CLIMAAX
climate ready regions

Deliverable Phase 2 – Climate risk assessment

CLIMAAX M16 Deliverable FSTP2 faza KULA NORINSKA

Croatia, Dubrovnik-Neretva County /Municipality Kula Norinska

Version 1.0 | July 2026

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

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101093864. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

Document Information

Deliverable Title	CLIMAAX M16 Deliverable FSTP2 faza KULA NORINSKA
Brief Description	Evidence-based Phase 2 climate risk assessment for drought and wildfire in the Municipality of Kula Norinska, revised for scientific clarity, impact interpretation and readability.
Project name	CLIMAAX M16 Deliverable FSTP2 faza KULA NORINSKA
Country	Croatia
Region/Municipality	Municipality of Kula Norinska
Leading Institution	Municipality of Kula Norinska and the project team
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Deliverable submission date	Planned resubmission: 09/10/2026
Final version delivery date	28/09/2026 (revision draft)
Nature of the Deliverable	R – Report
Dissemination Level	PU - Public

Version	Date	Change editors	Changes
1.0	26/06/2026	Project team	Original Phase 2 deliverable submitted
2.0	28/09/2026	Project team	Revised analysis and report prepared in response to reviewer comments
3.0	09/10/2026	Project team	Planned resubmission after final validation

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Abbreviations and acronyms

Abbreviation / acronym	Description
CLIMAAX	CLIMAte risk and vulnerability Assessment framework and toolboX
CRA	Climate Risk Assessment
EU	European Union
NGO	Non- Governmental Organisation
RCP	Representative Concentration Pathways
SSP	Shared Socio-economic Pathways
SPI-6	Six-month Standardised Precipitation Index
FWI	Fire Weather Index
GCM	Global Climate Model
CDS	Copernicus Climate Data Store
AWC	Available Water Capacity (soil)
GAEZ	Global Agro-Ecological Zones (FAO/IIASA)
GHSL	Global Human Settlement Layer (JRC)
IDW	Inverse-Distance Weighting (interpolation)

Executive summary

This report presents Phase 2 of the CLIMAAX climate risk assessment for the Municipality of Kula Norinska, a rural municipality of nine settlements and 1,414 inhabitants in the Neretva River delta. The assessment focuses on drought and wildfire because Phase 1 screening and local stakeholders identified them as the highest-priority climate risks. Phase 2 combines documented climate datasets, settlement-level exposure information and stakeholder evidence. Quantitative results are used to compare settlements, while stakeholder evidence provides local context and is not treated as validation of the climate models.

The clearest long-term signal is a warmer and drier summer climate. Under the high-emissions SSP5-8.5 scenario for 2071–2100, the five-model ensemble projects about 24% less summer precipitation, 11% less annual precipitation and 5.39 °C higher annual temperature relative to the reference climate. These are conditional long-term projections, not a forecast for a particular year. Drought hazard differs only slightly among the nine settlements, so the mapped differences mainly reflect where people and agricultural land are concentrated. Krvavac II has the highest drought hazard-weighted exposure for people, while Desne has the highest calculated agricultural drought risk (Table 2-3 and Annex B).

Wildfire results show a stronger summer fire-weather signal under higher forcing. Krvavac II has the highest hazard-weighted exposure for people in the historical period and in every future wildfire scenario. Satellite observations for 2001–2020 also show concentrated mapped burning, including 661.2 ha cumulatively in Krvavac II. These observations describe mapped burned area, not the number of individual fires, their ignition causes, direct damage or fire intensity (Tables 2-5 and 2-6).

For residents, the results identify places where more people are located under drought or fire-weather pressure; they do not predict casualties, illness or household losses. For agriculture, the results indicate where climate pressure coincides with agricultural land and limited soil-water and irrigation capacity, which can increase concern about crop stress and water demand. Effects on farm income, tourism and municipal expenditure remain qualitative because no monetary-loss model was developed. The 3,382.50 ha of protected wetland receptor area is reported separately, and ecological damage is not quantified.

Confidence is strongest for the relative drought ranking, which is stable across the five climate models and the tested agricultural-vulnerability weights. Confidence is lower for a complete assessment of consequences because future population and land use were not modelled, population vulnerability and building characteristics are unavailable, and the wildfire product provides only a multi-model ensemble mean. The results therefore support priority setting within Kula Norinska but do not estimate absolute probabilities or losses.

Phase 3 should prioritise practical options in Krvavac II, Krvavac and Desne while maintaining municipality-wide preparedness. Immediate evidence needs are a consistent fire-incident register, information on vulnerable residents and buildings, and monitoring of agricultural and wetland conditions. Candidate measures include prevention of deliberate vegetation burning, fire warning and evacuation planning, water-efficiency and soil-moisture measures, and ecologically supervised wetland restoration. Their feasibility, cost, safeguards and responsible institutions must be evaluated with stakeholders before adoption.

1 Introduction

1.1 Background

Municipality of Kula Norinska is situated in the southern part of Croatia, historical region of Dalmatia, in the Neretva River delta. It comprises 61 km^2 with total of 1414 inhabitants (according to the official 2021 Croatian population census) and population density of 23 inhabitants per square kilometer. It is a small rural Municipality that consists of nine rural settlements. The Municipality is located at the contact of the karstic hills (made of limestone and dolomite) and the alluvial plain of river Neretva that is partially covered by wetlands. The centuries-long interaction between humans and nature has created specific ways of life that were heavily dependent on the nature resources such as freshwater, wetlands and soil. This traditional way of life has been significantly transformed in the second part of the 20th century due to the process of the overall economic development of Croatia and especially the delta region. The socio-economic transformation of the delta during that period was stunning in every aspect of life. Nowadays, the local population is no longer dependent on agriculture, which is primarily an additional source of income and relies on modern types of farming (mandarin oranges, olives, vegetables). Majority of population is employed in various services and commute on everyday basis to the nearby town of Metković, the principal urban settlement in the delta. At the turn of the 20th and 21st centuries tourism started developing thanks to combined visits to the local wetlands and traditional gastronomy.



Fig 1-1 Geographic situation of Municipality of Kula Norinska in Dubrovnik-Neretva County, Croatia

1.2 Main objectives of the project

The objectives of the Phase 2 are following:
1) Conduct further analyses of two most relevant climate hazards (wildfires and droughts).
2) Define participation principles and stakeholder engagement in the process of climate change adaptation and mitigation.
3) assess severity and urgency of hazards that would provide us with better understanding of resilience capacity
4) define climate risk priorities.

The significance of the Phase 2 of the project is in further and deeper analyses of the climate hazards and risks that involves local stakeholders in the process of climate change adaptation and mitigation.

The most important expected benefit of applying the CLIMAAX Handbook is the designation of climate risk assessment of the Municipality of Kula Norinska which is a first step in creating an adequate climate adaptation plan and risk management plan. Such plans would help the Municipality to react quickly to climate change and to engage local stakeholders in the global process of climate mitigation. The prescribed methodological approach would make the analysis comparable with studies of other researched areas inside the CLIMAAX project.

1.3 Project team

Associate Professor Višnja Bukvić, Ph.D. is biologist specialized in ornithology, ichthyology and wetlands habitat. She is retired after decades of working at the University of Herzegovina in Bosnia and Herzegovina where she was teaching biological subjects and participating in various research from the field of biology.

Full Professor Nikola Glamuzina, Ph.D. is geographer specialized in economic geography, urban geography and research of conflicts in the protected nature areas. He works at the University of Split, where he teaches geographic subjects.

Associate Professor Ivan Vučković, Ph.D. is biologist specialized in water conservation and research of freshwater habitat. He currently works in the private sector as an expert in water ecology and environmental impact analysis. He also teaches biology at the University of Zagreb.

1.4 Outline of the document's structure

This document follows the CLIMAAX deliverable guidance and is organised as follows:

Executive summary provides a whole view of the document in a short form enabling a reader of the deliverable to understand the document without reading it in full.

The introduction consists of a short description of the area researched, the main objectives of the project and the members of the project team.

The Climate risk assessment – Phase 2 section follows the CLIMAAX framework: scoping, risk exploration, regionalised risk analysis and key risk assessment. It explains stakeholder participation, scenario selection, the drought and wildfire methods, settlement-level results, severity and urgency, resilience capacity, monitoring, and the Phase 3 work plan.

Conclusion – phase 2 concerns the conclusion regarding the climate risk assessments.

Progress evaluation describe the future work on the project in connection with the very deliverable.

This document ends with two sections that classify and list all the outputs produced during the work on the deliverable (**Supporting documentation**) and the literature consulted and cited (**References**).

2 Climate risk assessment – Phase 2

2.1 Scoping

*The scoping phase of the climate risk assessment defines **objectives** (desired results of the analysis), **context** (conditions for implementation) and **identifies stakeholders, experts and priority groups** that need to be involved in the project preparation.*

Scoping, as the initial phase of the climate risk assessment, relies on definition of objectives, context and definition of the relevant stakeholders, experts and priority groups involved in the project.

2.1.1 Objectives

The objective of this climate risk assessment is to identify and compare the main drought and wildfire risks affecting Kula Norinska and to understand how local stakeholders perceive and manage those risks. Its purpose is to provide an evidence base for municipal adaptation and risk management. The expected outcome is a clearer basis for prioritising settlements, receptors and data needs, while supporting future local plans and stakeholder decisions.

The assessment has important boundaries. There is no weather station within the municipality, so the revised quantitative analysis uses documented gridded climate datasets; nearby national station information is retained only as context. Climate inputs have coarser effective resolution than some settlement maps, and present-day exposure and vulnerability are held constant in future scenarios. Local fire-incident, building, sensitive-population, ecological-response and economic-loss data are incomplete. These limits restrict the conclusions to relative priority setting, not prediction of local damages.

The main challenges were limited local observations, incomplete records of fire incidents and ignition causes, and the difficulty of engaging all relevant groups in a small rural community. The project addressed these constraints by registering reproducible regional datasets, separating measured and modelled evidence from stakeholder observations, testing the robustness of rankings, and documenting the remaining data needs for Phase 3.

2.1.2 Context

Climate risk management in the region has historically emphasised emergency response and partial compensation after damaging events. Local, regional and national climate policies provide a formal framework, but Kula Norinska does not yet have a detailed evidence-based plan for reducing drought and wildfire risk before impacts occur.

The project addresses this gap by moving from a mainly reactive approach toward prevention and preparedness. It identifies priority hazards and settlements, clarifies which conclusions are supported by quantitative analysis, and establishes a basis for selecting proportionate adaptation measures in Phase 3.

Kula Norinska operates within Croatian regional and national legislation, while emergency response and environmental protection responsibilities are shared among municipal, county and national institutions. The municipality can prepare local plans, coordinate stakeholders and seek

national or EU support, but implementation depends on clearly assigned responsibilities, technical capacity and external financing.

Kula Norinska has limited economic diversification and relies partly on climate-sensitive natural resources. Three locally important areas require particular attention: agriculture, tourism and protected wetland ecosystems.

1) agriculture,
2) tourism
3) biodiversity

Agriculture is an additional source of income for many households and remains important to local identity. Longer or more intense dry periods can increase soil-moisture stress and irrigation demand. The Phase 2 analysis identifies Desne as the highest calculated agricultural drought-risk settlement, but it does not quantify crop-yield or income losses.
Local tourism depends partly on summer outdoor activities, wetlands and traditional gastronomy. Low wetland water levels, smoke, fire-damaged landscapes or restrictions during hazardous weather could disrupt visitor access and reduce the attractiveness of nature-based tourism. These pathways are plausible and locally relevant but were not quantified economically in Phase 2.
Protected wetlands and their biodiversity can be affected by prolonged dry conditions, altered water availability and fire. Phase 2 maps the protected receptor area separately but does not model species responses, ecosystem-service losses or recovery time. Ecological consequences are therefore treated as an important evidence gap rather than a quantified impact.

Local stakeholders and the fire brigade report that many reed fires are caused by human activity, including deliberate or negligent burning. However, a complete incident and ignition-cause database was not available for this assessment. Anthropogenic ignition is therefore treated as contextual evidence and a prevention priority, not as a quantitatively verified share of all fires.

Possible adaptation measures include community education on the consequences of vegetation burning, a multi-stakeholder system for wetland management, farmer support for water-efficient and low-fire-risk practices, improved fire detection and incident records, and monitoring of drought, water and ecosystem conditions. These options require feasibility, cost and environmental-safeguard assessment in Phase 3.

2.1.3 Participation and risk ownership

The Phase 2 of the project turned out to be more dynamic from the point of view of stakeholder involvement process. We had more interaction with relevant stakeholders that provided us with better understanding of their problems and worries regarding the climate hazards. It also gave us an insight into their local knowledge about the climate risks and an opportunity to bring closer to them the scientific understanding of such issues. We managed to involve the local fire brigade into the process since they have precious knowledge and experience regarding the wildfires in the Municipality and the wider region of the Neretva Delta. Their expertise confirmed the anthropogenic factor as the primal cause of fires in the reeds with destructive impact on environment. Our initial contacts that were established during the Phase 1 of the projects were maintained and deepened during the workshops of the Phase 2 just as through informal and continuous communication

outside of the workshops. All the stakeholders were extremely receptive and amiable and satisfied that their involvement in project was accepted and appreciated.
The stakeholders in the Municipality of Kula Norinska, who are directly influenced by such a policy are: local government, regional nature protection agency, farmers, citizens that use wetlands resources, tourism sector, environmental agencies (NGOs). All the named stakeholders agreed to participate in the CLIMAAX-related meetings.
The organigram (Fig. 2-1) shows connections among various stakeholders. While the local and regional governments are determined to enforce the laws and regulations regarding the climate change adaptation and mitigation policy (with regional government in addition to being responsible for implementation of nature protection policy) other stakeholders currently have less responsibility in the process. Farmers, individuals who use local nature resources and tourism developers have their concerns about the nature resource use in the Municipality. The three stakeholders have certain power in their hands since it is them who have decisive words in the democratic process of electing the local government. Environmentalists are in much different position than other three stakeholders because their influence on local electorate is minimal. At the same time, their impact on the implementation on climate change adaptation policy is also very small since the environmental movement in the Municipality has extremely limited political power. Our wish is to democratize the interaction among the stakeholders, their involvement in the process and to introduce the participatory model in the policies that address the climate change mitigation and adaptation just as the wetlands conservation. There are two principles that is necessary to take into consideration and adjust in the future stakeholders' involvement process:

- Respect the legislative frame when dealing with wetlands conservation and climate change policies since the local and the regional government are officially in charge of implementation of such policies.
- Innovate the current approach to these issues since the current model lacks efficiency especially when dealing with human-induced fires in the wetlands.

As a possible solution we propose introduction of a consortium that would involve representatives of all the local stakeholders. It should be an entity with an advisory role and would allow the local stakeholders to interact regarding the wetlands conservation and implementation of the climate change policy.

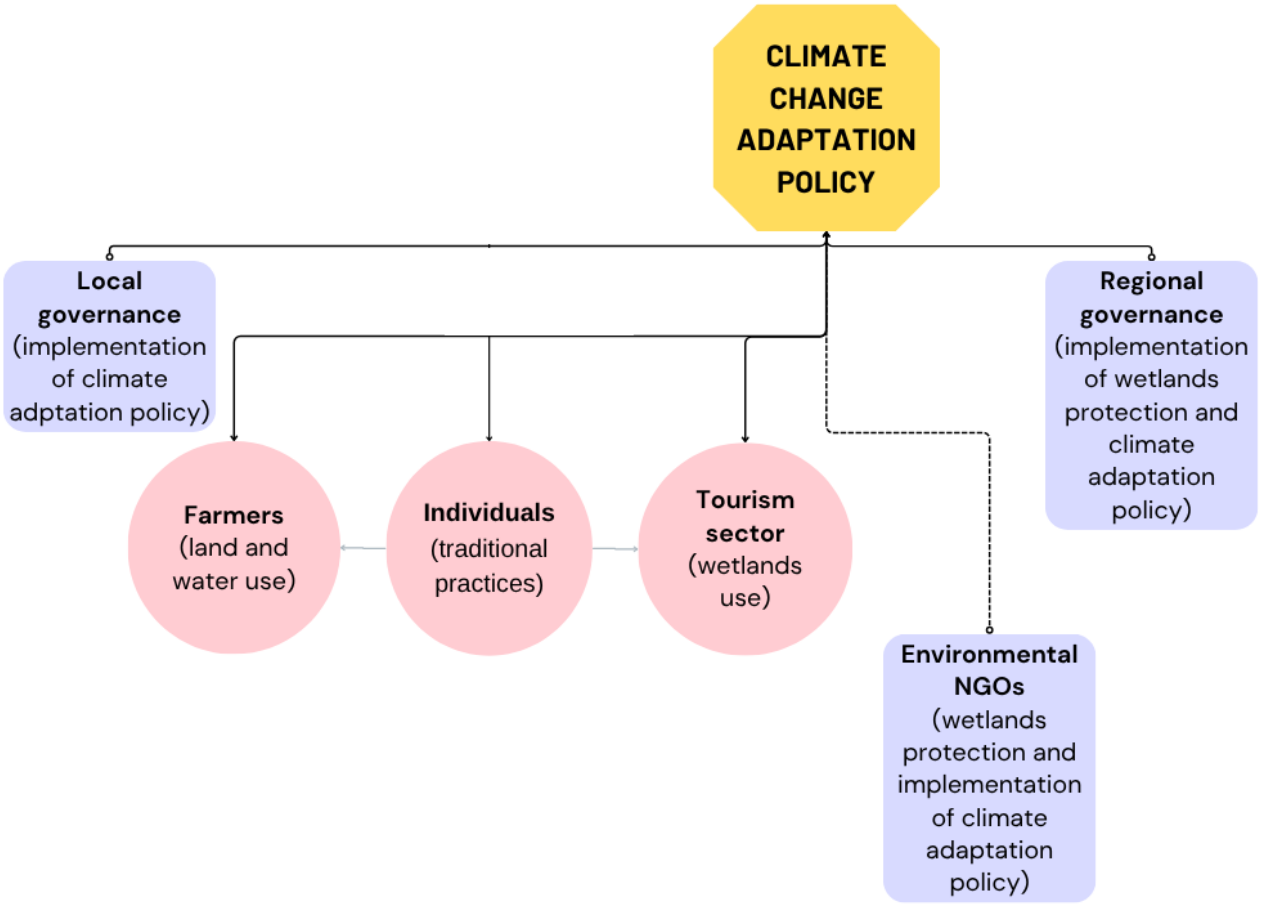


Fig 2-1 Current model of interrelation among stakeholders in the process of implementation of climate adaptation policy in the Municipality of Kula Norinska

Responsibility for the identification, assessment and mitigation of specific risks is on the national level and is legally distributed among various ministries and agencies, coordinated by the national government and the Ministry of Interior Affairs. Under the Ministry's jurisdiction is the central government body, Civil Protection Directorate, that deals with disaster (earthquakes, floods, wildfires) risk reduction. Their actions are proscribed by the Croatian Disaster Risk Reduction Platform that develop and coordinates strategies aiming to risk reduction and unites various stakeholders to mitigate risks from natural and human-induced disasters. The Platform defines National Risk Assessment that proscribes cooperation of various government bodies on national, regional and local levels with operational forces such as firefighters and the Red Cross.

According to the Croatia legislative frame relevant official representatives for of known vulnerable groups are various governmental bodies such as Ministry of Agriculture, Forestry and Water Management for farmers (vulnerable to droughts), Ministry of Tourism and Sport together with Croatian Tourism Board and local municipalities for tourism sector (vulnerable to wildfires) and environmental agencies (NGOs) that address environmental hazards while at the same time advocating for sustainable environmental policy. It important to mention various local NGOs that focus on environmental issues, vulnerable groups (such as elderly population and people with special needs) and traditional activities (such as farming and fishing).

Information available regarding the level of risk that is acceptable or tolerable to the Municipality of Kula Norinska, just as other Croatian municipalities, is primarily defined by national strategic documents that do not proscribe local quantitative thresholds. The most important document is Climate Change Adaptation Strategy of the Republic of Croatia that defines acceptable risk through ensuring social, economic and environmental stability. The Strategy is based on two climate change scenarios: RCP 4.5 (intermediate) and RCP 8.5 (worst-case climate change). On the other hand, tolerable risk is understood as an ability of managing the impacts of these scenarios regarding the food production (agriculture), water resources management, forestry, tourism and energy production.

2.1.4 Application of principles

The CLIMAAX Framework proscribes key principles that are crucial to comprehensive CRA approach that aims to be fair, robust and prudent.
The implementation of these principles is strongly connected to participatory multi-stakeholder process. In this section we will explain how we have incorporated these principles into our CRA for the Municipality of Kula Norinska.
Social justice, equity, inclusivity is a first group of interconnected principles concerned about reducing the unequal burden of climate risks as well as ensuring equity in the distribution of benefits and burdens of climate change adaptation and mitigation policies. Since the Municipality of Kula Norinska is predominantly rural area with no natural resources of economic development and growth there is no significant social stratification among the local population. There is a very small group of service sector employees that work in small shops, catering facilities, education (elementary school) and local administration is in the very Municipality. On the other hand, majority of population commutes to nearby Metković, the principal urban settlement in the Neretva Delta, and use farming as an additional source of income. Parcels of arable land are extremely small and can be found on the edge of the wetlands and in the karstic valleys. It is a predominantly low-scale agricultural production where majority of crops is used for local households with only small part of crops (almost exclusively mandarin oranges) being sold on market. Such economic realities result in a pretty even social structure of a closely-knit communities with no significant economic stratification and the burden of climate risks is pretty evenly distributed in the Municipality across the activities practiced by a vast majority of population: farming, fishing, tourism and catering. Therefore, we focused on including individuals from various economic sectors of the local population together with representatives of organisations that care about elderly and disabled. To accomplish such a goal, we involved the local government as an official representative of municipal inhabitants and various NGOs as an unofficial one (the only exception was regional nature protection agency that is a body of a regional government). This concept was applied in order to achieve different dimensions of just resilience: distributional justice (the fair allocation of burdens), procedural justice (fair, transparent and inclusive decision-making) and recognitional justice (respect of diverse values and perspectives).
Quality, rigour, transparency have been applied in order to guarantee applicability of the CRA, its comparability with other similar documents, validation and standardisation. Application of official climate data collected by the authorized agencies and programmes (such as *Copernicus*) provide us with rigorous and transparent results.

Precautionary approach is a necessary component of the multifunctional research process that involves societal dimension. Complex and changing conditions, together with uncertain and evolutive elements of the social structure push researches towards minimizing those impacts and factors. Therefore, continuous and repeated consultations with stakeholders were done to avoid getting the inaccurate conclusions.

2.1.5 Stakeholder engagement

Our engagement with stakeholders, experts and priority groups in the Municipality was established during our previous scientific research in the Neretva Delta (Glamuzina 2005; Glamuzina 2018; Bukvić and Glamuzina 2026) and maintained through the time. Our personal contacts, friendship and family ties allowed us to recognize the relevant stakeholders and to access them promptly and easily. Initial contacts were established with local government and deepened during frequent meetings. Other stakeholders were engaged through workshops and unofficial meetings where we got their feedback on the climate change and hazards in the Delta. These meetings started from the beginning of the project and we plan to continue with them until its ending. All the stakeholders involved in the process participated in two workshops in October of 2025 and March 2026.

The participants in the meetings/surveys were coming from official and unofficial sectors of the Municipality. The official was represented by the local government and regional nature protection agency while the unofficial consists of various NGOs concerned with agriculture and traditional activities just individuals form tourism/catering sector.

We used workshops as the principal way to **communicate the project goals and intermediate results** because we wanted to give opportunity to each stakeholder to voice their views, concerns and attitudes. Our communication with stakeholders did not stop on workshops but was further expanded during our informal separate mutual meetings.

Regarding the way how our results were received by participants we cannot do anything else but express our surprise because we expected some dissonant voices and attitudes based on our previous research and knowledge about the area. On the contrary, the results were received with interest, a positive reaction and extremely constructive feedback. It is obvious that stakeholders are more and more aware of the climate change issues, especially during the warm season. On the other hand, various organisations and individuals show are very sensitive concerning various environmental issues and ways of saving the natural values and economic activities for the future generations. A significant part of them expressed a wish to maintain the local nature and a way of life as a means of recognition the EU.

The project outcomes will be presented and served to the participants for further use in climate change adaptation and mitigation projects, programmes and policies. We expressed our preparedness to provide them with our scientific and project application expertise. By now we did not get any feedback from them regarding their further plans except for the local government that is interested to continue with similar projects, especially on the European level, in the future.

We encountered some difficulties during our work in the field of availability of specific climate data for such a small rural area that we needed for maps, diagrams and further hazards/risks analyses.

2.2 Risk Exploration

Risk exploration starts with a broad screening of the risks (their underlying hazards, exposures and vulnerabilities) that are most apparent or of significant concern to key stakeholders and the wider public.

Phase 1 identified farming, tourism and protected wetlands as priority receptors and highlighted drought and wildfire as the main hazards. Stakeholders reported that many wetland fires are linked to human activity and that their environmental consequences are severe. Phase 2 retains those concerns as local context while using climate, exposure and burned-area datasets for the quantitative assessment.

2.2.2 Screen risks (selection of main hazards)

Phase 1 screening and stakeholder consultation identified wildfire and drought as priority hazards for Kula Norinska. Phase 2 treats drought conditions as a factor that can increase fuel dryness and fire-conducive weather, while ignition is analysed separately; the quantitative basis is documented in Sections 2.2.3 and 2.3.

Phase 1 stakeholder consultation and nearby-station context identified severe summer drought and anthropogenic wetland fires as local priorities. The DHMZ Metković record is retained as contextual evidence only and is not used in the Phase 2 calculations; the observed and projected quantitative inputs are documented in Section 2.2.3 and Table 2-1.

Wildfires and drought are the two priority hazards identified through the Phase 1 screening and stakeholder consultation. Fire-conducive weather can increase fuel dryness, while ignition in the local record is reported mainly as anthropogenic. The local evidence does not establish spontaneous reed ignition as a measured process.
Drought affects agriculture, freshwater-dependent habitats and other wetland receptors during the warm season. The drought–wildfire relationship is interpreted through fire-conducive weather and fuel dryness; this report does not infer ignition cause from drought. Settlement-level results and limitations are presented in Sections 2.3.1 and 2.3.2.
Settlement differences are assessed from the reproducible hazard, exposure and vulnerability datasets documented in Sections 2.2.3 and 2.3. The absence of a major reported fire in one season is not used to infer long-term wildfire hazard or risk.

The assessment focuses on drought and wildfire because stakeholder consultation and the screening process identified their effects on agriculture, wetlands, biodiversity and local livelihoods as locally significant. Quantitative climate evidence used in this report is documented in Section 2.2.3 and Table 2-1.

Stakeholder consultation supplies contextual evidence on locally significant effects, while the measured and modelled findings use the datasets, periods and methods documented in Table 2-1 and the two data-overview tables.

Stakeholder interviews provide local context for hazard selection and impact pathways. Quantitative conclusions are based on the registered climate, exposure and vulnerability datasets described in Sections 2.2.3 and 2.3.

2.2.3 Choose Scenario

Observed precipitation and air-temperature changes were calculated from 19 ERA5-Land grid points supplied by the Copernicus Climate Change Service and accessed through Open-Meteo. The precipitation series combines the 1991–2024 record with a 1980-08–1990-12 ERA5-Land backfill that was bit-identical to the legacy ERA5-Land archive at all four shared validation points; the evaluation period 1991–2024 is compared with the 1981–2010 reference (Annex B). DHMZ station records used as contextual evidence in Phase 1 were not used to calculate the Section 2.2.3 changes, SPI-6 outputs or future maps, and no national climate-projection dataset contributes to the quantitative results in this section. Drought projections use CHELSA V2.1 downscaled CMIP6 monthly climatologies at approximately 1 km for five GCMs (GFDL-ESM4, IPSL-CM6A-LR, MPI-ESM1-2-HR, MRI-ESM2-0 and UKESM1-0-LL; r1i1p1f1) under SSP1-2.6, SSP3-7.0 and SSP5-8.5 for 2011–2040, 2041–2070 and 2071–2100 (Annex B).

CHELSA climatologies are long-term means rather than independent monthly weather sequences. The delta method constructs synthetic future precipitation series by applying scenario-specific monthly change factors to the observed 1981–2010 sequence, after which the same frozen 1981–2010 SPI-6 calibration is applied to the reference, evaluation and future series (Annex B). Wildfire projections use the Copernicus CDS product sis-tourism-fire-danger-indicators, a CMIP5 multi-model ensemble-mean Fire Weather Index for the historical period 1981–2005 and RCP2.6, RCP4.5 and RCP8.5 for 2021–2040, 2041–2060 and 2071–2098 (Annex B). CDS is the data-distribution service, whereas RCP identifies the source product's forcing pathway. The drought SSPs and wildfire RCPs are retained as the native scenario families of their respective products; the assessment does not convert, equate or pair individual SSP and RCP pathways and compares them only as separate lower-to-higher forcing brackets.

The inherited warming, precipitation-day and relative-humidity figures that lacked a reproducible dataset, model, member, scenario, baseline or calculation were removed. Socio-economic change is described qualitatively, and all future calculations hold present-day exposure and vulnerability constant. The resulting maps therefore isolate conditional changes in climate hazard and do not represent projections of future population, land use, irrigation, vulnerability or monetary loss (Annex B).

Table 2-1 Climate projection provenance and computed regional changes

Variable / evidence	Dataset, model and spatial support	Baseline, scenario and horizon	Computed result, method and limitation
Mean monthly precipitation (mm/month), observed evaluation	ERA5-Land, Copernicus C3S; monthly 1980–2024; 0.1° grid, 19 points; month-length weighted mean	reference 1981–2010; evaluation 1991–2024	annual climatological mean 122.53 → 124.04 mm/month (1.51 mm/month, 1.20%); JJA climatological mean 55.20 → 55.08 mm/month (-0.20%). 1980-08–1990-12 precipitation backfill splice validated bit-identical at 4 shared legacy points (Annex B)

Variable / evidence	Dataset, model and spatial support	Baseline, scenario and horizon	Computed result, method and limitation
Air temperature (°C), observed evaluation	ERA5-Land, Copernicus C3S; monthly 1980–2024; 0.1° grid, 19 points; month-length weighted mean	reference 1981–2010; evaluation 1991–2024	annual 13.25 → 13.94 °C (+0.69 °C); JJA +0.99 °C. ERA5-Land daily means aggregated to monthly values for 1980-01–2024-12; DHMZ station records were not used in this calculation (Annex B)
Precipitation (ratio to reference), projections	CHELSA V2.1 CMIP6 downscaled monthly, ~1 km; 5-GCM ensemble mean (GFDL-ESM4, IPSL-CM6A-LR, MPI-ESM1-2-HR, MRI-ESM2-0, UKESM1-0-LL; members r1i1p1f1); point extraction at 19 canonical locations	SSP1-2.6 / SSP3-7.0 / SSP5-8.5 × 2011–2040 / 2041–2070 / 2071–2100	annual SSP5-8.5 ff 0.8888 (-11%); SSP3-7.0 ff 0.9416; SSP1-2.6 ff 0.9966; JJA SSP5-8.5 ff 0.7581 (-24%), SSP1-2.6 ff 0.8934. delta method: synthetic future series = transformed 1981–2010 observed sequence; frozen SPI calibration
Air temperature (Δ vs reference, °C), projections	CHELSA V2.1 CMIP6 downscaled monthly, ~1 km; 5-GCM ensemble mean (GFDL-ESM4, IPSL-CM6A-LR, MPI-ESM1-2-HR, MRI-ESM2-0, UKESM1-0-LL; members r1i1p1f1); point extraction at 19 canonical locations	SSP1-2.6 / SSP3-7.0 / SSP5-8.5 × 2011–2040 / 2041–2070 / 2071–2100	annual ΔT: SSP1-2.6 +1.43 / +2.00 / +1.98; SSP3-7.0 +1.37 / +2.82 / +4.42; SSP5-8.5 +1.35 / +3.16 / +5.39 (2011–2040 / 2041–2070 / 2071–2100). delta method: synthetic future series = transformed 1981–2010 observed sequence; frozen SPI calibration; per-GCM min/max in Annex B
Fire Weather Index, June–August mean	Copernicus C3S/CDS sis-tourism-fire-danger-indicators; CMIP5 multi-model ensemble mean; source grid transformed to a 500 m EPSG:3765 analysis grid for settlement and receptor-weighted extraction	historical 1981–2005; RCP2.6 / RCP4.5 / RCP8.5 × 2021–2040 / 2041–2060 / 2071–2098	settlement-area mean 28.82–29.44 historically; 42.12–42.96 under RCP8.5 in 2071–2098. CDS is the distribution service and RCP is the product-native scenario family; the 500 m analysis grid does not imply 500 m source information; product ends in 2098

The key regional signals are: continued warming in all scenarios and horizons (annual ensemble-mean ΔT of +1.43/+2.00/+1.98 °C under SSP1-2.6, +1.37/+2.82/+4.42 °C under SSP3-7.0 and +1.35/+3.16/+5.39 °C under SSP5-8.5 for 2011–2040/2041–2070/2071–2100); a strong summer-drying signal (JJA precipitation ratio 0.758, i.e. −24%, under SSP5-8.5 in 2071–2100; 0.893 under SSP1-2.6); and an annual precipitation reduction confined to the higher-emission scenarios (annual ratio 0.889, −11%, SSP5-8.5 far future; 0.942 SSP3-7.0; 0.997 SSP1-2.6). Per-GCM minima/maxima and the full delta tables are provided in Annex B.

2.3 Regionalized Risk Analysis

The regionalised assessment follows the CLIMAAX climate-risk framework and the scientific convention that risk depends on hazard (H), exposure (E) and vulnerability (V). For endpoints with a defensible vulnerability indicator, the relative index is R = H × E × V. Where no defensible settlement-

level vulnerability data exist, the reported quantity is explicitly limited to hazard-weighted exposure, H × E, and is not presented as complete risk. All calculations use the same nine official settlement polygons, spatial processing in HTRS96/TM (EPSG:3765), fixed present-day exposure, and documented reference periods. Annex B contains the result tables, validation evidence, field definitions, data catalogue and checksums; Annex A contains the complete map series.

Reproducible calculation sequence

1. Use the nine official settlement polygons as the common reporting units; validate geometry and transform all area and distance operations to EPSG:3765.

2. Calculate drought and wildfire hazard with the fixed baselines, periods, thresholds and spatial aggregation rules stated below. Do not mix SSP drought cases with RCP wildfire cases.

3. Derive present-day receptor quantities from GHS-POP, GHS-BUILT-S and CORINE 2018. Calculate agricultural sensitivity from available water capacity and irrigated share. Keep receptor quantities out of vulnerability to avoid double-counting.

4. Apply the stated min–max transformation using the frozen nine-settlement bounds. Calculate H × E for endpoints without vulnerability and H × E × V only for agricultural drought.

5. Reproduce settlement tables, scenario differences and ranks from the unrounded component values. Compare maps only within the same hazard and endpoint because drought and wildfire hazard scales are different.

6. Verify the results against the validation statistics, record any software or source-version differences, and use the SHA-256 catalogue in Annex B to confirm that the packaged inputs are unchanged.

2.3.1 Hazard #1 - fine-tuning to local context

Table 2-2 Data overview workflow #1 – drought (SPI-6 composite; method version 1.1.0)

Hazard data	Vulnerability data	Exposure data	Impact metrics/Risk output
Historical monthly precipitation at 19 ERA5-Land grid points (1980–2024; 1980-08–1990-12 backfill validated bit-identically at shared legacy points); SPI-6 fitted per calendar month with a frozen 1981–2010 gamma calibration; H = 0.5 × frequency + 0.5 × severity, anchored at H_ref = 0.8612; IDW interpolation to nine settlements.	Agricultural drought vulnerability only: V = 0.5 × (1 − minmax AWC) + 0.5 × (1 − minmax irrigated share). AWC is OpenLandMap available water capacity summed over 0–200 cm (mm, 250 m, doi:10.5281/zenodo.2629149); irrigation is the GAEZ v5 LR-IRR share of cropland equipped for irrigation (~1 km, reference year 2015). People have no defensible V and are reported as H×E.	People use the area-weighted GHS-POP E2020 R2023A resident sum per settlement (42.01–258.63 before normalisation). Agriculture uses CORINE 2018 class 2xx area (0–290.53 ha). The dissolved Natura 2000, Ramsar and national protected-area union totals 3,382.50 ha and is reported separately as an ecological receptor.	Settlement-level H, E, V and R for reference 1981–2010, evaluation 1991–2024 and SSP1-2.6/3-7.0/5-8.5 × 2011–2040/2041–2070/2071–2100; five-GCM ensemble means and spread are recorded in Annex B .

Hazard data	Vulnerability data	Exposure data	Impact metrics/Risk output
CHELSA V2.1 CMIP6 monthly precipitation at ~1 km for five GCMs (GFDL-ESM4, IPSL-CM6A-LR, MPI-ESM1-2-HR, MRI-ESM2-0 and UKESM1-0-LL; r1i1p1f1); synthetic future series use the observed 1981–2010 sequence transformed by monthly scenario deltas and the same frozen SPI-6 calibration.	Present-day (2020-era) exposure and vulnerability held constant in all future rows; no socio-economic projections were modelled.	The GHS-POP and CORINE 2018 exposure layers are held constant across scenarios.	Future drought hazard-weighted exposure (people) and full R (agriculture) per scenario; deltas against the reference baseline; 5-GCM spread and rank agreement reported.

2.3.1.1 Hazard assessment

Drought hazard follows the CLIMAAX drought workflow and the WMO Standardized Precipitation Index guidance. At each of 19 ERA5-Land grid points, monthly precipitation is accumulated over six months. A gamma distribution is fitted separately for each calendar month using 1981–2010, including an empirical correction for zero precipitation. Those fitted parameters are then kept fixed when calculating SPI-6 for the reference, 1991–2024 evaluation and synthetic future series. A drought month is one with SPI-6 below −1. Frequency is the fraction of valid months below −1, and severity is the mean absolute SPI-6 value during those months. The point hazard is Hraw = 0.5 × frequency + 0.5 × severity and H = Hraw / 0.8612, where 0.8612 is the 1981–2010 mean composite across the 19 points. H is therefore a relative index and is not a probability. Point values are transferred to settlement centroids by inverse-distance weighting using all 19 points, distances in EPSG:3765 and power 2. The SPI implementation was checked against xclim 0.62.0 at every point (Pearson r = 1.0000; maximum absolute difference 0.000), and the pre-1991 precipitation splice was identical to the overlapping legacy record at four independent shared points (Annex B).

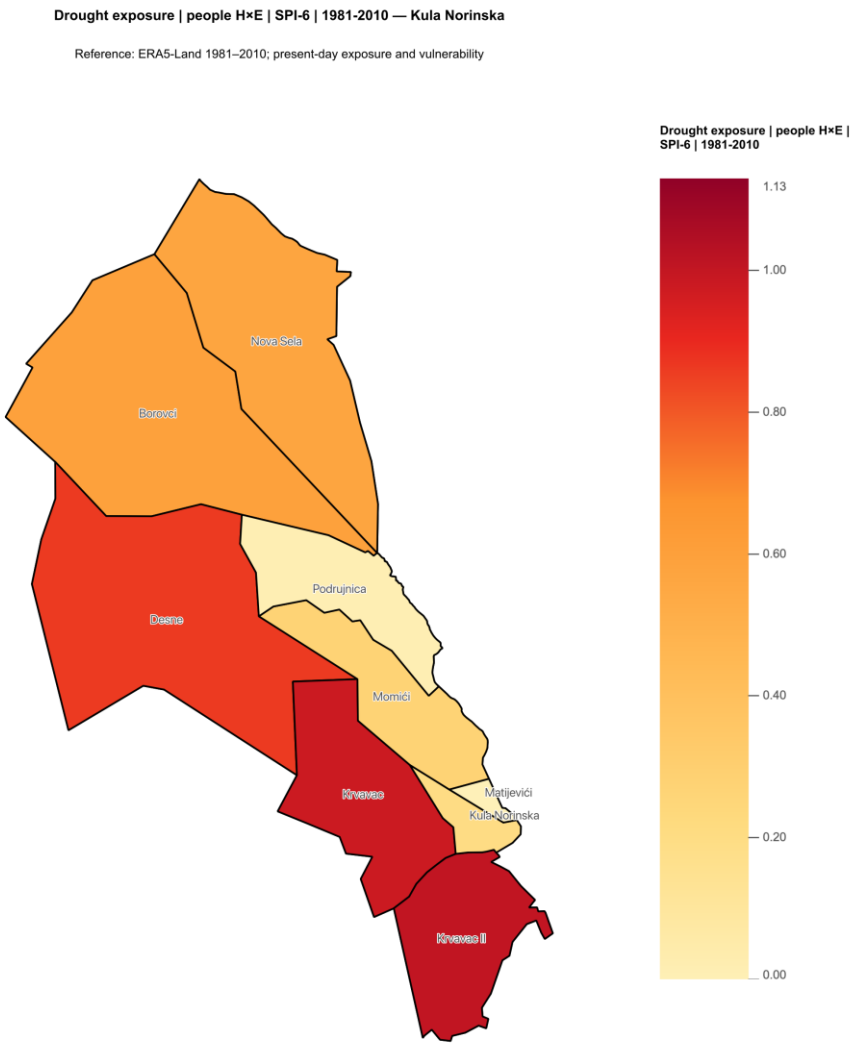


Fig 2-4 Drought hazard-weighted exposure – people (H×E, SPI-6, observed, reference 1981–2010).

Reference-period drought hazard varies only from H = 1.0041 to 1.0117, while normalised population exposure spans 0.0000–1.0000; the mapped contrast therefore reflects resident mass more strongly than local hazard variation (Table 2-3; Annex B). Krvavac II has the highest H×E value (1.0041) because its exposure is the relative maximum, whereas Matijevići has H×E = 0 because its exposure is the relative minimum (Annex B). The zero value is an effect of nine-settlement min–max scaling and does not indicate absence of residents or drought hazard.

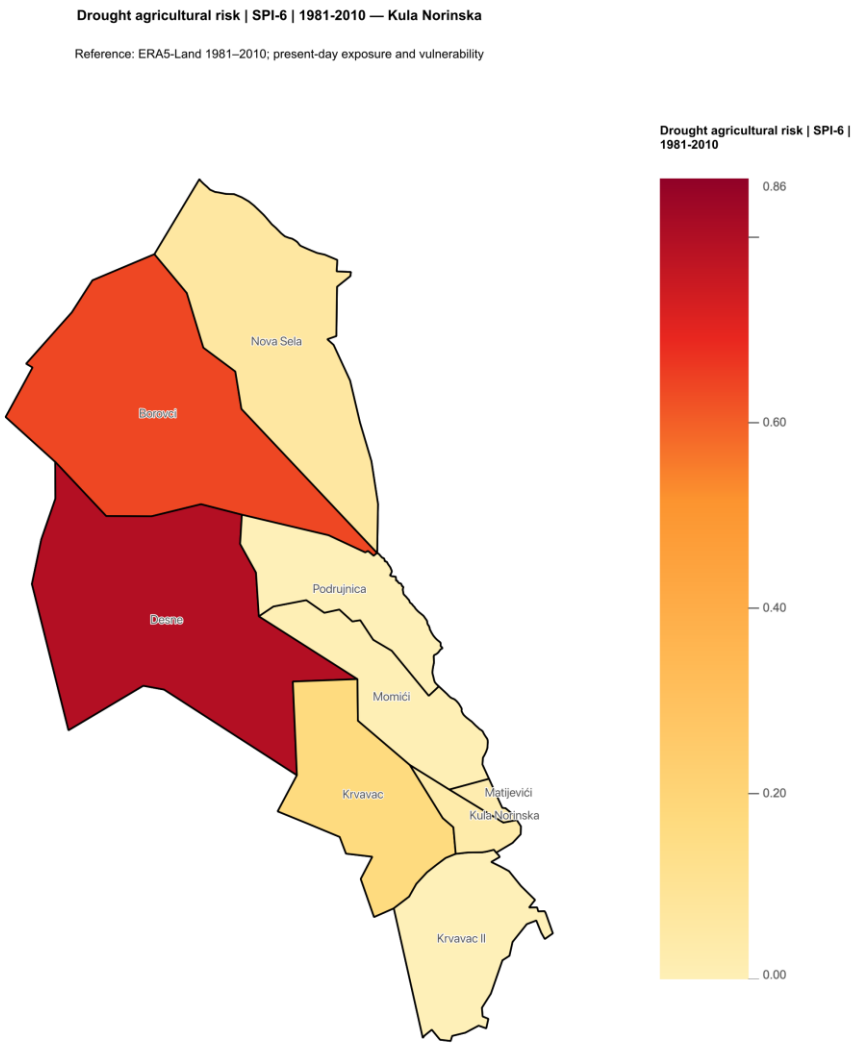


Fig 2-5 Relative drought risk – agriculture (R = H×E×V, SPI-6, observed, reference 1981–2010).

Desne has the highest reference agricultural drought risk (R = 0.7922), combining H = 1.0117, agricultural exposure E = 0.8680 and vulnerability V = 0.9021; its available water capacity of 222.8 mm is the lowest among the nine settlements (Table 2-3; Annex B). Podrujnica has the highest vulnerability (V = 0.9380) but its agricultural exposure is the relative minimum (E = 0), so its calculated R is also zero. Krvavac II has maximum agricultural exposure but V = 0 because its soil-water capacity and irrigated share define the relative minima in sensitivity; this normalised value does not imply invulnerability (Annex B).

Reference-period hazard (1981–2010) is nearly uniform (H = 1.0041–1.0117), with the maximum at Desne (1.0117); in the observed evaluation period (1991–2024) hazard is slightly lower (H = 0.9470–0.9896). Because the composite is deliberately anchored and min–max normalised within the study area, these values are relative ranks within the nine settlements, not absolute drought probabilities. Future hazard uses the same SPI-6 and frozen calibration on CHELSA delta-method synthetic series (Section 2.2.3) for the 5-GCM ensemble mean, with per-GCM spread retained in the released tables.

The drought hazard and receptor-weighted results have different spatial maxima because the hazard is derived from precipitation anomalies, while H×E and R also include the spatial distribution of receptors. Desne has the highest reference hazard (H = 1.0117), but Krvavac II has the largest area-weighted resident population (258.6) and therefore ranks first in hazard-weighted exposure for people (H×E = 1.0041; Table 2-3; Annex B). Agricultural risk follows a different pattern because it combines agricultural area with the available-water-capacity and irrigation vulnerability term. The complete component and scenario map series is provided in Annex A.

2.3.1.2 Risk assessment

For every settlement j, min–max normalisation is N(xj) = (xj − xmin) / (xmax − xmin), using the minimum and maximum across the same nine settlements and keeping those bounds fixed for all periods. Population exposure is Epeople = N(area-weighted GHS-POP resident sum), calculated with 25 m sub-cell coverage fractions; agricultural exposure is Eagriculture = N(CORINE 2018 class-2xx area). Agricultural drought vulnerability is Vagriculture = 0.5 × [1 − N(AWC)] + 0.5 × [1 − N(irrigated share)]. AWC is the OpenLandMap 0–200 cm available-water-capacity total and irrigated share is GAEZ v5 LR-IRR. Agricultural drought risk is R = H × Eagriculture × Vagriculture. Population headcount is used only in exposure; using it again in vulnerability would double-count the same receptor. Because settlement-level age, health, income, water-access and coping-capacity variables were not integrated, the people endpoint is H × Epeople. A normalised zero means the relative minimum among these nine settlements, not absence of people, agriculture, sensitivity or hazard. Input ranges, unrounded components and sensitivity tests are provided in Annex B.

No defensible settlement-level sensitivity dataset was available for people; drought results for this endpoint are therefore reported as hazard-weighted exposure (H×E) rather than complete risk. Min–max normalisation assigns zero to the least-exposed or least-sensitive settlement within the nine-settlement comparison. Krvavac II consequently has agricultural V = 0 as the relative sensitivity minimum, and Matijevići has people E = 0 as the relative exposure minimum; neither value indicates absence of vulnerability, residents or drought hazard (Annex B).

Table 2-3 Drought hazard, hazard-weighted exposure and agricultural risk by settlement (SPI-6 composite, method v1.1.0; ranks are relative within the nine study settlements)

Settlement	H (reference 1981–2010)	H×E people (reference)	H×E people (SSP5-8.5, 2071–2100)	Δ(H×E) people (SSP5-8.5 ff)	R agriculture (reference)	R agriculture (SSP5-8.5, 2071–2100)
Borovci	1.009	0.5997	0.6619	+0.0622	0.6346	0.7004
Desne	1.0117	0.862	0.931	+0.0690	0.7922	0.8556
Krvavac	1.0076	0.9746	1.0705	+0.0959	0.1723	0.1893
Krvavac II	1.0041	1.0041	1.1156	+0.1115	0	0

Settlement	H (reference 1981–2010)	H×E people (reference)	H×E people (SSP5-8.5, 2071–2100)	Δ(H×E) people (SSP5-8.5 ff)	R agriculture (reference)	R agriculture (SSP5-8.5, 2071–2100)
Kula Norinska	1.0048	0.2117	0.2347	+0.0230	0.041	0.0455
Momići	1.0078	0.2812	0.3087	+0.0275	0.0083	0.0092
Nova Sela	1.0098	0.5723	0.6365	+0.0642	0.0711	0.0791
Podrujnica	1.0092	0.0261	0.0286	+0.0025	0	0
Matijevići	1.0046	0	0	+0.0000	0.0296	0.0329

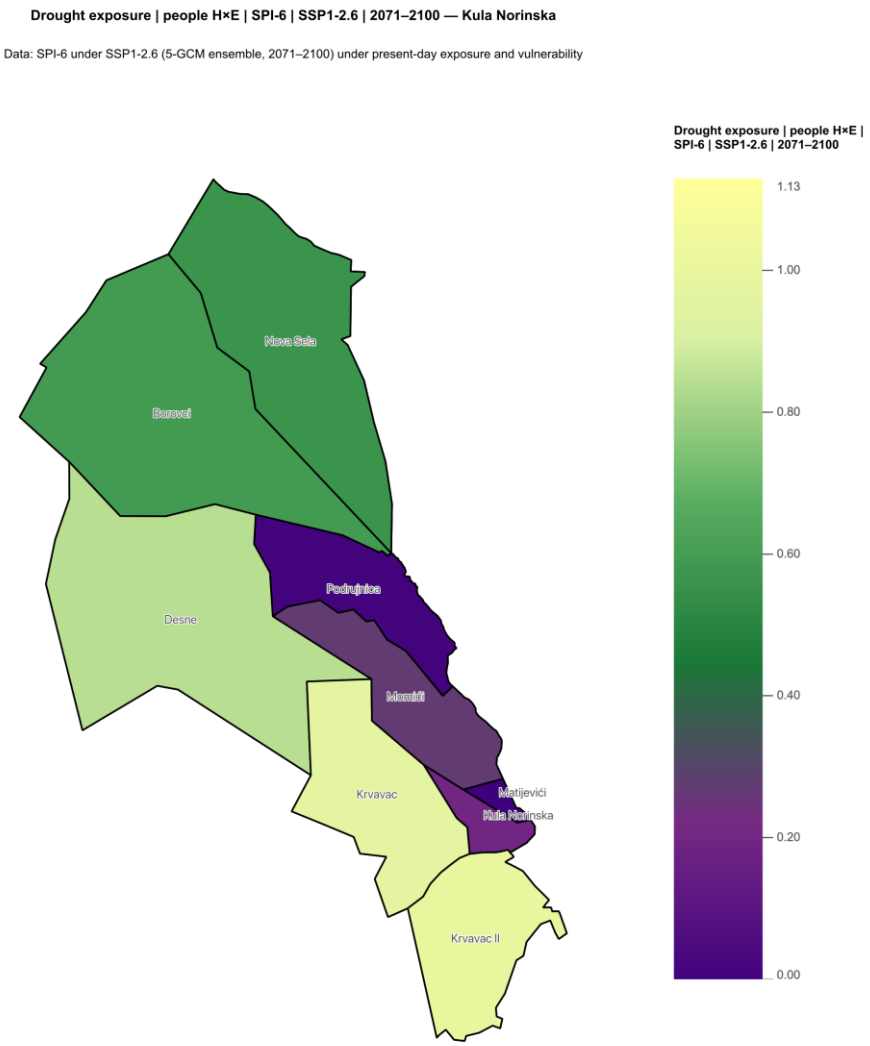


Fig 2-6 Drought hazard-weighted exposure – people (H×E, SPI-6, SSP1-2.6, 2071–2100; 5-GCM ensemble, present-day exposure).

Under SSP1-2.6 in 2071–2100, ensemble-mean changes in people H×E range from −0.0213 at Desne to 0.0000 at Matijevići, and no settlement increases relative to the reference period (Table 2-3; Annex B). The spatial ranking remains governed by the fixed present-day population exposure, so Krvavac II remains the highest H×E location despite the small negative climate increment. These conditional values do not include future population or vulnerability change (Annex B).

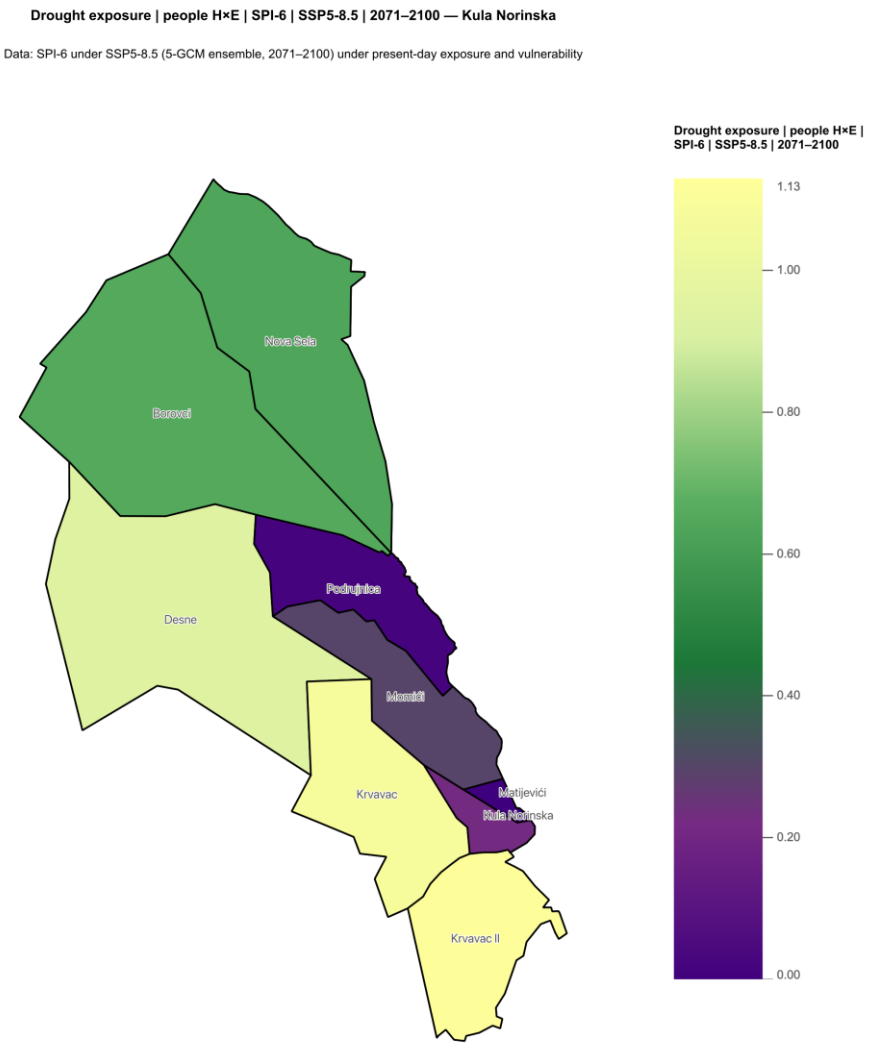


Fig 2-7 Drought hazard-weighted exposure – people (H×E, SPI-6, SSP5-8.5, 2071–2100; 5-GCM ensemble, present-day exposure).

Under SSP5-8.5 in 2071–2100, people H×E increases in every settlement with non-zero exposure; Krvavac II shows the largest increase, from 1.0041 to 1.1156 (Δ(H×E) = +0.1115), while Matijevići remains zero because its normalised exposure is fixed at the relative minimum (Table 2-3; Annex B). All ten pairwise GCM rank agreements equal 1.000, showing that the settlement ordering is stable across the five models. Because exposure is held constant, the increase represents the modelled climate-hazard contribution rather than demographic change (Annex B).

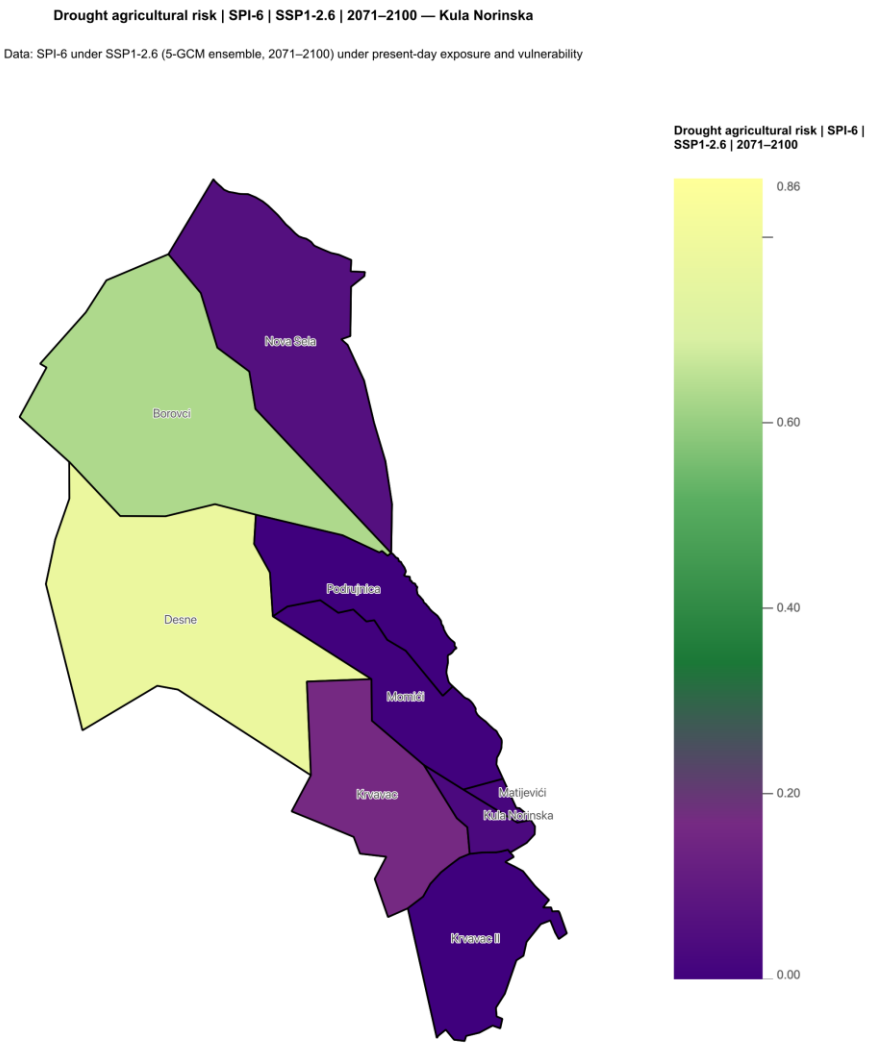


Fig 2-8 Relative drought risk – agriculture (R = H×E×V, SPI-6, SSP1-2.6, 2071–2100; present-day exposure and vulnerability).

Under SSP1-2.6 in 2071–2100, ensemble-mean agricultural ΔR is non-positive for all settlements, with the largest decrease at Desne (−0.0196) and unchanged zero values at settlements whose exposure or vulnerability is the relative minimum (Table 2-3; Annex B). The common numeric range used in Figures 2-8 and 2-9 permits direct comparison of the scenario magnitudes. Because agricultural exposure and vulnerability are fixed, this pattern reflects the drought-hazard response alone (Annex B).

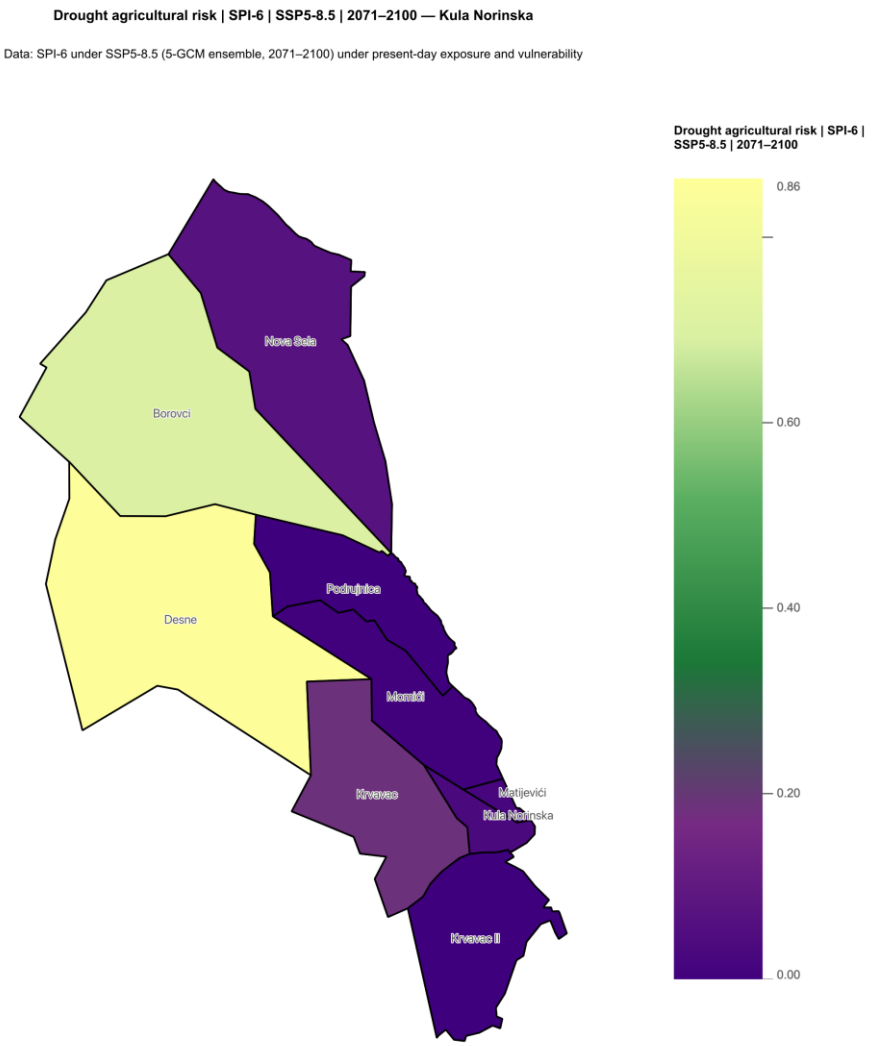


Fig 2-9 Relative drought risk – agriculture (R = H×E×V, SPI-6, SSP5-8.5, 2071–2100; present-day exposure and vulnerability).

Under SSP5-8.5 in 2071–2100, Borovci has the largest agricultural risk increase (ΔR = +0.0658, reaching 0.7004), while Desne remains the highest-risk settlement at R = 0.8556 (Table 2-3; Annex B). The difference between the largest increase and the highest final value reflects the combined effects of baseline hazard, agricultural exposure and vulnerability. Krvavac II remains at zero because its normalised vulnerability is the relative minimum, rather than because the settlement is invulnerable to drought (Annex B).

Under SSP5-8.5 in 2071–2100, hazard-weighted exposure for people increases at every settlement with non-zero exposure; Krvavac II has the largest increase, from 1.0041 to 1.1156 (Δ(H×E) = +0.1115), while agricultural risk reaches 0.8556 at Desne from a reference value of 0.7922 (Table 2-3). Under SSP1-2.6, ensemble-mean people Δ(H×E) ranges from 0.0000 to −0.0213, and no settlement increases. Figures 2-6–2-9 use fixed numeric ranges to compare the lower- and higher-forcing brackets for the far-future horizon. Annex A contains the complete 22-map drought series for the people and agriculture endpoints across the reference, evaluation and nine SSP–horizon combinations.

The reference drought-hazard range is narrow across settlements (H = 1.0041–1.0117), whereas normalised population exposure ranges from 0.0000 to 1.0000; consequently, the strong spatial contrast in the people maps primarily reflects where residents are concentrated rather than a similarly large local difference in precipitation hazard (Table 2-3; Annex B). Krvavac II is the highest people H×E location even though Desne has the highest reference hazard, while the agricultural pattern also reflects agricultural area and the AWC/irrigation vulnerability term defined in Annex B (OpenLandMap AWC, Hengl, 2018; GAEZ v5 LR-IRR, Mehta et al., 2024). Zero values for Matijevići people exposure, Podrujnica agricultural exposure and Krvavac II agricultural vulnerability denote the relative minimum produced by nine-settlement min–max scaling and do not demonstrate absence of people, agriculture, sensitivity or drought hazard. All future maps change climate hazard while holding present-day exposure and vulnerability fixed, so they compare conditional climate effects across SSPs without projecting future population, land use, irrigation or absolute losses (Table 2-2; Annex B).

2.3.2 Hazard #2 - finetuning to local context

Table 2-4 Data overview workflow #2 – wildfire (Fire Weather Index and FireCCI51 observations; method version 1.1.0)

Hazard data	Vulnerability data	Exposure data	Impact metrics/Risk output
Historical fire weather uses the CDS sis-tourism-fire-danger-indicators fwi-mean-jjas variable (June–August mean Fire Weather Index), CMIP5 multi-model ensemble, 1981–2005. Raw data were transformed to a 500 m EPSG:3765 analysis grid after legacy rasters were found to contain a 39% NaN artefact. FireCCI51 v5.1 monthly burned area covers 2001–2020 with 240/240 months complete.	No defensible settlement-level fire-specific sensitivity dataset was available; all wildfire endpoints are reported as hazard-weighted exposure H×E.	People: area-weighted GHS-POP E2020 R2023A resident sum. Assets: GHS-BUILT-S E2020 R2023A built-up hectares. Agriculture: CORINE 2018 classes 2xx area.	Receptor-mass-weighted FWI by settlement and H×E for people, assets and agriculture for 1981–2005 and RCP2.6/4.5/8.5 × 2021–2040/2041–2060/2071–2098; FireCCI51 burned-area statistics are reported by settlement in Table 2-5.

Hazard data	Vulnerability data	Exposure data	Impact metrics/Risk output
The same CDS ensemble product and construction are used for the historical period and every future case: 2021–2040, 2041–2060 and 2071–2098. The far-future period ends in 2098 because this is the final product year.	Present-day exposure held constant; no socio-economic projections were modelled.	The GHS-POP, GHS-BUILT-S and CORINE 2018 exposure layers are held constant across scenarios.	Future H×E is reported by scenario and endpoint with changes from the 1981–2005 baseline. Individual-GCM spread is unavailable because CDS distributes the selected indicator as a single ensemble-mean product.

2.3.2.1 Hazard assessment

The audited machine-learning susceptibility branch was excluded because its random-pixel validation was not spatially independent and its historical and future predictors mixed incompatible source families, resolutions and scenario systems. The released wildfire method instead uses the Copernicus Climate Data Store seasonal Fire Weather Index product for June–August. The same CMIP5 multi-model ensemble construction is used for 1981–2005 and RCP2.6, RCP4.5 and RCP8.5 projections for 2021–2040, 2041–2060 and 2071–2098. The rotated-pole source was transformed with NaN-aware bilinear interpolation to a 500 m EPSG:3765 processing grid; this grid spacing does not imply 500 m source information. For each receptor, settlement hazard is the receptor-mass-weighted mean $Hj = \Sigma(hk \times mk) / \Sigma mk$ over intersecting grid cells. Exposure is min–max-normalised population, built-up surface or agricultural area, and wildfire H × E is reported because no defensible fire-specific vulnerability term was available. FireCCI51 observations are an independent historical check: values 1–366 are treated as burned, 0 as observed unburned, −1 as unobserved and −2 as non-burnable; areas are calculated on the native 250 m grid. Fire-affected months are not interpreted as incident counts or fire intensity (Annex B).

The wildfire projections cover RCP2.6, RCP4.5 and RCP8.5 for 2021–2040, 2041–2060 and 2071–2098. The far-future window ends in 2098 because this is the last year available in the delivered product (Annex B). RCP labels are retained as the product-native CMIP5 pathways and are not converted to SSP labels. The assessment uses the distributed ensemble-mean product, so individual-GCM spread is unavailable for wildfire and uncertainty is reported as product-conditional.

FireCCI51 v5.1 monthly burned-area rasters provide a complete record for all 240 calendar months from 2001 through 2020; the earlier 225-month denominator resulted from missing downloads for 2007 and October–December 2019, which were recovered from the corrected source. A pixel is classified as burned when its Julian-day value exceeds zero. Cumulative burned area can include reburning, fire-affected months are not incident counts, and area per fire-affected month does not measure fire intensity or ecological burn severity (Annex B; Chuvieco et al., 2018).

Table 2-5 FireCCI51 burned-area observations by settlement, 2001–2020 (240/240 calendar months complete; cumulative area can include reburning and fire months are not incident counts)

Settlement	Months with detected burning	Cumulative burned area (ha)	Burned area per fire-affected month (ha)	Unique burned area (ha)
Borovci	5	532.78	106.56	432.58
Desne	4	341.72	85.43	323.50
Krvavac	1	442.07	442.07	442.07

Settlement	Months with detected burning	Cumulative burned area (ha)	Burned area per fire-affected month (ha)	Unique burned area (ha)
Krvavac II	5	661.17	132.23	314.62
Kula Norinska	1	50.14	50.14	50.14
Momići	2	255.19	127.59	255.19
Nova Sela	5	136.60	27.32	104.71
Podrujnica	6	291.54	48.59	227.76
Matijevići	1	13.67	13.67	13.67

Krvavac II shows the largest cumulative burned area (661.2 ha over 5 fire-affected months, 132.2 ha per fire-affected month); Krvavac burned 442.1 ha within a single fire-affected month; Borovci cumulated 532.8 ha over 5 months. These patterns merit investigation with fire-service records. Historical mean summer FWI is 28.8–29.4 across the nine settlements – raw FWI values of this magnitude correspond to the upper (extreme) FWI classes under standard interpretation tables, a class-interpretation caveat that is kept alongside the raw values.

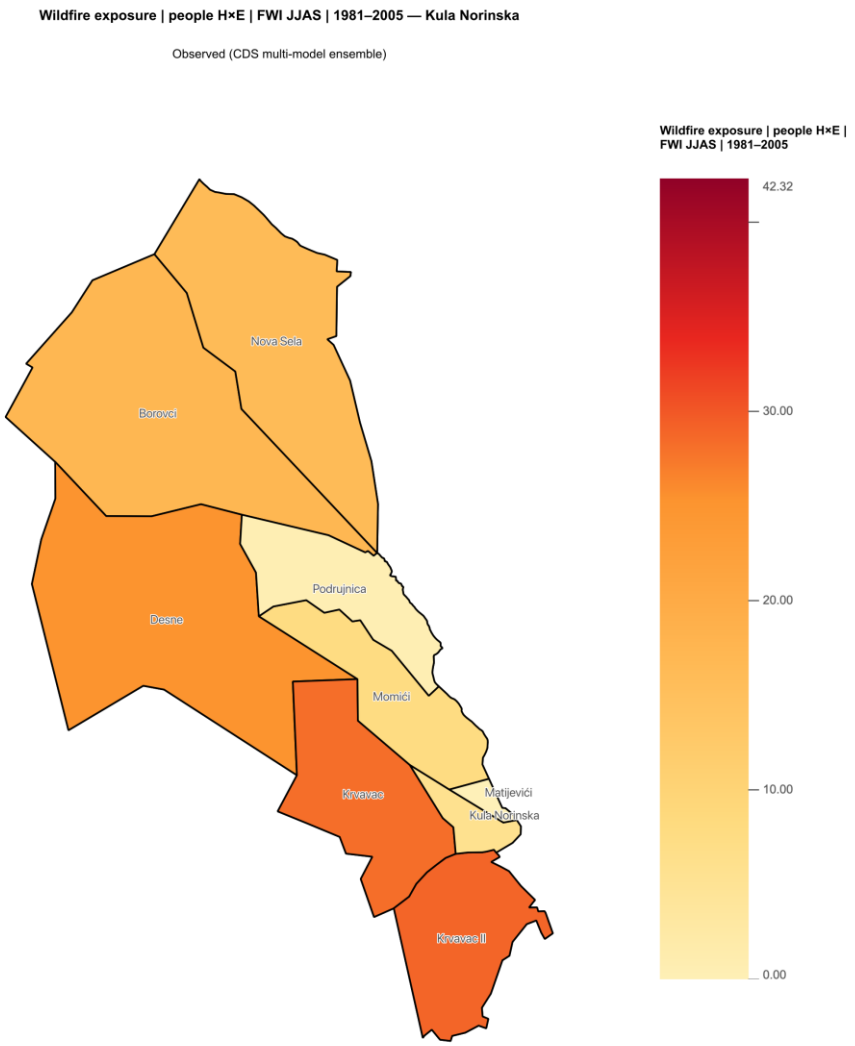


Fig 2-10 Wildfire hazard-weighted exposure – people (H×E, FWI JJAS, CDS multi-model ensemble, 1981–2005).

Historical receptor-weighted summer FWI varies narrowly from 28.89 to 29.50 across the nine settlements, while normalised population exposure spans 0.0000–1.0000; the mapped people H×E pattern therefore follows resident mass more strongly than local fire-weather variation (Table 2-6; Annex B). Krvavac II has the highest H×E value (29.00), while Desne has the highest receptor-weighted FWI (29.50). These FWI values fall within the upper fire-danger interpretation classes, but the continuous FWI value, rather than the ordinal class code, is used in H×E (Annex B).

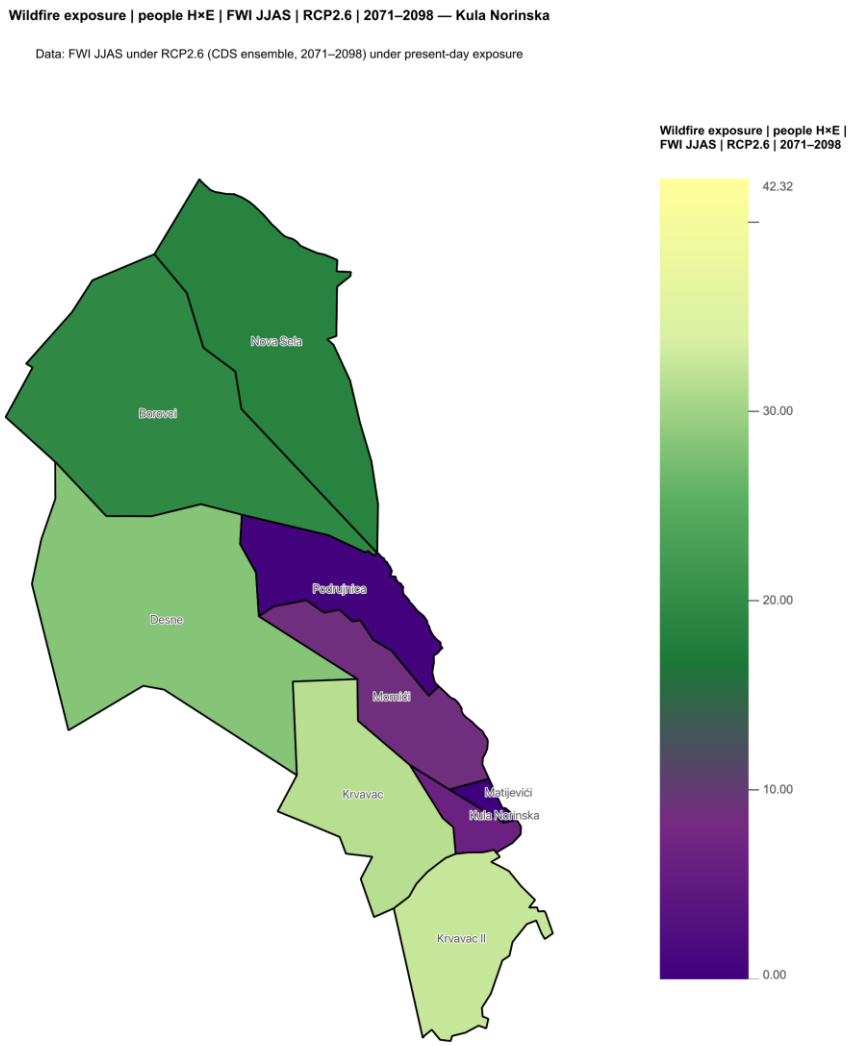


Fig 2-11 Wildfire hazard-weighted exposure – people (H×E, FWI JJAS, RCP2.6, 2071–2098; present-day exposure).

Under RCP2.6 in 2071–2098, Krvavac II remains the highest people H×E location and increases from 29.00 to 32.50 (Δ(H×E) = +3.50; Table 2-6; Annex B). The settlement-mean far-future FWI is 32.84, below the 2041–2060 mean of 35.06, so the lower-forcing pathway does not produce a monotonic increase through the three horizons (Annex B). The persistent spatial ranking reflects the use of fixed present-day population exposure.

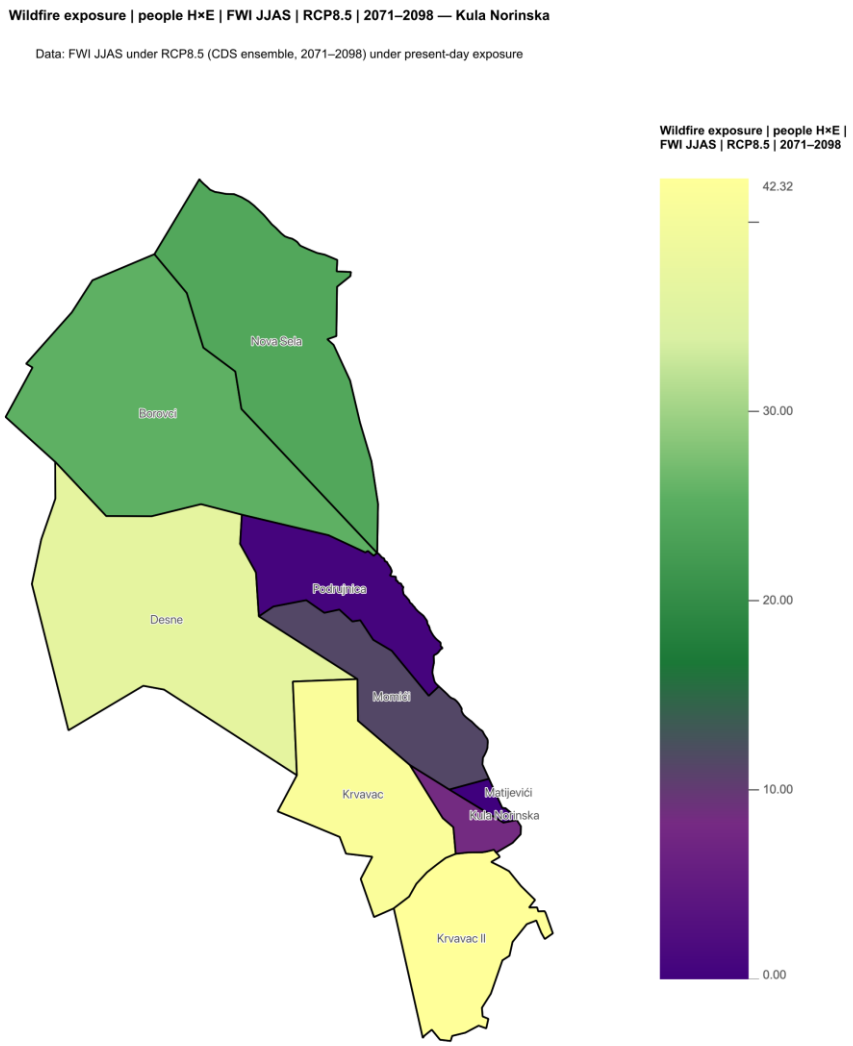


Fig 2-12 Wildfire hazard-weighted exposure – people (H×E, FWI JJAS, RCP8.5, 2071–2098; present-day exposure).

RCP8.5 in 2071–2098 produces the strongest assessed fire-weather signal, with settlement-area mean FWI values of 42.12–42.96 and Krvavac II people H×E increasing by 13.32 to 42.32 (Annex B; Table 2-6). The common numeric range in Figures 2-11 and 2-12 shows that the higher-forcing pathway produces a larger far-future increment than RCP2.6 while preserving the exposure-driven settlement pattern. This result is conditional on the single CDS multi-model ensemble-mean product, for which individual-GCM spread is unavailable (Annex B).

2.3.2.2 Risk assessment

Wildfire hazard per settlement is the receptor-mass-weighted mean of the 500 m FWI grid (dominant-class or plain-area means are never multiplied as ordinal codes; where no receptors are present, an area-weighted fallback is applied and flagged). Exposure uses the same min–max-normalised receptor masses as drought (people: GHS-POP resident sum; assets: GHS-BUILT-S built-up hectares; agriculture: CORINE 2018 hectares). No vulnerability term is applied: no defensible fire-specific settlement-level sensitivity data exist, so all wildfire rows are explicitly labelled hazard-weighted exposure (H×E), not complete risk.

Table 2-6 Wildfire hazard (FWI JJAS) and hazard-weighted exposure by settlement (CDS multi-model ensemble; H×E, present-day exposure)

Settlement	H FWI JJAS (1981–2005)	H×E people (1981–2005)	H×E people (RCP2.6, 2071–2098)	H×E people (RCP8.5, 2071–2098)	Δ(H×E) people (RCP8.5 ff)	H×E agriculture (RCP8.5, 2071–2098)
Borovci	29.12	17.31	19.59	25.47	+8.16	33.41
Desne	29.50	25.13	28.22	36.57	+11.44	37.26
Krvavac	29.26	28.30	31.69	41.16	+12.87	10.91
Krvavac II	29.00	29.00	32.50	42.32	+13.32	42.12
Kula Norinska	28.89	6.09	6.84	8.91	+2.82	3.85
Momići	29.20	8.15	9.16	11.90	+3.75	0.41
Nova Sela	29.05	16.46	18.68	24.29	+7.83	9.18
Podrujnica	29.39	0.76	0.86	1.11	+0.35	0.00
Matijevići	28.94	0.00	0.00	0.00	+0.00	1.69

Krvavac II has the highest hazard-weighted exposure for people historically (H×E = 29.00) and under every future case, reaching 42.32 under RCP8.5 in 2071–2098 (Δ(H×E) = +13.32); Desne follows at 36.57 (Table 2-6). Far-future values increase from RCP2.6 through RCP4.5 to RCP8.5, but the temporal response is not monotonic under RCP2.6: Krvavac II reaches 34.70 in 2041–2060 and 32.50 in 2071–2098. Figures 2-10–2-12 therefore support a higher far-future fire-weather signal under stronger forcing without establishing an increase at every successive horizon. Annex A contains the complete 30-map wildfire series for people, assets and agriculture across the historical baseline and nine RCP–horizon combinations.

Historical FWI varies only from 28.89 to 29.50 across the nine settlements, while people exposure spans the full normalised range from 0.0000 to 1.0000; the large contrast in mapped people H×E is therefore driven mainly by receptor distribution, with Krvavac II highest because it has the largest area-weighted population exposure and Desne recording the highest receptor-weighted historical FWI (Table 2-6; Annex B). The rise in Krvavac II people H×E from 29.00 historically to 42.32 under RCP8.5 in 2071–2098 indicates stronger modelled summer fire-weather conditions under unchanged exposure, but it does not predict burned area, ignition probability, fire intensity or monetary loss (Table 2-6; Copernicus C3S, sis-tourism-fire-danger-indicators). FireCCI51 provides independent historical context: Krvavac II records 661.17 ha of cumulative mapped burning over five fire-affected months, although cumulative area can include reburning and a fire-affected month is not an incident count (Table 2-5; Chuvieco et al., 2018; Annex B). The absence of a defensible

settlement-level fire vulnerability term limits these maps to screening-level H×E outputs for prioritising attention rather than complete H×E×V wildfire-risk or loss estimates (Table 2-4; Annex B).

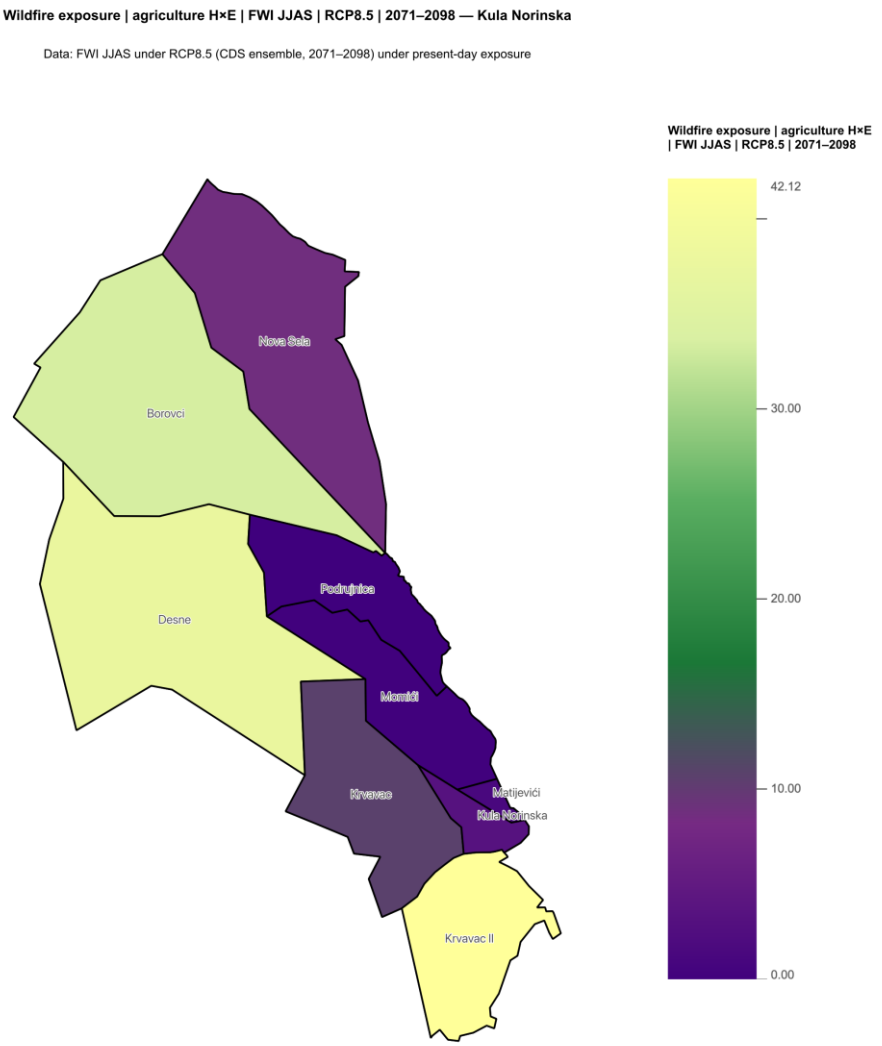


Fig 2-13 Wildfire hazard-weighted exposure – agriculture (H×E, FWI JJAS, RCP8.5, 2071–2098; present-day exposure).

Under RCP8.5 in 2071–2098, Krvavac II has the highest agricultural H×E value (42.12) and the largest increase from the historical baseline (Δ(H×E) = +13.30; Annex B). The wildfire workflow uses the settlement-area-weighted FWI fallback for the agricultural endpoint and records this method in each result row, so the hazard surface is area-comparable but is not weighted by the within-settlement distribution of agricultural receptors (Annex B). The map is therefore a screening measure of fire weather combined with total agricultural exposure, not a complete agricultural wildfire-risk estimate.

2.3.3 Additional assessments based on local models and data

2.3.3.1 Hazard assessment

Agricultural drought sensitivity was re-based on corrected data descriptions. Soil water capacity is the OpenLandMap USDA available water capacity summed over the 0–200 cm soil profile, in mm at 250 m resolution (doi:10.5281/zenodo.2629149, CC-BY-NC-SA-4.0) – not a SoilGrids product and not mm/m. The raster ignores depth-to-bedrock, so soil water capacity is systematically overestimated (~10–15%) on karst terrain. Irrigation is the GAEZ v5 LR-IRR layer – the share of cropland equipped for irrigation at ~1 km resolution with reference year 2015 (FAO/IIASA, CC-BY-4.0; Mehta et al., 2024) – not an ~11 km suitability product; untagged sea cells (0.0) are disclosed per settlement through a dilution flag (no effect for the nine Kula settlements, all ≥ 3.3 km inland). These two inputs form the only quantified vulnerability term (drought × agriculture).

The dissolved union of Natura 2000 habitats, Natura 2000 bird areas, national protected areas and Ramsar wetlands intersected with the settlements totals 3,382.50 ha after overlapping polygons are removed (Annex B). This area is reported as a separate ecological receptor and is not multiplied into the people, assets or agriculture indices. A low socio-economic proxy score does not demonstrate low ecological risk in a sparsely populated protected wetland, while Natura 2000 designation and static water-cover fraction do not quantify physical sensitivity or water availability during drought. These variables are therefore excluded from the vulnerability term (Annex B).

2.3.3.2 Risk assessment

The available calculations do not include a compound-hazard index, joint-event probability or compound-loss model. Table 2-8 therefore presents an exploratory comparison of independently computed drought and wildfire H×E values and identifies settlements that rank highly in both assessments without implying statistical dependence or joint probability. Stakeholder observations provide attributed qualitative context for the hazard priorities and are not treated as validation of the model outputs.

2.4 Key Risk Assessment Findings

Phase 1 stakeholder engagement classified drought and wildfire as very-high-priority risks for Kula Norinska. River flooding and heatwaves were classified as moderate priorities, while coastal flooding, heavy rainfall, snow and wind were classified as low priorities. These categories are qualitative municipal judgements; Phase 2 adds quantitative evidence for drought and wildfire but does not re-model the other hazards.

Risk workflow Severity Urgency Capacity Risk priority

C F Resilience/ CRM					
River flooding	Moderate	Moderate	Watching brief	Substantial	Moderate
Coastal flooding	Limited	Limited	No action needed	High	Low
Heavy rainfall	Limited	Limited	No action needed	High	Low

Heatwaves	Moderate	Substantial	More action needed	Substantial	Moderate
Drought	Substantial	Critical	Immediate action needed	Medium	Very high
Fire	Critical	Critical	Immediate action needed	Medium	Very high
Snow	Limited	Limited	No action needed	High	Low
Wind	Limited	Limited	No action needed	High	Low

Resilience

Severity Urgency Capacity Risk Ranking

Critical Immediate action needed High Very high

Substantial More action needed Substantial High

Moderate Watching brief Medium Moderate

Limited No action needed Low Low

Fig 2-2 Key Risk Assessment of each risk workflow in the Municipality of Kula Norinska

Wildfire was assigned critical current and future severity and immediate-action urgency through the stakeholder process. The local fire service is experienced, but response remains largely reactive and can be constrained during extensive wetland fires. The medium resilience rating reflects this gap. It does not constitute a quantified estimate of response capacity.

Drought was assigned substantial current severity, critical future severity and medium resilience. Stakeholders report concern about longer dry seasons and uneven irrigation access, especially on karst terrain. The Phase 2 climate analysis supports concern about future summer drying under higher forcing, but it does not establish that every recent year or the period since 2020 was drier than the reference period.

Phase 1 – Phase 2 comparison

Phase 1 already contained settlement-level fire maps and future-scenario material. Table 2-7 distinguishes the revised data and methods from changes in the assessed climate signal, and identifies where Phase 2 changes the interpretation or comparability of the results.

Table 2-7 Phase 1 – Phase 2 comparison (evidence-based)

Aspect	Phase 1 (screening deliverable)	Phase 2 (this deliverable)	Methodological changes and resulting differences in the assessment
Focus	Screening of priorities: wetlands, agriculture and tourism; stakeholder consultation; hazard shortlist (drought, fire).	Detailed, reproducible drought (SPI-6 composite) and wildfire (FWI + FireCCI51) assessments for all nine settlements, with versioned methods and validated computations.	Phase 2 retains the Phase 1 hazard priorities and provides the quantitative evidence required to compare settlements and support adaptation planning.
Data sources	Local climate-station material, standard CLIMAAX workflow inputs, stakeholder evidence and previously prepared fire-weather maps.	ERA5-Land observations; CHELSA V2.1 CMIP6 climatologies; CDS CMIP5 FWI; FireCCI51 burned area; GHS-POP/GHS-BUILT-S; CORINE 2018; Bioportal protected areas; OpenLandMap AWC; and GAEZ v5 LR-IRR.	Phase 2 replaces unsupported inherited climate figures with checksum-registered and versioned sources linked to the calculations. National station material remains contextual and is not used to calculate the revised drought or wildfire outputs.
Spatial resolution	Settlement-level fire maps were available, whereas drought figures were reported mainly at county/NUTS scale.	Climate inputs comprise ERA5-Land at 0.1° (~11 km), CHELSA at ~1 km and CDS FWI transformed to a 500 m analysis grid; receptor layers range from ~100 m to ~1 km, and final outputs are aggregated to all nine settlements.	Drought results are now reported consistently for every settlement. The 500 m wildfire grid is a processing grid and does not increase the information content of the source indicator, so fine within-settlement differences are not interpreted.
Drought methodology	WASP and relative drought charts from the standard CLIMAAX workflow.	SPI-6 per calendar month with frozen 1981–2010 gamma calibration (validated exactly against xclim 0.62.0), 19 ERA5-Land points with validated backfill, IDW interpolation, composite H, R = H×E×V.	The revised SPI-6 calculation and explicit receptor terms produce settlement-relative scores that are not numerically interchangeable with the Phase 1 drought figures. The values support ranking within Kula Norinska rather than absolute probability or loss estimates.
Wildfire methodology	FWI-related maps including RCP4.5/8.5 scenario material.	FireCCI51 burned-area observations (240/240 months) plus the CDS sis-tourism-fire-danger-indicators FWI ensemble (1981–2005; RCP2.6/4.5/8.5 × 2021–2040/2041–2060/2071–2098) on rebuilt 500 m rasters; ML susceptibility branch retired and documented.	Phase 2 separates weather-based fire danger, observed burned area and susceptibility. The released H×E results use a matched historical/future FWI product and exclude the susceptibility model that failed the source-compatibility and spatial-validation audit.

Aspect	Phase 1 (screening deliverable)	Phase 2 (this deliverable)	Methodological changes and resulting differences in the assessment
Scenario framework	RCP fire and SSP drought scenarios were already present in Phase 1 material.	Local CHELSA processing (5-GCM ensemble, delta method) for drought horizons 2011–2040/2041–2070/2071–2100; CDS FWI horizons 2021–2040/2041–2060/2071–2098 (product ends 2098).	The revised assessment preserves SSP labels for CMIP6 drought data and RCP labels for the CMIP5 wildfire product without conversion or one-to-one pairing. Future results isolate climate-hazard change while holding present-day exposure and vulnerability constant.
Resulting assessment	Broad priorities and spatial patterns from screening.	Settlement rankings and component values with GCM agreement (drought: all pairwise Spearman 1.000; wildfire: single ensemble product, disclosed) and sensitivity tests.	Krvavac II, Krvavac and Desne emerge as the principal cross-hazard priority settlements, while agricultural drought risk peaks at Desne. Differences from Phase 1 reflect revised methods, corrected computations and additional data as well as the climate scenarios, so scores should not be compared numerically across phases.
Stakeholder evidence	31 stakeholders reported engaged (workshops and consultations).	Engagement continued: two workshops (October 2025, March 2026) plus informal contacts; local fire-brigade knowledge on the anthropogenic origin of reed fires; 31 of the 50-stakeholder target achieved to date.	Stakeholder evidence informs hazard priorities and local context but is kept separate from validation of the model outputs. Engagement toward the 50-stakeholder target continues in Phase 3 (Table 4-1).

Quantitative cross-hazard synthesis, robustness and sensitivity

Table 2-8 compares future hazard-weighted exposure for people under the higher-forcing brackets of both hazards. The indices use different hazard definitions, baselines and scenario families and are computed independently. The comparison identifies settlements that warrant attention across both assessments but does not establish joint probabilities or compound losses.

Table 2-8 Exploratory cross-hazard comparison of future hazard-weighted exposure (independently computed indices; no joint probabilities are implied)

Settlement	Drought H×E, people (SSP5-8.5, 2071–2100) [rank]	Wildfire H×E, people (RCP8.5, 2071–2098) [rank]
Borovci	0.6619 (4)	25.47 (4)
Desne	0.931 (3)	36.57 (3)
Krvavac	1.0705 (2)	41.16 (2)
Krvavac II	1.1156 (1)	42.32 (1)
Kula Norinska	0.2347 (7)	8.91 (7)
Momići	0.3087 (6)	11.90 (6)

Settlement	Drought H×E, people (SSP5-8.5, 2071–2100) [rank]	Wildfire H×E, people (RCP8.5, 2071–2098) [rank]
Nova Sela	0.6365 (5)	24.29 (5)
Podrujnica	0.0286 (8)	1.11 (8)
Matijevići	0 (9)	0.00 (9)

The drought priority ranking is stable across the five GCMs: all ten pairwise Spearman agreements equal 1.000 and all nine settlements meet the spread criterion, defined as a far-future spread no greater than two standard deviations of baseline R (Annex B). The wildfire ranking is conditional on a single CDS multi-model ensemble-mean product because individual-GCM values are unavailable. The relationship between drought and wetland carbon cycling remains a hypothesis: methane responses depend on the hydrological pathway, a rewetted-fen study measured reduced CH_4 emissions under drought, and no local flux observations are available (Beyer et al., 2021). The assessment consequently draws no general causal conclusion about local drought-driven methane emissions or reed ignition.

The agricultural ranking remains unchanged when the AWC and irrigation vulnerability weights are varied from the adopted w = 0.5 to 0.3/0.7 (Spearman 1.000; maximum |ΔR| = 0.067; Annex B). Replacing absolute resident mass with population density yields Spearman −0.067, maximum |ΔR| = 1.114 and a different top-three order. The assessment retains absolute resident mass because the defined endpoint is the total population exposed within each settlement, while the density result is reported as a sensitivity test. IDW interpolation from 19 points and approximately 1 km climate inputs do not provide equivalent effective information resolution at settlement scale, so small differences between neighbouring settlements remain uncertain.

Implications for people, the economy and the environment

The indices in this report are screening tools. A high value means that climate hazard coincides with a relatively large exposed receptor or, for agricultural drought, the available vulnerability indicators. It does not mean that a specific loss will occur, and values from the drought and wildfire workflows are not directly comparable in magnitude.

Population. Krvavac II, Krvavac and Desne contain the largest population-weighted exposure across the two assessed hazards. This supports prioritising preparedness and further vulnerability assessment in those settlements. Health effects, smoke exposure, evacuation needs, vulnerable residents and household losses were not quantified.

Economy and livelihoods. Agricultural drought risk is highest at Desne, and low available water capacity also makes Podrujnica important for water and soil management even though its normalised agricultural exposure is the local minimum. Potential consequences include greater irrigation demand, crop stress, variable yields and disruption to nature-based tourism. No monetary losses, business interruption or municipal response costs were calculated.

Environment. Drought and fire can place pressure on freshwater-dependent habitats, while repeated burning may affect vegetation and ecosystem recovery. The assessment identifies 3,382.50 ha of protected wetland receptor area but does not quantify ecological vulnerability, biodiversity loss or greenhouse-gas effects. Claims about irreversible damage therefore require dedicated ecological evidence.

Candidate adaptation priorities for Phase 3

The following options are derived from the identified hazards, exposure patterns and data gaps. They are candidates for appraisal with stakeholders, not measures already proven cost-effective in Kula Norinska.

• Establish a standard fire-incident register covering date, location, ignition cause, burned area, assets affected and response time.

• Strengthen prevention of deliberate or negligent vegetation burning through education, reporting procedures and proportionate enforcement.

• Review fire detection, access, warning, evacuation and smoke-communication arrangements, beginning with Krvavac II, Krvavac and Desne.

• Assess irrigation efficiency, soil-moisture conservation, drought-tolerant farming practices and seasonal water-management triggers, with particular attention to Desne and Podrujnica.

• Monitor wetland water conditions, vegetation and recovery, and assess restoration or fuel-management options under ecological safeguards.

• Develop baseline indicators for agricultural losses, tourism disruption, municipal response costs, vulnerable residents and critical buildings so future adaptation benefits can be evaluated.

These are climate-risk adaptation measures. Emissions-mitigation measures such as renewable energy, carbon pricing or circular-economy policies should be presented separately because they do not directly reduce the mapped drought and wildfire exposure.

2.4.1 Mode of engagement for participation

Engagement and participation process with relevant stakeholders, experts and priority groups have already been described in section 2.1.5. of this deliverable. The risk assessment gathered mostly confirmative feedback from the stakeholders involved in the process. On the other hand, a minor part of the stakeholders expressed their different views regarding two issues:
1) From the beginning of current decade droughts and wildfires are more interconnected and it is very hard to separate their impact. Because of that, some stakeholders had problems dividing their impacts into separate categories.
2) Resilience capacity for fires should not be understood as a static term because the severity and size of fires in the wetlands sometimes determine lower resilience capacity. Although the resilience capacity oscillates between low and substantial it was generally accepted that category *medium* may be used as the most relevant.

2.4.2 Gather output from Risk Analysis step

The risk evaluation uses the result tables in Annex B, including 1,278 records of hazard, exposure, vulnerability and risk by settlement, endpoint, scenario and climate model. Annex B also provides summary tables, sensitivity and scenario-change results, and the drought and wildfire geospatial layers in EPSG:3765. The accompanying schema table defines the result fields.

Column	Meaning
name / settlement_id	Official settlement name and cadastral identifier
hazard_type	drought_spi6_composite or wildfire_fwi_jjas
endpoint	people, assets or agriculture (receptor group)
baseline_id	reference_1981-2010 (drought) or historical_1981-2005 (wildfire)
scenario / period_start / period_end	reference, historical_eval, ssp126/370/585 or rcp26/45/85 with explicit period bounds
gcm	observed, ensemble_mean, or one of the five GCMs
H, E, V, R	hazard, exposure, vulnerability and risk components (R = H×E×V; H×E where no defensible V exists – flagged)
delta_H / delta_R / pct_H / pct_R	change against the baseline (pct qualified near zero baselines)
quality_flag / method_version	quality-control meaning and calculation-method version

2.4.3 Assess Severity

Severity categories were established through the structured stakeholder process and are used as qualitative priority judgements. They are not a validation of the modelled spatial patterns or a monetary-loss estimate.
The future qualitative priority judgements are interpreted alongside the quantitative climate scenarios, while remaining distinct from the modelled hazard and exposure outputs.

The assessment identifies drought and wildfire as the highest municipal priorities during the warm season. This qualitative priority is supported by stakeholder consultation and by the conditional climate-hazard and exposure results presented above.
No monetary-loss or local greenhouse-gas-emission inventory was produced for this deliverable. Ecological and livelihood implications are therefore discussed qualitatively and should not be read as quantified losses.
Stakeholders consider the combined pressure of drought and wildfire potentially severe for protected wetlands and biodiversity. Phase 2 supports concern about climate pressure and documents historical burned area, but it does not quantify ecological damage, recovery time or irreversibility.

Stakeholder and priority-group perspectives added information about local livelihoods, wetland use, fire practices and implementation barriers that is not contained in the spatial datasets. Decision makers understand the importance of the risks, but require additional support to compare, fund and monitor specific adaptation options.

2.4.4 Assess Urgency

Assessing urgency was done applying the same approach as assessing the severity. The final assessment was done after consulting with the local stakeholders. As we expected four hazards with lowest severity (coastal flooding, heavy rainfall, snow, wind) were designated to have lowest level of urgency (category **no action needed**). In next category named **watching brief** was assigned only to risk of river flooding that use to be the most important risk in the past. Construction of

hydroelectric power plants in the upper course of Neretva, together with introduction of modern flood protection system in the Delta region, has significantly decreased the impact of river flooding. The risk of heatwaves was put in category **more action needed** meaning that the adaptation and mitigation policy is necessary at this moment. Drought and fire are recognized as risks with highest urgency (**immediate action needed**) because of their prolonged and intensive negative impact.

In general, risk severity does not change significantly from current to future risk since it is staying in same category for six hazards (river flooding, coastal flooding, heavy rainfall, fire, snow, wind). Only for two hazards, heatwaves and drought, the severity is changing in a negative way by moving into the next category.

The evidence supports early action because fire incidents already occur and the scenarios indicate stronger future summer drying and fire-weather conditions under higher forcing. The analysis does not identify a specific year when major damage will occur. Near-term priorities are preventing avoidable ignitions, improving preparedness and developing a drought adaptation plan with clear monitoring triggers.
Continued deliberate or negligent burning could add avoidable ignition pressure to increasingly fire-conducive conditions. Potential consequences for wetlands, agriculture and tourism may be serious, but their magnitude and reversibility have not been quantified. This uncertainty strengthens the case for prevention and monitoring without justifying unsupported damage estimates.
Salinisation was outside the scope of this Phase 2 assessment and is not interpreted here as a climate-risk result. It should be assessed through a separate hydrogeological and climate evidence base if prioritised in Phase 3.
Drought and wildfire are retained as priority hazards for Phase 3 because the evidence in this deliverable shows continuing climate pressure and a persistent need for prevention, preparedness and adaptation planning.
Different perspectives from the stakeholders highlighted the risks that were not so obvious from the scientific point of view. They provided us with wider contextual understanding of purely theoretical risk approach. At the same time, inclusive policy helped us to establish trust and ensured that our perception of urgency was matching the impact on communities affected by the risks. Such a gave certain legitimacy to the whole process.

2.4.5 Understand Resilience Capacity

The stakeholder process assigned medium resilience to drought and wildfire. Existing emergency services and institutional partnerships provide response capacity, but important weaknesses remain: limited prevention, no formal climate-risk monitoring system, incomplete incident and vulnerability data, uneven irrigation access, and dependence on external finance. Resilience should therefore be understood as partial and variable rather than sufficient under all events.

Current climate-risk measures are mainly reactive or still being planned. For drought and wildfire, adaptation should focus on prevention, preparedness, water and land management, ecosystem resilience and monitoring. Renewable energy, carbon pricing and circular-economy policies are climate-change mitigation measures and should be assessed separately from measures that directly reduce local drought and wildfire risk.
The municipality has limited financial and specialist capacity and will require cooperation with county, national and EU institutions. Human capacity can be strengthened through training and

sustained stakeholder participation. Natural, physical and social capacity should not be assumed sufficient without measurable indicators for ecosystem condition, warning coverage, critical services, vulnerable groups and response performance.
Existing laws, emergency arrangements and post-event financial assistance provide a foundation, but detailed local prevention and adaptation plans are still missing. Phase 3 should convert the priority risks into actions with named responsible institutions, schedules, costs, safeguards and monitoring indicators.

2.4.6 Decide on Risk Priority

Stakeholder engagement provided us with access to their local knowledge and helped us in the process of assigning risk priorities (Figure 2-3) that is necessary for future CRM planning and implementation. The open mutual exchange of knowledge and scientific data through participation and inclusion was crucial in defining severity, urgency and resilience capacity of the Municipality.

Risk workflow Severity Urgency Capacity Risk priority

C F Resilience/ CRM					
Workflow 1 (Fire)	Critical	Critical	Immediate action needed	Medium	Very high
Workflow 2 (Drought)	Substantial	Critical	Immediate action needed	Medium	Very high

Resilience
Severity Urgency Capacity Risk Ranking

Critical Immediate action needed High Very high

Substantial More action needed Substantial High

Moderate Watching brief Medium Moderate

Limited No action needed Low Low

Fig 2-3 Risk prioritization of two most important risk workflows in the Municipality of Kula Norinska: (wild)fires and droughts

Wildfire is a priority hazard for Kula Norinska. Stakeholders and the local fire brigade report that many reed fires are anthropogenic; drought and hot conditions can increase fire-conducive conditions. Spontaneous reed ignition remains an unmeasured hypothesis and is not used as an analytical conclusion.
The second hazard, droughts, occur during the summer months are a natural feature of the Mediterranean climate that is reinforced with global climate change. Droughts extend to the whole Municipality of Kula Norinska and the whole Delta region. Although the impact of droughts is obvious in the areas of karstic hills of the Municipality where there are no watercourses or lakes, the wetlands are especially vulnerable to extremely dry seasons. Low level of water in wetlands

and periodical drying of certain areas alters wetland greenhouse-gas fluxes; the direction and magnitude of any methane response is pathway-specific and has not been measured locally, so no quantitative claim is made (drought can reduce CH4 emissions in rewetted fens; Beyer et al., 2021). And last, but not least in any way, is devastating impact on biodiversity, especially wetland vegetation and animals that demand fresh water for their survival and existence.

2.5 Monitoring and Evaluation

We **learned from the second phase** of the climate risk assessment that through intensive communication and field work it is possible to establish mutual trust and respect with majority of stakeholders. On the other hand, we are still careful to rush with early conclusions regarding the behavioural change since it is something that has to validated and confirmed through longer time period.
Stakeholders play extremely important role in Monitoring and Evaluation because their actions, cooperation and, hopefully, behavioural change are crucial for implementation of an effective adaptation policy. Another important feature of stakeholders is the local knowledge that facilitate the work of scientists and regional agencies that deal with protection and conservation of local wetlands that are especially endangered by climate hazards.
The **feedback** that we have **received from the stakeholders** during the second phase of the project is predominantly positive and affirmative. Our mutual communication turned out to be very constructive with general shift towards more receptive attitude of the majority. There is also interest for similar projects in the future.
The learning process is still being developed and by now it is mostly done during the workshops and through unofficial contacts with certain stakeholders.

The revised analysis adds ERA5-Land, CHELSA, FireCCI51, FWI, population, land-cover and soil-water datasets. Remaining gaps concern local station observations, fire-service incident records, sensitive-population and building-stock data, and local wetland flux measurements.
We would like to **communicate the final outcomes of the projects** locally to the stakeholders involved in the process during workshops where representatives of each stakeholder group would be invited to participate. Since communication in the Municipality nowadays relies on digital technologies and the Internet is widely used as a means of communication, we would also make the results public on relevant websites.

At the present moment we do not have a monitoring system in place that considers the analysed risks. We realize informal monitoring based on reports from the local stakeholders.

Stakeholder participation was strongest in communication, cooperation and support for climate-change adaptation and wetland conservation. Settlement-level analysis remains constrained by the effective resolution of the available climate inputs and by gaps in local vulnerability and incident data, as documented in the limitations and Phase 3 priorities.

Our use of resources, primarily of time and staff, was satisfactory efficient and there were no major additional costs of the project.

We were limited by the projects rules regarding the time needed for the CRA process and opinion is that more time for the work on the CRA would definitely result with a more comprehensive analysis.

The CRA definitely improved understanding of climate hazards and risks in the Municipality. It helped to shape public awareness about the climate change issues. Engagement of local stakeholders is also a positive side of the project and there is a willingness to continue with similar projects in the Municipality in the future.

2.6 Work plan Phase 3

Phase 3 (M17–M22 | July–December 2026) will translate the Phase 2 evidence into a prioritised adaptation plan. Farmers, the fire service, environmental bodies, community representatives and municipal decision makers should evaluate feasibility, cost, equity, environmental safeguards and responsibility for each option.

The main Phase 3 activities will be:

• Co-designing adaptation objectives and acceptable monitoring thresholds with local stakeholders.

• Appraising drought options such as irrigation efficiency, soil-moisture conservation, water-management triggers and drought-resilient farming.

• Appraising wildfire and wetland options such as ignition prevention, incident recording, warning and evacuation, ecologically supervised vegetation management and habitat restoration.

• Establishing indicators for climate conditions, fires, agricultural effects, tourism disruption, vulnerable residents, ecosystem condition, implementation cost and adaptation performance.

Milestones for the Phase 3:

Milestone 10. Presentation of the project results to an international audience in the Final CLIMAAX Workshop in Brussels (End of 2026), including policy and decision-makers.

Milestone 11. Delivery of the final project outcomes to local, regional, and potentially national decision-makers to influence policy.

Milestone 12. A comprehensive review meeting to evaluate the project outcomes against the initial objectives.

The Phase 3 output should be a practical risk-management plan that links each selected measure to the Phase 2 evidence, a responsible institution, implementation schedule, estimated resources, safeguards and a measurable indicator. Measures should then be integrated into municipal planning and funding applications.

Salinisation remains outside the scope of Phase 2 because the project did not assemble the hydrogeological, river-flow, sea-level, groundwater and water-use evidence required for a defensible attribution assessment. No conclusion about its dominant cause is made here. If prioritised, it should be assessed through a dedicated study.

3 Conclusions – Phase 2 climate risk assessment

Phase 2 confirms drought and wildfire as priority climate risks for Kula Norinska and provides a reproducible basis for comparing all nine settlements. The strongest long-term signal is a warmer and drier summer climate under higher forcing. Because drought hazard varies little among settlements, population and agricultural exposure largely determine the spatial ranking. Krvavac II has the highest hazard-weighted exposure for people under both hazards, while Desne has the highest calculated agricultural drought risk. Historical satellite observations also show concentrated mapped burning in Krvavac II, Borovci and Krvavac.

For residents, these findings identify priority locations for preparedness and further vulnerability assessment; they do not predict health effects, casualties or household losses. For agriculture, the results support attention to soil moisture, irrigation demand and farming resilience, especially in Desne and Podrujnica. Agriculture, tourism and protected wetlands may experience disruption through water stress, smoke, fire and ecosystem degradation, but Phase 2 did not quantify crop losses, tourism revenue, municipal costs or ecological damage.

The main conclusion is therefore one of priority and preparedness rather than predicted loss. Phase 3 should assess the candidate actions identified in this report, beginning with better fire records and ignition prevention, warning and evacuation arrangements, agricultural water and soil measures, wetland monitoring, and data on vulnerable residents and critical assets. Decisions should retain the report's uncertainty limits: future exposure is held constant, wildfire model spread is unavailable, population and ecological vulnerability are incomplete, and all economic consequences remain qualitative.

4 Progress evaluation

Connection Between the Delivery of the Document for Phase 2 and Subsequent Phases
The main focus of Phase 2 was a regionalized risk analysis based on fine tuning of hazard and risk analyses that were done during the previous phase of the project. Stakeholder involvement was continued and further deepened during capacity-building workshops and educational programs that are a part of creating a participatory process. The feedback from the stakeholders will be used for completion of climate-related policies and adaptation strategies.

This delivery is also a foundation for the Phase 3, the final phase of the project with focal point on detailed analysis of climate risk management objectives in the Municipality of Kula Norinska that corresponds to the local climate priority risks. The outputs of the Phase 2 that interconnect assessing severity and urgency with understanding of local resilience capacity are important for creating of feasible climate change adaptation strategy for the Municipality.

Phase 3 will build upon this by continued involvement of stakeholders through participatory processes, capacity-building workshops, community awareness and educational programs, joint development of adaptation strategies and climate-related policy recommendations for the local government.

Key Performance Indicators and **Milestones** achieved in this phase and the actions just like the actions executed to achieve them are shown in tables 4-1 and 4-2 (below).

Table 4-1 Overview key performance indicators

Key performance indicators	*Progress*
1. Number of Climate Risk Assessments Completed – At least 2 assessments conducted by Month 16 (June 2026).	Completed
2. Number of Stakeholders Engaged – At least 50 stakeholders (farmers, NGOs, public officials) engaged in workshops and consultations by Month 22 (December 2026).	Partially achieved – 31 of the 50 stakeholders engaged to date (workshop and consultation records: two workshops, October 2025 and March 2026, plus informal consultations; the Phase 1 report records 31 participants). The remaining engagement is planned work for Phase 3, not completed.
3. Number of Community Awareness and Educational Programs Conducted – Minimum of 4 programs delivered, 2 in Phase 2 and 2 in Phase 3, ensuring widespread awareness.	Completed
5. Volume of Climate-Related Data Collected and Integrated – A minimum of 10 datasets collected and integrated into local governance and planning documents by Month 16	Completed

Table 4-2 Overview milestones

Milestones	*Progress*
Milestone 7. Finalization of refined risk assessments using high-resolution local data.	Completed
Milestone 8. Sharing preliminary results with Kula Norinska's local government and key stakeholders.	Completed
Milestone 9. Completion of the draft adaptation strategy incorporating stakeholder feedback and scientific assessments.	Completed

5 Supporting documentation

All released analysis outputs, maps and project-specific processed inputs are provided with this deliverable. Annex A contains A4 map exports. Annex B contains separate open-format result tables, a field dictionary, plain-language methodology and validation notes, a complete data catalogue and SHA-256 checksums. The spatial_data folder contains the settlement geometry, project-area raster/vector inputs, climate point series, monthly burned-area crops, processed hazard rasters and single-layer GeoNode upload files. Large global public source datasets are represented by the exact project-area extracts used by the assessment, with provider, version, licence, resolution and source URL recorded in Annex B.

Annex A – Complete drought and wildfire map series in PNG and PDF.

Annex B – Separate result tables, field definitions, methodology, provenance, validation, data catalogue, GeoNode upload manifest and checksums.

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