:30 – 19:30	*Cocktail - Food & music*

Tuesday, 30th Sep

9:30 – 11:00	*Plenary* **A Dialogue on the Meaning and Purpose Climate Service**
11:30 – 13:00	*Interactive Session* **How to Build a Climate Service**
11:30 – 13:00	*Marketplace*
14:15 – 15:45	*Plenary* **Seeds of Change: Climate Services for Agriculture**
16:15 – 17:45	*Interactive Session & World Café* **Climate Service – The Experience**

Wednesday, 1st Oct

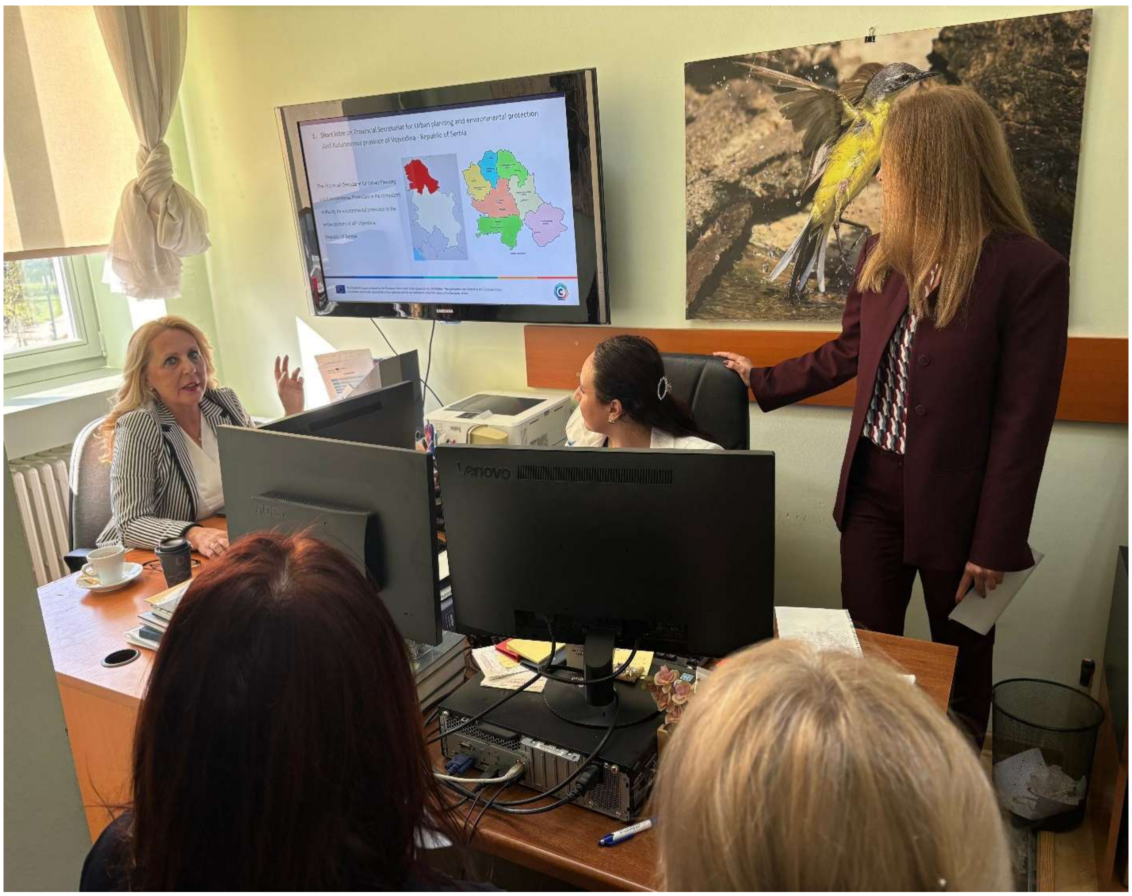
9:30 – 11:00	*Plenary* **All You Need Is Health: Climate Services for Health**
11:30 – 13:00	*Interactive Session* **The Future of Climate Services**
14:30 – 16:00	*Plenary* **Mission Adaptation in the Region – Dialogue**
16:30 – 18:00	*Plenary* **Finale & Feedback: Honouring Interactions**

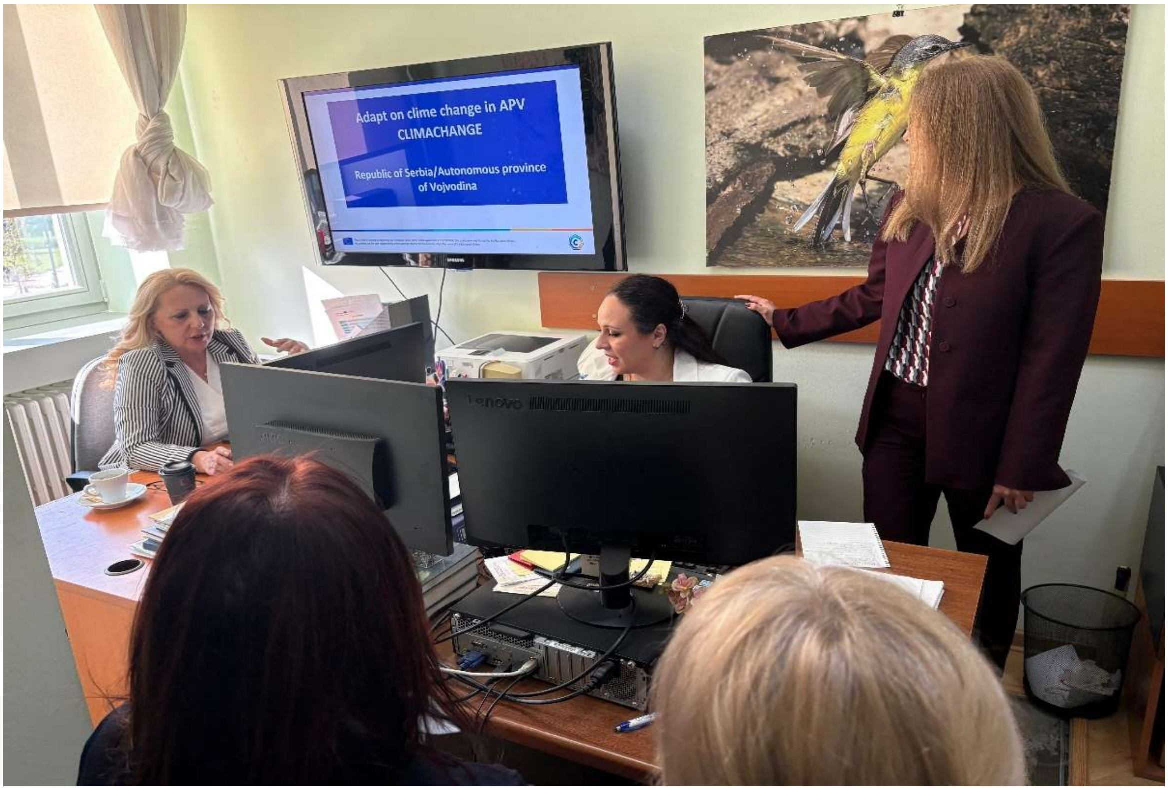
LISTA PRISUTNOSTI - Attendance list

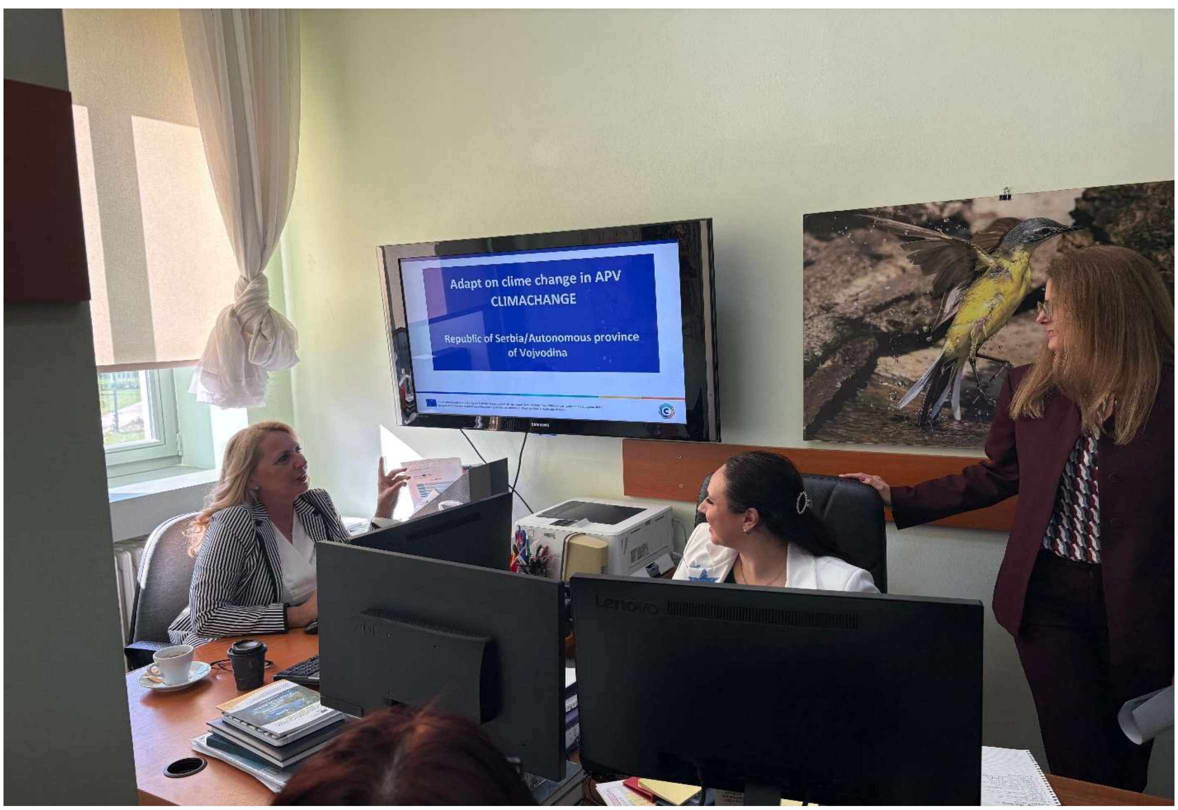
Datum: 14. Oktobar 2025. (utorak) u 11:00 časova

Program: CLIMAAX
Project name: CLIMACHANGE

	Ime i prezime (Name and surname)	Institucija (Institution)	Pozicija (Position)	Contact (e-mail, phone)	Potpis (Signature)
	MILICA VRAČARIĆ	Reg. agencija ALMA MONS.	direktorka	milica.vracaric@almamons.rs	[signature]
	Sanda Nastić	Fimek fakultet	profesor	kontroling.konsultant@gmail.com	[signature]
	SANJA SIMEUNČEVIĆ RADULOVIĆ	POKRAJINSKI SEKRETARIJAT ZA URBANIZAM I ZAŠT. ŽIV. SRED.	SAVETNIK ZA URBANIZAM	SANJA.SIMEUNCEVIC@VOJVODINA.GOV.RS	[signature]
	TEODORA SUBOTIĆ	— II —	SAVETNIK	teodora.subotic@vojvodina.gov.rs	[signature]
	TATJANA ĐURIĆ	PROVINCIAL SECRETARIAT FOR URBAN PLANNING AND EN. PROT.	ADVISOR	tatjana.djuric70@vojvodina.gov.rs	[signature]




Adapt on clime change in APV
CLIMACHANGE
Republic of Serbia/Autonomous province
of Vojvodina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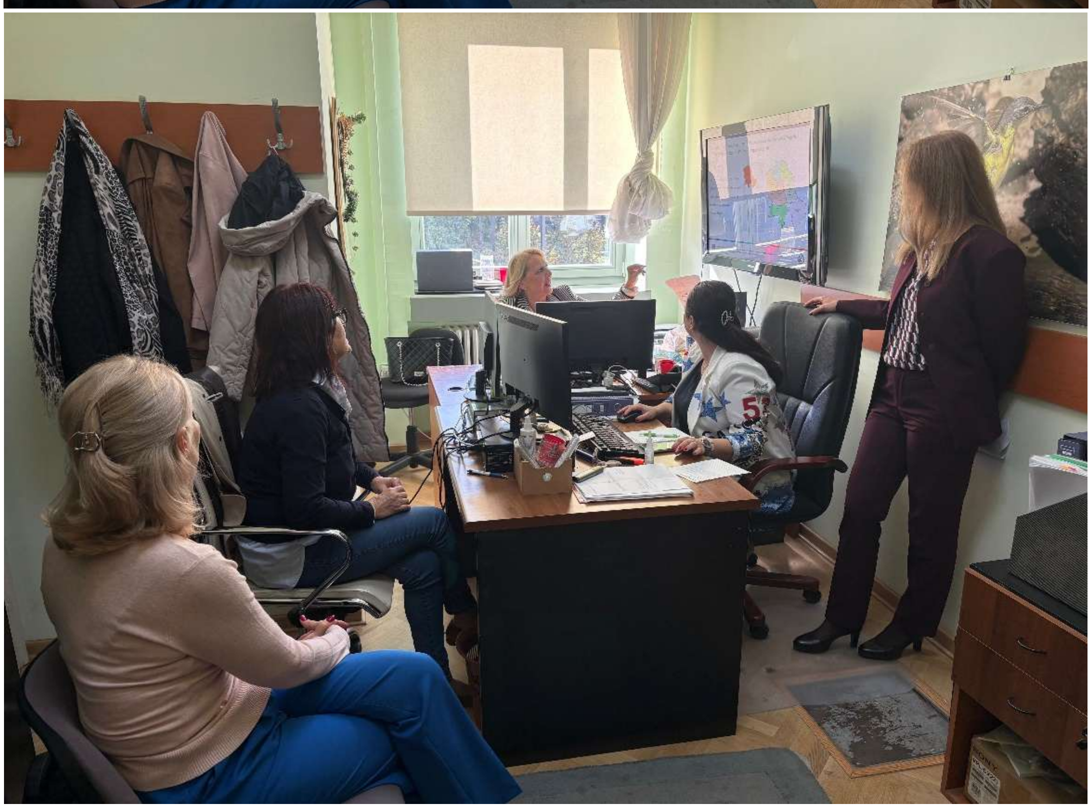
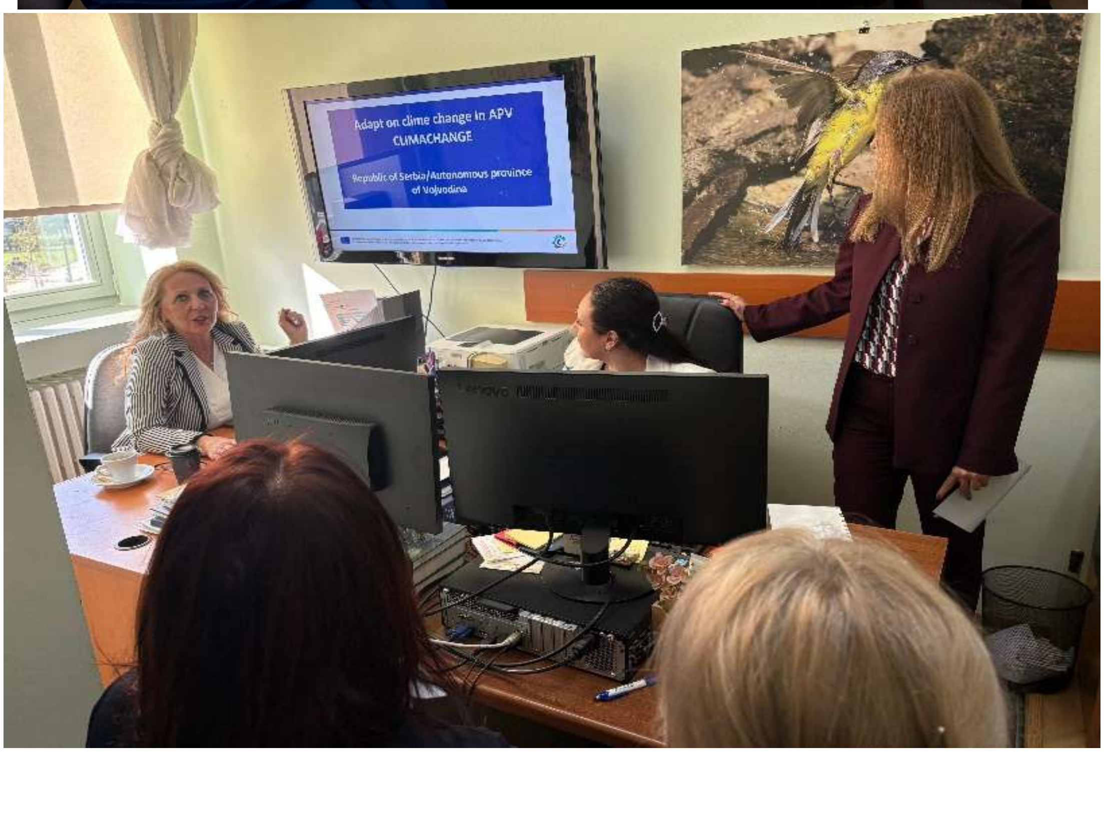
CLIMACHANGE
Republic of Serbia/Autonomous province
of Vojvodina

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CLIMACHANGE
Republic of Serbia/Autonomous province
of Vojvodina

CLIMAAX climate ready regions

MEETING WITH STAKEHOLDERS - PROVINCIAL SECRETARIAT FOR AGRICULTURE, WATER MANAGEMENT AND FORESTRY

LISTA PRISUTNOSTI - Attendance list

Datum/Date: 15. 10. 2025.

Program: CLIMAAX
Project name: CLIMACHANGE

	Ime i prezime (Name and surname)	Institucija (Institution)	Pozicija (Position)	Contact (e-mail, phone)	Potpis (Signature)
1	ПЕТАР САМОЛОВАЦ	ПС ЗА ПОЉОПРИВРЕДУ	ПОМОЋНИК СЕКРЕТАРА	petar.samolovac@vojvodina.gov.rs 064 814-4563	[signature]
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8					
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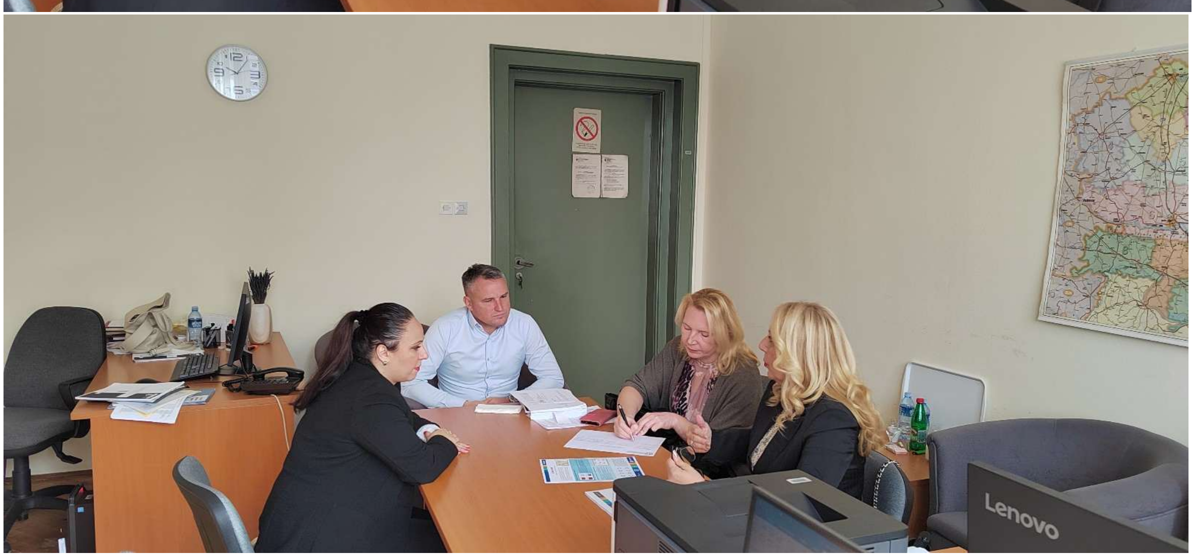
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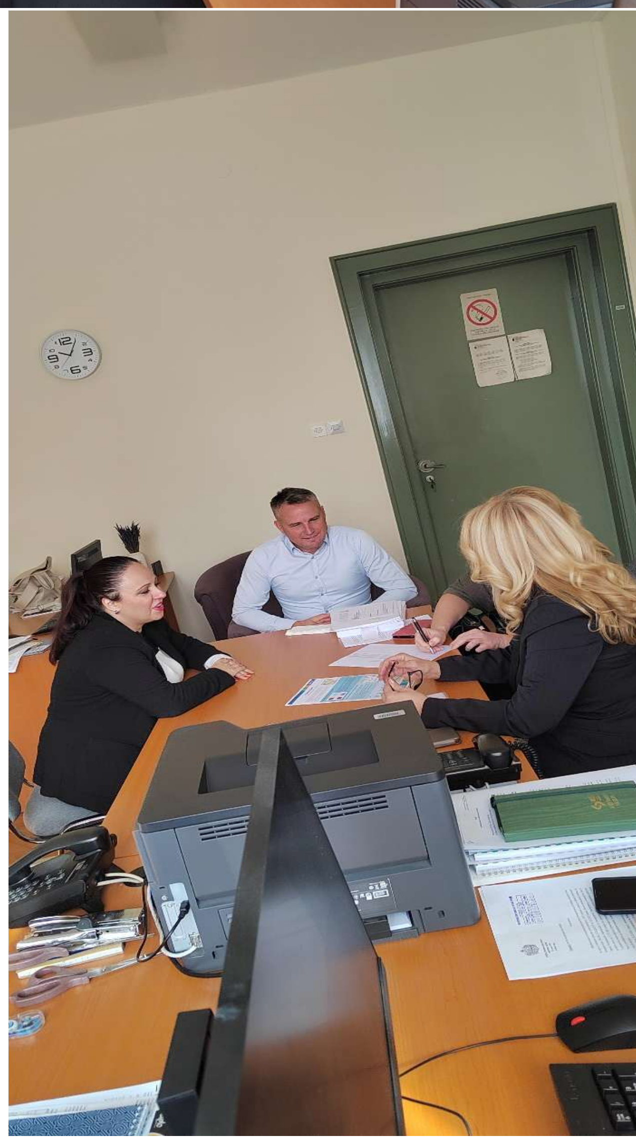

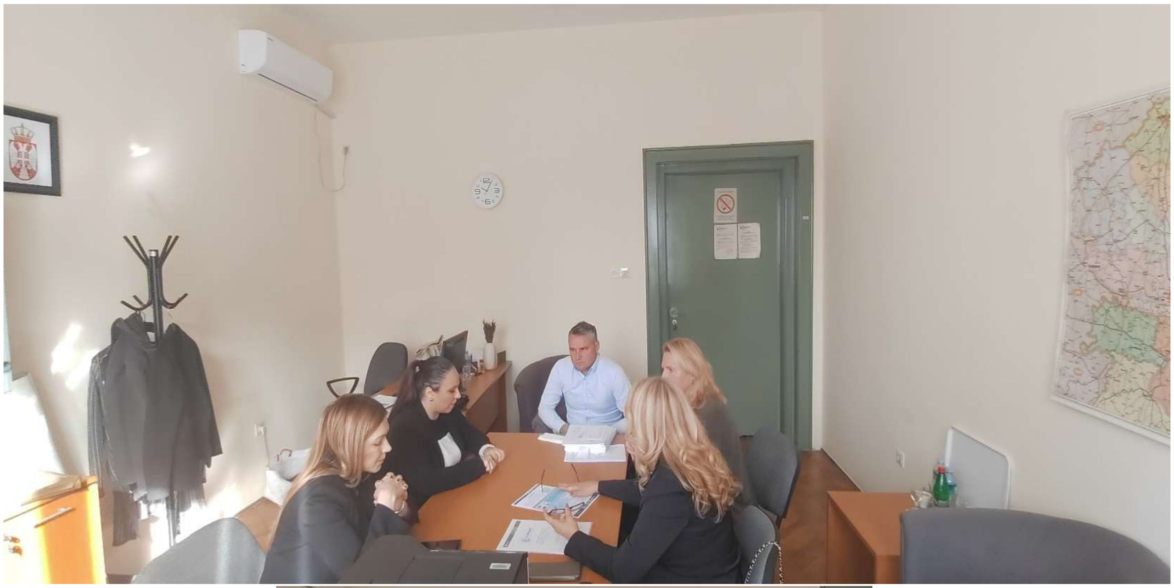

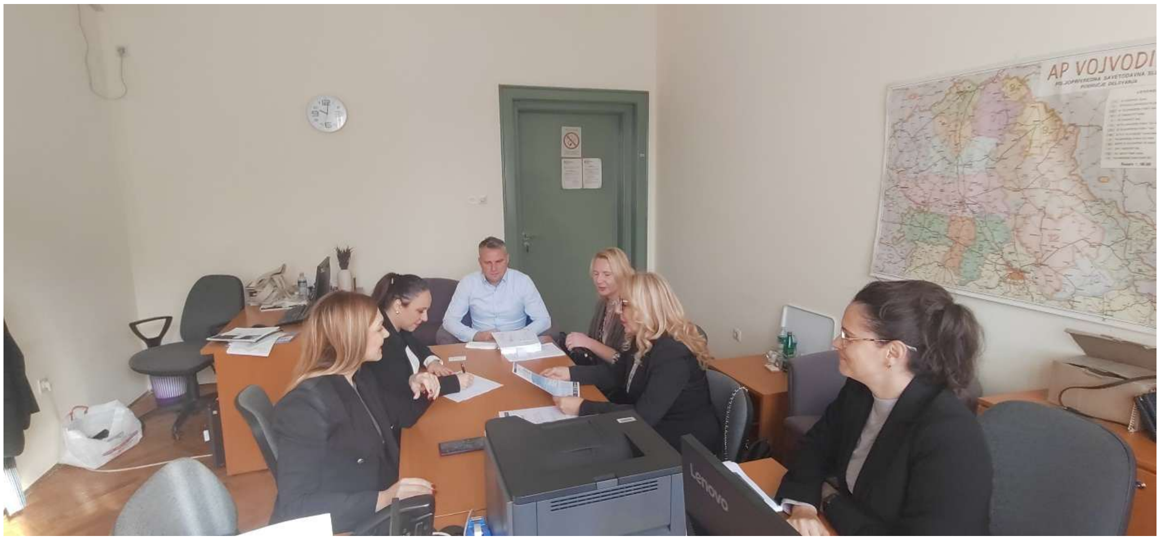


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